



# Transforming the future of ageing

This Evidence Review Report has been produced under the auspices of the SAPEA Consortium, as a deliverable under Grant Agreement 737432 "Science Advice for Policy by European Academies" (SAPEA) that was signed by the Consortium and the European Commission on 22 November 2016.

The text of this work is licensed under the terms of the Creative Commons Attribution licence which permits unrestricted use, provided the original author and source are credited. The licence is available at: <http://creativecommons.org/licenses/by/4.0>. Images reproduced from other publications are not covered by this licence and remain the property of their respective owners, whose licence terms may be different. Every effort has been made to secure permission for reproduction of copyright material. The usage of images reproduced from other publications has not been reviewed by the copyright owners prior to release, and therefore those owners are not responsible for any errors, omissions or inaccuracies, or for any consequences arising from the use or misuse of this document.

A list of the experts who contributed to the report is in Annex 1.

In accordance with Article 35, paragraph 1 of the aforementioned Grant Agreement, the Consortium identified all relevant interests of the experts requested to contribute to the Evidence Review Report, assessed whether an interest constituted a conflict of interests, and took — where relevant — measures to exclude that an interest could compromise or be reasonably perceived as compromising the impartiality or objectivity of the report. Further information about SAPEA's working processes is available at [www.sapea.info/guidelines](http://www.sapea.info/guidelines).

The information, facts and opinions set out in this report are those of the authors and do not necessarily reflect the opinion of the European Commission. The SAPEA Consortium is not responsible for the use which may be made of the information contained in this report by anyone, including the European Union institutions and bodies or any person acting on their behalf.

This report can be viewed online at: [www.sapea.info/ageing](http://www.sapea.info/ageing)

---

ISBN 978-3-9820301-1-1

DOI 10.26356/ageing

SAPEA, Science Advice for Policy by European Academies. (2019). Transforming the Future of Ageing. Berlin: SAPEA. <https://doi.org/10.26356/ageing>

version 2019.1.0

## **PUBLISHER**

SAPEA  
c/o acatech  
Pariser Platz 4a  
10117 Berlin, Germany

## **CONTACT**

SAPEA Communications Office  
Rue d'Egmont 13  
1000 Brussels, Belgium  
[contact@sapea.info](mailto:contact@sapea.info)



Science Advice for Policy by European Academies

# Transforming the future of ageing

Informs the forthcoming Scientific Opinion  
of the European Commission Group of Chief Scientific Advisors

## *Version history*

Version	Date	Summary of changes
2019.1.0	27 June 2019	First published version



## About SAPEA

SAPEA (Science Advice for Policy by European Academies) brings together outstanding expertise in engineering, humanities, medicine, natural and social sciences from over 100 academies, young academies and learned societies across Europe.

SAPEA is part of the European Commission's Scientific Advice Mechanism. Together with the Group of Chief Scientific Advisors, we provide independent scientific advice to European Commissioners to support their decision-making. We also work to strengthen connections between Europe's academies and Academy Networks, and to stimulate debate in Europe about the role of evidence in policymaking.

Funded through the EU's Horizon 2020 programme, the SAPEA consortium comprises Academia Europaea, All European Academies (ALLEA), the European Academies' Science Advisory Council (EASAC), the European Council of Academies of Applied Sciences, Technologies and Engineering (Euro-CASE), and the Federation of European Academies of Medicine (FEAM).

# Table of Contents

---

Preface.....	9
Executive summary .....	12
General overview .....	22
Overview of Chapter 1 .....	25
Overview of Chapter 2.....	26
Overview of Chapter 3.....	27
Overview of Chapter 4.....	28
Overview of Chapter 5.....	28
Chapter 1. Transforming challenges into opportunities .....	30
Demographic changes in the EU: trends and predictions .....	30
1a. The European health landscape in transition.....	43
1b. Appreciating ageing as an opportunity.....	46
1c. Revisiting the concept of healthy ageing.....	48
1d. Life course approach.....	52
1e. Fighting against all types of age discrimination.....	53
1f. Integration of social and health care systems.....	56
Chapter 2. Addressing the health challenges of ageing across the life course .....	60
Introduction.....	60
2a. Biological research into determinants, mechanisms and modulations of the ageing process .....	61
2b. Identifying and acting on global and life course determinants of ageing.....	66
2c. Identifying and acting on early and midlife risk factors for functional ageing and age-related diseases.....	75
2d. Opportunities for healthy ageing: reinforcing health promotion and targeted preventive strategies.....	113
Chapter 3. Optimising health and social care for older EU citizens.....	124
Introduction.....	124
3a. The health care challenges.....	125
3b. Integrating and expanding environments and communities for all ages.....	129
3c. Easing mobility and driving conditions.....	134
3d. Favouring ageing at home.....	137
3e. Developing care facilities to suit all ages.....	148
3f. Reducing emergency visits and hospital admissions.....	154
3g. Reducing length of stay in hospital.....	164
3h. Avoiding polypharmacy and inappropriate drug prescriptions.....	169
3i. Reducing health care-associated infection.....	173
3j. Promoting interventions for early rehabilitation.....	176
3k. Preventing hospital readmissions and delaying nursing home admissions.....	177
3l. Encouraging more age-friendly long-term care facilities.....	179

3m. Developing palliative medicine and care culture.....	183
3n. Combating elder abuse.....	186
<b>Chapter 4. The use of technology to promote healthy ageing.....</b>	<b>190</b>
4a. Telemedicine, digital medicine, wearable sensors, mobile and wireless technologies.....	190
4b. Lifelong self-tracking of health.....	192
4c. Ageing in place.....	194
4d. Acceptance by older people.....	197
4e. Global efficiency and proven outcomes.....	198
4f. Regulation and certification.....	199
4g. Reimbursement and health economics.....	202
4h. Integrated diagnostics and data science.....	204
4i. Unique electronic health record: interoperability, legal and ethical aspects in eu countries.....	205
4j. Examples of the use of technologies in care of older people.....	207
4k. Concluding remarks.....	210
<b>Chapter 5. Intensifying skilled health workforce training.....</b>	<b>212</b>
5a. Estimating and understanding the lack of health and social care workers in the EU.....	212
5b. Addressing the shortage of the health workforce: recruitment challenges.....	214
5c. Addressing the shortage of the health workforce: educational challenges.....	216
5d. Addressing the shortage of the health workforce: sustainability and retention.....	224
5e. Attesting to the role of the health workforce as the centre of robust health systems.....	225
5f. Conclusion.....	226
<b>Conclusions.....</b>	<b>229</b>
<b>Annex 1: Working Group members.....</b>	<b>233</b>
<b>Annex 2: External contributing experts.....</b>	<b>234</b>
<b>Annex 3: Discussion workshop and participants.....</b>	<b>235</b>
<b>Annex 4: Glossary of terms.....</b>	<b>237</b>
<b>Annex 5: List of abbreviations.....</b>	<b>244</b>
<b>Annex 6: Acknowledgements.....</b>	<b>248</b>
<b>Annex 7: Systematic literature search method report.....</b>	<b>249</b>
<b>References.....</b>	<b>255</b>



# Preface

The European population is ageing rapidly: its median age is the highest in the world. The topic of ageing has received significant attention in recent years, as is evident in the multiple international reports on ageing published during the last five years and the existence of at least eight active working groups on ageing at the EU level.

The SAPEA Working Group on Transforming the Future of Ageing aims to provide a scientific perspective to address the question of what policies at the EU level could support the member states in their response to the current and future opportunities and challenges posed by ageing.

In this project, SAPEA assembled a large multi-disciplinary working group, with world-leading expertise in the biomedical, human, social and engineering sciences. The Federation of European Academies of Medicine network led the project. The resulting report reflects not only the outstanding knowledge of the experts, but also their exemplary commitment to the voluntary task of collaborating in an interdisciplinary way and bringing the best and latest scientific knowledge into evidence-based policymaking.

The report aims to make a unique contribution from a broad public health standpoint to a complex topic in a way that complements other related resources, thereby providing evidence-based science advice for the highest policy level in Europe. In particular, the working group has made a conscious effort not to duplicate the same aspects of ageing covered in existing reports. Likewise, by adopting a multi-disciplinary approach in the present report, the working group has distinguished itself from other EU ageing-related

initiatives. These include the European Innovative partnership for Active and Healthy Ageing, Horizon 2020 projects in response to identified societal challenges posed by ageing, and the EU health programme managed by DG Santé focusing on healthy ageing, as well as existing networks funded by the EU, such as Innovation, Futurage, Mopact, Nestpar, and SHARE . The choice of topics covered in this report, or excluded, is based upon the expressed interest of policymakers throughout the scoping process, e.g. health, social affairs, employment, and technology.

SAPEA is an integral part of the European Commission's Scientific Advice Mechanism (SAM). This Evidence Review Report is presented to the European Group of Chief Scientific Advisors, informing their Scientific Opinion which will be published later in 2019. Both this report and the Scientific Opinion are delivered directly to the College of Commissioners, and will be used for planning and policymaking. By such means, the best available science, distilled and analysed by the leading experts in Europe, should have a direct and tangible impact on decisions taken by the European Commission which influences the lives of some 500 million people across our continent.

Professor George Griffin  
President of FEAM

Professor Sierd Cloetingh  
Chair of SAPEA Board

Professor Jean-Pierre Michel  
SAPEA working group chair





# Executive summary

This Evidence Review Report examines how public health aimed at protecting and improving the health of people and their communities can improve the prospects of current and future ageing of EU citizens.

In 2016, there were 98 million people in the European Union (EU) aged 65 years or older, compared with 80 million children aged below 16 years. Taking into consideration that the life expectancy of the next generation of older adults is likely to surpass that of their parents, it becomes absolutely necessary to foresee and plan for the challenges that they will face. The two combined strategies are:

- promoting healthy lifestyles over the life course, as well as detecting and modifying early and mid-life risk factors of impaired function and chronic diseases, in order to delay age-related disability;
- providing more appropriate health and social care for the aged EU population by offering integrated and holistic care in all-age community and health care facilities.

Both of the aforementioned approaches must bear in mind that:

- technology will not only transform entire population attitudes toward life but will also revolutionise care delivery systems
- whatever the impact of technology, an adequate number of skilled health care professionals is absolutely essential

## **1** The present report understands ageing as an opportunity for both individuals and society as a whole.

At the individual level, the ageing process is extremely heterogeneous, as huge social and cultural variations have a significant impact on the quality of ageing. However, ageing is usually preferred over early death, as it gives people a second, third and even fourth chance at life and provides multiple opportunities for personal fulfilment. This should not be overlooked but rather celebrated, as ageing represents a continuing chance to redefine oneself during life.

At the societal level, rapid changing societal structures, such as smaller and more fragmented family units, the co-development of age discrimination and health inequities, and the emergence of new geriatric syndromes and longer periods of disability, greatly

impact labour force, pensions, and social and health care costs. However, ageing overall allows for increased productivity, greater work expertise and intergenerational exchanges of material and non-material goods (e.g. education and experience), thus forming bonds between young and old generations.

## 2

Four main principles guided the thinking and writing of the present report.

- **The updated definition of “healthy ageing”** proposed by the first World Health Organisation report on *Ageing and Health* (2015) was chosen as the reference to drive the public health interventions proposed therein: “the process of developing and maintaining the functional ability that enables wellbeing in older age”. Functional ability depends on the interaction between “intrinsic capacity, the composite of all physical and mental capacities, and the specific life environment of each individual”. Indeed, this global concept of functional ageing depends on socioeconomic factors and psychological condition.
- **The concept of the life course approach**, which includes studying the natural history of the growth, maintenance and decline in physical and mental (cognitive and emotional) capacities over the life course, as well as the onset and development of chronic diseases, clinical disorders, and their preclinical intermediate outcomes. The purpose of a life course approach is to identify opportunities throughout life to reduce the risk of chronic clinical conditions and age-related disability.
- **The belief that age is just a number** and, where possible, should not be used to categorise individuals. Once again, the high heterogeneity in aged populations should be acknowledged. The report challenges ageism and adultism stereotypes and prejudices and promotes intergenerational contact and education. Moreover, antidiscriminatory laws, regulations and public health policy options should specially prohibit age and gender discrimination, using human rights arguments.
- **The internalisation of costs and benefits as an essential part of health and social care policy.** Without this, it is impossible to truly assess the impact of policy changes in light of financial resources applied. While the current report does not explicitly analyse the financial aspects of care, the idea of costs constrained is a current thread.

## 3

The report gathers evidence from longitudinal studies on **physical and social exposures during gestation, childhood, adolescence and adult life** that may have long-term effects on the ageing process. Such exposures may impair or protect capacity and

increase or decrease risk of disease, operating through behavioural, psychosocial and biomedical pathways.

First, common risk factors related to broad ageing outcomes are reviewed, such as physical and cognitive performance, as well as disability and mortality. Then, major organ functions and diseases most commonly disturbing the ageing process are explored. Among these, obesity, diabetes, cardio-, neuro-, and nephro-vascular functions and diseases, musculoskeletal disorders and cognitive ability function and dementias emerge as the focus of prevention strategies.

The choice of these major individual functions is linked to:

- growing evidence that environments that adversely affect physical, cognitive and emotional development are associated with a higher risk of disease development, impaired functional capacity and earlier mortality;
- strong evidence that socioeconomic position and social isolation are key determinants of health and ageing. Lower socioeconomic position in childhood and adulthood and a lack of social interaction are associated with all-cause mortality, cardio-metabolic and respiratory impairments and diseases, as well as reduced physical and cognitive performance;
- strong evidence that lifetime health behaviours, such as being a non-smoker, consuming little or no alcohol and being physically active, considerably improve the prospect of healthy ageing. Sedentary lifestyles have been associated with various adverse indicators of physical function and cardiovascular health and earlier mortality. These health behaviours begin in adolescence and are partly determined by earlier factors, including social background, education, and access to resources;
- growing scientific evidence of common cellular hallmark pathways of ageing and age-related diseases. Identifying these pathways will provide new ways of monitoring the quality of ageing as well as personalised interventions.

**4 Innovative health promotion and early and midlife preventive strategies** may enable younger generations to enjoy healthy ageing in the future.

To achieve this, an increased awareness is needed of how certain risk factors for age-related functional decline are modifiable by lifestyle choices at all life stages. In line with the WHO concept of healthy ageing, the present report proposes three broad strategies

for improving functional ageing and preventing age-related chronic diseases over the life course:

- the first is to build physical and cognitive capacities or to enhance reserve so that maximum potential is reached by early adulthood (until approximately 30 years of age);
- the second is to maintain function and delay the onset and pace of functional decline and disease during adult life (from approximately 30 to 50 years of age);
- the third is to slow the rate of decline or disease progression in older adults (beyond approximately 50 years of age).

Transforming the ageing process of young and middle-aged EU citizens requires cross-sectorial actions at both the societal and individual level. For each of the organ functions and associated diseases, the report provides careful analysis of possible health promotion and preventive strategies and targeted interventions, starting with education.

## 5

Lifelong health promotion and disease prevention play crucial roles.

**Health promotion** enables people to increase control over their own health. It covers a wide range of social and environmental interventions that are designed to benefit and protect the health and quality of life of individuals by addressing and preventing the root causes of illness. Good governance in health and a strong implication of cities in promoting health literacy campaigns aim to enable populations to improve their health by adopting healthy lifestyles and behaviours. As different strategies may be better suited to different life stages, carefully choosing the type and timing of health promotion campaigns may improve effectiveness.

Opportunities for lifelong population- and individual-based health promotion strategies are available in different settings:

- schools (e.g. promoting health literacy);
- workplaces (engaging companies and employers in maintaining health);
- general practices (e.g., social prescribing, lifetime vaccination).

**Disease prevention** differs from health promotion because it focuses on specific efforts aimed at reducing the development and severity of chronic diseases and other morbidities by targeting specific risk factors. The report focuses on:

- Biological and functional biomarker age scores continue to be developed and refined to identify those at risk of functional decline due to advanced biological or functional

age rather than chronological age. For example, a biomarker of accelerated ageing that suggests that a risk of being metabolically compromised should help tailor individual care.

- In parallel, innovative technologies (m-health), such as lifelong tracking of health, record changes in intrinsic capacities or monitor real-time exposure to risk (for example, level of physical activity), which may help identify individuals with accelerated functional decline at an earlier stage and motivate them to modify their lifestyles or behaviours.

**6 All-age communities** enable older people to feel secure and to go about their daily life comfortably. The present report stresses that architects, urban planners, experts in mobility and ergonomics, social care experts and geriatricians must cooperate to achieve all-age communities. Consequently, special efforts must be made to drive attractive and well-funded projects involving all relevant stakeholders working together to support a greater integration of older people in society.

**7 Favouring ageing in the home is a high priority.** Training and supporting informal carers (usually partners, family members or friends) is essential for maintaining care supply, but so is ensuring the wellbeing of care receivers and carers. In order to prevent burnout in informal care, it is important to offer (affordable and available) formal care alternatives for all socioeconomic groups, thereby enabling an adequate care mix, to facilitate the balance among care, work and leisure, and to reduce the care burden for all parties involved. The interoperability of these human agents, incorporating home visits and new home technology, should be considered in the context of the 'Internet of Things'. Moreover, to favour ageing in the home, the report stresses the possible positive impact of expanding health insurance coverage to include professional care, as well as the potential role of municipal subsidies.

**8 Creating all-age health care facilities** (hospital settings and long-term care institutions). The present report stresses the need for the evidence-based design of health care facilities as age-inclusive urban places strongly integrated in the neighbourhoods and communities they serve, and for proposed changes in facility design, where appropriate. Pragmatic, holistic and transdisciplinary sustainable design increases the effectiveness

of care delivery, improves patient safety and the habits of both older patients and health workers, which in turn, leads to an overall enhance health care quality.

This report insists also on the fact that, regardless of institutional structures, health care management is essential. Appropriate care for older adults requires:

**Avoiding emergency visits and hospital admissions**, as suggested by this report, by employing an integrated geriatric care model. The development of an interoperable universal medical record for all EU member states will greatly assist in determining which care pathway will fit best with patient needs (clinical, functional or social). A "one-site,-one-stop model" will prove essential for the diagnosis and regular follow-up of patients suffering from disabling health conditions, such as frailty, musculo-skeletal disorders, falls, heart failure and mental/cognitive disturbances.

- **Reducing the length of hospital stays, as well as readmissions.** To reach these goals, in addition to the aforementioned universal medical chart, older inpatients need a comprehensive geriatric assessment to help identify medical, social, economic and environmental problems at hospital admission. In multimorbid older patients with poly-medication, comprehensive geriatric assessment will allow for establishing realistic prognoses and help interdisciplinary teams better coordinate the care required, start or accurately stop appropriate treatments, and propose personalised nutrition supplementation and effective rehabilitation. This approach will avoid or decrease adverse drug effects as well as hospital-acquired side-effects and infections. Moreover, the number of transfers from hospitals to long-term care institutions will be reduced. Once again, the unique universal chart will allow a careful follow-up of patient trajectory and immediately alert health care professionals in charge to intervene adequately.
- **Providing appropriate long-term care** (at home, assisted living arrangements or shelter housing and nursing homes). Long-term care is typically addressed to older people with decreased levels of functional, mental and physical capability, as well as increased support needs. To establish all-age long-term care environments and increase residents' satisfaction with the care received, this report insists on leadership committed to addressing ageism, the use of evidence-based care in favour of advanced care planning and the identification of surrogate decision markers including regular evaluation. By adopting an all-age long-term care approach, staff members may better handle support services with different perspectives and measurable outcomes: preventive, supportive, disease managerial and rehabilitative care (allowing for de-institutionalisation), but also palliative and terminal care.
- **Addressing the specific needs of older people as they near the end of life.** Eighty percentage of deaths occur among older people. Beyond its main goals of extending

and preserving life, palliative medicine and care, including pain relief and end-of-life symptom control, must be promoted widely. Traditionally offered to patients with cancer, palliative care has been extended to long-term care facilities and dementia units. Unfortunately, evidence suggests that people with dementia too often have unmet needs, have underdiagnosed and undertreated pain and are subjected to burdensome and futile care plans. This report insists on the fact that palliative care should be offered to everyone in all care settings and not limited to the final days of life.

- **Tackling the problem of elder abuse in all settings.** One in six adults over 60 years of age suffers from elder abuse (psychological, financial, neglect, physical or sexual), independent of whether in institutional or community living. This report highlights the need for urgent action to tackle the problem by identifying situations where abuse is suspected to take place, continuously fighting against ageist stereotypes and insisting on respect for human rights at all ages.

## 9 Technology will both impact individual and population ageing and revolutionise health care delivery.

Among the expected technological advances for the ageing population, we note:

- Physical health and social and cognitive health applications have started to appear, making it very likely that smartphone-based m-health will play an increasingly important role in lifelong tracking of health. By providing regular advice, alerts and recommendations, the mobile applications will allow supporting positive changes in lifestyle behaviours and preventing age-related disease/disability.
- Universal design and smart home technology will also favour ageing in the home by providing increased security, safety, help in daily living activities, and social connectedness. Moreover, the rapid development of assistive robots will facilitate ageing in the home and at-home care delivery.
- Prescribed devices and apps may provide information to support clinical decision-making and accelerate hospital discharge.
- Care technologies will ease the lifelong follow-up of health and chronic clinical conditions and functional abilities through remote monitoring, at-home physical rehabilitation, brain training and control of medications compliance.
- Technology will also transform diagnostic and surgical procedures. Applications of machine learning algorithms (artificial intelligence, or AI) in the field of ageing research offer enormous possibilities. Such methods applied to data, acquired at a single time point or longitudinally, can be employed to generate predictors of disease and identify

moments for early intervention. AI-derived biomarkers of ageing enable a holistic view of biological processes and allow for the development of new methods to build causal models, extracting the most important features and identifying biological targets, thereby favouring drug discovery.

Although technology offers fantastic promise for facilitating healthy ageing, practical applications are currently limited for multiple reasons:

- **Acceptance.** Technology uptake varies substantially among older individuals, influenced by affordability, ease of use and functionality of devices, as well as personal preferences, knowledge and concerns over data privacy. Moreover, developing technical solutions for home monitoring requires consideration of both care receivers and care providers (formal or informal), who may not be sufficiently trained in this domain.
- **Global efficiency & proven outcomes.** Some remote health care monitoring models have shown clear benefits for patients with chronic diseases, while others have not been able to demonstrate significant improvements. There are still several obstacles to achieving widespread use: economical sustainable reimbursement systems, interoperability between electronic health record systems, and technological capacity to accommodate bandwidth-heavy telemedicine programs in smaller hospitals, clinics and in the home.
- **Standardisation.** Developing standards in this area will need strong liaisons and collaborations with regulatory agencies to fully standardise data from wearable devices, as well as the transmission, processing and storage of data generated from the home.
- **Funding.** Reimbursement for equipment varies across EU member states. More expensive equipment is funded on a means-tested basis and according to local funding criteria. These items can be provided directly and free of charge to patients, or, if approved, purchased through personal budgets granted by local councils.

**However, none of these current obstacles will stop the development and use of technology.** A rapidly growing number of wearable devices for medical use has arisen, due to the prevalence of smartphones, the surge in the use of connected devices known as the Internet of Things, the portability of wearable devices and the increasing costs of health care. The advantage of this consumer market is that the cost of devices will continue to decrease while the devices become more technically advanced. Prescribing devices and apps that may provide information to support clinical decision-making and accelerate hospital discharge is an area of promise.

Regarding the use of advanced technology, the challenge posed to acute care in hospitals, but also to long-term care of older adults at home, is the development of processes to ensure the assessment of data from smart devices for validity; consent to access data must be appropriately acquired and data storage correctly managed (including consideration of whether these data carry implications for the electronic health record system).

**10** However technology advances, **an adequate number of skilled health care professionals will be absolutely essential.** The aforementioned strategies for transforming the future of ageing depend, at the same time, on the care needs of the population, the organisation of health services and the quality and preparedness of the health workforce. Without coordinated efforts among ministries of education, health, finances and labour, a shortage of skilled health care workers will remain a daunting problem. Improving the health of the population, health services and health education should be seen as an investment rather than a cost.

Altogether, **the 51 countries of Europe currently suffer from a lack of 1 million health care workers** (physicians, nurses, midwives, associate and allied health professionals, care workers and carers). Without urgent, coordinated educational initiatives and attractive human resources policies, the lack of health workers in Europe will reach 4.1 million by 2030.

In this context, the current health care workforce crisis in the EU is due, in part, to the fact that:

- the workforce itself is ageing and suffers from an annual rate of attrition reaching 10%;
- the needs and demands of the increasing older population are rapidly changing;
- the health services provided need to adopt more efficient planning, hiring and management procedures in a world embracing a technological revolution.

Keeping in mind the close relationship between health workforce size and global health outcomes, the report insists on the urgently needed efforts to build and retain a strong and skilled health workforce and to match its supply to population care needs, current and future.

**Education will play a major role in transforming ageing into an opportunity for all.** Enhancing health education from primary school to adulthood is indispensable. Identifying middle school students who later may be candidates for entering the health workforce may be one method to attract greater numbers of health care workers. Enhancing and improving workforce training (knowledge, skills and attitudes) to make

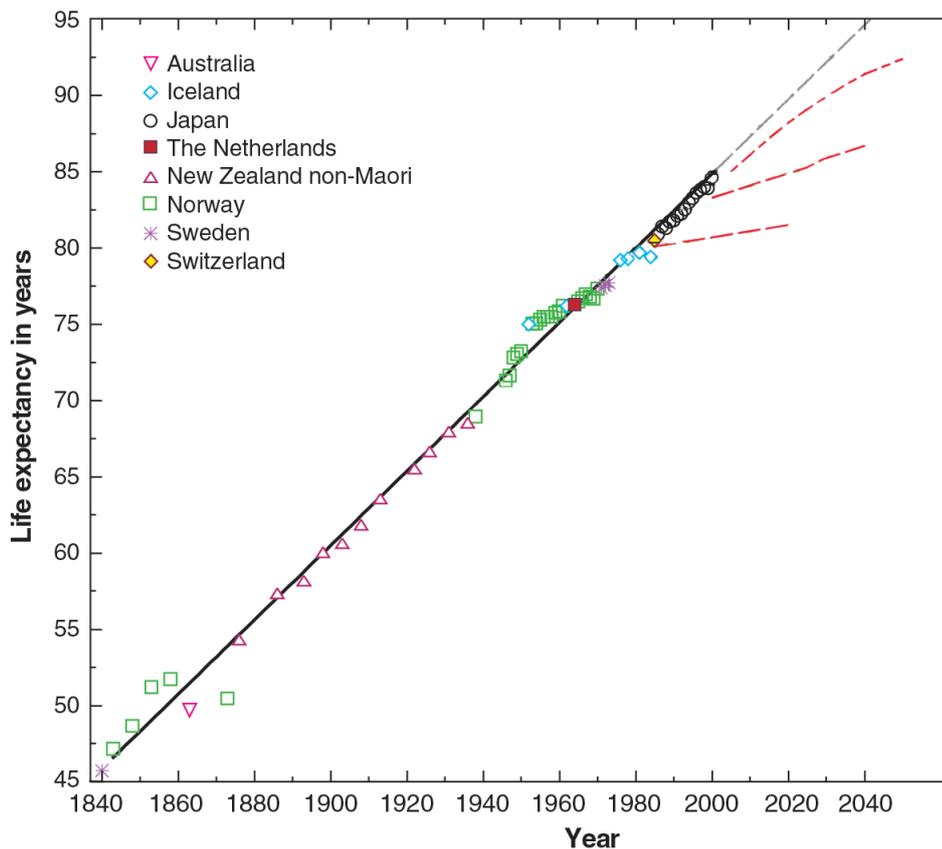
it more attractive requires developing more transversal education programmes for physicians, nurses, associate and allied professionals, adopting interactive teaching, using mannequins to teach technical care gestures, and employing information communication technology (for example, blended teaching, serious games, multidisciplinary virtual scenarios and virtual reality).

**Human resource policies needs to attract and retain health care workers and allow for lifelong learning** tied to an attractive career ladder and opportunities for advancement. Furthermore, it must not be forgotten that developing and promoting a strong health care workforce not only leads to improved quality of care, but also serves as an excellent stimulus for economic development.

In summary, ageing is part of the life course and may be associated with health challenges, but also opportunities. A broad spectrum of individual and societal measures, including education, are required to facilitate best ageing.

# General overview

The exceptional increase in life expectancy in Europe, which rose from 45 years in 1840 to 85 years in 2000, is one of the most remarkable indicators of progress in modern development (Oeppen & Vaupel, 2002):



**Figure 1.** Record of female life expectancy from 1840 to the present (Oeppen and Vaupel, 2002). The dashed red lines denote projections of female life expectancy in Japan by the United Nations in 1986, 1990 and 2001.

Europe, at the forefront of this demographic transition, now enters a stage characterised by low fertility and low mortality. After the collapse of the communist regimes in Central and Eastern Europe around 1990, there was a big and sudden drop in fertility, from 2.1 to 1.3 children per woman. According to Eurostat, the fertility rate is now slightly higher, around 1.7 (Eurostat, 2019a). Consequently, in 2016, there were 98 million people in the European Union aged 65 years or older, compared with 80 million children aged 16 or younger (Eurostat, 2018h). Projections show that this trend is currently only halfway through and will reach its peak around 2040-2050.

- The percentage of adults aged over 65 years will increase from 19.5% in 2016 to 29.5% of the global EU27 population;

- The percentage of adults aged over 80 years will rise from 5.5% in 2016 to 11.5% of the global EU27 population.

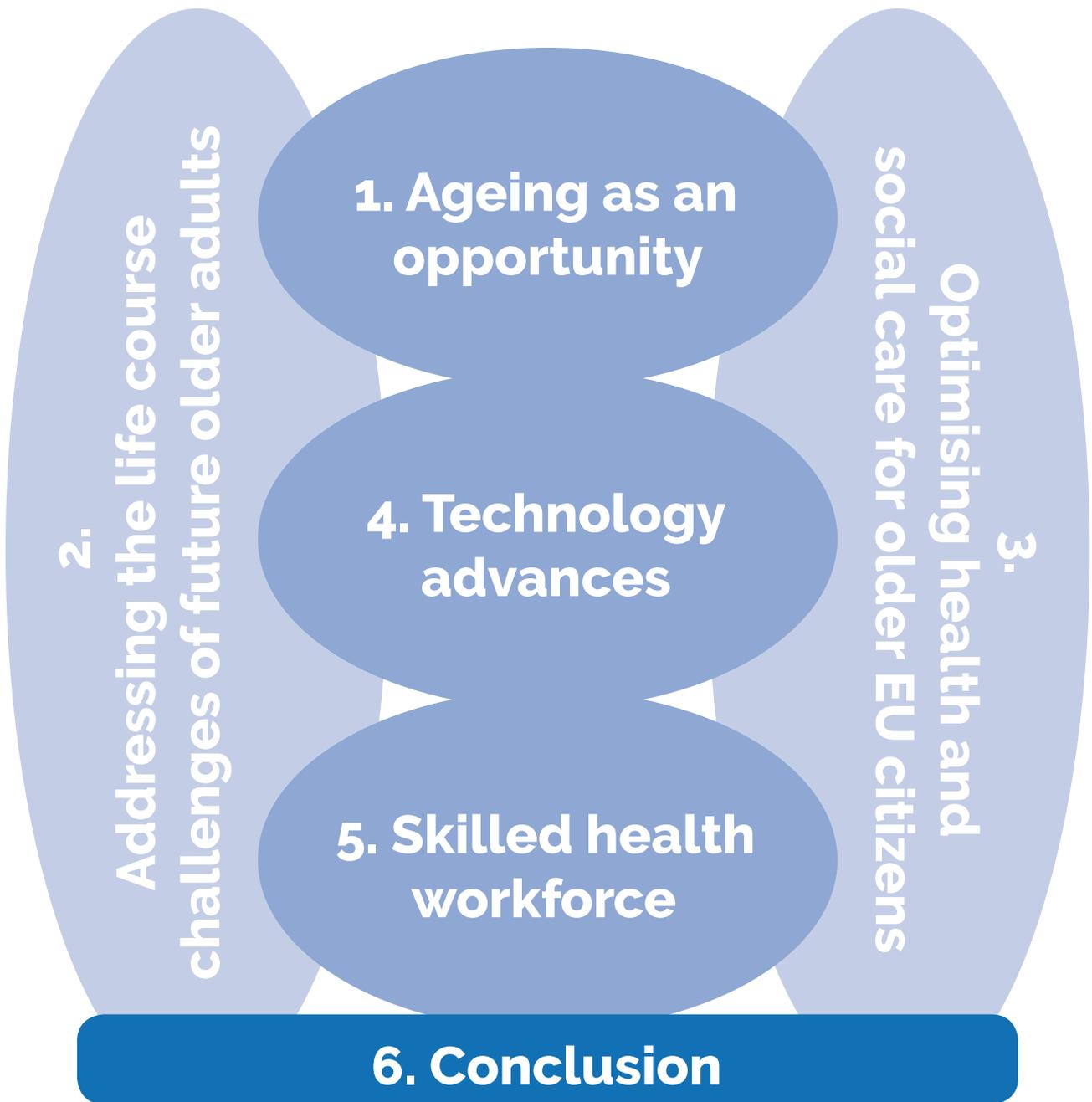
Thus, the ageing of European populations and their individual care have become topics of utmost importance for all EU policymakers.

Over the past few years, this situation has prompted a very large number of reports on ageing-related challenges, in particular, the economic impact of delayed retirement age, labour participation, the "silver economy", health care and long-term care expenditures, migration flows, and pensions. In this complex array of reports, the present Evidence Review Report reflects a conscious decision to focus essentially on individual health and social care from a broad scientific perspective on public health. The main goal of this approach is to emphasise the fact that each individual is an active player in his or her own ageing process and makes conscious and unconscious decisions that pave the way for healthy or unhealthy ageing.

However, this focus on individual health and social care does not mean that the present report ignores the fact that ageing must be considered in a holistic way, representing an opportunity for both individuals and society as a whole (Gonzales, Matz-Costa, & Morrow-Howell, 2015).

- At the individual level, for most, ageing is much preferred over early death, as it allows people to realise their potential, achieve personal fulfilment, and bring stability to their family and surroundings using their insight and problem-solving abilities. Moreover, additional healthier years of life enable older adults to remain engaged in the economy as taxpayers and active consumers (Davey & Glasgow, 2006). This approach to ageing contrasts with outdated negative stereotypes of elderly citizens and celebrates age as a continuing chance to redefine oneself over the life course. However, the ageing population is not homogenous; there are huge social, economic and cultural variations that have a significant impact on ageing and need to be properly considered.
- At the societal level, ageing allows for increased productivity, greater professional expertise, and the growing global longevity economy, including the intergenerational exchange of both material and non-material items (education, experience, know-how, etc.) (Gurven & Schniter, 2010), which forms lasting bonds between generations (Albertini, 2016).

In order to tackle the ambitious task of producing an Evidence Review Report on ageing and health from a medical standpoint, which was underrepresented in previous publications, twenty-three working group members and twenty-seven additional external contributors from different disciplines — geriatric medicine, gerontology, epidemiology, psychology, sociology and technology, as well as architecture, economics, engineering and law — worked as a team for nine months. Sharing the belief that close collaboration and dialogue among researchers, health care providers, and policymakers is absolutely essential, the participants in the present report



**Figure 2.** *The main sections of this Evidence Review Report.*

worked toward the goal of providing the most scientifically solid arguments to EU policymakers in order to answer the following questions:

- What measures are needed to enable health care systems to face the challenges posed by the current generation of older adults?
- How can public health policy best organise efficient prevention, control and treatment of early and midlife risk factors, to ensure that people have good functional ability when they enter old age?

Two sub-questions evolve from these questions, namely:

- What public policies can facilitate the taking up of innovative technologies, including software and communication tools, by older adults and health care institutions, in order to meet the challenges and opportunities posed by an ageing society?
- What is needed to build and sustain an appropriately skilled workforce in the coming decades for the optimum organisation of health systems and for the delivery of quality health and social care to older adults?

## OVERVIEW OF CHAPTER 1

Chapter 1 of this Evidence Review Report provides current demographics and updated prospects, explains the choice of the WHO definition of "healthy ageing" and its focus on combating ageism.

The term "healthy ageing" first appeared in scientific literature in 2006 (Swedish National Institute of Public Health, 2006). It was preceded by "successful ageing" five decades earlier (Havighurst, 1961) and, more recently, by "active ageing" (WHO, 2002) and "active healthy ageing" (European Commission & European Committee of the Regions, 2011).

In 2015, after a careful analysis of the aforementioned terms, the first WHO report on ageing and health proposed the new term "healthy ageing" as "more than just the absence of disease" (as Margaret Chan, former director-general of the WHO, put it) but rather "the process of developing and maintaining the functional ability that enables wellbeing in older age" (WHO, 2015b). Functional ability depends on the interaction between "intrinsic capacity, the composite of all physical and mental capacities, and the specific life environment of each individual" (WHO, 2015b).

Social and behavioural scientists severely criticise the term "healthy ageing" for its strong medical and biomedical connotations. However, in order to maintain the focus of the present Evidence Review Report on functional ageing, it was decided that this term properly stressed

the importance of physical, mental and cognitive daily functioning in performing specific tasks, including self-care activities in different life environments, in order to fulfil the current and future care needs of the ageing EU population.

Ageism — discriminatory attitudes and behaviours toward older adults — is perhaps the clearest example of how changing societal values have contributed to the projection of negative images of ageing and older adults. In both subtle and obvious ways, ageism is manifested by individuals, communities, institutions, and entire governments. As explained in the recent AGE Platform Europe Position on Structural Ageism, the systematic stereotyping of ageing and older people has enabled society and its institutions to "sustain ageist attitudes, actions or language in laws, policies, practices or culture", as seen in "upper age limits, the inadequate provision of services for the needs of older people, the failure to take situations, experiences or aspirations of individuals into account when making decisions or allocating resources, or the segregation of people in later life due to a lack of real choice to remain active in their communities" (AGE Platform Europe, 2016). Women are particularly vulnerable to ageist policies, especially in terms of elder abuse (see page 186) but also inadequate pensions, which are often penalised by career breaks taken in order to assume care responsibilities.

The lack of positive models of ageing and older adults must be effectively addressed now to prevent the situation from exacerbation for an ageing society. Furthermore, it is a sign of much more serious underlying societal issues.

## OVERVIEW OF CHAPTER 2

Chapter 2 of the report presents the life course perspective used to address healthy ageing.

The life course approach taken in this report builds on the concept of functional ageing by studying the natural history of the growth, maintenance and decline in physical and mental (cognitive and emotional) capacities across the whole life. It summarises what is known about biological mechanisms of ageing at the cellular and molecular levels, which operate from the beginning of life. Biological age may prove more useful than chronological age in identifying health care needs and may help to tackle the ageism that exists within societies. The life course approach examines the long-term effects of physical and social exposures during gestation, childhood, adolescence and adult life that act independently or interactively to impair or protect capacity and increase or decrease disease risk (Kuh, Ben Shlomo, 2004; Kuh, Cooper, Hardy, Richards, & Ben Shlomo, 2014a). The large heterogeneity in the ageing process encourages scientists to investigate functional change and disease development over the life course and whether associations between risk factors and ageing outcomes change with chronological or biological age. The life course approach attempts to better understand the interconnected biomedical, behavioural and socioeconomic pathways involved in the development of age-related disability and to intervene early in life to pave the way for a positive life course trajectory.

Three broad strategies are presented for improving "healthy ageing" and preventing age-related chronic diseases and disability over the life course:

- to build physical and cognitive capacities and thus enhance reserves so that maximum potential is reached by early adulthood;
- to delay the onset and pace of functional decline and disease during midlife;
- to slow the rate of decline or disease progression in late adulthood.

In the face of a daunting burden of disease, multimorbidity and disability, individuals and society should be made aware that it is seldom too late to intervene or too early to prevent chronic diseases and age-related disability.

## OVERVIEW OF CHAPTER 3

Chapter 3 of the report deals with concrete and practical issues facing current health and social care for older citizens in the European Union. Its major concern is how to develop and optimise integrated health and social care in both the community and in acute and long-term care facilities. The frequency of chronic diseases, geriatric syndrome, multimorbidity and their functional impact on daily living activities are surveyed.

The special needs of older adults necessitate the sustainable development of environments and communities designed for all ages, to better engage them in the life and development of the society as a whole. In this context, mobility and driving are main issues currently witnessing innovations such as the rapid development of self-driven vehicles.

Ageing in people's private homes needs to be favoured to better respond to the clear wishes of the aged population which, moreover, promote active economic involvement as encouraged by policymakers. Stronger support for informal carers as well as reinforcement of community health professionals is urgently needed. Technology in the home is a valuable care support tool, whose development, entailing public and private partnerships, has only just begun.

In parallel, a radical transformation of care facilities is needed. The development of hospitals for all ages and long-term care facilities conceived as a whole and integrated into the community provides promise for easing and increasing care delivery quality and security.

Indeed, even if care structures are modernised, care management and delivery must also be revamped. Medical structures for all ages will benefit from the expertise of geriatricians in care design:

- Reduction of emergency visits and avoidance of hospital admissions will benefit integrated care, including the implementation of universal health and social records. Early identification

of sarcopenia and frailty will avoid one of the most frequent causes of emergency visits: falls in older adults.

- Decreasing the length of hospital stays and readmission rates also depends on the implementation of transborder universal electronic health and social records in all EU countries. Moreover, the systematic application of a comprehensive geriatric assessment of all admitted older patients will allow for easier identification of the potential problems they face, including medical (malnutrition, inappropriate drug prescriptions), functional (disability, loss of autonomy) and social (loneliness, financial difficulty).
- Strict hygiene control, identification of shared care goals in collaboration with patients, fixed date for treatment evaluation and adjusted interventions (medication review, early rehabilitation) appear essential for effective and secure hospital care and control (reduction of acquired hospital admission), as well as for shorter hospital stays.
- Indeed, the integrated care system, including both universal health and social care records and a systematic comprehensive geriatric assessment of older patients, will allow the rate of nursing home admissions to be reduced.
- Long-term care, provided either at home or institutions for all ages (residences or nursing homes), must favour resident wellbeing while favouring de-institutionalisation and developing a palliative care culture.

## OVERVIEW OF CHAPTER 4

In Chapter 4, technology advances are highlighted to complement the previous sections of the report.

Information communication technology increasingly empowers and engages EU citizens in health self-management, as exemplified by wearable sensors and m-health; assists older people living at home, offering them security, safety and help in daily functioning; and facilitates communication with family members, friends and communities. A unique electronic medical chart interoperable in all EU countries, telemonitoring, and integrated diagnostic and data science could help transform health services, from diagnostics to care delivery and rehabilitative processes, and benefit from robotic assistance. However, these quickly developing technologies raise innumerable questions regarding acceptance, privacy, regulation, and certification, as well as proven outcomes, reimbursement and health economics.

## OVERVIEW OF CHAPTER 5

Chapter 5 focuses on the health and social care workforce in relation to all the previous sections of the Evidence Review Report. At the EU level, there is currently a lack of one million health and social care professionals. Prospects for 2030 are alarming, with an expected deficit of

4.1 million workers in this sector. This situation requires strong and coordinated efforts at the EU level along ministries of health, education, labour and finances, in order to overcome the health care workforce crisis and to better cope with the current and future needs of the EU population. Indeed, basic and health education appear essential to improve not only the health behaviours of the general population, but also the knowledge, skills and attitudes of the health care workforce. A more positive and attractive perception of ageing needs to include innovative training initiatives aimed at future health care professionals; use information communication technology; favour transversal and multidisciplinary training scenarios; and adapt professional teaching activities to virtual reality. However, these efforts will not prove effective without human resources policy changes, including tempting recruitment, lifelong education, regular recertifications and the establishment of career ladders and incentives.

### Policy options



Throughout this report, specific policy options are highlighted in orange.

Orange icons highlight policy options proposed for the European Union itself; EU member states; and research and academia.



# Chapter 1. Transforming challenges into opportunities

## DEMOGRAPHIC CHANGES IN THE EU: TRENDS AND PREDICTIONS

### *The global context*

Sweeping changes have taken place across European society, particularly over the last century, changing the paradigm of ageing. The basic structures underlying business, education, tax distribution and social benefits, family units, places of residence, communication and even leisure have experienced fast and profound changes. Taking into consideration that the life expectancy of the next generation of older people is likely to surpass that of their parents, it becomes absolutely necessary to foresee and plan for the problems that they will face. This section sets out the demographic framework behind these changes and sets the stage for understanding the ageing process in Europe.

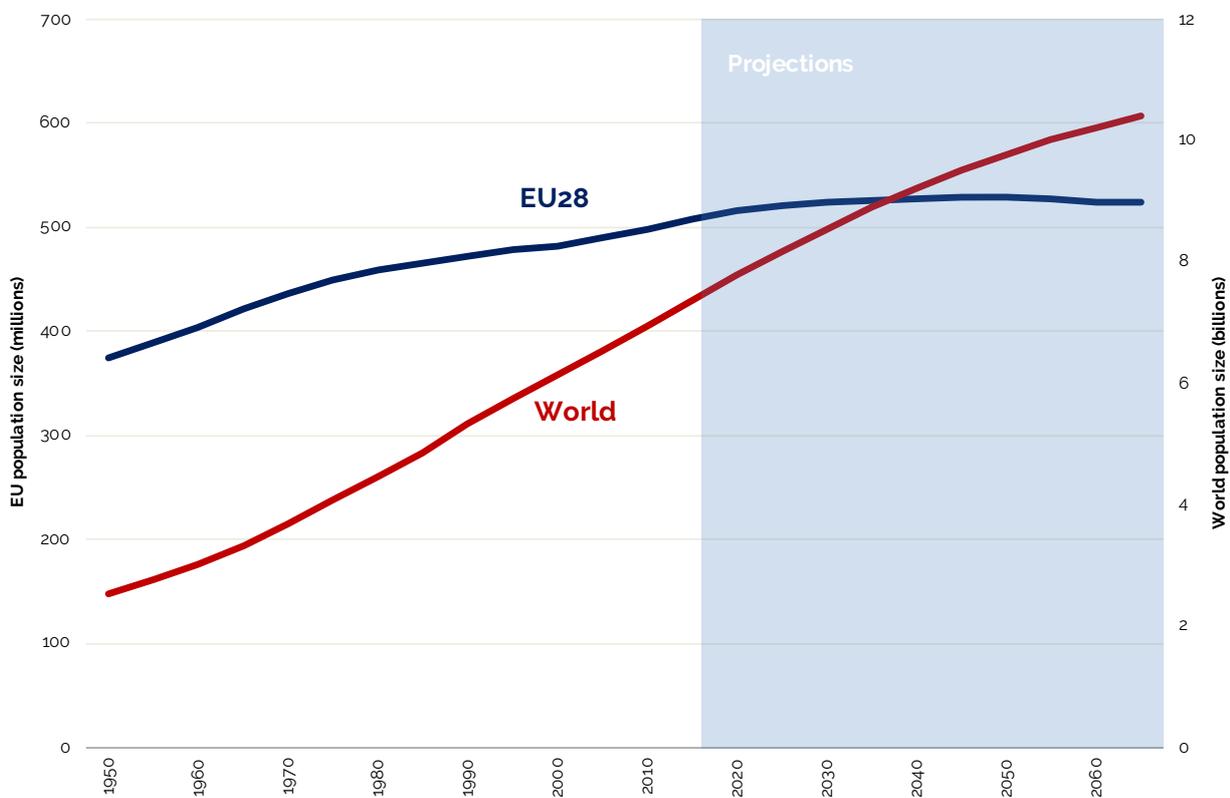
The 20th century witnessed a stunning demographic change worldwide. At the beginning of the 20th century, the world population measured 1.6 billion inhabitants, compared to 7.3 billion today. The pace of world population growth rate has accelerated dramatically since 1950. Around 1976, world population growth reached its peak of 2.1 per cent per annum, after which it slowly started to decelerate to 1.5 per cent today, which still means a doubling of the size of the world population over 46 years. This long-term growth path of the human population has been described as the first demographic transition, an almost universal pattern worldwide, but with different timing and intensity across regions and countries.

The demographic transition may be characterised by three distinct phases: an initial phase of very low population growth, as a result of high mortality and high fertility; followed by a fast growth phase of declining mortality levels, but still high fertility levels; and a third phase of slow growth again when fertility dropped to low values.

- **Europe** has clearly been a frontrunner in this transition and has reached the third stage of low population growth. The EU28 has even reached the stage of zero population growth, and the population is projected to decline in the 21st century; world population growth, although still high, is also decelerating (Figure 3).

- **North America** and **Australia** have also reached the third stage of the transition, but for these regions the impact of migration as an additional growth component in the past has been higher.
- **Latin America** and **Asia** have followed much later and are still in the second phase of rapid population growth, but the growth rate is decelerating and before the end of the 21st century they will also reach the third stage.
- The trend in **Africa** is slower. It has experienced the fastest drops in mortality worldwide, but fertility has only recently started to decrease.

As a result of these developments, the share of the EU28 countries in the world population has dropped considerably, from 14 per cent in 1950 to 6.8 per cent today, and it is anticipated to drop to 4 per cent in 2060. The current size of the world population is 7.6 billion and will grow to 9 billion in 2040 and 10.2 billion in 2060.



**Figure 3.** EU28 (left axis) and world (right axis) population, 1950–2060. Sources: Eurostat (2019); United Nations (2017).

### *The changing impact of natural increase and migration*

Without migration as a growth component, the population of the EU28 would start to decrease as of now. Natural increase (births minus deaths) is around zero at present and will decrease steadily in the coming decades (Figure 4). Net migration has reached historically high levels in

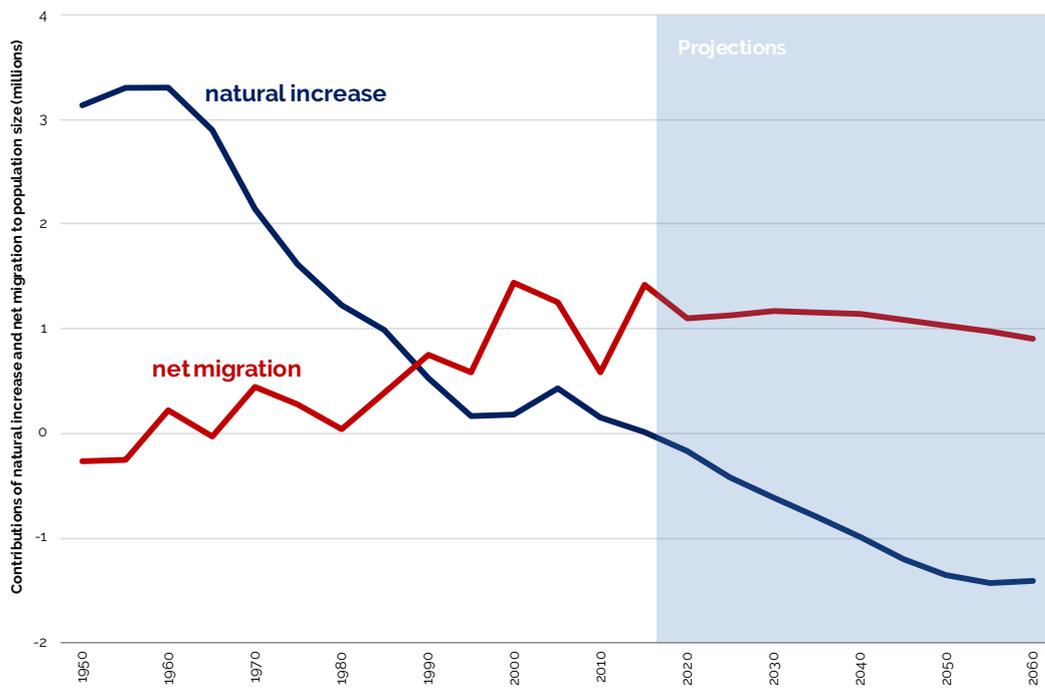
recent years, but in the baseline Eurostat projections<sup>1</sup> it is assumed that it will remain structurally at about 1 million individuals per year during the coming decades. As a result of this positive migration component, the EU28 population will continue to grow from its current level of 508 million to an estimated 529 million in 2045, but will start to decrease thereafter. Compared to world population growth, this is a very low growth rate. Population growth is also very unevenly distributed across the EU28, with a strong decline in Eastern European countries (Bulgaria, Romania), and small growth in Northern and Western Europe. There is also a strong divide between rural and urban areas, with population decline and ageing going hand-in-hand in most European rural regions.

Since the 1960s, Europe has been a continent of structural immigration. Over time, the motives of migrants, as well as their origins, have become more diverse. As a result, Europe has become a multi-ethnic society, which adds to the diversity in demographic behaviour, but also to significant integration and inequality challenges as well as increasing societal tensions. Currently 11.2 percent of the EU28 population is foreign-born, up from 9.8 per cent in 2010, of which a large minority is from other EU countries.

Ageing and migration are related. First, migration is viewed by some as the 'solution' to the ageing process, since it adds numbers to the working-age population (United Nations, 2001). Given the sheer numbers required, this solution can at best be partial. Second, migration could help to mitigate the labour shortages in the care sector for older adults (WHO, 2006b). Finally, ageing is becoming an issue in many migrant populations as well (Fokkema & Nedelcu, 2017).

---

<sup>1</sup> Unless otherwise specified, all projections in this section refer to the Eurostat population projections that use the population from 1 January 2015 as a baseline (Eurostat, 2019b).



**Figure 4.** Natural population increase and net migration in EU28, 1950–2060. Sources: Eurostat (2019); United Nations (2017).

### *The root cause of population ageing: baby boom and bust*

One of the most profound changes in Europe's demography, and a key factor behind ageing, has been the stark drop in fertility during the 1960s and 1970s (Figure 5). Many countries in Europe experienced a baby boom after World War II, leading to large post-war generations and high population growth. This post-war surge in fertility temporarily interrupted the longer-term decline in fertility, as described in the first demographic transition in many countries. In the 1950s, the European total fertility rate, i.e. the average number of children a woman has during her lifetime, was 2.66, but values above 3 were no exception, such as Poland (3.6), Slovakia (3.5), Ireland (3.4), Portugal (3.1), and the Netherlands (3.1). This baby boom was followed by a baby bust, although in Eastern Europe this occurred somewhat later. This sudden transition has been labelled the 'Second Demographic Transition' (Lesthaeghe, 2014; Van De Kaa, 1987).

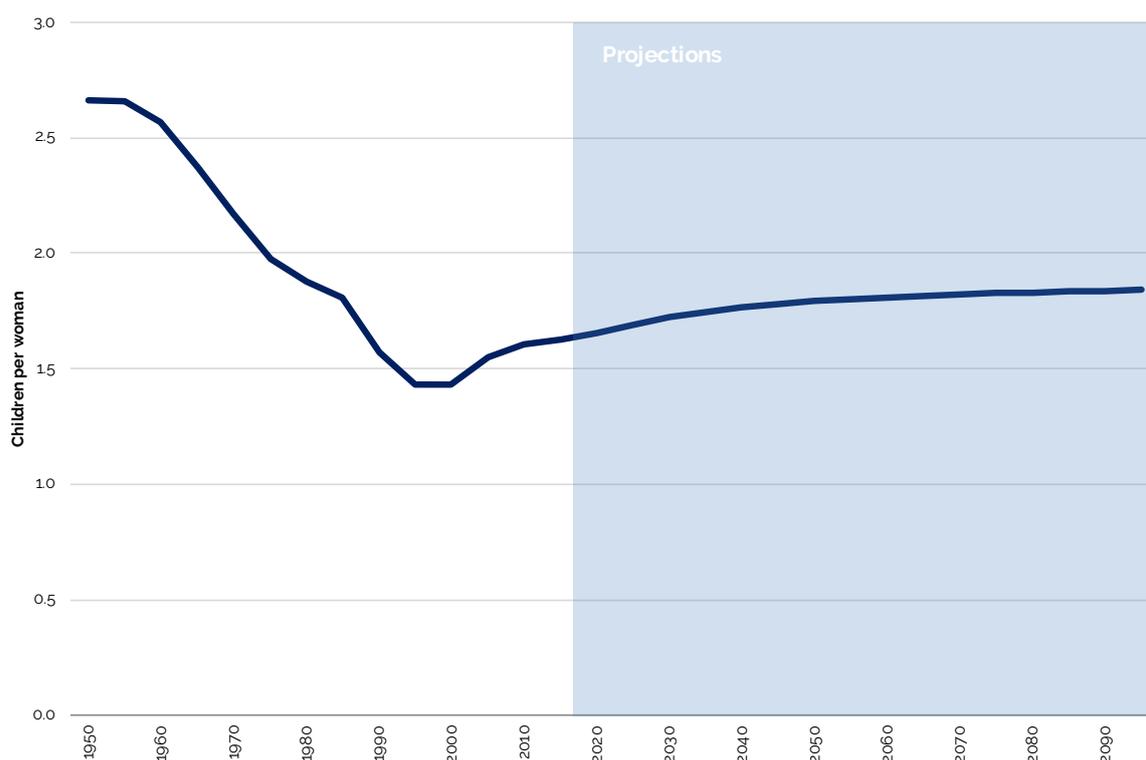
A key factor behind the Second Demographic Transition was the introduction of the contraceptive pill, which allowed women to postpone childbirth. In 1950, the average age for having the first child in Europe was 22.8 years. This increased to 28.7 years in 2015, with the highest values for Spain (30.4 years) and Italy (30.6 years) (Eurostat, 2015).

The Second Demographic Transition fits in the larger picture of changing cultural values in Europe (Van De Kaa, 1987). Rising incomes, as well as educational expansion for the post-war generations, allowed them to develop a lifestyle different from that of their parents, characterised by greater freedom and individuality.

The pattern in Eastern Europe developed somewhat differently. In the Communist era, women were expected to combine a working career with motherhood, which resulted in a much more moderate drop in fertility, from 2.9 in 1950 to 2.2 in 1970. A second big and sudden drop in fertility (from 2.1 to 1.3) occurred after the collapse of the Communist regimes around 1990.

The Eurostat baseline population projection foresees that the average number of children of future European generations will be slightly higher, around 1.7 children per woman. This is the consequence of reaching the end of postponing childbearing age, which will have an upward effect on the (period) value of the total fertility rate (Bongaarts & Feeney, 1998).

The structural drop in fertility is well illustrated by the change in the size of the respective birth cohorts since 1945. The baby boom generation (those born between 1945 and 1975) was 217 million persons. Their children's generation (1975–2005) was 170 million. According to the current Eurostat projections, the following two generations (2005–2035 and 2035–2065) will be 148 million and 139 million respectively. This will impact upon the potential for provision of informal care, especially for those without children who are in need of care (Agree & Glaser, 2009).



**Figure 5.** Total fertility rate in Europe, 1950–2090. Sources: Eurostat (2019); United Nations (2017).

### *Living longer*

The exceptional increase in life expectancy in Europe since the middle of the 19th century is one of the most remarkable indicators of progress in human development. Oeppen and Vaupel (2002) have shown that maximum life span worldwide since 1850 has increased by 2.5 years

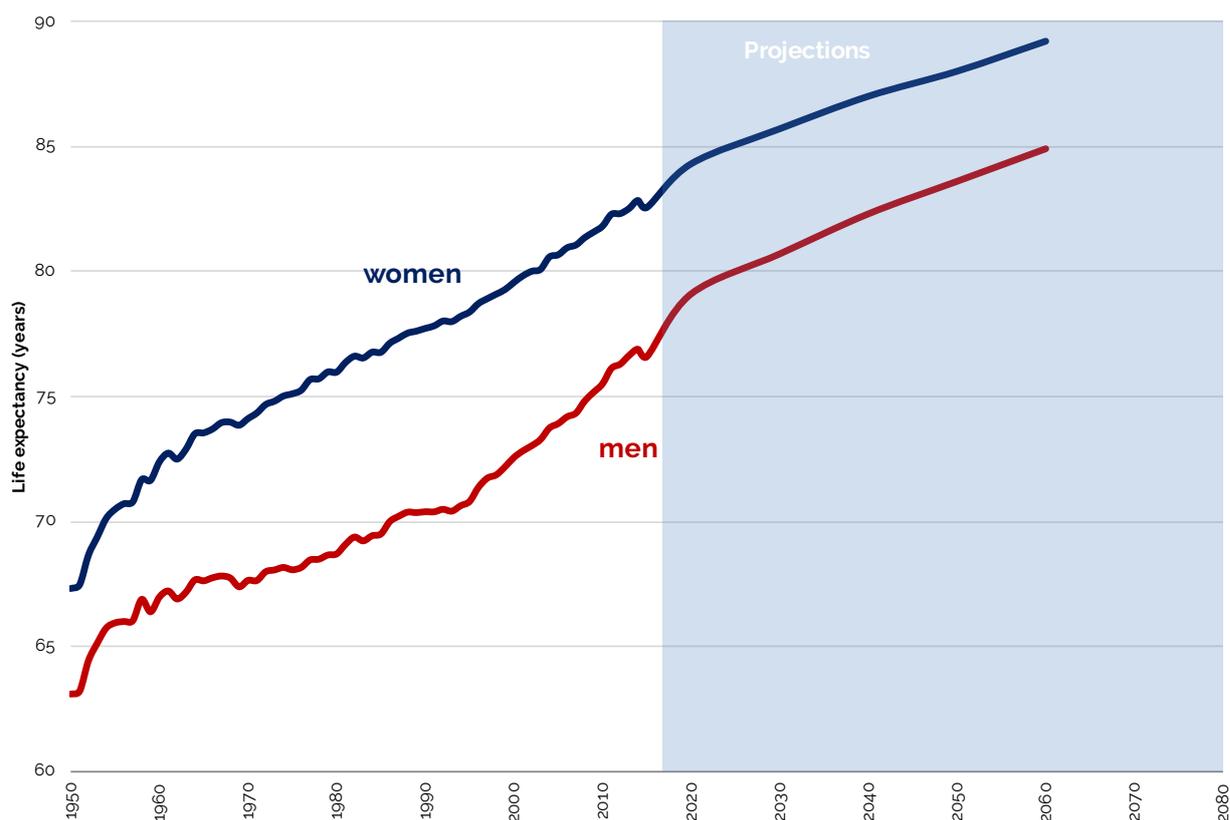
per decade. This increase can be explained by the epidemiological transition (Omran, 2005), which describes how mortality has decreased since the end of the 18th century, as a result of overcoming death caused by:

- phase 1: pestilence and famine (which took place in Europe largely before 1850)
- phase 2: pandemics (in Europe in the latter half of the 19th and first half of the 20th century)
- phase 3: degenerative and man-made diseases (since 1950), which may be further subdivided into diminishing cardiovascular diseases in the 1960s and 1970s, and the age of controlling ageing-related diseases since the 1980s (Barrett et al., 1998).

For most of this time, European countries (especially Sweden and France) were the frontrunners in highest life expectancy, but since the middle of the 1980s Japan has taken the lead.

Nevertheless, European countries in general have an impressive record in this respect. Figure 6 shows that, since 1950, life expectancy at birth increased from 67 to almost 83 years for females, an increase of more than 15 years, or 2.4 years per decade, and from 63 to almost 77 years for males, which is an improvement of almost 15 years, or 2.2 years per decade. The gender gap widened in the 1970s due to a stagnation of the increase among males which was largely caused by the smoking epidemic (Janssen et al., 2007; Vallin & Meslé, 2004).

According to Eurostat projections, the children and grandchildren of baby boomers are expected to live even longer than their parents and grandparents. Currently, life expectancy is 77.7 years for men and 84.3 for women. The next generation may expect to see about another five years added to their lives. According to Eurostat projections, life expectancy in the EU28 for males is expected to increase by 7.2 years to 84.9 between 2015 and 2060, 4.9 years of which (or 68 per cent) will be after 65 years of age. For women the values show a 6.2-year increase, with 4.7 years (or 75 per cent) due to improvements in survival after age 65.



**Figure 6.** Life expectancy at birth in the EU28, 1950–2060. Sources: Eurostat (2019); United Nations (2017).

Differences among countries within Europe diminished until the 1970s, mainly because of catching up of infectious disease control in Eastern Europe (Mackenbach, 2013). The trend has reversed since then, again due to the diverging path of Eastern Europe. Northern, Southern and Western Europe have converged as a result of better controlling man-made diseases such as cardiovascular diseases and breast cancer; the development of an extensive health care system; and accident prevention (Figure 8). Eastern European life expectancy stagnated or decreased since the 1960s, only to show an increase after 2000.

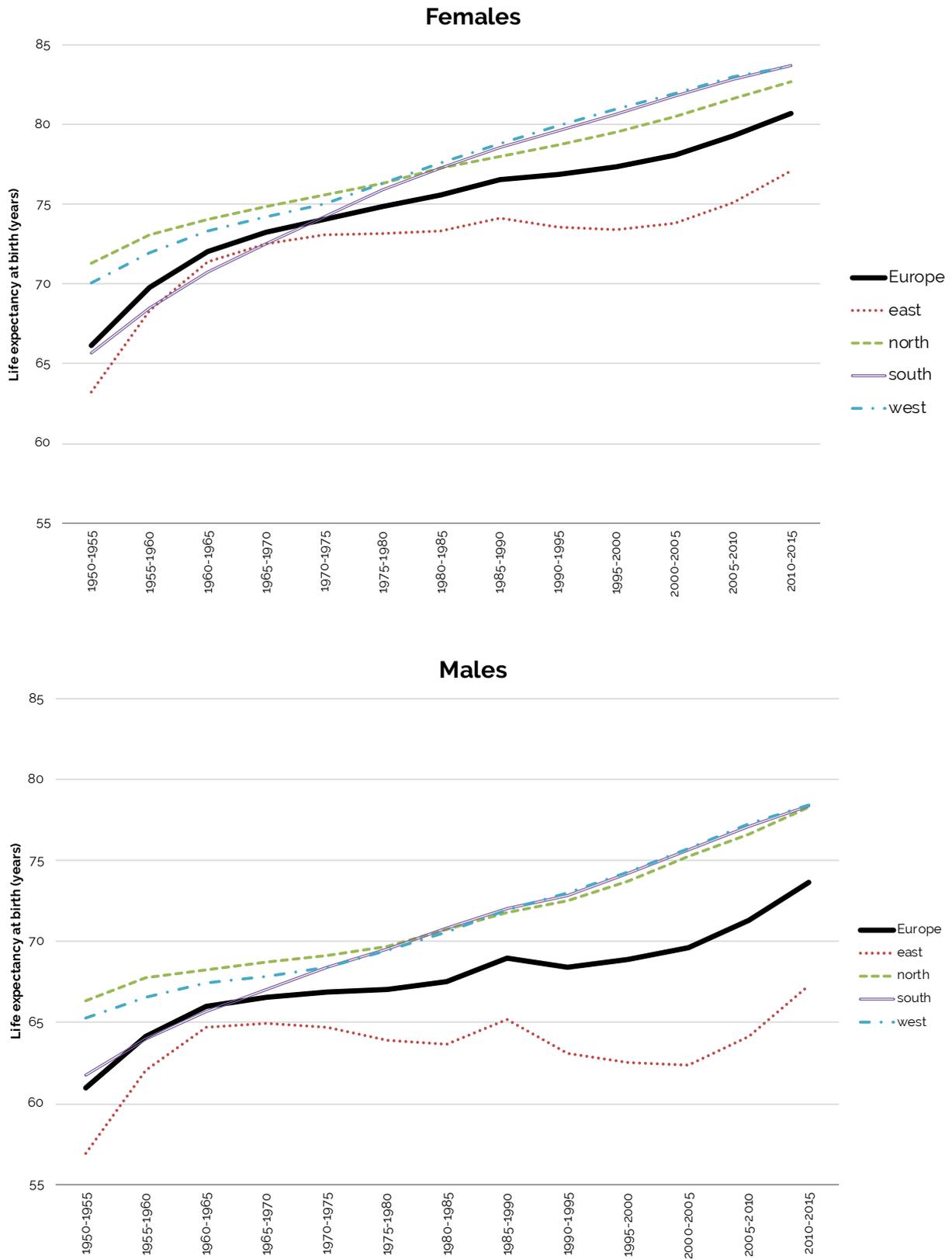
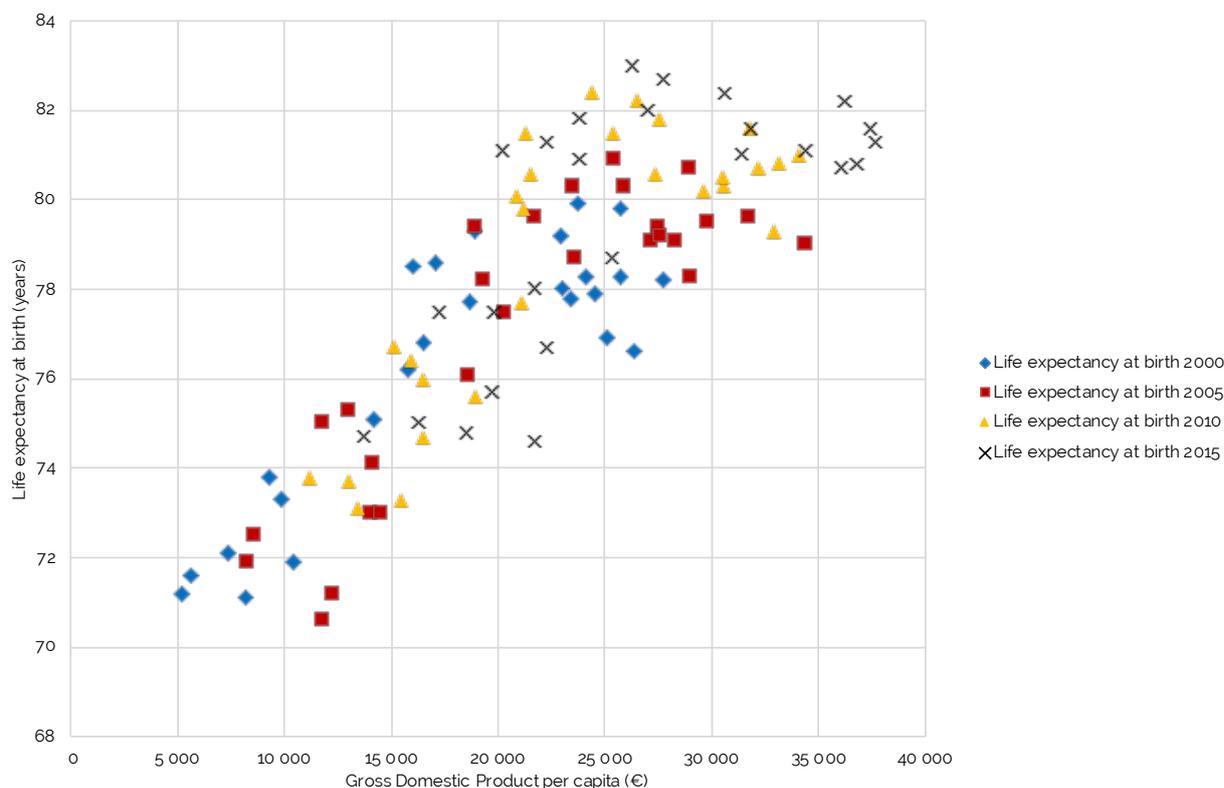


Figure 7. Life expectancy in four European regions and Europe as a whole, 1950–2015. Source: United Nations (2017).

## Economic and social gradients in life expectancy

The main driver behind the demographic and epidemiological transitions is modernisation, which is indicated by economic development and education. There is a clear linear relationship between economic development (as indicated e.g. by GDP per capita) and life expectancy. As seen in Figure 8, a difference of €10 000 in GDP per capita between countries corresponds to a difference of 0.5 years in life expectancy.

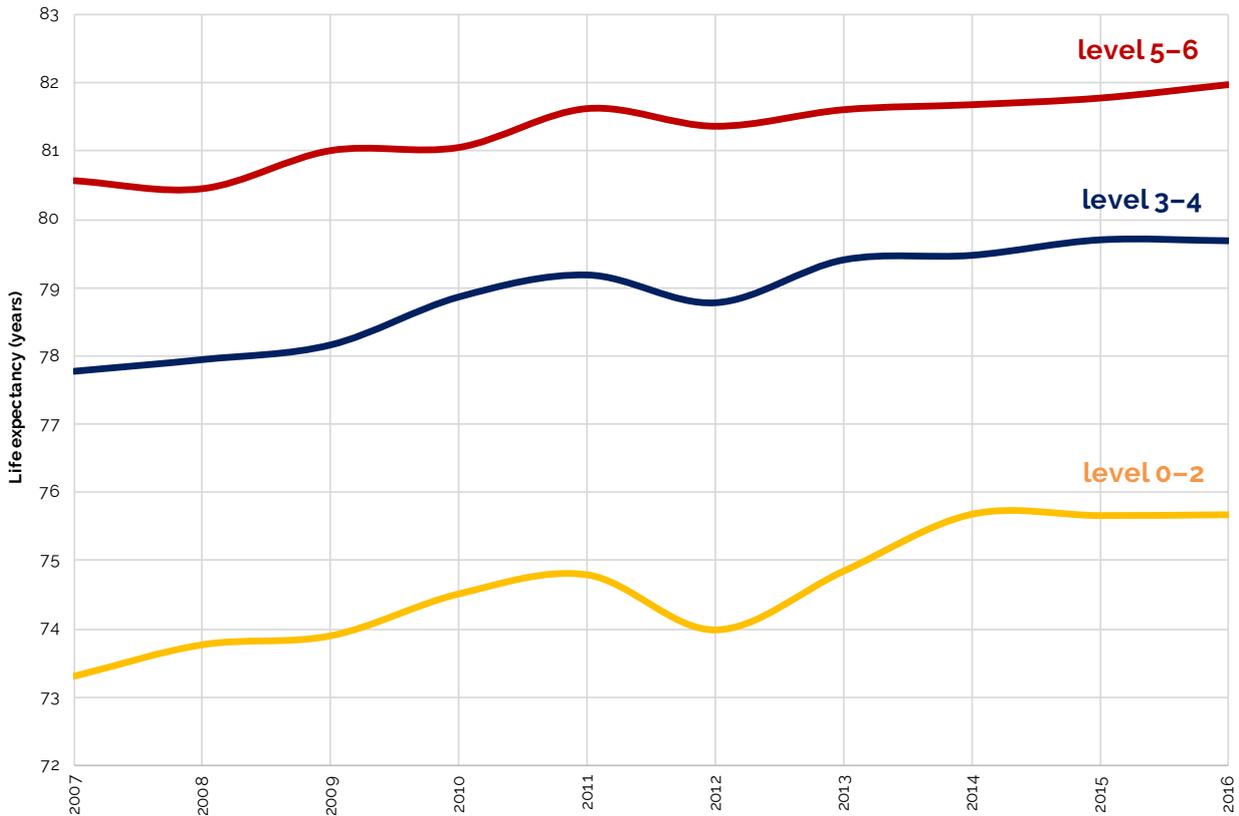


**Figure 8.** *Gross Domestic Product versus life expectancy at birth in the EU28 (excluding Luxembourg), 2000–2015. Source: Eurostat (2018b; 2018d).*

In some countries, the next generation of older adults represents the first to have completed compulsory health education integrated in the school curriculum, as well as to have the highest rate ever of successful completion of basic primary and secondary education. This will have profound effects on their health status. Figure 9 demonstrates the role of education in improving health. Moving up from basic education to mid-level education results in an increase in life expectancy of about four years. Having completed the highest educational levels adds another 2.5 years to life. These figures are evidence of the potential of education for primary prevention of disease and disability.

Nevertheless, innovative educational programmes are necessary to target at-risk groups more effectively, as detrimental habits are often adopted regardless of exposure to basic and health education. Exploring ways of integrating concepts from emerging fields such as m-health and

personalised medicine into education programmes in a way that is attractive, user-friendly, and more directed toward specific groups could help harness the potential of these programmes.



**Figure 9.** Life expectancy at birth by educational level in the EU28, 2007–2016. Source: Eurostat (2018c).  
Explanation of educational levels: Level 0–2: Less than primary, primary and lower secondary education; level 3–4: Upper secondary and post-secondary non-tertiary education; level 5–8: tertiary education.

### Healthy life expectancy

An important question concerning healthy life expectancy is how the extra years of life are spent (largely beyond 65 years). Are the extra years healthy years or years with disability, with severe consequences for health care budgets?

Table 1 provides some recent evidence at the European level. For females, on average 64.2 years of life are spent in good health, and 19.4 years (almost a quarter of the lifetime) with some disability (2016). Males, although they live on average more than five years less, spend five years less in poor health, which means that the extra years lived for females are almost all spent in poor health. This is called the ‘female–male health survival paradox’ (Oksuzyan et al., 2008). The time trend is positive, for both sexes: the life years gained between 2010 and 2016 are all in good health, and the unhealthy years have even decreased in absolute terms.

Healthy life expectancy has an even stronger gradient with socioeconomic status than mortality. People with low income and low educational attainment not only live shorter lives, but also more years of their lives are spent unhealthy and with functional limitations (Stringhini et al., 2018).

	Females			Males		
	Life expectancy	Healthy years	Unhealthy years	Life expectancy	Healthy years	Unhealthy years
2010	82.8	62.6	20.2	76.9	61.8	15.1
2016	83.6	64.2	19.4	78.2	63.5	14.7
Change	+0.8	+1.6	-0.8	+1.3	+1.7	-0.4

**Table 1.** EU 28 life expectancy at birth, healthy life expectancy at birth, and unhealthy years in 2010 and in 2016 (Eurostat, 2018a, 2018b).

### *Old age dependency ratios*

The post-war generation started to move into retirement around 2010. Due to the size of this generation, this has resulted in a stark increase in the percentage of retirees since then. Added to this development is the extension of the length of life, leading to the older cohorts taking up an even larger share of the population.

The number of people aged 65+ to people in the working age range (20–65 years) is called the **old age dependency ratio**, and is expressed per 100 persons of working age. This number has increased significantly, from 16 in 1950 to 21 in 1980 and to 28 at present (Figure 10). It will further increase until the level of 50 around 2050, and remain stable thereafter, which will mark the end of the ageing transition in Europe.<sup>2</sup>

The **child dependency ratio** is the ratio of dependent people aged 0–14 to those typically in the labour force (the productive part aged 15–64). Used to measure the pressure on the productive population, it dropped from 59 children per 100 persons of working age in 1950, to 52 in 1980, and to 33 now. It will decrease further to 25 and stabilise at levels below 30 thereafter.

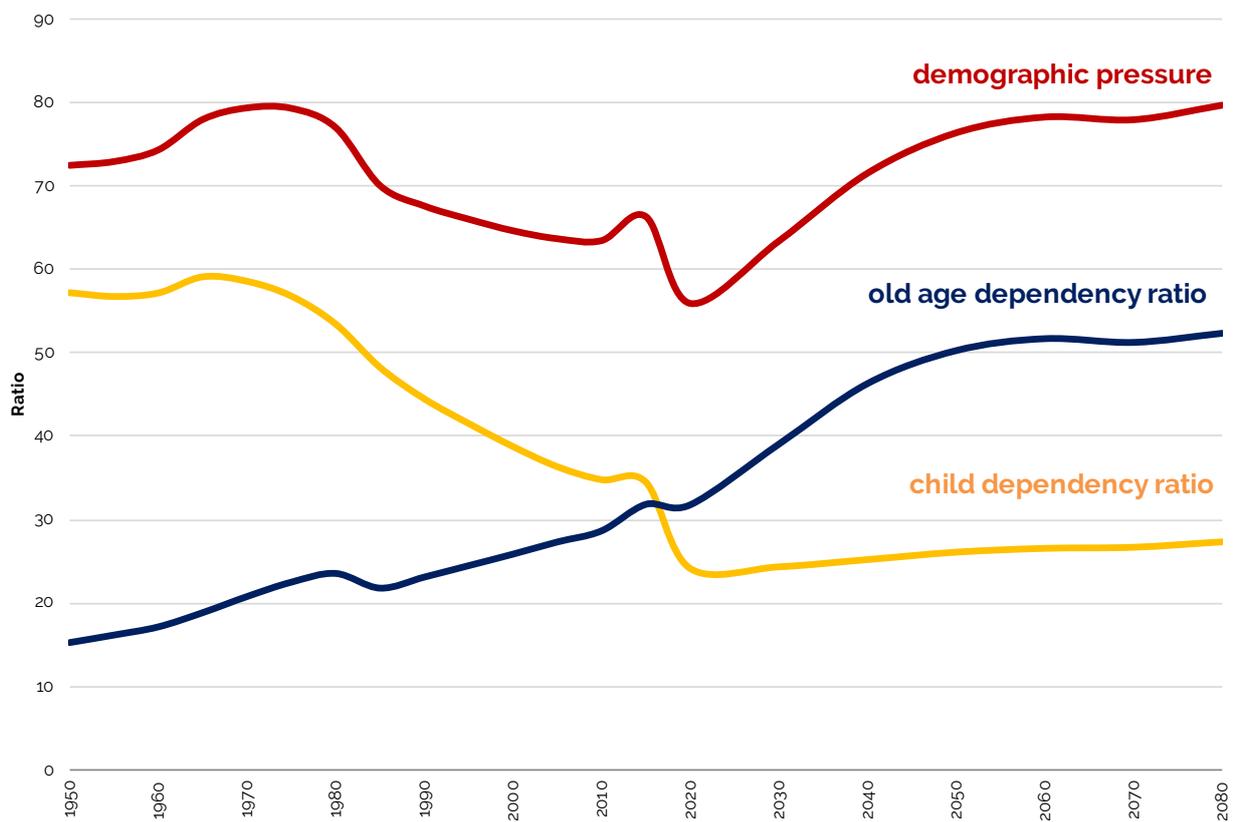
As the combined result of both these developments, the **demographic pressure** (i.e. the sum of old-age dependency ratio and child dependency ratio) has decreased since 1950, and is currently at its lowest point, to increase again in the future to about 80 around 2050. Whereas it was mostly due to the number of children in the past, it is now the number of older adults that make up almost half of the demographic weight. Obviously, it concerns the same generations: the young of the past are the older people of today (Figure 10).

Not only is the proportion of the 65+ age group increasing over time, but, after 2030, it is primarily the 85+ age group that will grow in proportion and number. This means that the ageing process will represent a double challenge for society, as the demand for health services increases while the available supply decreases. Informal health care is an important resource for this age group, which is to a large extent provided by those in the age group 50–74 (see Chapter 4). The **oldest**

<sup>2</sup> The use of 'dependency ratios' has been criticised as ageist; see page 53 for further discussion.

**old support ratio** is the number of 50–74-year-olds for each person aged 85+ (Robine et al., 2007). Currently there are 12 persons aged 50–74 for each person aged 85+, but in 2040 there will be only 6 persons, and in 2060 this number will have further dropped to 4. Undoubtedly, therefore, the future resources for informal caregiving to those in need of it will diminish and alternative solutions will need to be developed.

Fortunately, future generations of older adults will be more highly educated than previous generations (Commission/EACEA/Eurydice, 2019; Koucký et al., 2010). As a consequence of this, on the one hand, the incidence of dementia will be delayed, and on the other hand more highly educated people are in general more familiar with digital technologies and internet-based applications. It is thus likely that many of them will be avid users of ICT tools developed to assist them with their future health and social care needs, to substitute for the reduced resources for informal care from family and friends. In addition, robotics and artificial intelligence have emerged as areas where innovation could lead to the greatest impact on assistance and monitoring of the older adults.



**Figure 10.** Old age (65+ vs 20–64) and child (0–19 vs 20–64) dependency ratios and demographic pressure (the sum of old age and child dependency ratios) in Europe, 1950–2080. Sources: Eurostat (2019); United Nations (2017). Note that the age ranges used in this figure are slightly different from those discussed in the preceding text.

### *Concluding remarks*

Europe's demography has changed significantly in the last century. It has reached the last stage of the first demographic transition and gone through the second demographic transition, with the result that its population is now stagnating, and would even decrease without migration. Fertility levels have dropped to below replacement levels and, at the same time, life expectancy has surged. European citizens are getting older than ever before, but at the same time they spend a significant share of their lives with disability. The population diversity in health and mortality is important, in terms of geographical, educational, income and ethnic background.

A stabilising population is an ageing population, and again Europe is globally at the forefront of these developments. A negative replacement fertility level in an affluent society such as Europe will almost automatically need a significant migration influx, as indeed indicated by projections. Ageing and migration are therefore the two most pressing demographic and societal issues for some time to come, but ageing is by far the more significant of the two, in terms of its consequences for wellbeing and sustainability of society, as reflected in social, economic, and ecological concerns.

Future projections show that the demographic transition previously described is, at present, only halfway through and will peak around 2040–2045. At the European level, the process of population ageing, defined as an increase in the share of older adults, will come to an end around 2050, with three out of ten persons being over 65 years of age by then. Moreover, after 2030 the double load of ageing will become manifest, as currently older adults will have reached the age at which disability typically appears.

#### **Policy option**



It would be beneficial to take greater account of data on demographic trends to inform policymaking. The data highlights certain challenges that governments face and allows the targeting of appropriate issues for policy actions.

## 1A. THE EUROPEAN HEALTH LANDSCAPE IN TRANSITION

### *Demographic transition*

The European health landscape is gradually adjusting to the challenges and opportunities posed by the demographic transition. Longevity is rising steadily, albeit at a slower pace than in the past half century, and fertility rates are at historically low levels. Jointly, these trends give rise to an increasing share of individuals aged 65 and over, leading to an old-age dependency ratio of 55.9 in 2050 (OECD, 2017b). With the advance in life expectancy gradually levelling off, healthy life expectancy is gaining more traction as a concept and policy objective. Indeed, while women in the EU are currently expected to live for 83.6 years and men for 78.2 years, their healthy life expectancy is 19.4 years shorter for women and 14.7 years shorter for men (Eurostat, 2018a). Closing this health gap in life expectancy is one of the key challenges for the years to come.

### *Epidemiological transition*

Together with the demographic transition, the European health landscape is confronted with a new phase in the epidemiological transition, with an ever-increasing burden of chronic non-communicable diseases such as cancer, cardiovascular disease, chronic and obstructive pulmonary disease and dementia (James et al., 2018). Ever more frequently, we observe individuals afflicted with multiple chronic conditions (Barnett et al., 2012), which leads to potential problems with polypharmacy when individuals are confronted with multiple (prescription) medicines to combat and manage a host of different conditions. As the interaction between many different medicines is hard to ascertain, each patient's reaction to his or her combination of medicines is a matter of significant uncertainty (Guthrie et al., 2015).

Importantly, the origins of many chronic conditions can be traced back to life course socioeconomic, environmental and lifestyle factors. This implies that prevention strategies aimed at promoting healthy lifestyles and a reduction of environmental risk factors can potentially lead to a mitigation of the current and future burden of chronic diseases. In spite of its name, prevention does not, however, end with the prevention of disease. Indeed, a healthy lifestyle and environment can not only prevent disease but also limit disease progression and enhance treatment success. Therefore, to deal with the epidemiological transition, we should aim for a symbiotic relationship between prevention, cure and care (Bauer et al., 2014).

While the brunt of chronic conditions affects older adults, school age and working populations are confronted with a larger (relative) burden of mental health problems such as anxiety and depression (Whiteford et al., 2013). Given the early onset of these problems, they tend to have a composite effect over the life-cycle leading to a large loss of income and wellbeing, both for

the individual and for society as a whole (Knapp et al., 2011). Indeed, mental health problems in adolescence may lead to lower school performance, then in early adulthood may lead to absenteeism or presenteeism which limit career progression and finally cause early retirement (Koenen et al., 2013). As such, the costs of mental health problems manifest themselves mainly in the non-medical domain. The early onset of mental health problems also implies that effective prevention interventions aimed at children and adolescents can potentially generate very large benefits for individuals and society at large (Angelini et al., 2018).

### *Health inequalities*

The demographic and epidemiological transitions are not uniformly felt across different socioeconomic groups. Indeed, the extant literature shows that individuals in lower socioeconomic groups tend to have worse health outcomes than individuals in higher socioeconomic groups (Stringhini et al., 2017). While the causality between health outcomes and socioeconomic status is complex and multi-directional, a growing body of literature acknowledges that adverse socioeconomic conditions in childhood are causally related to a variety of adverse health outcomes later in life (van den Berg & Lindeboom, 2014). Ongoing and future research should shed more light on the mechanisms — in particular modifiable mechanisms — by which socioeconomic conditions early in life affect health outcomes later in life (Almond et al., 2017). These mechanisms can be part of a prevention policy agenda aimed at mitigating the impact of adverse early life conditions on health outcomes over the life-cycle.

While much of the literature, and policy, focuses on understanding and mitigating differences in health outcomes between socioeconomic groups, health outcomes also differ quite substantially within socioeconomic groups (Ferrer & Palmer, 2004). These differences reveal that there are individuals in lower socioeconomic groups who do very well in terms of health outcomes and, simultaneously, there are individuals in higher socioeconomic groups who are actually quite unhealthy. Potentially, these differences within groups give rise to policy anchors that are more promising than those derived from differences between socioeconomic groups. After all, identifying why certain individuals seem to be 'immune' — in both a positive and a negative sense — to their environment may hold the key to designing laws, policies and interventions that can improve health and wellbeing in all socioeconomic groups.

In the near future, health differences between groups are likely to widen due to the interplay between the demographic and epidemiological transitions. Indeed, with chronic diseases manifesting themselves mainly later in life, as well as an increasing share of older adults in society and a higher prevalence of chronic diseases among lower socioeconomic groups, the observed average gap in health outcomes between groups will be more pronounced. Potentially, this will have consequences for the sustainability of the health care system that rests on a large degree of solidarity between sick and healthy individuals. To counter the widening gap in health

outcomes, preventive interventions early in life should be supplemented with interventions at each point of the life-cycle to mitigate and maybe even ameliorate the health impact of adverse socioeconomic conditions.

### *Health clusters*

While prevention, cure and care tend to be organised quite differently and separately from each other in most European countries, sustainability of the European health landscape calls for a deeper integration between prevention, cure and care, particularly in primary care (Linde-Feucht & Coulouris, 2012). To achieve this integration, it serves to organise health in regional clusters around, for instance, the referral area of tertiary care centres. In general, individuals within such a cluster will enjoy the lion's share, if not all, of the cure and care that they receive over their life-cycle from a provider within the cluster. Within these regional health clusters, policy and practice in prevention, cure and care can coordinate and plan the provision of health with different degrees of formality, and knowledge development can be facilitated by closely aligning the clusters with knowledge institutes in translational networks so as to improve the quality of prevention, cure and care (Ogilvie et al., 2009).

Health clusters will interact intensively with other clusters in their own country — for instance, in the case of treatment of rare or complex diseases — but also with clusters in adjacent countries. While citizens of the European Union have the right to use health care in a country of their choice, only very few individuals are aware of this right, let alone use it (European Commission, 2016). Nevertheless, 150 million individuals live in a border region and could potentially gain from being able to use health care infrastructure in a bordering country. With (human) resources in health being increasingly scarce, efficient joint use of infrastructure in border regions seems like a straightforward strategy to increase capacity.

### *Concluding remarks*

The epidemiological transition will increase the burden in:

- Non-communicable diseases (e.g., cancer, cardiovascular disease, chronic and obstructive pulmonary disease and dementia) in the older population
- Mental health problems (e.g., anxiety and depression) in school age and working populations

These medical conditions will lead to a large loss of income and wellbeing, both for the individuals and for society as a whole.

Causality between poor socioeconomic status and health outcomes is complex and multi-directional; adverse socioeconomic conditions in childhood are causally related to a variety of adverse health outcomes later in life.

Integration of prevention, cure and care will lead to increasing public health knowledge and higher quality of care.

### Policy options



To counter the widening gap in health outcomes, comprehensive preventive interventions early in life should be complemented with interventions at each point of the life cycle (midlife is a period of particular importance).



Good policymaking would be supported by European collaboration to assess common challenges in ageing and gathering best practice in policies that have been effectively used to tackle them.

## 1B. APPRECIATING AGEING AS AN OPPORTUNITY

Whatever the trends of the demographic and epidemiologic transitions (sections A and B), the present report stems from the understanding that ageing itself is an opportunity for the individual and society.

### *Ageing opens opportunities at the individual level*

As the French entertainer Maurice Chevalier put it, “old age isn’t so bad when you consider the alternative”. Everyone (or the great majority) wants to grow old, given that the alternative is to die young.

Ageing allows for people to have a second, third and even fourth chance in life. Today, more than ever, older people have opportunities to have a second or third career (Ahn et al., 2017), a second, third or fourth relationship (Koren, 2011), and multiple diverse opportunities for lifelong learning (Narushima, 2008). This should not be overlooked, but rather celebrated as an ongoing prospect to redefine oneself over the life course, realise one’s human potential, achieve personal fulfilment and bring stability to one’s family and surroundings using insight and problem-solving abilities. In old age, people are more likely to have time, wisdom and experience that can allow them to fulfil and explore their potential (Etezadi & Pushkar, 2013; Glueck & Bluck, 2018). Moreover, research has shown that older adults who feel that their time in this world

is shortening are more attuned to positive aspects of their lives and experience less of the emotional turmoil which characterises younger age groups (Mather & Carstensen, 2005).

These processes could potentially serve as opportunities to come to terms with challenging experiences in one's past. Opportunities for intergenerational relationships, not only with children but also with grandchildren, which many times serve as a chance to repair old family wounds, are additional benefits that may come with age (Burn & Szoeker, 2015; Gunderson & Carr, 2016). So is the opportunity to contribute to society and to exchange knowledge, skills and abilities with younger generations and each other (June & Andreoletti, 2018; Murayama et al., 2015; Zhang, 2018). Older adults also benefit from the fact that normative expectations on them are more lenient, unlike other age groups that have to obey predefined roles and norms, which allows older people to redefine themselves.

However, the ageing population is not homogenous; there are huge social, economic and cultural variations that have a significant impact on ageing and need to be carefully considered.

### *Ageing as an opportunity at the societal level*

Old age also has a tremendous potential for society at large (Gonzales et al., 2015). Specifically, given declining numbers of younger European employees, older people could potentially take on more productive roles in the workforce (Walker, 2019). Older people can be experienced workers who have time on their hands and are known to be highly reliable and devoted to their work (Walker, 2019). Moreover, society at large can capitalise on older adults' wisdom and experience, and benefit from a lifelong perspective that allows for the dissemination and continuation of tradition and customs to the younger generations (Schniter, 2009). Older people provide a comprehensive perspective which incorporates lifelong experiences and knowledge (Walker, 2019), and exchange both material and non-material commodities with the younger generations (Gurven & Schniter, 2010). Specifically, research has shown that the transfer of financial commodities is more likely to go from old to young, who often support their adult children for many years after adolescence and early adulthood (Attias-Donfut et al., 2005). Moreover, older people also provide assistance in various tasks such as grandparenting or housing, for instance, that are not always financially quantified, yet have a tremendous value to both older adults, their adult children and grandchildren (Albertini et al., 2007).

However, the opportunities for intergenerational solidarity do not only go one way. Older adults also allow for intergenerational exchanges to go from young to old (Albertini, 2016; Albertini et al., 2007). Such exchanges have the potential to create a more inclusive and compassionate society, which encourages empathy and understanding towards others, even if they do not contribute in active and productive ways, as not all older adults can or wish to stay productive members in society (Walker, 2019).

### *Concluding remarks*

At the individual level, ageing offers more freedom, facilitates personal fulfilment and choices of a second or third chance in life. With wisdom, more experience and time and less emotional turmoil, old adults can enjoy more leisure, do more shopping, travel longer or increase their lifelong learning or sponsoring big natural causes. Ageing can also favour intergenerational relationships and society contributions.

At the societal level, individual ageing allows for productive roles and disseminates experiences and knowledge, as well as traditions and customs, to the younger generations. Transfers of financial or non-material commodities are extremely frequent and appreciated. Such exchanges encourage empathy and understanding of others.

### **Policy options**



There should be a greater recognition of the value that older people contribute to the economy and society. Effective policy can leverage that contribution to a greater extent, rather than just viewing ageing as a negative process and a drain on finances.

## 1C. REVISITING THE CONCEPT OF HEALTHY AGEING

In 2018, more than 3500 scientific papers were published in peer-reviewed journals on "successful ageing" (N=473) and "healthy ageing" (N=3064) (PubMed). The main problem faced by the readers of this prolific literature is the confusion surrounding the exact meaning of these two terms qualifying the ageing process: "successful" and "healthy" (Michel & Sadana, 2017; Sadana & Michel, 2019).

### *Defining successful, active and health ageing*

While the benefits of preserving and maintaining health during later life are self-evident, over the last seven decades, the numerous attempts to conceive and define the ageing process across the life span has been impressively diverse. The approaches to the concept of ageing have evolved from the disengagement theory promoted in 1961 and towards a positive gerontology approach in the late 1980s, with a stronger focus on social participation (Rowe & Kahn, 1987).

Disengagement theory (1961)	Desire and ability of older people to disengage from active life in order to prepare themselves for death	Cummings
Successful ageing (1963)	Having inner feelings of happiness and satisfaction with one's present and past life	Havighurst
Index of activities of daily living (ADL) (1963)	Systematic approach to measuring physical performance in a population of older or chronically ill persons	Katz
Ageing successfully (1972)	Coping style: prior ability to adapt, and expectations of life, as well as income, health, social interactions, freedoms, and constraints. Personality adds also complexity to the definition of successful ageing	Neugarten
Successful ageing (1987; 1998)	Interplay between social engagement with life, health, and functioning for a positive ageing experience (low probability of disease and disease-related disability)	Rowe
Active ageing (2002)	The process of optimising opportunities for health, participation and security, in order to enhance quality of life as people age	WHO
Healthy ageing (2006)	Optimising opportunities for good health, so that older people can take on an active role in society and enjoy independence and a high quality of life	Swedish National Institute of Public Health
Healthy and active ageing (2011)	The process of optimising opportunities for health to enhance quality of life as people age and grow old	European Commission
Healthy ageing (2015)	Healthy ageing is more than just the absence of disease; it is the process of developing and maintaining functional ability, needed for wellbeing in older age	WHO

**Table 2.** Brief history of the ageing concept. For more information and references, see Michel & Sadana (2017).

Since the 1980s, three definitions stand out in terms of their measurement criteria as most commonly used in scientific literature (Michel & Sadana, 2017):

- The term **active ageing** promoted by WHO in 2002 was enthusiastically received and immediately followed by proposals to create an Active Ageing Index (Oxley, 2009; Zaidi et al., 2013).
- The term **active and healthy ageing**, introduced by the EU in 2011, which was developed by the European Innovation Partnership on Active and Healthy Ageing (2019), became the object of numerous and high-quality working group reports (Bousquet et al., 2017; Malva & Bousquet, 2016). This attractive definition combines multiple psychological, social, economic and medical approaches to optimising health and to enhancing quality of life as people age. Its ultimate aim is to extend healthy living for two additional years for all European citizens by 2020.
- The 2015 WHO definition of **healthy ageing** (WHO, 2015b) represents a welcome balance between the adaptive processes that ageing adults undergo over the life course to modify their goals in the face of functional decline, and objective measurements to maintain or restore their functioning within the limits of researchers' predetermined cut-offs. "Intrinsic capacity" is the composite of all physical and mental activities of an individual. Functional

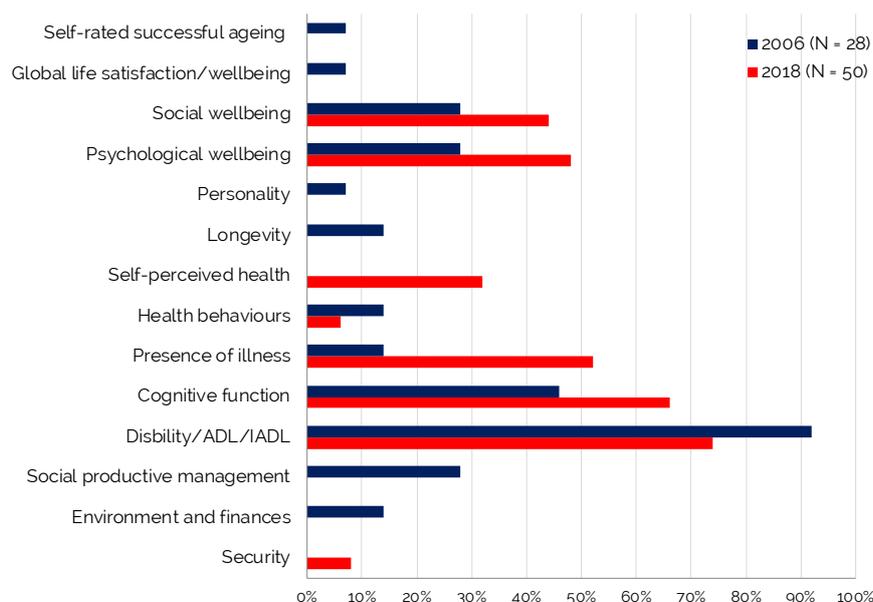
ability depends on the interaction between "intrinsic capacity" and the specific life environment of each individual" (WHO, 2015b).

### *The different conceptual approaches*

Among this flood of papers, Kusumastutia et al. (2016) have made a major contribution to the current understanding of these concepts by reviewing all papers on successful ageing written from 1902 to 2015 (Kusumastuti et al., 2016) and visualising outcomes using timeline-based citation patterns, thus differentiating between two distinct citation networks:

- The first, known as the **Havighurst cluster**, contained 1146 publications and 3946 citation links and focused on successful ageing from the perspective of older people themselves. Across the lifespan, the Havighurst cluster highlighted the importance of the adaptive processes that adults undergo to modify their goals in the face of age-related losses (e.g. death of the spouse, children, divorce, retirement, loss of job).
- The second, known as the **Katz cluster**, had 609 publications and 1682 citation links. It viewed successful ageing primarily from the perspective of objective measurements as determined by researchers. According to this view, to be successful, older people have to maintain their functional ability within the limits of researchers' predetermined cut-offs.

Two extensive reviews have made an inventory of all individual measurements used to assess the ageing process in a total of 78 longitudinal studies (N= 28; Deep CA et al 2006 and N = 50 Lu W et al 2018).



**Figure 11.** Comparison of the criteria for successful/healthy ageing, used in the 28 longitudinal studies analysed by Depp and Jeste (2006) and the 50 different longitudinal studies analysed by Lu W et al. (2018). Figure by Michel (2019).

Figure 11 shows how difficult it is to compare the results of longitudinal studies using so many various subjective and objective measurements, formulated differently from one study to another.

- Preservation of health as well as physical and cognitive functions appears essential.
- Evidence indicates that subjective aspects such as psychological and social wellbeing are also important to the individual.
- Environment and finances are not considered in the top priorities of individuals participating in this review analysis, while it is known that health inequities between high- and low-resource settings (Hanson et al., 2016) generally interfere greatly in health outcomes over the lifespan. However, with some exceptions (Kuh et al., 2014b), health inequities have been too often forgotten in research.
- Security is a new emerging topic, not already used in 2006.

### *The choice of the 2015 definition of “healthy ageing” for this report*

In light of the various above concepts, terms and definitions, it is important to explain briefly why the present report adopts the 2015 WHO definition of healthy ageing, which corresponds to a realistic and pragmatic concept of healthy ageing.

- Functional abilities across ageing merge individual determinants of health and roles played by the individual life environment.
- Functional ageing is the best possible approach to address ageing across the life course, understanding the importance of acquiring the most important functional abilities at a young age and preserving them during the lifespan. Complementary to health promotion, mid-life identification of risk factors will allow targeting individualised prevention strategies to avoid or delay chronic diseases and age-related disability (Michel, 2019).
- The new definition of “healthy ageing” involves reshaping health care delivery systems from a disease-centred practice to a more integrated concept of care from birth to very advanced age.
- Moreover, the general biomedical approach used in this report fits best with the latest functional approach to ageing.

It could be argued that this functional approach to ageing is too restricted because it does not integrate “active and healthy ageing”, participation in society, paid or voluntary work after retirement, recreational outdoors activities or capacity-building. These multiple criteria were not frequently used in longitudinal studies published before 2018.

### *Concluding remarks*

The functional approach to ageing has been chosen for this report as it considers both the various individual determinants of health and the surrounding life circumstances of each individual and their interactions.

Functional ageing is the best possible approach to address ageing across the life course, knowing the importance of acquiring the most important functional abilities at a young age and preserving them during the whole life. This approach can support the policy objective for citizens to live healthier as well as longer.

## 1D. LIFE COURSE APPROACH

A growing trend over the last twenty years is the increasing use of the life course approach to health and ageing, which has multidisciplinary roots and incorporates the developmental origins and social determinants of adult function and disease (Ben-Shlomo et al., 2016; Kuh et al., 2014a). Various strategic and policy documents on ageing also cite a life course perspective (see for example Walker, 2019; WHO, 2002).

The life course approach taken in this report builds on the WHO concept of healthy ageing by studying the natural history of the growth, maintenance and decline in physical and mental (cognitive and emotional) capacities across the lifespan, as well as the onset and development of chronic diseases, clinical disorders, and their preclinical intermediate stages (Kuh, 2019). It examines the long-term effects of physical and social exposures during gestation, childhood, adolescence and adult life that act independently or interactively to impair or protect capacity and increase or decrease disease risk (Kuh & Ben Shlomo, 2004).

The purpose of a life course approach is to identify opportunities at different life stages for promoting healthy ageing and reducing the risks of future disability and dependence. The life course approach offers an opportunity to understand better the interconnected lifelong biomedical, behavioural and socioeconomic pathways involved in the development of age-related disability and to intervene earlier in life for a healthier life course trajectory. Innovative health promotion and early preventive strategies may enable younger European generations to have a healthier old age in the future and to be aware that some risk factors for age-related functional decline are modifiable by lifestyle choices at all life stages.

## Policy options



It should be recognised that ageing is a continuous process from conception. A life course approach can identify opportunities at different life stages for promoting healthy ageing and reducing the risks of future disability and dependence.

## 1E. FIGHTING AGAINST ALL TYPES OF AGE DISCRIMINATION

### *Ageism*

Ageism is defined by the World Health Organisation as stereotypes, prejudice, and discrimination towards people because of their age. It is manifested in the way we think, feel and act towards age and ageing (Officer & de la Fuente-Núñez, 2018). Ageism can be both negative (e.g., not hiring a person for a job because of his or her age) and positive (e.g., giving up your seat to a person who looks old) and can be directed towards people of any age group (Ayalon & Tesch-Römer, 2018), as both young (Rachel Gordon, 2007) and old (Kite & Wagner, 2002) people in society experience ageism.

Ageism is the most prevalent type of "ism" in society (compared with sexism and racism), reported by one in three Europeans (Ayalon, 2014). Although not all of us are members of a minority group, all of us, if we are lucky, will become old and thus have the likelihood of experiencing ageism. The report focuses primarily on the negative manifestations of ageism directed towards older people because of their negative impact on older people and on society at large.

Ageism impacts all aspects of our lives and is manifested at the cultural and institutional level, at the family and relational level, and at the individual level (Ayalon & Tesch-Römer, 2018). At the **cultural and institutional level**, ageism determines what policies and legislation are developed, for example defining premature death as occurring prior to the age of 70 (Lloyd-Sherlock et al., 2015), using constructs such as the dependency ratio, which assumes that all people over the age of 60 are dependent (Angus & Reeve, 2006; see page 40 for more explanation), and imposing a mandatory retirement age (Dennis & Thomas, 2007), which forces older people to become dependent on their life savings and old age pension.

Ageism is particularly prevalent in the **health care system** (Wyman et al., 2018). Research has shown that older adults are less likely to receive optimal treatment (Peake et al., 2003).

more likely to be approached using "elder talk" (Schroyen et al., 2018), and more likely to be offered medical interventions even for social conditions (Gewirtz-Meydan & Ayalon, 2017). Moreover, older adults are less likely to be given the opportunity to enrol in clinical trials, even for conditions which are more prevalent in old age, such as stroke (Hadbavna & O'Neill, 2013), dementia (Banzi et al., 2016) or diabetes (Cruz-Jentoft et al., 2013). The negative effects of ageism also contribute to the shortage of health and social care workers willing to work with older adults (Ouchida & Lachs, 2015) and to the high prevalence of negative attitudes towards older adults reported by health care professionals (Higashi et al., 2012; Higgins et al., 2007; Liu et al., 2013). Furthermore, ageism affects the long-term care services available to older adults, who as consumers often experience paternalistic treatment which disregards their autonomy (Shippee, 2009). Moreover, elder abuse may be justified or precipitated by views of old people as incapable and dependent (Phelan, 2008) and by views of abuse towards old people as being less severe than abuse towards young people (Yechezkel & Ayalon, 2013).

Ageism is also manifested in the **built environment**, where we see a separation between younger and older population groups in the configuration of public space (Ayalon, 2015; Noon & Ayalon, 2018). This results in the marginalisation and social isolation of older adults (Vitman et al., 2014).

An important social arena that reflects the depth and explicit negative expression of ageism is the **workforce** (Stypińska & Nikander, 2018). In the workforce, ageism is manifested in the mandatory retirement age which is enacted in many European countries despite laws that prohibit workforce discrimination based on age (e.g., the EU Equal Treatment Directives). Moreover, research has shown that older people have a harder time finding a job and are likely to be the first employees to be laid off due to economic considerations (Radović-Marković, 2013).

At the **individual level**, many old people have already internalised negative perceptions towards their own ageing, and this affects both physical and mental health. Research has shown that older adults who think negatively about their own ageing are likely to die 7.5 years before those who think more positively about their ageing (Levy et al., 2002). Moreover, those older adults who hold more negative attitudes towards their own ageing are more likely to have physical impairments (Levy, 2003), falls (Ayalon, 2016), deteriorated cognitive functioning (Levy, 1996), and to recover more slowly from disability (Levy et al., 2012). Ageism also affects the mental health of older adults (Wurm & Benyamini, 2014) and the social interactions of older adults with their peers, with those older adults who report more anxiety about their own ageing process also reporting higher levels of loneliness (Ayalon, 2018).

The negative effects of ageism are often amplified when in combination with other disadvantages (Potter et al., 2018). This is because it is almost never age alone, but age in interaction with multiple other disadvantages, which results in inferior treatment and social standing in society (Krekula et al., 2018). For instance, the interaction between old age

appearance and **gender** makes women particularly vulnerable to become invisible in society (Walkner et al., 2018). Meanwhile, the interaction between old age and **minority status** may make some older minorities particularly susceptible to poor health and disability (Vasquez et al., 2018), whereas the interaction between old age and **migration status** places some people at a social, economic and health disadvantage which cannot be accounted for by old age alone (Dolberg et al., 2018).

### *Adultism*

"Adultism" describes the power that older generations have over younger generations. The negative effects of ageism on younger people have two main sources:

- First, from early on, young children internalise negative perceptions towards old people (Teater & Chonody, 2017). Although these negative perceptions may not have a direct effect on their childhood and early adulthood, when people age, the beliefs and attitudes they have internalised throughout their lives impact their ageing process (Levy, 2009). The effects of ageism do not end here, though.
- Although under-researched, there is some evidence to show that children and young adults are also subjected to ageist attitudes and practices by older generations. The negative effects of ageism on younger generations have been documented in several large-scale social surveys that have shown that younger people, more than older people, report exposure to discrimination based on age (Ayalon, 2014; Kessler et al., 1999). Research in the European Social Survey shows that public feelings towards older people are less negative than those towards younger people (Ayalon, 2013). Young people mainly report ageism in the workplace (Horhota et al., 2018). The experiences of ageism are not only subjective, but also have a strong objective basis. Young people are particularly affected during an economic downturn, when they experience very high rates of unemployment (Caliendo & Schmidl, 2016). Moreover, there is a general negative tone which characterises the discussion around younger generations (e.g., describing the millennials as the "me generation") (Beal, 2016).

The intersectionality of ageism towards young people (Kelan, 2014) should also be noted as young women, people of colour and young people of lower socioeconomic status are particularly disadvantaged in our society. Although we still lack rigorous research to document the impact of these negative experiences on younger people's health and wellbeing, there is no doubt that ageism is prominent in their life and thus should be challenged.

### *Concluding remarks*

Age discrimination is more prevalent in society than sexism or racism, concerning one in three European citizens. Age discrimination can be both negative (e.g., not hiring a person for a job

because of his or her age) and positive (e.g., giving your seat to a person who looks old) and can be directed towards old people (ageism) or young persons (adulthood).

Age discrimination impacts all aspects of our lives and is manifested both at the individual level, at the family and relational level, and at the cultural and institutional level. Indeed, fighting against age discrimination implies actions at different levels in society, including laws and regulations at both national and European levels.

### Policy options



Age is just a number and therefore it should not be used to categorise individuals. There is a high heterogeneity in older age that should be acknowledged. Arbitrary categorisation simply based on chronological age should be discriminatory and thus should be avoided.



The existing legislation to prevent age discrimination at work, the EU Employment Equality Directive and the national legislations that implement it, cover age discrimination in the workplace but there is a gap in measures to ensure equal treatment outside of the workplace. An approach based on human rights and social rights could be beneficial.

## 1F. INTEGRATION OF SOCIAL AND HEALTH CARE SYSTEMS

Integration of social and health care systems is essential to adapt to the demographic transition. Social security systems are fundamental instruments to insure against major lifetime risks. They insure against:

- risk of large health expenses (health insurance)
- costs of care in old age (long-term care insurance)
- risks of income losses due to unemployment (unemployment insurance), work disability (disability insurance) and old age (public pension systems).

These elements have interactions both on the individual and on the macro level (Börsch-Supan et al., 2016). For example, older individuals may claim unemployment or disability insurance benefits as a substitute for early retirement benefits.

The distinction between health insurance and long-term care insurance is often blurred. As spending on public pension benefits increases, it will be harder to finance additional health care services through health insurance or long-term care services through long-term care insurance. Ageing puts financial pressures on all social security systems.

Social insurance systems vary dramatically across EU member states (OECD, 2017b). Benefits may be generous or only partial; they may be financed by general taxes or dedicated contributions; they may be pay-as-you-go financed or fully funded. These three fundamental characteristics, explained in the following paragraphs, influence the interconnections and discrepancies between health care and other social systems.

### *Generosity of social benefits*

If social benefits are generous, population ageing has large crowding-out effects in the sense that large expenses in one subsystem (e.g. public pensions) diminish the ability to increase expenses in another subsystem (e.g. health insurance).

One possible policy response to population ageing is therefore to make insurance partial. In public pensions, this means reducing social security benefits and making households save more instead, for instance via private and occupational pensions. In health insurance, this means increasing co-payments and excluding certain health care services, for example dentistry. Long-term care insurance is typically partial: it may finance only professional help (unlike Germany, where also help by relatives is covered) and it may only pay a certain percentage of the costs involved.

### *Method of financing*

Financial 'crowding-out' at the macro level (e.g., the government of a country) is largest if social systems are tax-financed, since there is direct competition among alternative uses of tax revenues.

If social expenses are financed by dedicated contributions, such crowding-out is more subtle on the individual level of households and companies. For households, higher contributions create a larger gap between gross and net income and reduce their consumption possibilities. For a far-sighted household, this may not matter too much, since the contributions will finance consumption (public pensions) or cover expenses (health insurance) in old age. For less forward-looking households, contributions simply cut into their budget. If contributions to social systems

are shared between employers and employees (present in many countries and referred to as social partnership systems), employers may insist on a certain threshold of total contributions, as is currently the case in France and Germany, for example. Thus, raising the contribution rate to public pensions will crowd out a rise in health insurance contributions.

### *Pay-as-you-go financing vs full funding*

The distinction between pay-as-you-go financing versus fully funding is also important for the interconnections between social systems. Pay-as-you-go financing means that the younger generation pays the benefits of the older generation, while in fully funded systems, one generation saves when young and uses these savings later for consumption when older.

Population ageing thus puts a lot of pressure on pay-as-you-go systems, since the benefits for an increasing number of older people must be financed by fewer and fewer younger people. In a funded system, financing happens within a single generation such that population ageing does not directly affect other generations, except for feedback on the macro level such as a reduced interest rate due to ageing (Börsch-Supan et al., 2002). Countries in which old-age income is largely funded via occupational pensions, for instance (the UK, the Netherlands, Denmark) will therefore face less crowding-out of health and long-term care expenses than countries with generous pay-as-you-go public pension systems (Germany, France, Italy).

Interconnections may also exist on an administrative level. Some countries, such as the US, have health insurance that is largely employer-based. Retirement then necessitates a switch of health insurance. Whether this switch is beneficial or not greatly affects the choice of retirement age (Coile & Gruber, 2001). Within a social partnership-financed health care system, somebody has to step in after retirement for the part of the contributions that was formerly paid by the employer. If not (as in the UK), it creates discontinuities. In many countries, the public pension system steps in and becomes the sponsor of health and long-term insurance (e.g., Austria and Germany). Changes in the earliest, statutory or mandatory retirement age of a country's public pension system have implications for the finances of this country's health insurance system. In some countries (e.g., Germany), providing long-term care to a relative is counted towards pension benefits. This may become a major expense item as population ageing accelerates.

### *Needs at the EU and member state levels*

The typical silo approach to public policy — where public pensions belong to the ministry of employment and social affairs, while health and long-term care insurance is regulated by the ministry of health — may lead to unwanted fiscal effects, since the interconnections have been ignored. Reforms which are beneficial from a public pension sustainability point of view, like increasing the retirement age, may have unexpected negative side-effects on health insurance coverage, and vice versa. This also holds for expenditure projections, which need to include all

interrelated social systems. At the EU level, the Directorate for Economic and Financial Affairs has carefully avoided this silo trap.

Moreover, the design of reforms in one social subsystem needs to take account of the effects on the other subsystems. Effects may be financial, as already pointed out; they may also be more subtle, in terms of health outcomes. There is an emerging literature on the effects of retirement on cognitive and physical health (Adam et al., 2007; Bonsang et al., 2012; Börsch-Supan & Schuth, 2014; Rohwedder & Willis, 2010). Raising the retirement age seems to increase cognition because active individuals keep their memory abilities longer than passive ones. It seems to decrease physical health, especially in physically demanding occupations, while the effect appears to be the opposite for office workers and similar occupations (Calvo et al., 2013; Coe et al., 2012); Sustainability reforms, such as the increase of the statutory retirement age, may thus be beneficial for a pension system's finances but may harm the finances of the health insurance system.

### *Concluding remarks*

A final lesson is to be careful that costs and benefits are sufficiently internalised. That is, additional costs to another subsystem should be carried by the subsystem that initiated the reform. Examples abound in non-universal health care systems. The benefits of preventive health care interventions are often long-term.

If individuals switch their health insurance provider during life, the first insurance provider carries the costs of prevention or early intervention, but the second provider enjoys the benefits of a lower incidence rate. This reduces the incentive to provide prevention. A case in point is diabetes, where early interventions only pay off in the long run. Other examples are salient for the many interactions between health insurance and long-term care insurance.

### **Policy option**



Policymakers commonly attempt to reform and integrate health and social care systems. Strategies and financing must recognise that benefits are often derived long term; for example, prevention and health campaigns can take decades to pay off, but may have profound impacts. Costs and benefits need to be sufficiently internalised: that is, additional costs and benefits should be borne by the subsystem that initiates or drives the reform.



# Chapter 2. Addressing the health challenges of ageing across the life course

## INTRODUCTION

This part of the report describes the major health challenges and opportunities for healthy ageing that should be addressed to ensure that younger generations of European citizens improve their chances of a healthy old age. It updates the scientific evidence to support three broad public health strategies based on a life course perspective:

- To build physical and cognitive capacities and enhance reserve so that maximum potential is reached by early adulthood (approximately until 30 years of age).
- To maintain capacities and delay the onset of diseases during midlife (approximately 30–50 years of age).
- To slow the rate of functional decline or disease progression at more mature ages and adapt the environment to maintain functional ability, independence and quality of life.

Evidence for these strategies comes from a broad range of multidisciplinary scientific advances, from the biomechanisms of ageing that underlie many aspects of functional ageing and age-related diseases, the focus of section A; through to common global and life course determinants of mortality and other broad ageing outcomes, the focus of B. Section C then builds on this basic science and global context by focusing on specific intrinsic capacities and associated diseases, identifying temporal trends and the early and midlife risk factors. Population-based and individual-based strategies for health promotion and disease prevention are the focus of section D: as many risk factors (such as poor socioeconomic conditions, smoking, obesity and inactivity) have been found to be common within a wide range of functional domains, strategies with the potential to influence multiple rather than single outcomes may be particularly effective.

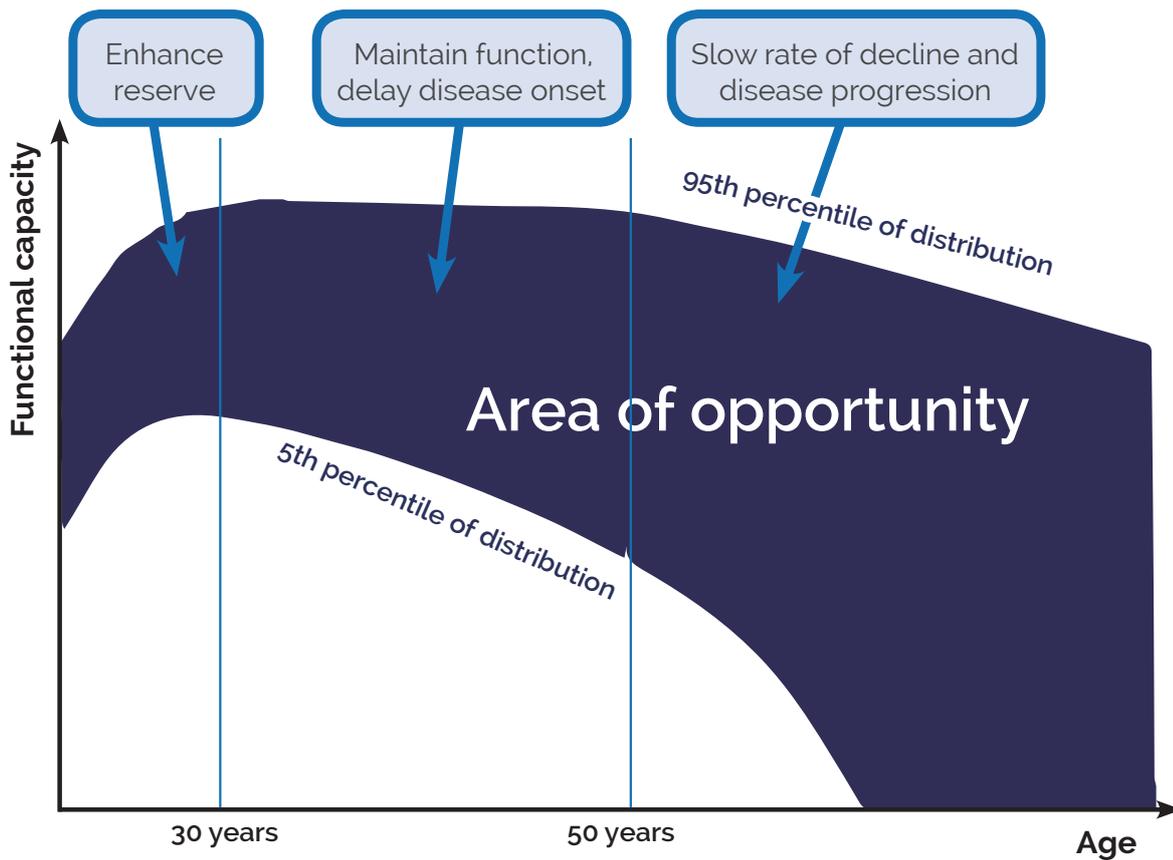


Figure 12. Public health strategies for functional ageing from a life course perspective.

## 2A. BIOLOGICAL RESEARCH INTO DETERMINANTS, MECHANISMS AND MODULATIONS OF THE AGEING PROCESS

### *Lifespan and longevity*

During the last 200 years, average human life expectancy has doubled in most developed countries (Oeppen & Vaupel, 2002) due to improved hygiene, nutrition and medical care. The increased lifespan originally started with reduced child mortality and reduced morbidity and chronic disease in adulthood (Fogel & Costa, 1997). Although the increased lifespan was not paralleled by a health span increase, in the oldest old it did gradually associate with increased physical and cognitive functioning in successive birth cohorts (Christensen et al., 2013).

Not all individuals profit equally from these societal accomplishments. Due to variation in lifestyles, geography, socioeconomic position and so on, there is a large variability in the ageing rate, morbidity patterns and age at death of individuals. In addition to the environmental hazards, genes play a role in susceptibility to disease and intrinsic capacity to survive to old age. However, the influence of genes on the variation in age at death of individuals in populations is generally

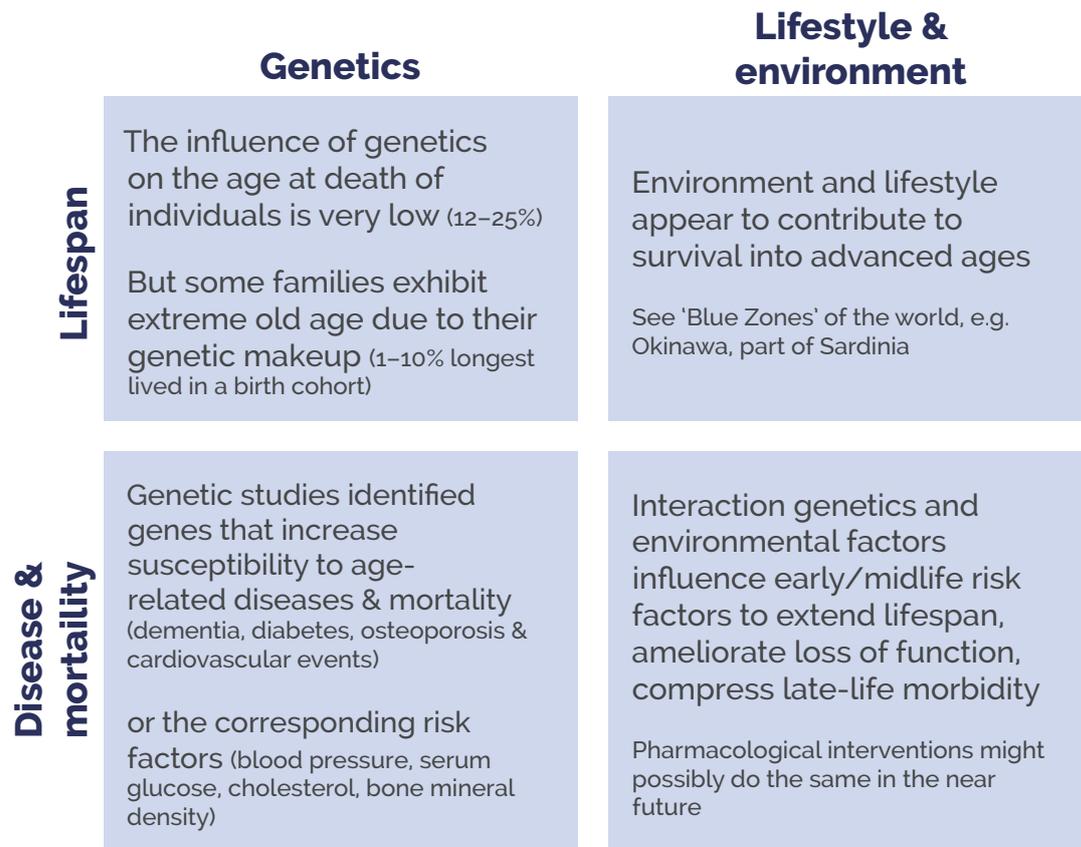
very low (12–25%) (Kaplanis et al., 2018; Skyttthe et al., 2003), except for families in which many family members reach exceptionally high ages (i.e. belong to the 1–10% longest lived of a birth cohort) (van den Berg et al., 2017; van den Berg et al., 2019). Members of these long-living families illustrate the holistic nature of healthy ageing. They have a lifelong survival advantage compared to their birth cohort, and a lower risk of coronary artery disease, cancer and type 2 diabetes (Terry et al., 2004; Westendorp et al., 2009). In middle and old age, they express better immune and metabolic health than other individuals of the same age in the general population (Ash et al., 2015; Deelen et al., 2016) and they show compression of late-life morbidity (Andersen et al., 2012; Christensen et al., 2008). In addition to exceptional longevity running in families, in which for example the APOE and FOXO3A genes play a role, (Partridge et al., 2018), this phenomenon is also observed in the 'Blue Zones' of the world (Okinawa in Japan, part of Sardinia in Italy, etc..) where the environment and lifestyle appear to contribute to survival into advanced age (Poulain et al., 2013).

Genetic influences on age-related human diseases are much more prominent than on lifespan. Using large collaborative genome-wide association studies (Fuchsberger et al., 2016), numerous locations in the genome and polygenic risk scores were identified that associate with increased susceptibility to specific age-related diseases (such as dementia, diabetes, osteoporosis and cardiovascular events) or the corresponding risk factors (blood pressure, serum glucose or cholesterol, bone mineral density) summarised in the GWAS catalogue (2017). For most diseases and traits, functional genomic studies are required to understand how specific genetic variation at the identified genomic locations and genes influences the age-related traits.

### ***The ageing process***

Calendar age is the major risk factor for the onset and progression of virtually all common diseases affecting the general population of the Western world today (Rae et al., 2010), suggesting that common processes of ageing are involved in the aetiology of many diseases. The ageing process is characterised by a progressive and systemic loss of function at the cellular, tissue and organismal level, thus affecting the general capacity for maintaining bodily homeostasis (Kirkwood & Austad, 2000). The biomedical field of ageing research aims to identify causal determinants that maintain and modulate intrinsic capacity and bodily homeostasis (resilience) during ageing. Most advanced are the insights into cellular determinants that emerged from studies into lifespan regulation in animal species and cellular models. Hallmark mechanisms (Lopez-Otin et al., 2013) that seem most relevant for human biological ageing (Partridge et al., 2018) include cellular senescence, changes in serum factors, stem cell exhaustion, accumulation of damaged proteins and genomic instability (cleared by proteostasis and DNA repair mechanisms), nutrient sensing (cellular response to nutrients), mitochondrial dysfunction (or energy homeostasis in general), and epigenetic dysregulation. The causal relationship of these hallmarks to the physiology of ageing has been demonstrated especially in

animal models so far, but these mechanisms are clearly also at play in human long-living families and age-related diseases (Partridge et al., 2018).



**Figure 13.** Gene–environmental interactions determine lifespan and susceptibility for age-related disease.

### *Modulating the ageing process*

Two lines of evidence strongly suggest that a reduction in the length and severity of the period of disease (compression of morbidity) is physiologically feasible. First, there is the long life and compression of late-life morbidity in centenarians (Andersen et al., 2012; Christensen et al., 2008). Second, the ageing process across yeast, nematode worms, fruit flies and mice was shown to be remarkably malleable through the hallmark mechanisms mentioned above. Genetic, environmental and pharmacological interventions can extend lifespan, ameliorate the loss of function and diseases of ageing and, in some cases, compress late-life morbidity (Fontana, 2017; Kenyon, 2010).

The challenge for future research is to gain a better understanding of the genetic and environmental determinants of human lifespan and health span, and to translate the results of discoveries in model organisms into health improvements for ageing humans. In the first place, this requires an improvement of biological age indication. At older ages, calendar age is not very informative on the holistic health status or intrinsic capacity of individuals. Biomarkers of the ageing process (often referred to as biological age indicators) ideally reflect the physiological state of the systems that form a common denominator to the risk of multiple age-related

diseases. Such whole-system indicators need to be an early reflection of deficits and/or decline in intrinsic capacity. Multiple biomarkers of ageing have been generated, based on organ functions (Levine et al., 2013) or molecular age changes (Horvath, 2013; Toledo et al., 2015). The increased understanding of human ageing and joint efforts on analysis of multiomics and other big data needs to be translated to well defined, standardised and feasible biomarkers to provide scores that monitor individual ageing trajectories that can be used for risk assessment and personalised interventions in human and model systems, and to monitor the individual and often heterogeneous response to interventions.

The opportunities to better fit what works for whom are often represented as '4P research':

- improving **prediction** tools
- **preventive** methods and interventions
- **personalised** solutions
- **participation** of citizens to assure that the health and quality of life outcome is relevant to the person.

### *Interventions now and in the future*

Preventive interventions to slow down human ageing have resulted in reductions in hypertension, diabetes and brain atrophy, improved cognitive performance, and reduction in mortality due to cancer and cardiovascular disease. These have all been achieved by alterations to lifestyle. Specific diets such as the plant-based Mediterranean diet (Estruch et al., 2018; Toledo et al., 2015), exercise (Penedo & Dahn, 2005), the two combined (Heilbronn et al., 2006), cognitive training and vascular risk management (Ngandu et al., 2015), caloric restriction (Most et al., 2017), intermittent fasting (Mattson et al., 2017) and supplementation of vitamin D (Laird et al., 2018) have all been reported as effective for specific conditions. Responses to these interventions usually show marked individual variation, and it may become possible to target them to those individuals who will benefit most when robust biomarkers become available.

However, compliance with lifestyle-based interventions is quite a challenge. One might envision a more pharmacological approach to slow down ageing based on the results of animal models, for example by testing whether existing drugs used to treat single age-related diseases also prevent multimorbidity (secondary prevention). For instance, the licensed drug sirolimus (rapamycin) inhibits mTOR complex 1, part of the nutrient-hallmark and stress-sensing network, and can extend lifespan in model organisms including mice, where it improves many, but not all, aspects of health during ageing, and protects against cancer (Johnson et al., 2013). As in old mice, the poor immune response of older humans to immunisation against influenza can be enhanced by pre-treatment with the related drug everolimus (Mannick et al., 2014). The antidiabetic drugs metformin and acarbose can also extend lifespan in laboratory animals and

are currently registered for clinical trials against ageing itself, which has not previously been recognised as a valid target (Barzilai et al., 2016; Espeland et al., 2017).

Another intervention is presented by the selective removal of senescent cells from tissues to restore homeostasis. In mice, this increases health span and lifespan (Childs et al., 2017; Jeon et al., 2017). The first human trials have already started, such as the treatment of osteoarthritis, glaucoma and treatment prior to kidney transplantation (van Willigenburg et al., 2018).

Finally, the 'microbiome' (the microorganisms present in the gut) is increasingly implicated in the health of the gut itself and of other organs during ageing (Clark & Walker, 2018; Kundu et al., 2017). The composition of the human gut microbiome shows marked individual variation and is labile to many environmental factors, including habitual diet, (O'Toole & Jeffery, 2015). The microbiome can beneficially be modulated by nutrition and faecal transplantation.

### ***Linking life course cohort studies and interventions***

'Individualised health' entails focusing on individual responses to interventions and life course trajectories, i.e., zooming in on the biological, psychological, and social factors that determine individual characteristics over time, which can be more closely observed in the rich life course cohort studies, taking gender, age and cultural effects into account. The individual physiological history will result in "responders" and "poor or non-responders" to medical and lifestyle interventions, which can be observed in such experimental studies, but these are rarely linked to the understanding of heterogeneity that may come from observational (cohort) studies. Along these lines, it is important to broaden the understanding of the phenotypic characteristics that render every individual unique.

It is important to explore how calendar age, which is the classic way of determining age in the biomedical and clinical domain, can be complemented by novel ways of determining biological age. Both may be very different from an individual's understanding and experience of age. This can help to explain varied outcomes among older people exposed to the same intervention. In the future, average values for groups will be less important than individual responses, and individualised health will have a major impact on the understanding of the trajectories of ageing and life course exposures.

The emerging evidence from basic research as well as intervention studies show that human longevity can be extended, and that health span can be increased to prevent or delay several age-related diseases.

## *Concluding remarks*

Calendar age is the major risk factor for the onset and progression of virtually all common diseases, suggesting that common processes of ageing are involved in the aetiology of many diseases.

Responses to preventive interventions usually show marked individual variation and it may become possible to target them to those individuals who will benefit most when robust biomarkers become available

### **Policy option**



There is a gap in 4P research (prediction tools; preventive methods and interventions; personalised solutions including biomarkers; and participation of citizens). Improved research in this area will allow more understanding of what works for whom, leading to a more efficient and effective tailored approach.

## **2B. IDENTIFYING AND ACTING ON GLOBAL AND LIFE COURSE DETERMINANTS OF AGEING**

In this section, we complement the consideration of lifelong mechanisms that underlie the biology of ageing (see section A) by acknowledging how the macro physical and social environments can affect healthy ageing (see Figure 14). To illustrate the influence of the macro physical environment, we have selected three widely acknowledged global environmental challenges: climate change, environmental pollution and antimicrobial resistance.

The macro social environment includes social and cultural norms, demographic change, changing political and economic conditions (e.g. globalisation, growth in income and wealth inequalities) and government policies and regulations (including health and social care spending). These challenges at the macro level require societal responses at the multinational and national level, and have been addressed by other reports (EEAC, 2018a, 2018b; European Commission, 2018c; PricewaterhouseCoopers International, 2018). There is clear evidence that life expectancy improves with economic development, although less is known about why some countries do better than would be expected from their economic status (Baum et al., 2018). There is increasing evidence that countries with a high level of social spending, or a higher ratio of social to health spending, have a higher life expectancy than countries with lower social spending (Rubin et al., 2016; van den Heuvel & Olaroiu, 2017).

Here, we focus on the ways in which the macro environment impacts healthy ageing by influencing the lives of individuals within each birth cohort through living conditions, social relationships, health and social service provision, developmental and educational opportunities and lifetime behaviours. Their interrelationships over the life course are illustrated in Figure 14, and their effects on healthy ageing may be modified by genes, gender and ethnicity. In this section, we briefly review the evidence which examines how these individual factors influence broad ageing outcomes such as mortality, disability and composite indicators of healthy ageing. Risk factors for specific intrinsic capacities and age-related diseases are considered in section C.

### *Examples of global challenges in the macro physical environment*

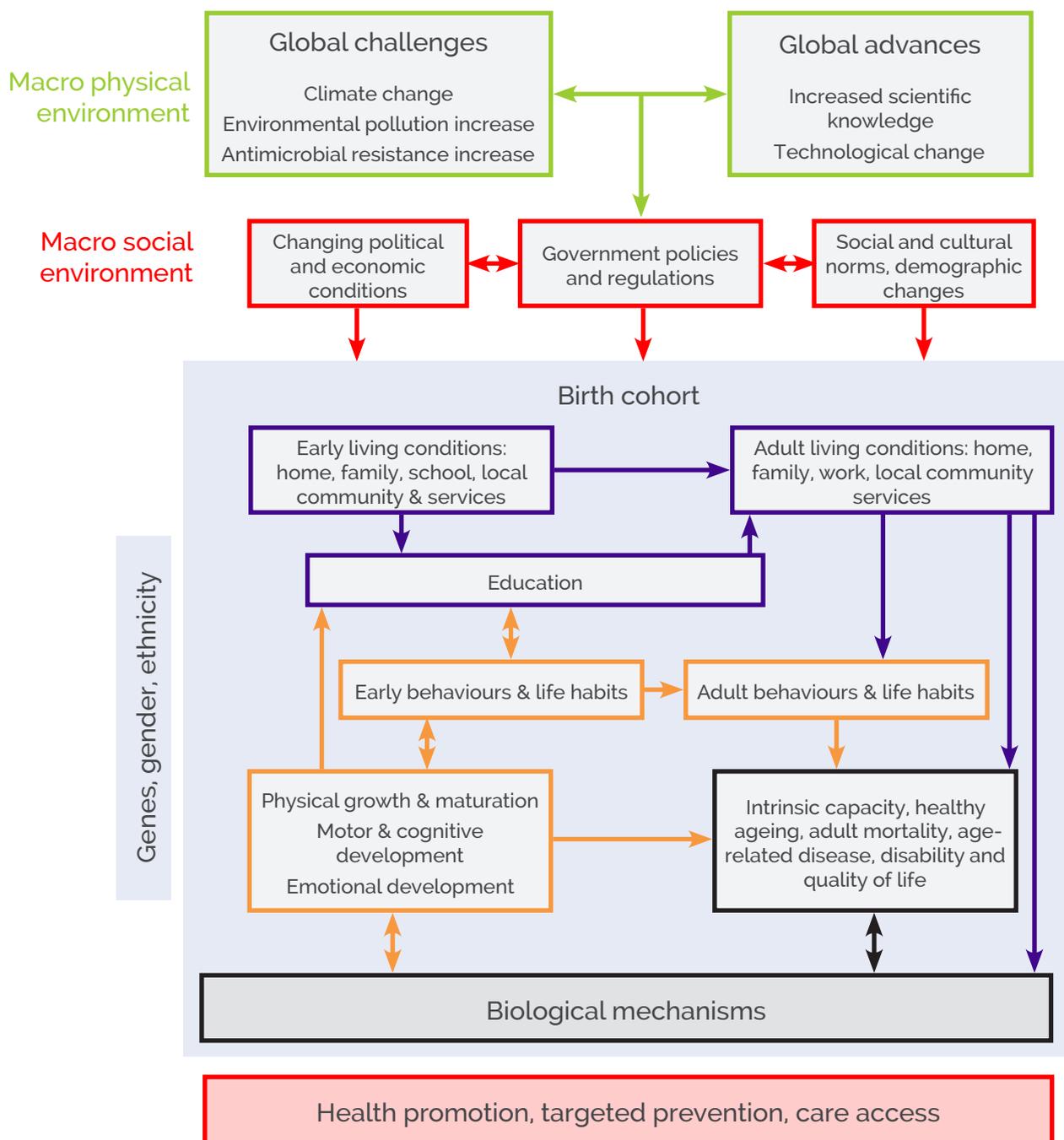
#### **Climate change and environmental pollution**

Earth system changes, including rising temperatures and sea levels, ocean acidification, and changes in precipitation, are considered to be a consequence of increased atmospheric concentrations of carbon dioxide, directly related to the spike in greenhouse gas emissions from human activities following the industrial revolution. These activities are also responsible for generating increased pollutants found in air, land, and water. An assessment of current and projected impacts of climate change in Europe has recently been published (European Energy Agency, 2018b).

Climate change and environmental pollution may adversely affect health in a number of ways, including:

- heat stress and reduced work capacity due to heat-related disorders
- asthma and other respiratory disorders
- infectious diseases such as vector- and water-borne diseases
- undernutrition and growth stunting linked to reduced crop production
- increased food systems and food insecurity
- even mental health disorders, including depression and post-traumatic stress disorder associated with climate-related disasters and displacement (Patz et al., 2014).

In this sense, older adults are more highly represented among the groups at a higher risk of suffering heat-related disorders, along with those living in poverty, social isolation, or with mental illness (Bouchama et al., 2007).



**Figure 14.** Impact of macro environment on health and ageing within each birth cohort, over the life course.

Air pollution is of particular relevance to healthy ageing (European Energy Agency, 2018a). Exposure to particulate matter air pollution is associated with chronic diseases such as cardiovascular morbidity and mortality (Brook et al., 2010) and there is increasing interest in its effects on biomarkers of ageing such as telomere length and the epigenome (Cohen et al., 2017). Older adults are likely to be particularly susceptible to air pollution. Cognitive outcomes, via pathways linked to respiratory and cardiovascular diseases, may also be affected. Clifford et al. (2016) conducted a review including 31 studies and found evidence to support a negative impact of pollutants (mostly derived from traffic-related exposures) to impaired cognitive development in early life, and cognitive decline in later life.

There is widespread exposure of children to air pollution worldwide, harming their health and development which may have long-term effects on ageing outcomes (WHO, 2018b).

Endocrine-disrupting chemicals (EDCs) and potential EDCs are threats to lifelong health. They are mostly man-made, found in various materials such as pesticides, metals, additives or contaminants in food, and personal care products. EDCs may be associated with altered reproductive function in males and females, increased incidence of breast cancer, abnormal growth patterns and neurodevelopmental delays in children, as well as changes in immune function (Bergman et al., 2013). EDCs are increasingly recognised as a risk factor for obesity and diabetes, especially in early life (WHO, 2014).

Coordinated efforts involving governments, private enterprises, NGOs and individuals across the globe are required to act on climate change and environmental pollution. Two main strategies to reduce the adverse effects of climate change and environmental pollution on health are primary prevention, corresponding to mitigation or reduced carbon emissions, and secondary prevention, corresponding to adaptation or public health preparedness for potential threats (European Energy Agency, 2018a, 2018b; Patz et al., 2014).

### **Antimicrobial resistance**

The modern developed world has been made keenly aware of its dependency on effective treatment for bacterial infections with the rise of antibiotic-resistant strains (for example, rise of carbapenem-resistant *Enterobacteriaceae*), with the widespread use of antibiotics in hospitals, communities and livestock as the suspected culprit (Laxminarayan et al., 2013). The consequences for human health of antimicrobial resistance are significant, translating into longer recovery times from illnesses, higher mortality rates, increased treatment costs, and serious limitations to interventions that require the effective prevention of infections. It is calculated that approximately 25,000 people die in Europe each year from bacterial infections that fail to respond to antibiotics (ECDC/EMA Joint Working Group, 2009), a situation that prompted the creation of the European Surveillance of Antimicrobial Consumption Network (European Centre for Disease Prevention and Control, 2019). Furthermore, the worldwide situation is expected to worsen for the next generation of older adults: deaths from antimicrobial resistance are projected to rise from 700,000 in 2015 to up to 10 million per year in 2050 (O'Neill, 2016).

While a less-than-rational use of antibiotics by hospitals and individuals has contributed to the problem, antibiotic use in animals is viewed as a major driver of the crisis of antibiotic resistance. This is especially true regarding antimicrobials administered to livestock, not just for veterinary use, but for growth promotion, a practice commonly used in Europe since the 1940s in response to the demands of industrial food production (Laxminarayan et al., 2013), until the European Commission banned their use for growth promotion in 2006. A relationship was established

between the use of antibiotics in animal husbandry and antibiotic resistance in humans and livestock (for example, against *Escherichia coli*, *Salmonella sp.* and *Campylobacter sp.*).

Here again, coordinated efforts involving governments, private enterprises, NGOs and individuals across the globe are required to act on the threat of antimicrobial resistance. The 'One Health' approach, promoted as a response to this global health challenge, is defined by the World Health Organisation, as "designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes". In simpler terms, it views the health of people, animals and the environment as all interconnected, reflected in policy options spanning sectors such as health, agriculture and food. In 2015, WHO announced its Global Action Plan on antimicrobial resistance in veterinary medicine, with two main objectives: 1. a prudent and rational use of antibiotics, with antibiotics selected from those not of critical importance; and 2. the development of more effective and targeted antibiotics (WHO, 2015c). These measures apply not only to farm animals, but also pets, as resistances of some bacterial species (*E. coli*) can also be found in domestic dogs and cats (Van Cleven et al., 2018).

The Committee for Veterinary Medicine of the European Medicines Agency has adopted a five-year strategic plan (2016-2020) on the availability of effective antibiotics against important infectious diseases while minimising risks both for humans and animals (European Medicines Agency, 2015).

Vaccination in both animals and humans is seen as one of the most effective ways of preventing diseases and reducing the use of antibiotics to treat them, thereby lessening the threat of antimicrobial resistance. As a contribution to the global actions in this area, in April 2015, the Office International des Epizooties (OIE) convened an ad hoc Group on Prioritisation of Diseases for which vaccines could reduce antimicrobial use in animals. Animal diseases for which availability and use of vaccines could reduce the call on antimicrobial agents were identified and recommendations were made to better target research programmes for new or improved vaccines (Epizooties, 2015). As for veterinary medicine, practitioners and governments have to contend with pseudo-scientific arguments and so-called individual liberties supporters, who often hamper efforts for widespread vaccinations to prevent infection. Vaccination policies for humans, especially children and older adults, are discussed later in this chapter (page 193).

Advancements in the development of new antibiotics, along with a strengthened academia-industry interface and new business models, are all needed to provide global solutions (Laxminarayan et al., 2013). Increased prevention and biosecurity through hygiene and vaccination are required worldwide to help lessen the burden of antimicrobial resistance.

Similarly, antifungal resistance has emerged as a new health challenge for the next generation of older adults, as the Global Action Fund for Fungal Infections estimates that 1.6 billion deaths

a year are linked to fungal infections, especially *Cryptococcus*, *Pneumocystis*, *Aspergillus* and *Candida sp.* Furthermore, *Aspergillus* bronchopneumonias have been found to provoke severe asthma, especially in immunosuppressed individuals, such as older adults, HIV patients and those undergoing chemotherapy or organ transplantation. As with antibiotics, in many cases, a balance between "access to" and "excess of" antifungals is a tricky balance to achieve, prompting officials in public health and agriculture to investigate potential alternatives. However, to date no preventive measures have been adopted.

While regulatory guidelines for reasonable antimicrobial and antifungal use have been issued by international organisations in addition to WHO, including the OIE and the UN Food and Agriculture Organisation (FAO), the development of global solutions to fight resistance falls mostly on the shoulders of research institutions, requiring partnerships among different stakeholders in different sectors and countries. In short, antimicrobial resistance will present an important threat to healthy ageing unless coordinated worldwide efforts are successful.

### ***The macro environment***

Risk factors for adult health and ageing are strongly influenced by the macro environment.

#### **Lifetime living conditions, social relationships and educational attainment**

Socioeconomic position (SEP), whether assessed by occupation, education, income or wealth, is a commonly-used indicator of living conditions and an established distal determinant of health and ageing. There is strong evidence that lower adult SEP is associated with all-cause mortality, cardiometabolic and respiratory diseases, and physical and cognitive performance (Chapko et al., 2018; Galobardes et al., 2006; Petrovic et al., 2018; Stringhini et al., 2017). A recent systematic review of 114 articles showed that smoking, alcohol consumption, physical activity and dietary patterns account for a considerable part of the socioeconomic gradient in all-cause mortality and cardio-metabolic outcomes, more so in Northern Europe than in Central or Southern Europe (Petrovic et al., 2018). For quality of life, there are somewhat conflicting results, though social mobility appeared to be a determinant of better quality of life (Niedzwiedz et al., 2012). There is growing evidence that childhood SEP is also associated with many of these adult outcomes, such as cardiovascular disease (Galobardes et al., 2006) and muscle strength and physical performance (Birnie et al., 2011), but the mediating factors have not yet been systematically reviewed.

The rise in inequalities in earnings and household income in the EU and other OECD countries over the past three decades and the accumulation of disadvantage across life are likely to lead to increased health and economic inequalities in old age for younger generations unless action is taken (OECD, 2017c). In Europe, relative inequalities in mortality by educational level have almost universally increased over the past decades (Mackenbach, 2013; Mackenbach et al., 2018).

Multiple aspects of social relationships, including social isolation or lack of social interaction are associated with cardiovascular disease, cognitive decline and an increased risk of incident dementia (Gow & Mortensen, 2016; Kuiper et al., 2015; Kuiper et al., 2016; Valtorta et al., 2016). Work stress has been one of the main occupational psychosocial characteristics examined. There is reasonable evidence of an association with cardiovascular outcomes (Sara et al., 2018). Those exposed to high levels of mentally challenging work tasks, work demands, or job control had higher levels of cognitive function in mid and late life, but the associations with cognitive decline were conflicting (Gow et al., 2014; Nexø et al., 2016).

### **Lifetime health behaviours and life habits**

The evidence is well established that behaviours such as smoking, physical inactivity, poor nutrition and heavy alcohol consumption have adverse effects on ageing outcomes. Strategies required to promote health behaviours are both societal and individual. Health behaviours are often initiated in adolescence and are partly determined by earlier factors, including social background, education, and access to resources. So, as well as being important mediators linking adult SEP to ageing, they are also likely to be important mediators within a casual chain linking factors in early life to later life outcomes.

In two recent and related systematic reviews (Daskalopoulou et al., 2017; Daskalopoulou et al., 2018), being a non-smoker or former smoker and being more physically active considerably increased the odds of healthy ageing, variously defined but encompassing aspects of health status, physical function, cognitive and mental health. A positive association between "limited" alcohol consumption and healthy ageing was observed, though the authors note that standardisation across studies from different countries can be difficult (Daskalopoulou et al., 2018). A very large combined analysis of individual-participant data from 83 prospective studies recently concluded that risk thresholds for alcohol consumption in regard to all-cause mortality and cardiovascular disease are lower than previously assessed (Wood et al., 2018). Sedentary lifestyles have been associated with earlier mortality and various adverse indicators of physical function and cardiovascular health (de Rezende et al., 2014; Wirth et al., 2017). It is estimated that physical inactivity is responsible for 6–10% of coronary heart disease, Type 2 diabetes, breast and colon cancers (Lee et al., 2012). Unhealthy diets and obesity are key risk factors for ageing and age-related diseases. It is increasingly recognised that they coexist and interact with climate change, and that joined up global strategies on sustainable food systems are required to tackle them (Swinburn et al.; Willett et al., 2019), as well as strategies designed to change individual behaviours.

Recent systematic reviews have provided evidence of associations between a Mediterranean diet and global cognition in healthy older adults (Loughrey et al., 2017), and between various indicators of healthy diets and higher quality of life (Govindaraju et al., 2018), better cognition and mental health (Milte & McNaughton, 2016), and a lower risk of frailty (Lorenzo-Lopez et al., 2017).

There is evidence that higher BMI raises the risk for 20 chronic conditions that generally increase with age: ischemic heart disease, ischemic stroke, haemorrhagic stroke, hypertensive heart disease, diabetes mellitus, chronic kidney disease, oesophageal cancer, colon and rectum cancer, liver cancer, gallbladder and biliary tract cancer, pancreatic cancer, breast cancer, uterine cancer, ovarian cancer, kidney cancer, thyroid cancer, leukaemia, knee osteoarthritis, hip osteoarthritis, and lower back pain (GBD 2015 Obesity Collaborators et al., 2017). Some of these risks may be exacerbated by an earlier age of onset or a greater duration of overweight and obesity, which are increasingly experienced by younger birth cohorts. More than half of European adults are overweight or obese (Legler et al., 2015). The prevalence of obesity among children is particularly high in southern European countries, with 15% of them being overweight or obese in Greece, Italy, Portugal and Spain (Legler et al., 2015). A life course approach is important, as children who are obese are more likely to remain so as adults, with consequences for morbidities, quality of life and health care costs throughout life, and there is good evidence that foetal and infant undernutrition are risk factors for obesity throughout the life course (Swinburn et al.).

### **Physical, cognitive and emotional development**

Increasing evidence has linked indicators of adverse physical, cognitive and emotional development to poorer adult health and ageing outcomes, including an increased risk of chronic diseases. For example, in regards to physical growth, there are sufficient data from longitudinal studies to undertake systematic reviews and meta-analyses showing that low birth weight (a crude indicator of an adverse prenatal environment) is associated with higher risks of earlier mortality (Risnes et al., 2011), ischaemic heart disease (Huxley et al., 2007), diabetes (Whincup et al., 2008), and poor muscle strength (Dodds et al., 2012), whereas associations with blood pressure are modest (Huxley et al., 2002) and with cholesterol were weak (Huxley et al., 2004).

In terms of postnatal growth, shorter adult height is associated with mortality from cardiovascular disease and COPD whereas taller height is associated with mortality from several cancers (The Emerging Risk Factors Collaboration, 2012). Shorter height, particularly shorter leg length, is an indicator of adverse early life risk exposures, and is consistent with the evidence linking low childhood SEP to later life outcomes. Data on heights and weights through childhood and adolescence have been used to study growth patterns in relation to cardiovascular disease and its risk factors, osteoarthritis, bone density and fractures (Ben-Shlomo et al., 2016), although systematic reviews are not common because there are few studies on each outcome, and the analysis and interpretation of these data are more complex. However, the data generally show that linear growth in the first few years of life is beneficial for later life ageing outcomes. The current research focus in the developmental origins of adult disease is on understanding the underlying biological mechanisms that link prenatal and postnatal exposures to adult health and ageing (Hanson & Gluckman, 2014).

A parallel field of research area has linked childhood characteristics such as lower cognitive ability with a range of health outcomes, from all-cause mortality (Calvin et al., 2011), cardiovascular and respiratory disease to physical functioning and reproductive ageing (see the next section). It is an ongoing and policy-relevant debate whether these associations are due to poorer childhood cognitive ability being a mediator of early adversity or neurodevelopmental delay, or a determinant of subsequent educational attainment, socioeconomic position and other life chances. A related research field has demonstrated how indicators of emotional development and early psychosocial adversity relate to adult mental health and psychopathology (Rutter et al., 2006). It is challenging to test whether different adversities operate through social, behavioural or biological pathways (Ferrucci et al., 2016; Rutter, 2012). These pathways are increasingly being investigated in younger cohorts with more precisely assessed exposures and stress responses.

### *Concluding remarks*

In briefly introducing some of the global environmental health challenges and some of the lifetime risk factors that are common to many aspects of healthy ageing and age-related diseases, the current section sought to illustrate the range of factors that are modifiable, at an individual or societal level, and across the life course. While most risk factors are examined separately, risk factors often cluster or co-occur. Thus, health promotion and preventive strategies need to be assessed for their effectiveness on multiple rather than single outcomes, or targeted towards risk factors or protective factors that have a wide breadth of effect.

#### **Policy option**



Many risk factors (such as poor socioeconomic conditions, smoking, obesity and inactivity) have been found to be common within a wide range of diseases. Strategies with the potential to influence multiple rather than single outcomes may be particularly effective.

A "health in all policies" approach may support policymakers to better tackle the negative impacts of disparate policy fields including education, climate change, environmental pollution, food and nutrition, endocrine disrupting chemicals and antimicrobial resistance.

Fiscal and regulatory policies that facilitate tobacco control and promote healthy diets would target and manage risk factors for CVD and cancer, for example.

## 2C. IDENTIFYING AND ACTING ON EARLY AND MIDLIFE RISK FACTORS FOR FUNCTIONAL AGEING AND AGE-RELATED DISEASES

A life course approach to promote healthy ageing and to prevent or slow down functional decline requires an understanding of early and midlife influences on, and trends in, functional ageing and age-related diseases.

This section is divided into subsections focusing on different intrinsic capacities (immune, metabolic, cardiovascular, respiratory, musculoskeletal, cognitive, psychological and sensory function) and their associated diseases and cancers. Within each section, drawing on systematic reviews where available, each health challenge is summarised by describing what is known about how capacities change and age-related diseases emerge across life, their health consequences, and their early and midlife risk and protective factors. Are there trends over time reported in the evidence — trends between generations, variations by gender, socioeconomic, or cultural groups — which EU policymakers need to take into account when developing public health strategies, in addition to population ageing?

The biological mechanisms underlying ageing, and some of the common lifetime determinants of ageing, were described in the preceding two sections. Here, the focus is on evidence about factors associated with characteristics of individuals and the social and physical environment in early and midlife that influence specific capacities and associated diseases. In the next section (2d, page 113), we consider the public health promotion and preventive disease strategies that evidence reveals may be most effective at each life stage, to reduce risks and build protection from the biological to the societal level.

### *Diabetes and metabolic function*

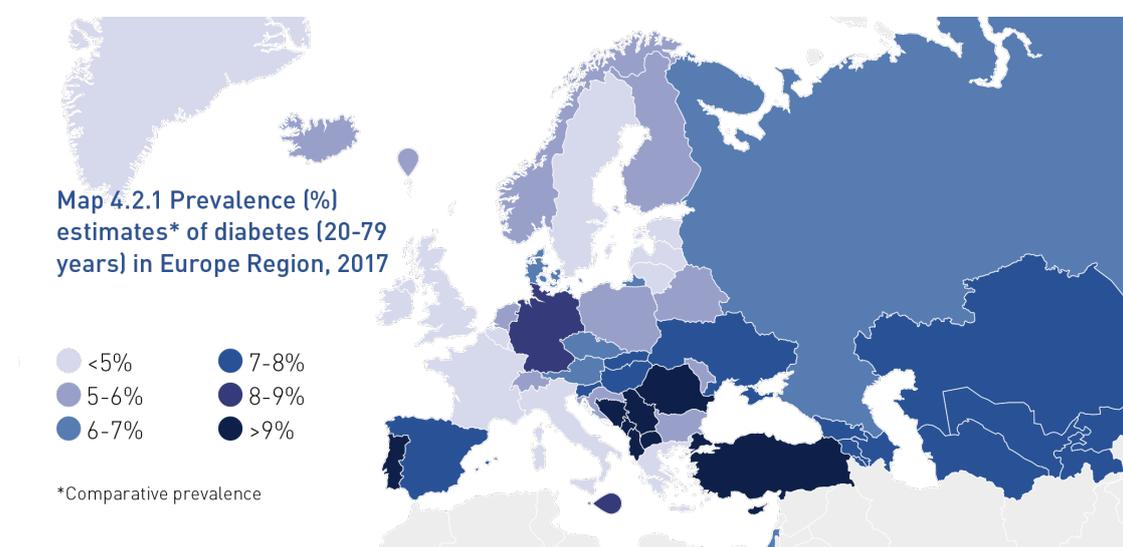
Diabetes is a chronic disease characterised by high levels of glucose in the blood. With ageing, diabetes occurs either because the pancreas stops producing insulin (type 1 diabetes), or, more often, through a combination of the pancreas having reduced ability to produce insulin alongside the body becoming resistant to its action (type 2 diabetes).

The International Diabetes Federation estimates that in the whole of Europe in 2017, 8.8% (7.0–12.0%) of adults (20–79 years) are diagnosed with diabetes, corresponding to 58 million inhabitants. Their 2045 projections suggest that this prevalence will rise to 10.2%, or 66.7 million people (International Diabetes Federation, 2017). In addition, each year 28,200 children are newly diagnosed with type 1 diabetes.

Adverse trajectories of metabolic function, including obesity and elevated levels of glucose and triglycerides, precede the diagnosis of type 2 diabetes up to 20 years or more (Hulsegge et al.,

2017; Malmstrom et al., 2018) and contribute to the development of cardiovascular disease and other morbidities. Fasting and postload glucose levels have been found to increase with age from early adulthood to old age, with a suggestion of a sharp increase in the rate of increase in glucose and insulin from approximately 60 years of age, probably driven by age-related weight gains and declines in physical activity (Hardy et al., 2015).

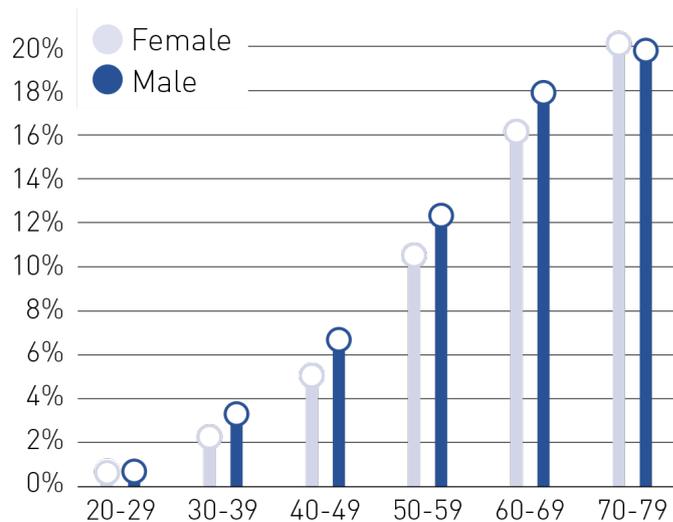
There is considerable variation among European countries in the proportion of the population with diabetes (from <1% to almost 10%) and the numbers have been rising over time (Figure 15) (Wilkins et al., 2017). People with diabetes are at greater risk of developing cardiovascular diseases such as myocardial infarction, heart failure, and stroke if the disease is left undiagnosed or poorly controlled. They often have other cardiovascular risk factors, including hypertension and dyslipidaemia. Although treatment goals for people with prediabetes are the same as for the general population, increased vigilance is warranted to identify and treat these and other cardiovascular risk factors (e.g., smoking).



**Figure 15.** Prevalence of diabetes in Europe by country (International Diabetes Federation, 2017).

With ageing, people with diabetes also have higher risks for sight loss, foot and leg amputation due to damage to nerves and blood vessels, and chronic kidney disease eventually requiring dialysis or transplantation. Cognitive decline is greater and more common in diabetics than in non-diabetics. Research has shown that the disorders of cognition are underestimated in individuals with diabetes (Cukierman et al., 2005); there is a significant relationship between a long-term increase in blood glucose level and lower scores of various tests evaluating cognitive function (Cukierman-Yaffe et al., 2009). The mechanisms involved in these cognitive alterations are poorly studied and could involve hyperglycaemia and glycaemic fluctuations with severe hypoglycaemia, macrovascular ischemic cerebral lesions and microangiopathy, insulin-resistance and chronic (Buysschaert et al., 2015). An increase in dementia risk associated with severe hypoglycaemia due to anti-diabetic treatment has been found in patients with diabetes.

Therefore, this evidence supports that strategies which target interventions aiming to prevent obesity and diabetes, and their morbidities, are major ways for favouring healthy ageing.



**Figure 16.** Prevalence (%) of diabetes in Europe by age and sex, 2017 (International Diabetes Federation, 2017).

In Europe in 2017, the global related health care expenditures of adults (20–79 years) with diabetes was substantial. The health expenditure of EU member states allocated to prevent and treat diabetes and its complications was estimated to be in the order of \$166 billion in 2017 (International Diabetes Federation, 2017), with a mean expenditure per person with diabetes of \$3122. Over one quarter of this health expenditure was spent on treating elevated blood glucose, another quarter on treating long-term complications of diabetes, and the remainder on additional general medical care. People with diabetes also have a lower probability to be employed, and, when they are employed, have more days of sick leave and earn less. The growing direct and indirect costs related to diabetes reinforce the need for effective preventive actions and the provision of quality care to effectively manage diabetes and its complications (OECD/EU, 2016).

### Risk factors and prevention

Type 2 diabetes is largely preventable. Numerous lifestyle factors, such as being overweight or obese, alcohol intake and inactivity are modifiable, and alterations here can also help to reduce complications associated with diabetes (American Diabetes Association, 2017). The long window of elevated metabolic risk factors before a diabetes diagnosis provides opportunities for prevention (Hulsege et al., 2017; Malmstrom et al., 2018).

In older population groups of EU countries, people with a lower level of education are more than twice as likely to report having diabetes as those with a higher level of education. Research in this area has found that people with lower levels of education often have poorer nutrition and are more likely to be obese, which are important risk factors for diabetes (American Diabetes Association, 2018). Low socioeconomic level is associated with higher use of junk food, and the

unreliable availability of food has been shown to increase the risk for obesity and diabetes by a factor of two or three, with their morbidity consequences (Hill et al., 2013).

Challenge: Preventing or postponing type II diabetes	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>Form or mobilise responsible partners, care providers, teachers, etc.</li> <li>Train in use of available technologies for obese and at risk patients</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>Reduce caloric intake (favouring Mediterranean diet, monounsaturated fat, avoiding sugar-sweetened beverages)</li> <li>Physical activity (150 minutes per week)</li> <li>No smoking</li> </ul>
	<b>Possible targeted prevention</b> <ul style="list-style-type: none"> <li>Diabetes prevention programme</li> <li>Identify and control early and midlife risk factors of obesity and cardio-metabolic diseases</li> <li>Regular medical follow-up and appropriate targeted advice</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>Importance of information technology (m-health)</li> <li>Identify health issues</li> <li>Monitor glycemic levels using available technology</li> <li>Ease treatment</li> <li>Ensure careful follow-up of global health conditions</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>Proactively regulate agro-industry, business, goods distribution, advertisement campaigns</li> <li>Tax super-sweetened beverages</li> <li>Town planning</li> <li>Control of endocrine disruptors</li> </ul>

**Table 3.** Challenge: preventing or postponing type II diabetes.

Endocrine-disrupting chemicals are mostly man-made, and found in various materials such as pesticides, metals, additives or contaminants in food, and personal care products. Exposure to these chemicals is increasingly recognised as a contributor to obesity and diabetes, mainly in early life and independent of diet and physical activity (Legler et al., 2015). For example, prenatal exposure to bisphenol A is associated with an increased risk of childhood obesity, and exposure to phthalate is associated with an increased risk of obesity and diabetes (Legler et al., 2015).

The peri-conceptual period and time of early embryonic development are now known to be key windows and a determinant of future chronic disease in adults. Suboptimal maternal and paternal nutrition, and maternal under- or over-nutrition and obesity, can increase the offspring's risk of obesity, type 2 diabetes and cardiovascular disease into adulthood by way of metabolic imprinting, i.e. types of epigenetic cellular and metabolic mechanisms that happen very early on in development of life, but only reveal their effects later (Fleming et al., 2018; Hanson & Gluckman, 2014; Simeoni & Barker, 2009).

## *Cardio-, neuro- and nephro-vascular diseases and vascular function*

### **Cardiovascular disease**

Despite steady declines in cardiovascular disease (CVD) mortality rates over the last 40 years, heart disease and stroke remain the first and fifth leading causes of death respectively in most high-income countries, and their associated mortality rates have recently begun to plateau in the general population and even increase in some sub-groups (Wall et al., 2018). However, given population ageing and CVDs' association with ageing, the global burden of CVD is expected to continue to rise; premature deaths will increase from 5.9 million to 7.8 million between 2013 and 2025 if current risk factors for CVD do not change (National Academies of Sciences et al., 2017).

At age 45, estimates of lifetime risk for total CVD (including fatal and nonfatal coronary heart disease, all forms of stroke, congestive heart failure, and other CVD deaths) were 60% for men and 56% for women (Wilkins et al., 2012). These estimates were based on data from US community-based cohorts between 1964 and 2008 only, as similar data for the EU are not available. By midlife, subclinical atherosclerosis is already highly prevalent, and was shown to affect 63% of the population (71% men, 48% women) in a large Spanish group study of asymptomatic subjects between the ages of 40 and 54 (Fernandez-Friera et al., 2015).

Favourable EU trends in CVD are not only related to changes in risk factor exposures (see below) but also to improvements in risk factor management and treatment, leading to mortality declines that were earlier and greater than declines in incidence (Bhatnagar et al., 2016; Mensah et al., 2017). Of current concern are the consequences of CVD and CV risk for physical and cognitive capacity and frailty (Forman et al., 2018; Melzer et al., 2018; Samieri et al., 2018). Also of importance are the persisting socioeconomic inequalities observed in CVD mortality and morbidity, based on child as well as adult socioeconomic indicators (Galobardes et al., 2008).

Atrial fibrillation is the most common sustained cardiac arrhythmia in humans, affecting more than 30 million people globally. Its association with complex, resource-intensive medical conditions such as stroke, heart failure and dementia means it will have profound impacts across existing health care structures.

### **Stroke**

Stroke ranks second after ischemic heart disease as a cause of lost disability-adjusted life-years in high-income countries, and as a cause of death worldwide. The rate of new strokes and stroke deaths, when adjusting for age, has decreased over the last two decades in all European countries (Wilkins et al., 2018). However, the number of strokes is set to rise because the proportion of Europeans over 70 is increasing. The projections indicate that, between 2015 and 2035, there will be a 34% increase in total number of stroke events in the EU and a 32% increase

in disability-adjusted life years lost in the same period. In the EU, the total cost of stroke in 2015 was calculated as €45 billion. 44% of this amount, €20 billion, was caused by direct health care costs: 72% of direct health care costs were for in-hospital care and 7% for drugs (Stevens et al., 2017).

In Western societies, about 80% of strokes are caused by focal cerebral ischemia due to arterial occlusion, and the remaining 20% are caused by haemorrhages (van der Worp & van Gijn, 2007). Atherosclerosis (leading to thromboembolism or local occlusion) and cardio embolism (usually secondary to atrial fibrillation) are the leading causes of brain ischemia. Ischemic brain injury is thought to result from a cascade of events from energy depletion to cell death. The likelihood of a poor outcome after stroke increases with increasing age, with the coexistence of diseases such as ischemic heart disease and diabetes mellitus, and with increasing size of the infarct (van der Worp & van Gijn, 2007).

Stroke is preventable, but public knowledge about the risk factors for stroke is low. The proportion of the population with one or more risk factors for stroke is significant. High blood pressure, the most important risk factor for stroke, is significantly under-treated. The proportion of people with known high blood pressure who achieve adequate blood pressure control is well below 50%. Atrial fibrillation, another important risk factor, is often not diagnosed until after a stroke event, or not treated according to widely available national evidence-based guidelines (Stevens et al., 2017; Wilkins et al., 2017).

**Challenge: Preventing or postponing cardio-, neuro- and nephro-vascular diseases and functions**

Cross-sectoral actions	<b>Education</b>	<ul style="list-style-type: none"> <li>School education and workplace lifelong learning on coherent and comprehensive life habits</li> </ul>
	<b>Individual behaviour</b>	<ul style="list-style-type: none"> <li>Individual choice, family influence, cultural and ethnic groups, workplace</li> <li>Adolescence is a vulnerable period for uptake of smoking, drinking alcohol, stopping sports, and spending too much time on screens</li> </ul>
	<b>Possible targeted prevention</b>	<ul style="list-style-type: none"> <li>Detect and control arterial hypertension lifelong</li> <li>Empower primary care professionals to prevent and reduce harmful use of alcohol, tobacco and junk food</li> <li>Regularly control weight/glycemic/cholesterol and establish total cardiovascular risk estimation</li> <li>Maintain healthy lifestyle changes</li> <li>Drink fresh water</li> <li>150 minutes a week of moderate intensity physical activity</li> </ul>
	<b>Technology</b>	<ul style="list-style-type: none"> <li>e-health stimulating programs</li> <li>m-health self-management of physical activity, blood pressure, cardiac rhythm, functional ability</li> </ul>
	<b>Society</b>	<ul style="list-style-type: none"> <li>Unhealthy food, tobacco and alcohol: media and educational campaigns, consumer-friendly labelling, marketing limitations, increased taxes</li> <li>Subsidise the cost of healthier foods</li> <li>Ban smoking in public places</li> <li>Implement countermeasures against drink driving</li> </ul>

**Table 4.** Challenge: Preventing or postponing cardio-, neuro- and nephro-vascular diseases and functions

**Nephro-vascular disease**

Nephro-vascular disease refers to chronic kidney disease (CKD) in diabetes mellitus (both type 1 and type 2), which represents a microvascular complication, and CKD secondary to systemic arterial hypertension, which represents both a microvascular and macrovascular complication. The prevalence and associated economic and social burden of CKD is rising worldwide, with the fastest growth occurring in low- and middle-income countries (LMICs) (Levin et al., 2017). CKD is associated with impaired quality of life and reduced life expectancy at all ages. It represents an independent risk factor for cardiovascular disease and is associated with excess risk of other conditions such as diabetes, infections and cancer (Levin et al., 2017). The number of drug side-effects is much more important in older patients with CKD (Gallieni & Cancarini, 2014). Despite a global prevalence as high as 10–15% (Hill et al., 2016), CKD is not included in most non-communicable diseases priority lists, and few countries have explicit policies or public programmes aimed at CKD prevention and control (Levin et al., 2017).

## Risk factors and prevention

The key risk factors for CVD are well known: elevated blood pressure and cholesterol, diabetes, smoking, heavy alcohol use, obesity and high sodium intake. Maintenance of optimal levels in the first four of these risk factors in middle age was associated with substantially longer morbidity-free survival (Wilkins et al., 2012). Compared with participants with at least two major risk factors, those with an optimal risk factor profile lived up to 14 years longer free of total CVD. The positive relationship between regular physical activity and cardiovascular health is also well established according to the latest US guidelines (Piercy & Troiano, 2018):

- Decreased incidence of cardiovascular disease, including stroke and heart failure
- Decreased cardiovascular disease mortality
- Reduced blood pressure (in people with normal blood pressure, prehypertension and hypertension)
- Decreased incidence of hypertension
- Weight loss, especially when combined with dietary changes to reduce calorie intake
- Prevention of weight regain after weight loss
- Reduced or slowed weight gain over time
- Decreased incidence of type 2 diabetes mellitus (includes those at any body weight)
- Decreased risk of adverse lipid profile

Somewhat less well known is the importance of these risk factors from an early age. Based on a review of life course trajectories in blood pressure, lipids and glucose, Lawlor and Hardy (2014) conclude that higher blood pressure, LDL-cholesterol, and fasting glucose in adolescence and early adulthood are associated with adverse cardio-metabolic events in older age, independent of these risk factors in adulthood. Moreover, blood pressure, body mass index (BMI) and glycaemic control measures in childhood, adolescence and early adulthood, and subsequent longitudinal trajectories of blood pressure and BMI, are predictive of future abnormalities in cardiac structure and function (Ghosh et al., 2014). Therefore, understanding underlying 'normal' or 'healthy' life course trajectories and the characteristics that drive deviations from such trajectories offer potential for early prevention and for identifying means of preventing future disease (Hardy et al., 2015). Furthermore, the Developmental Origins of Health and Disease concept has received strong evidential support, suggesting that poor developmental experience (in utero and in the early postnatal period) can increase the risk of non-communicable diseases in later life, including cardiovascular and metabolic comorbidities, such as hypertension, obesity, and type 2 diabetes (Hanson & Gluckman, 2014; Turkeshi et al., 2015).

In people with no known vascular disease, the main risk factors for both ischemic and haemorrhagic stroke are age, hypertension, diabetes, current cigarette smoking and male

sex (Baigent et al., 2009). Female-specific characteristics increasing stroke risk include any hypertensive disorder in pregnancy (HDP) for ischemic stroke; late menopause and gestational hypertension for haemorrhagic stroke; and oophorectomy, HDP, preterm delivery, and stillbirth for any stroke (Poorthuis et al., 2016). Hysterectomy is possibly protective against any stroke. Male-specific characteristics that increase stroke risk include medical androgen deprivation therapy for ischemic and any stroke, and erectile dysfunction for any stroke (Poorthuis et al., 2016).

Diabetes mellitus and hypertension are the dominant global risk factors for CKD. Obesity is closely linked to diabetes and hypertension and might also predispose people to CKD. Good management of diabetes, hypertension, and excess body weight reduces the risk of CKD and improves outcomes in patients with CKD (Levin et al., 2017). In the MRC National Survey of Health and Development, being overweight throughout early life or becoming overweight in early adulthood was found to be associated with CKD in later life (Silverwood et al., 2013a; Silverwood et al., 2013b). Thus, reducing or preventing overweight in early life or early adulthood may considerably reduce the burden of CKD in the population (Silverwood et al., 2013a; Silverwood et al., 2013b).

The ongoing epidemic of obesity results in people becoming overweight at earlier ages (in early adult life, and more recently in adolescence and childhood), and this leads to a substantial increase in exposure to metabolic abnormalities associated with overweight and obesity, which could have important consequences for CKD as well as for CVD (Tirosh et al., 2011).

Given the limited therapeutic options to reduce the risk of atherothrombotic events and progression to renal replacement therapy (and high cost of the latter) (Levin et al., 2017), preventing or delaying the onset of CKD appears as a high priority for reducing the economic and social burden of CKD in future older people.

### ***Pulmonary function and chronic respiratory diseases***

Lung health is intimately associated with good health in older adults. Breathing difficulties and poor blood gas exchange are key determinants of poor metabolic health, leading to physiological inefficiencies, susceptibility to the onset or fast progression of diseases, and poor physical and mental performance (Goodwin et al., 2006). Pulmonary function is an independent predictor of mortality in old people: in very old adults, low forced expiratory volume (FEV<sub>1</sub>) is a short-term predictor of all-cause mortality, hospitalisation and decline in physical and mental functioning independently of age, smoking status, chronic lung disease and other multimorbidity (Turkeshi et al., 2015).

The lung grows until puberty and matures until it reaches its maximum function at 20–25 years of age (Janssens et al., 1999). Lung function then declines progressively with age as a consequence

of structural and physiological changes of the lung and immunosenescence (Bowdish, 2018). There are structural changes in the lung, the chest wall and respiratory muscles over time (Miller, 2010). The nine hallmarks of ageing (Lopez-Otin et al., 2013) are all involved in the ageing lung (Meiners et al., 2015): genomic instability, telomere attrition, epigenetic alterations, loss of proteostasis, deregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, altered intercellular communication and stem cell exhaustion.

Chronic respiratory diseases (CRDs) are chronic diseases of the airways and other structures of the lungs. They represent a model of non-communicable disease across the life course. CRDs affect over one billion people in the world (WHO, 2007b). CRDs are the fourth leading cause of death (WHO, 2012) and a major cause of burden (GBD 2015 Mortality and Causes of Death Collaborators, 2016). Major preventable CRDs include chronic obstructive pulmonary disease (COPD), asthma and respiratory allergies, and occupational lung diseases. The burden of preventable CRD has major adverse effects on the quality of life and disability of affected individuals; they cause premature death and create large adverse and underappreciated economic effects on families, communities and societies in general. The prevalence of some CRDs, such as COPD and pulmonary fibrosis, sharply increases with age. In this section we focus on COPD and asthma, as they represent the greatest burden.

COPD is a major public health problem and will remain a challenge for the future. It affects 5–10% of European adults aged over 40, with a higher prevalence in men than women (European Lung White Book, 2019). Globally, over 4 million people die from COPD annually (Figure 17). COPD is a heterogeneous disease with various clinical presentations. It is characterised by abnormal tissue repair, resulting in (small) airways disease and emphysema, and by persistent airflow limitation, which is usually progressive and associated with an enhanced chronic inflammatory response in airways and lungs to noxious particles and gases (Barnes et al., 2015).

COPD is a major source of physical and social disability (Liu et al., 2014), and of frailty. Physical disability stems from exercise-induced dyspnea (shortness of breath), muscular deconditioning, and other factors that have a major impact on the quality of life of the patients (Rasekaba et al., 2009). Many individuals with COPD have a low body weight associated with impaired pulmonary status, reduced diaphragmatic mass, lower exercise capacity and higher mortality than those who are adequately nourished (Ferreira et al., 2012a). Up to 15% of patients with stable COPD have sarcopenia (loss of skeletal muscle mass), which impairs function and health status (Jones et al., 2015). Severity of COPD can be assessed by gait speed, which captures many of the multi-systemic effects of COPD (Ilgin et al., 2011), and correlates with age, clinical symptoms, pulmonary functions and quality of life scores.

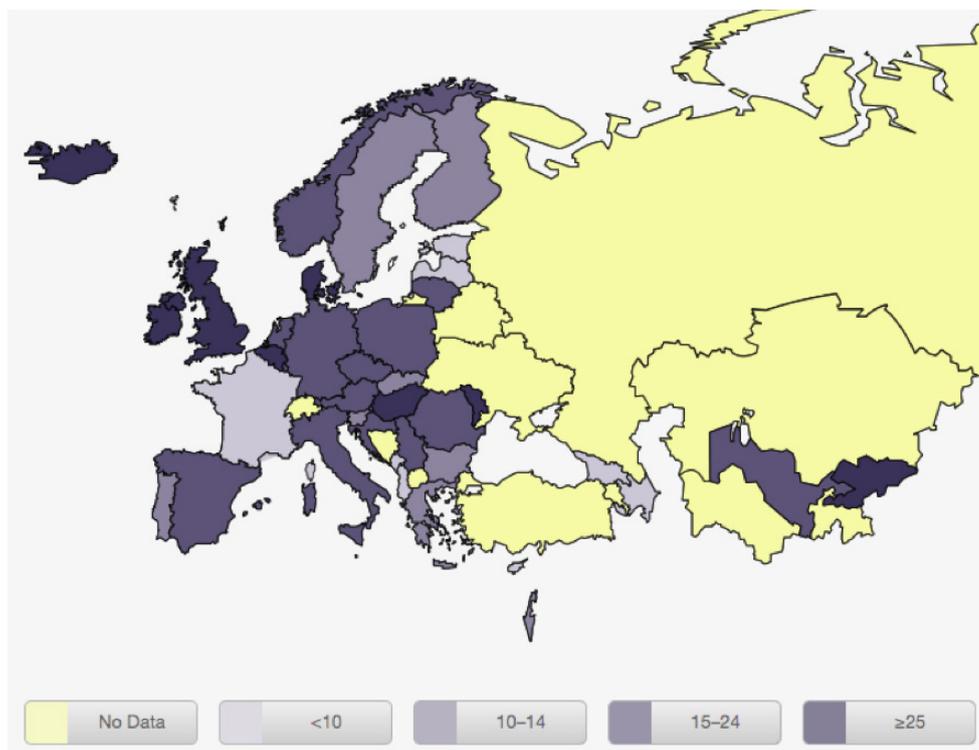
Asthma is defined as an airflow obstruction that is reversible, spontaneously or after treatment. Inflammation of the airways and non-specific bronchial hyperreactivity are features of asthma (Boulet et al., 2015). Asthma and allergic diseases often occur in early childhood and persist

across the life cycle (Samoliński et al., 2012). Asthma is a global health problem affecting over 300 million people worldwide. Patients from all countries, all ethnic groups, and all ages suffer from asthma. The prevalence of asthma can be higher than 20% of the population in some age groups. Asthma affects social life, sleep, school and work. Long-standing asthma can cause disability and COPD. Various social and economic effects are associated with asthma, including absenteeism and presenteeism (Fletcher et al., 2015).

Long-term prognosis of patients with characteristics of both COPD and asthma (asthma–COPD overlap) is poor and seems to be affected by the age of recognition of asthma, being worst in those with late asthma onset (after 40 years of age). Such patients should be followed up closely to prevent fast lung function decline and exacerbations (Lange et al., 2016).

### Risk factors and prevention

The airways are constantly exposed to the outside environment, which impacts lung structure and function and thus determines lung health. A life course approach is therefore essential to prevent and control CRDs in order to promote healthy ageing (Bousquet et al., 2015). As with diabetes and obesity, factors across life from the prenatal period onwards influence CRDs. Factors that affect lung growth during pregnancy and early childhood may increase the risk for COPD (Vestbo et al., 2013). Major early-life risk factors for later respiratory disease include abnormal antenatal lung growth, low birthweight, prematurity and bronchopulmonary dysplasia, passive smoke exposure and viral infections. The links between such early life events and subsequent risk of disease in adulthood are accumulating (Allinson et al., 2017).



**Figure 17.** Mortality rate for COPD (age-standardised rate per 100,000) (European Lung White Book, 2019). Reproduced with permission of the European Respiratory Society.

Ageing is a major risk factor for CRDs (Meiners et al., 2015). For COPD, there is accumulating evidence that ageing hallmarks are prominent features (Barnes, 2017; Brandsma et al., 2017). Worldwide, the most common risk factors for COPD are tobacco smoking, indoor and outdoor air pollution (Cohen et al., 2017), and occupational exposures to vapour, dust, gas or fumes (Caillaud et al., 2012). Low socioeconomic status also increases the risk of developing COPD. Bronchitis, airway hyper-responsiveness and asthma accelerate decline in FEV1 independent of exposures (Vestbo & Lange, 2016).

Challenge: Preserving respiratory function until very old age	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>Basic education starting at school</li> <li>Lifelong health literacy</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>No smoking</li> <li>No exposure to polluted air and toxins</li> <li>Limit and control occupational exposure</li> <li>Physical activity</li> <li>Healthy nutrition</li> </ul>
	<b>Possible targeted prevention</b> <ul style="list-style-type: none"> <li>Identify and control earliest risk factors in life: antenatal conditions; birth weight; prematurity; growth; childhood allergy; viral infections; smoking and pollution exposure</li> <li>Identify and manage midlife pre-frailty and frailty</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>Mobile health app providing allergen and toxin alerts</li> <li>Detect the first symptoms</li> <li>Reduce acute and chronic respiratory diseases</li> <li>Evidence-based care and better treatment adherence</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>Sustainably control noxious particles and gases, indoor and outdoor pollution</li> <li>Improve socioeconomic status of population at risk</li> </ul>

**Table 5.** Challenge: Preserving respiratory function until very old age

For asthma, the role of ageing is not sufficiently well understood and needs more studies considering different phenotypes, environmental risk factors and multimorbidity.

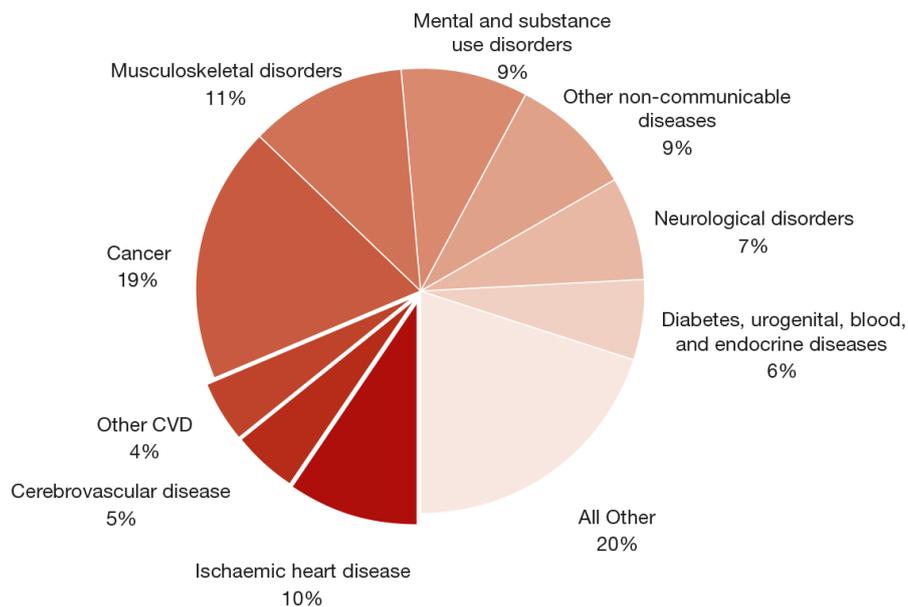
COPD impact is expected to rise globally in the future, partly due to continued exposure to COPD risk factors and partly due to ageing (Barnes et al., 2015). Strategies should be considered to reduce exposure to CRD risk factors, especially smoking; to use gait speed as a functional capacity indicator; and to provide sustainable models for preventing CRDs and promoting good lung health.

***Musculoskeletal and physical function, and related diseases***

Maintaining musculoskeletal function for the maximal period of time, and preventing musculoskeletal disorders, are important aspects of healthy ageing, enabling people to remain

active and independent for longer (Cooper et al., 2014) and reducing the risk of common clinical conditions such as back pain, osteoporosis, sarcopenia (muscle weakness), falls and osteoarthritis. In Europe, musculoskeletal disorders rank second in their contribution to loss of disability-adjusted life years (Figure 18) (Wilkins et al., 2017).

The musculoskeletal system underpins the individual's intrinsic capacity to maintain mobility and other aspects of physical function needed to undertake the physical tasks of daily living, although other body systems also contribute. Physical function tests are good indicators of such intrinsic capacity. Hand grip strength, which relates directly to upper body function, is a commonly used indicator of overall muscle strength, while tests of walking speed, chair rises, and standing balance are good indicators of lower body function (Cooper et al., 2014).



**Figure 18.** Disability-adjusted life years lost by cause. 2015 data for the EU (Wilkins et al., 2017).

Low bone mineral density is a major risk factor for osteoporosis and fractures, commonly at the hip, spine and wrist. Low grip strength has been recently recommended as the key criterion for defining sarcopenia, confirmed by an assessment of muscle mass and severity defined by poor walking speed (Cruz-Jentoft et al., 2019). Hip and knee osteoarthritis are major causes of disability (expected to become the 4th leading cause of disability by 2020 (Runhaar & Zhang, 2018)). Weaker grip, slower walking and chair rise speed, and shorter balance times are associated with future morbidity, disability, falls, and mortality across populations of different ages, ethnicities and income levels (Cooper et al., 2011; Cooper et al., 2010; den Ouden et al., 2011; Kim et al., 2017).

At a population level, musculoskeletal and physical function develop during childhood and adolescence, reach a peak or plateau in early adulthood and then decline with age (Dodds et al., 2014; Ferrucci et al., 2016; Gabel et al., 2018; Nahhas et al., 2010). There is an accelerated decline

in strength and physical function by the end of the seventh decade and in bone mass after menopause (Dodds et al., 2014; Ferrucci et al., 2016; Nahhas et al., 2010). The clinical sequelae (osteoporosis and fracture, sarcopenia, osteoarthritis and falls) all show an increase with age, with the exception of back pain, which may peak in midlife (Hoy et al., 2012). By midlife, osteoarthritis is already a burden, particularly for women (Litwic et al., 2013). With population ageing, numbers affected will inevitably rise, and increasing obesity and sedentary lifestyles from early life will increase numbers further.

Women generally have lower levels of musculoskeletal and physical function and are more at risk of all the common clinical sequelae. The main ethnic differences are in fracture risk, with white Caucasian groups being most at risk compared with black African groups, and Asians having an intermediate risk (Cauley et al., 2014).

### Risk factors and prevention

- **Socioeconomic status:** A lifetime of socioeconomic disadvantage is associated with lower muscle strength and physical function, and their age-related decline (Birnie et al., 2011; Stringhini et al., 2017), and greater functional consequences of fractures (Truong et al., 2018).
- **Lifetime body size:** Greater adiposity is a major determinant of knee and hip osteoarthritis (Blagojevic et al., 2010) and earlier onset of adiposity may increase the risk further (Wills et al., 2012). Greater adiposity is also a risk factor for reduced physical function, particularly when it coexists with sarcopenia or low muscle strength (Hardy et al., 2013). The relationship of adiposity with bone mineral density (BMD) and fracture risk is site-specific (Compston et al., 2014). Poorer prenatal growth (indexed by lower birthweight) is associated with weaker grip throughout life, independent of adult body size (Dodds et al., 2012), and with lower bone size during adulthood (Baird et al., 2011). Puberty is an important period for bone growth and mineral accrual, with 20–30% of an individual's total body bone mineral accrued during the pubertal growth spurt. Later puberty and/or peak height velocity have been associated with lower BMD, osteoporosis and fracture risk (Bonjour & Chevalley, 2014; Day et al., 2015; Kuh & Ben-Shlomo, 2016).
- **Lifetime health behaviours:** Adult physical inactivity and sedentary lifestyles are risk factors for lower levels of BMD (Bolam et al., 2013), muscle strength and physical function (Ferreira et al., 2012b; Shaw et al., 2017). Higher childhood levels of physical activity are formative for later muscle and bone strength (Gordon et al., 2017), and in adult life can play an important role in rehabilitation and recovery of muscle mass. Smoking, high alcohol consumption and a diet lacking in protein, calcium or vitamin D are risk factors for peak bone mass (Gordon et al., 2017) and later bone loss (Al-Bashaireh et al., 2018). Overall, an unhealthy lifestyle is associated with decline in strength (Cooper et al., 2016) and with physical function (Robinson et al., 2013).

- **Health status:** The associations between depressive symptoms and musculoskeletal and physical function from midlife onwards are probably bidirectional (Mezuk et al., 2012; Schweiger et al., 2016). Lower levels of childhood and adult cognition are associated with subsequent lower levels of grip strength and physical function (Clouston et al., 2013; Cooper et al., 2017), indicating that neurodevelopmental and neurodegenerative processes are involved.
- **Cardiovascular disease:** Those with CVDs or high cardiovascular risk scores subsequently have worse physical function (Forman et al., 2017; Hamer et al., 2010; Windham et al., 2017), bone loss and fractures (den Uyl et al., 2011), and more incident falls, hospitalisations with fragility fractures, and osteoarthritis (Melzer et al., 2018). Poor metabolic health affects osteoarthritis by the mechanical burden due to overweight and through independent metabolic mechanisms. Higher levels of inflammation are associated with weaker muscle strength, poorer physical function and faster decline (Anton et al., 2015; Newman et al., 2016). Hormonal dysregulation, particularly of the hypothalamic-pituitary-adrenal and hypothalamic-pituitary-gonadal axes, is an underlying biological mechanism of ageing affecting physical function (Anton et al., 2015), and hormonal changes accompanying the menopause in women increase the loss of BMD and risk of hip fracture (Banks et al., 2009).

In summary, given the evidence, the promotion of musculoskeletal and physical function needs to start early in life (Cooper et al., 2014; Gordon et al., 2017) and continue across life. In the following sections, this report aims to offer public health strategies which seek to optimise peak function by early adulthood, and monitor change and encourage healthy lifestyles and body weight throughout life, with the aim of delaying the onset or progression of functional decline and disorders (Deary et al., 2009). Such strategies will have multifaceted consequences that cut across different domains of age-related pathophysiological changes.

Challenge: Improve physical function, prevent or postpone musculoskeletal disorders	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>For parents and health professionals: Improve health literacy about prenatal and prepubertal growth, later puberty and hormonal dysregulation in children</li> <li>For children: Educate in role of exercise, sports and appropriate nutrition</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>No smoking</li> <li>No or low alcohol intake</li> <li>Physical exercise</li> <li>Healthy diet</li> <li>Regular low-intensity sun exposure</li> </ul>
	<b>Possible targeted prevention</b> <ul style="list-style-type: none"> <li>Medically prescribe physical exercise and high-protein diet</li> <li>Address obesity and sedentary lifestyle</li> <li>Ensure adequate calcium intake and vitamin D supplement if needed</li> <li>Manage cardio-metabolic health and mood</li> <li>Stimulate cognitive activity</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>Everyday technology for mental stimulation</li> <li>Mobile health app to monitor physical function</li> <li>Stimulate adequate and diverse physical activity every day</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>Promote sports and exercise at all ages</li> <li>Provide easy access to sports facilities and green spaces</li> <li>Integrate this policy within health-friendly and ageing-friendly communities</li> </ul>

**Table 6.** Challenge: Improve physical function, prevent or postpone musculoskeletal disorders

### *Cognitive function and dementias*

Dementia is a 21st-century epidemic. The World Alzheimer Report (Alzheimer’s Disease International, 2015) estimates that 131 million people will be living with dementia in the year 2050, up from 47 million in 2015. The increase in life expectancy means that the overall number of people with dementia, and therefore its societal impact, will increase dramatically in the coming decades. Emerging evidence suggests that the age-specific incidence of dementia is declining in high-income countries, thought to be due to better control of cardiovascular risk factors and improved education and living standards (Chene et al., 2015; Langa, 2015; Larson et al., 2013; Matthews et al., 2013). This trend is observed in European studies (Qiu et al., 2013). However, dementia continues to increase in rapidly industrialising countries due to increased cardiovascular risk factors and rates of smoking, obesity, and metabolic diseases (Prince et al., 2016).

Alzheimer’s disease (AD) is the most common cause of dementia, accounting for up to 70% of all dementia cases. The research paradigm that dominates thinking in AD revolves around the

amyloid cascade hypothesis, where the overproduction or poor clearance of amyloid-beta is thought to trigger a cascade of changes that lead to neuronal injury and loss (Glenner & Wong, 1984; Hardy & Selkoe, 2002). Considerable financial and intellectual investment has led to better understanding of the sequence of changes in imaging and cerebrospinal fluid biomarkers (Jack et al., 2013).

However, pharmaceutical interventions to modify the course of disease have met with limited success, and the failure rate of drug trials is greater than for any other chronic disease (Cummings et al., 2014). Several authors have highlighted inconsistencies in the evidence to support the amyloid hypothesis (Morris et al., 2014). Reduced cerebral blood flow, hypoxia, and blood–brain barrier dysfunction may be initiators of neurodegenerative changes independently and/or prior to deposition of amyloid beta (Zlokovic, 2011). Furthermore, the pathophysiological process of AD and related dementias is thought to begin as long as 20 years prior to emergence of clinical symptoms of dementia (Bateman et al., 2012; Jack et al., 2013; Nelson et al., 2009; Sperling et al., 2011; Villemagne et al., 2013), highlighting the importance of a life course approach to dementia and cognitive function.

The life course approach proposes that interactions between genes and environmental factors drive cognitive development to a peak or plateau in early adulthood, and determine the onset and rate of functional decline and in some cases the clinical expression of dementia (see Figure 19) (Whalley et al., 2006). There are age-related changes in cognitive abilities that, while associated with age, are not necessarily markers of an underlying disease process. In general, cognitive abilities show characteristic changes with increasing age, though the trajectories of change differ from person to person (both the timing of change and the extent to which these are experienced) (Hertzog et al., 2008). Those individual differences in cognitive development and in the degree of age-related cognitive decline help to identify the potential risk and protective factors which, when modified, might enhance cognitive reserve and delay the onset and progression of cognitive decline and dementia. A one-year delay in dementia onset is projected to lead to 9.2 million fewer cases worldwide by 2050 (Brookmeyer et al., 2007).

### **Risk factors and prevention**

A range of social, psychological and neurobiological processes and factors shape cognitive maturation and ageing, along with pathogenesis common to many dementia syndromes. The case for understanding cognitive development in childhood is tied to tremendous cognitive plasticity early in life. It is urgent to assess how neurocognitive development in infancy and childhood is impacted by changes in social and family structure, as well as physical, environmental and other psychosocial factors.

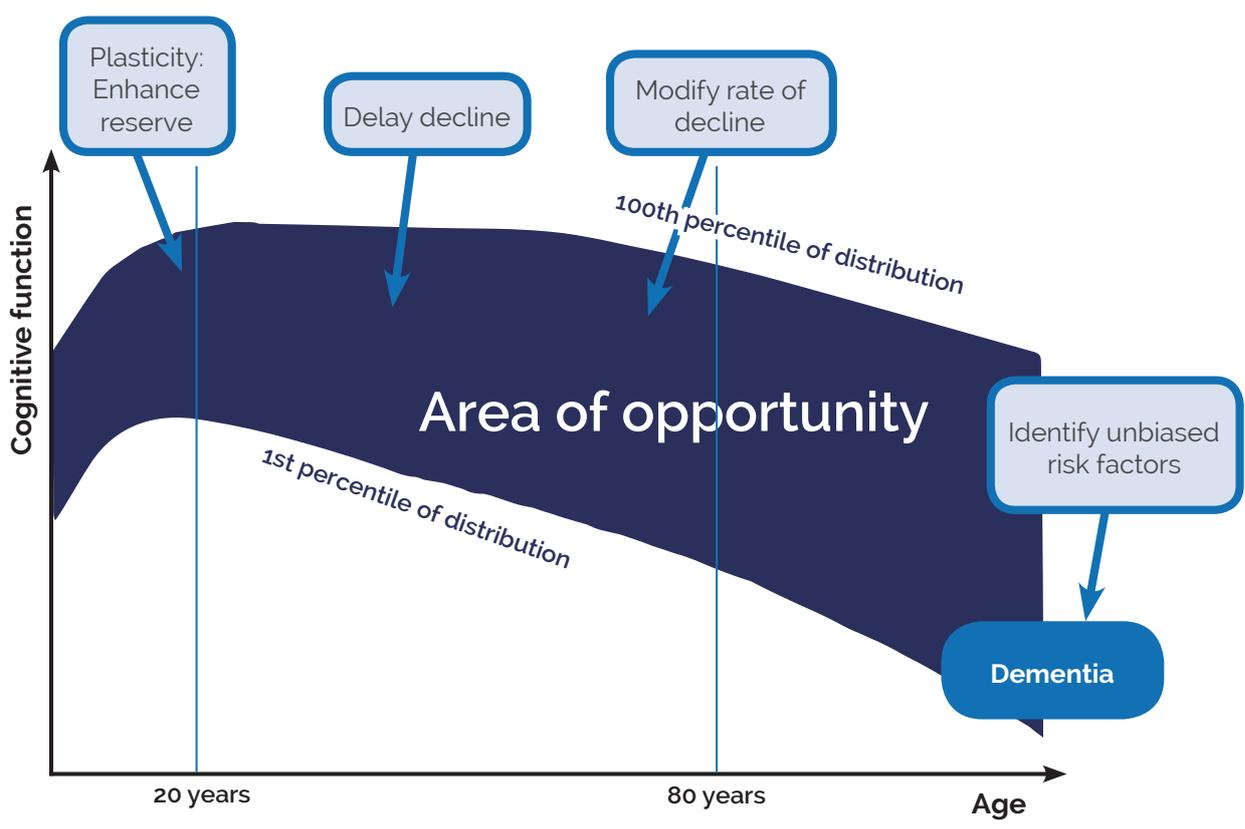


Figure 19. Life course model of cognitive health.

Better cognitive performance in young adulthood has salience for late-life outcomes due to the protective effect of 'reserve' — the capacity to offset the detrimental effect of neuropathology later in life. Recent findings highlight the role of lifestyle factors (Gow & Mortensen, 2016; Gow et al., 2017; Sabia et al., 2014; Sabia et al., 2012), metabolic (Sabia et al., 2014; Singh-Manoux et al., 2012; Tuligenga et al., 2014), cardiovascular (Kaffashian et al., 2013a; Kaffashian et al., 2013b; Kaffashian et al., 2011) and inflammatory (Singh-Manoux et al., 2014) risk factors for cognitive ageing trajectories.

In regard to dementia, a number of factors are often cited as potentially associated with an increased or decreased risk, although there are differences in the approach used. We describe the current evidence, separating out the approach of a priori risk factors from those based on reviews of the literature.

Three major studies in the last decade have identified risk factors for dementia from a literature review, and then used the prevalence of each risk factor and the strength of its association to provide population-based estimates of attributable risk (the a priori approach) (Barnes & Yaffe, 2011; Livingston et al., 2017; Norton et al., 2014). Seven potentially modifiable risk factors — diabetes, midlife hypertension, midlife obesity, insufficient physical activity, depression, smoking, and low educational attainment — may account for about one third of Alzheimer's cases in the US and Europe (Winblad et al., 2016). The same analysis indicated that even a modest 10% reduction in each of these risk factors could reduce the prevalence of Alzheimer's disease in

these regions by about 8% by 2050. The latest study by Livingston et al. (2017) calculated the population-attributable fraction associated with risk factors from across the life course: poor education in early life (before approximately 18 years of age), hypertension, obesity, and hearing loss in midlife (approximately 45–65 years of age), and smoking, depression, physical inactivity, social isolation, and diabetes in later life (after approximately 65 years of age). Their results suggest that around 35% of dementia is attributable to a combination of these nine risk factors:

- Young age (approximately <18 years)
  - Low education in early life
- Midlife (approximately 45–65 years)
  - Hypertension
  - Obesity
  - Hearing loss
- Later life (approximately >65 years)
  - Smoking
  - Depression
  - Physical activity
  - Social isolation
  - Diabetes

There have also been four major reviews of the literature over the last ten years (Baumgart et al., 2015; Kane et al., 2017; National Academies of Sciences, 2017; Winblad et al., 2016). The extensive review by Winblad et al. (2016) reiterated the multifactorial nature of dementia, highlighting the interplay between genetic susceptibility and environmental factors across the lifespan. The authors presented a long list of risk and protective factors but cautioned that the evidence to support the factors listed is variable, and the relevance of several proposed factors is open to debate. The most pronounced risk factors are advancing age and carrying one or two APOE 4 alleles.

The National Institute of Ageing of the US National Institutes of Health (NIH) asked the US National Academies of Sciences, Engineering and Medicine to convene a committee to examine the state of knowledge about what works in preventing or slowing cognitive decline and dementia (Brookmeyer et al., 2007). The goal was to use the recommendations for communicating with the public. The systematic review highlighted significant methodological shortcomings in the evidence. Based on this body of evidence, the committee identified three classes of interventions — cognitive training, blood pressure management for people with hypertension, and increased physical activity — as being supported by modest but inconclusive evidence at present. This strength of evidence did not, in the committee's judgement, warrant

aggressive public health campaigns at the present time. The report also noted that evidence should be strengthened on the following categories of interventions, alone or in combination, for which there is currently insufficient evidence to determine their effectiveness:

- new anti-dementia treatments
- diabetes treatment
- depression treatment
- dietary interventions
- lipid-lowering treatment/statins
- sleep quality interventions
- social engagement interventions
- vitamin B12 plus folic acid supplementation

The review by Kane et al. (2017) assessed evidence for interventions aimed at preventing or delaying the onset of age-related cognitive decline, mild cognitive impairment, or clinical Alzheimer's-type dementia. 263 eligible studies were identified and the authors report finding "no high-strength evidence for the effectiveness of any intervention" to delay or prevent these outcomes. The study reported finding moderate-strength evidence that cognitive training improved performance in the trained cognitive domains, but not in domains not trained. Evidence of an effect on dementia incidence was weak. There was a mix of positive and negative findings for different outcomes, all of low strength, for physical activity, antihypertensives, nonsteroidal anti-inflammatory drugs (NSAIDs), B vitamins, nutraceuticals, and multimodal interventions. Signals seem more promising for physical activity and vitamin B12 plus folic acid. This review also highlighted widespread methodological problems in the available literature.

Challenge: Building reserve, preventing or postponing cognitive decline	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>■ Lifelong education: improving cognitive ability, boosting cognitive performance life</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>■ Physical activity</li> <li>■ Mediterranean diet</li> <li>■ No obesity</li> <li>■ No smoking</li> <li>■ Socially and mentally stimulating activities</li> <li>■ Avoid head trauma</li> <li>■ Light to moderate alcohol consumption</li> </ul>
	<b>Possible targeted prevention</b> <p>Moderate but inconsistent evidence for efficacy of management through:</p> <ul style="list-style-type: none"> <li>■ Cognitive training</li> <li>■ Targeting and controlling cardio-metabolic risk factors</li> <li>■ Increasing physical exercise</li> </ul> <p>Insufficient evidence for effects of:</p> <ul style="list-style-type: none"> <li>■ New statin treatments (anti-dementia, anti-diabetes, anti-depression, lipid-lowering)</li> <li>■ Interventions related to diet, sleep quality, social engagement</li> <li>■ Vitamin B12 and folic acid supplementation</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>■ Mobile health app to detect cognitive decline and ease early diagnosis</li> <li>■ Biomarkers or companion diagnosis</li> <li>■ Precision medicine?</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>■ Reduce loneliness and combat ageism</li> <li>■ Favour social integration</li> <li>■ Promote age-friendly communities and stimulating leisure activities</li> <li>■ Enhance research activities on brain health</li> </ul>

**Table 7.** Challenge: Building reserve, preventing or postponing cognitive decline.

In assessing the evidence, however, others have noted that the evidence for some factors is now sufficiently strong to justify action (Baumgart et al., 2015). For example, Kannel et al. (1976) summarised the risk and protective factors as having strong, moderate, lower or unclear evidence for dementia and for cognitive decline. In terms of increased risk of dementia, they concluded that the strongest evidence was available for traumatic brain injury, with moderate evidence for obesity and hypertension in midlife, smoking and diabetes as risk factors, while years of education appeared to lower risk (strong evidence) with the benefit of physical activity being moderately supported. In terms of cognitive decline, they suggested that there was strong evidence for traumatic brain injury, obesity and hypertension in midlife, smoking and diabetes as risk factors, while years of education and physical activity were protective (Kannel et al., 1976).

There are key gaps in understanding the role of risk factors for cognitive decline and dementia and for many other aspects of functional decline and age-related diseases. First, much of the

evidence on risk factors for dementia comes from studies on adults aged 65+ at recruitment, and uses one-off measures of risk factors with subsequent tracking of dementia. When risk factors are assessed once in older cohorts and the follow-up is short, the estimates necessarily include the effects of reverse causation, i.e. the effect of preclinical dementia on risk factors. Lack of consideration for the long preclinical phase of Alzheimer's disease is the primary explanation for inconsistency in findings. Issues of reverse causation are also relevant to cognitive decline not associated with dementia. Second, while there is considerable consensus on the importance of midlife cardio-metabolic factors, they have not been examined systematically, particularly in relation to age of exposure, threshold levels, and changes over time. 'Midlife' remains poorly characterised in studies, and few have undertaken research on critical time windows for exposures (midlife vs. late-life). The exceptions are recent findings on obesity and hypertension that suggest that exposure at age 50 but not at age 70 increases risk for dementia. In addition, many cardio-metabolic factors may carry risk for dementia below the threshold established for cardiovascular disease; thus, thresholds established for cardiovascular disease may not transpose directly to cognitive dysfunction.

In summary, the consistently explored risk factors for dementia include diabetes, hypertension, obesity, smoking, and low educational level. Taken together, these analyses suggest that such factors might account for about one third of dementia incidence, and therefore that these factors should be among the targets for intervention as they also drive CVD and CKD; these are considered further in following sections.

### ***Psychological function and mental disorders***

Mental disorders are one of the most important public health challenges in the European region, whether measured by prevalence, burden of disease or disability (WHO, 2015a). One of the most common mental disorders is depression, which has a lifetime prevalence of 9% among European adult men and 17% among European adult women (WHO, 2016d). The economic costs associated with depression amounted to €136.3 billion in the European Economic Area in 2007, €99.3 billion from reduced productivity and €37 billion from health care costs (McDaid & Park, 2011).

A survey of fourteen European centres using the EURO-D depression scale in 21,724 subjects aged 65 years or more found consistent differences in prevalence across centres that could not be explained by demographic differences; consistently higher rates were found with increasing age, female gender and by widowhood and separation (Prince et al., 1999). A further study of the prevalence of depressive symptoms and syndromes in 10 centres in the SHARE study found higher rates in the Latin ethno-lingual group of countries, especially symptoms related to motivation. They also found that women scored higher on affective suffering and older people and those with impaired verbal fluency scored higher on motivation (Castro-Costa et al., 2007).

Common mental disorders (CMDs), largely anxiety and depressive disorders, are associated with age. In the UK, the Adult Psychiatric Morbidity Survey (McManus et al., 2016) showed that working-age people were twice as likely to have CMDs as those aged 65 and over. Between 16 and 64, the proportion remained around 17%–18%, but among those aged 65 and over the rate was much lower (10.2% of 65 to 74-year-olds and 8.1% of those aged 75 and over). Both men and women experienced a tailing off of CMDs in later life. This pattern was similar, although even more pronounced, in rates of severe symptoms.

Since the previous APMS in 2007 (NHS Digital, 2009), there were increases in CMDs in late midlife men and women (aged 55 to 64). This continued an upward trend observed in midlife women since 1993, whereas the longer-term trend in men was less clear. Those in late life have also seen a steep increase in rates of reported lifetime self-harm. Men in this age group have the highest rates of registered suicide and have been identified as a priority group in England's National Suicide Prevention Strategy. There have also been increases in rates of severe CMDs in women aged 55 to 64 (from 5.5% to 9.3%), and for men aged 55 to 64 (from 5.7% to 9.1%) (McManus et al., 2016). Overall, and for men, the recent change in rates of severe CMDs between 2007 and 2014 in 55–64-year-olds was statistically significant. This increase may relate to people of this age being particularly vulnerable at time of economic recession (Frasquilho et al., 2016). One interpretation of this may be that the recession, which began in 2008, has had more of an impact on the mental health of adults approaching retirement than of those who had already reached retirement age.

Among older adults, disability has been associated with increased risk of depression (Prince et al., 1997b). In a recent study, once disability had been taken into account, somatic disease did not contribute independently to variance in depression (Verhaak et al., 2014). The association was stronger for those aged 60–69 years than for those older than 70 years. In particular, disability in participation, self-care and social activities contributed to increased risk of depression. It is also possible that the causal association may work in the opposite direction: depression may contribute to a deterioration in physical capacity, an inverse association has been found in NHANES between depression and hand grip strength (Brooks et al., 2018). Poor self-rated health and depression have been found to be the strongest predictors of needing assistance in one or more activities of daily living in a Norwegian cohort study (Storeng et al., 2018). There is a robust prospective relationship between depression and incident frailty; frailty and depression can be difficult to separate in advanced old age (Vaughan et al., 2015).

### **Risk factors and prevention**

Social disadvantage in childhood is associated with a higher risk of major depression in adulthood adjusting for childhood sociodemographic factors, family history of mental illness and adult social position (Gilman et al., 2002). Exposure to adversity in childhood, especially physical and sexual abuse, is a predictor of both depressive and anxiety disorders in young adulthood and

mid-life (Clark et al., 2010); part of this may be mediated through changes in HPA axis function. Deficits in social support and life events, especially involving personal illness, bereavement and theft have been associated with an increased risk of depression in older adults; loneliness was also strongly related to depression in the older people in a London-based community sample (Prince et al., 1997a). Perceived social isolation and loneliness are major risk factors for mental illness in later life (Ong et al., 2016). High levels of support from spouses, and better social network integration in men and support from friends and children in both sexes was protective against depression in prospective analyses from the TILDA Study (Santini et al., 2016). A high level of social strain from children was a risk factor for depression in women. Loneliness mediated these associations. Interventions based on attachment theory can be used to combat loneliness and improve self-esteem, coping and problem-solving abilities (Loboprabhu & Molinari, 2012). Elder abuse has been reduced in a randomised controlled trial by an educational intervention mediated through increased social support, self-efficacy and health promoting behaviours (Estebansari et al., 2018). Support for carers of the elderly who suffer high levels of stress and depression resulting from the burden of caring, may also help to sustain caring for longer.

Work is generally beneficial for health, and retirement or premature exit from the workforce may reduce sources of social support as well as the financial benefits of working, which may influence psychological health in older adults. Psychological ill-health in childhood and adulthood predicts earlier exit from the workforce (Clark et al., 2017), and reduced physical and cognitive capability in midlife may reduce the likelihood of having bridge employment following retirement, which may cushion the impact of retirement and provide benefits to psychological health (Stafford et al., 2017). In the same way, volunteering after retirement may have beneficial effects on psychological health in older people (Tabassum et al., 2016). Thus, extending working lives, if the working conditions are good, may help to prevent depression in older people.

Physical activity has been shown to protect against the emergence of depression in both older and younger people in a review of 49 prospective studies (Schuch et al., 2018). Moreover, physical activity may also prevent depression in people with chronic disease (Seo & Chao, 2018). Alcohol and drug misuse are health problems currently in older adults (Wang & Andrade, 2013). Alcohol use disorders in older adults are risk factors for dementia and depression; prevention of drinking relapse is often more successful in older than younger patients (Caputo et al., 2012). Insomnia is a risk factor for depression in the old adults and interventions to improve sleep could have a positive effect on mental health (Gooneratne & Vitiello, 2014).

Challenge: Preventing or postponing mental disorders	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>■ Fight all forms of discrimination</li> <li>■ Learn and respect human rights</li> <li>■ Promote resilience and mental fitness at school and in the workplace</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>■ Continued physical activity</li> <li>■ Build social networks</li> <li>■ Work and late retirement are beneficial if working conditions are good</li> <li>■ Volunteer engagement in various social activities</li> </ul>
	<b>Possible targeted prevention</b> <ul style="list-style-type: none"> <li>■ Strong support of family and friends</li> <li>■ Improve self-esteem</li> <li>■ Improve quality of sleep</li> <li>■ Fight against drinking relapse</li> <li>■ Competitive memory training</li> <li>■ Reminiscence group meetings</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>■ Support self-help with interactive and engaging programs over the internet or on mobile devices: scalability, low cost, privacy, less stigma, ease of use</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>■ Enhance working conditions</li> <li>■ Fight inequality</li> <li>■ Universal prevention programme for avoiding isolation and loneliness</li> <li>■ Accessible and affordable community mental health services</li> <li>■ Support carers of older adults (who can suffer high stress levels and depression from the care burden)</li> </ul>

**Table 8.** Challenge: preventing or postponing mental disorders

A systematic review of different non-pharmacological interventions for depression in older people found that cognitive behaviour therapy, competitive memory training, reminiscence group therapy, problem-adaptation therapy, and problem-solving therapy were all effective in reducing depressive symptoms (Apostolo et al., 2015). Prevention of suicide in older adults is largely focused on identifying and treating depression and decreasing social isolation (Lapierre et al., 2011). Further strategies might include engaging family and community, keeping in touch with isolated adults by telephone or other communication devices, restricting means for suicide, and educating physicians about suicide risk in older adults.

There is a need for more studies linking early and midlife risk and protective factors to psychological health in old age, and more intervention studies that focus on both the psychosocial and clinical aspects of depression simultaneously. There is also a need for studies with an emphasis on understanding the mechanisms of how psychosocial and behavioural risk factors affect health, for example, the effects of loneliness on psychological health (Ong et al., 2016).

In summary, interventions to reduce social isolation and loneliness, increase social support, support carers, extend meaningful work, maintain physical activity, reduce alcohol intake and maintain healthy sleep may all help to prevent psychological disorders in older people.

### ***Sensory function and associated diseases***

Vision, hearing and balance play major roles in our daily life. With age, these sensory systems tend to lose function, not only because of the biology of ageing but also through independent mechanisms unique to each of them (Gadkaree et al., 2016). In other words, sensory decline is an inevitable physiological process that is aggravated by some specific aetiological factors. The impact of such declines is of utmost importance for individuals and societies due to their physical, cognitive and socioeconomic consequences.

#### **Vision**

There is rapid eye growth before the age of two years and, by ten years, axial growth of the eye has reached almost adult size (Williams et al., 2018). Myopia is the most common eye disease and is often diagnosed in childhood. The earlier onset of myopia is associated with greater severity and increased complications in adult life (Williams et al., 2018). The prevalence of mild or moderate myopia has increased across Western and Northern Europe in successive birth cohorts, and is one of the few health challenges that are more likely to affect those with higher educational and occupational levels (Williams et al., 2015). This increased prevalence will result in more visual impairment in middle-aged and older adults, with economic, social and health care consequences.

Starting around the fourth decade, structural changes affect the retina and peripheral nerve fibers: loss of cones and rods, reduction of pupil diameter, senile myosis, slowing of the pupillary reflex, yellowing of the crystalline lens, etc. These alterations impair several system functions, including field of view, acuity, colour discrimination, contrast sensitivity at high spatial frequencies, depth and motion perception, and visual processing speed. The main causes of moderate or severe vision impairment in European adults aged 50 years or older are uncorrected refractive error (just under 50%) followed by cataracts, age-related macular degeneration and glaucoma (Flaxman et al., 2017).

Impaired accommodation is the most sensitive and earliest index of age-related vision impairment. This has a significant impact on daily living, including mobility-based activities and quality of life (Peres et al., 2017; Crews et al., 2017). A large body of evidence suggests that diminished visual information, whatever its cause, is associated with increased risk of falls, depression and anxiety (Heesterbeek et al., 2017; Kempen et al., 2014), and may affect vision-dependent cognitive outcomes (Clemons et al., 2006). Some studies (Albers et al., 2015; Rizzo et al., 2000) suggested that individuals with advanced age-related macular degeneration have a

greater two-year risk of developing Alzheimer's disease than those with better vision. Conversely, deficits in visual cognition in Alzheimer's patients have been widely reported. Finally, some studies have shown that visual stimulus enhancement has a positive impact on many aspects of the functional impairments experienced by patients with Alzheimer's disease (Cronin-Golomb et al., 2007).

### **Risk factors and prevention**

The increase in myopia prevalence has encouraged research into the factors that could reduce its development and progression during childhood (Rahi et al., 2011; Williams et al., 2018). Early-life factors associated with myopia risk, assessed in adult life (Rahi et al., 2011) include higher maternal education, paternal social class, lower birth weight adjusted for gestational age, maternal smoking in early pregnancy, higher cognitive ability, more near-work activities, playing less sport, greater height and lower body mass index in childhood. A recent study of twins assessed in adolescence replicated some of these associations, and additionally found that early schooling and playing computer games were associated with excess risk, while parental fertility treatment was associated with lower risk (Williams et al., 2018). The authors of both studies concluded that early-life factors influence ocular growth trajectories, and further studies are warranted. A third study found that reported exposure to childhood febrile illnesses was also associated with myopia but the scientific reasons for this were unclear (Guggenheim & Williams, 2016).

Four main pathologies have particularly significant impact on decreased vision, even by midlife, and require treatment: chronic glaucoma, retinopathy, cataract, and age-related macular degeneration. The main protective factor is a systematic midlife ophthalmologic examination that could detect these four eye diseases, acquired or genetic with late revelation, liable to exacerbate the adverse effects of ageing. This is further considered in the following sections.

Challenge: Preventing or postponing sensory impairments		
Cross-sectoral actions	<b>Education</b>	<ul style="list-style-type: none"> <li>Educate on consequences of unprotected sun exposure</li> <li>Educate on consequences of hearing trauma from daily acoustic exposure (headphones, earphones)</li> <li>Educate on consequences of sedentary behaviour</li> </ul>
	<b>Individual behaviour</b>	<ul style="list-style-type: none"> <li>Vision: No UV exposure, avoid progressive glasses and lenses</li> <li>Hearing: Avoid hearing trauma, use hearing protection</li> <li>Balance: Physical activity, structurally safe surroundings</li> </ul>
	<b>Possible targeted prevention</b>	<ul style="list-style-type: none"> <li>Treat and control general diseases such as cardio-metabolic conditions</li> <li>Vision: Midlife assessment (fundus and visual field)</li> <li>Hearing: Midlife audiology evaluation, no ototoxic drug use, early use of hearing aids</li> <li>Balance: Midlife tests (up and go; unipodal stance); comprehensive assessment after fall; family and environment counselling</li> </ul>
	<b>Technology</b>	<ul style="list-style-type: none"> <li>Vision: artificial retina, bionic eye</li> <li>Hearing: hearing aid technology is constantly improving</li> <li>Balance: wearable sensors to control balance and prevent falls</li> </ul>
	<b>Society</b>	<ul style="list-style-type: none"> <li>Campaigns to stress the importance of lifelong protection of sensory ability (loss of sensory ability is a major cause of age-related disability, loneliness and poor wellbeing)</li> </ul>

**Table 9.** Challenge: Preventing or postponing sensory impairments

Alongside these specific ophthalmologic pathologies, each requiring specific treatment, preventive measures should address the general and environmental risk factors of visual impairment (Arné et al., 2013). From midlife, disadvantaged social position was strongly associated with poorer visual function in the UK Biobank study (Cumberland & Rahi, 2016). High blood pressure, diabetes, sedentary lifestyle and obesity aggravate the process of ageing and increase the risk of eye stroke. Diabetic status is a strong risk factor for retinopathy since it develops in nearly all individuals who have type I diabetes with more than 15 years' progression, and in 50–80% of type II diabetic patients after 20 years (Klein et al., 1984; Stéphan et al., 2014; Toth et al., 2017). Prolonged excessive use of psychotropic drugs or antidepressants also aggravates ageing processes and is a leading cause of dry eye. Alcohol abuse and smoking are known to induce optic neuropathy. Ultraviolet radiation exposure leads to phototoxicity (Arné et al., 2013). Oxidative stress has been implicated in the development of cataracts but there is no evidence from randomised controlled trials that beta-carotene, vitamin C or vitamin E prevent or slow down the progression of age-related cataract (Mathew et al., 2012). For some pathologies, such as age-related macular degeneration, there are genetic as well as environmental origins (Lechanteur et al., 2015).

## Hearing

Hearing loss in children is relatively uncommon, and only about 4% of those with hearing loss (in the US) are under 18 years old (Russ et al., 2018). However, detecting impairment early may reduce future cognitive deficits (Kennedy et al., 2015). The cumulative prevalence of hearing loss rises sharply with age. Age-related hearing loss, known as presbycusis, has high prevalence, doubling with each successive age decade, with onset beginning around the 40s or 50s and affecting over two-thirds of adults aged over 70 years. It is the third most prevalent chronic medical condition after osteoarthritis and hypertension, and has major, although underestimated, socioeconomic and medical implications as it increases the risk of physical and cognitive decline as well as affecting working ability (Lin et al., 2013; Bozic et al., 2017). The lack of European studies of hearing loss at different ages is a knowledge gap (Roth et al., 2011).

Clinically, the most common and earliest complaint in age-related hearing loss is difficulty in understanding speech, especially in the presence of background noise (the 'cocktail party effect'). This symptom is due to poor frequency resolution of sounds by an impaired cochlea, and to higher-level cognitive factors. Impaired communication leads to socio-familial isolation, withdrawal, depression (Pronk et al., 2011; Gates et al., 2002). A major issue in this regard is that hearing loss in older adults may incur a long-term risk of dementia (Gates et al., 2002; Dartigues & Feart, 2011; Ray et al., 2018), with a shared neuropathologic aetiology including synaptic alterations in central pathways, deficits in central auditory processing that in turn affect executive functions, and auditory difficulties requiring greater cognitive resources to process auditory perception, to the detriment of other cognitive processes such as working memory. Conversely, recent studies have suggested that patients with normal cognitive function carrying the APOE4 allele, the most robust genetic risk allele for Alzheimer's disease, show significantly more severe presbycusis than non-carriers (Albers et al., 2015). A convincing argument for a relationship between presbycusis and dementia was provided by a recent study suggesting that early rehabilitation by hearing aids postpones onset of dementia; this finding awaits replication (Amieva et al., 2015).

### Risk factors and prevention

As in other sensory systems, presbycusis involves both intrinsic and extrinsic factors (Gates & Mills, 2005; Schuknecht, 1974). Intrinsic factors include structural and genetic components. Structurally, inner and outer hair cells are post-mitotic cells unable to multiply and any loss, whatever its cause, is irreversible, leaving a "dead zone" in the organ of Corti. From a genetic perspective, three genes are considered as susceptibility genes for presbycusis, suggesting that systematic genetic screening could provide an epidemiologic picture and lead to preventive measures (Ibrahim et al., 2018; Vozzi et al., 2014; Plevova et al., 2017).

Extrinsic factors comprise two main aetiologies. First, drugs may cause hearing loss, disequilibrium or tinnitus (Hawkins, 1973). Their action mechanism is not fully elucidated, but at least partly involves individual genetic susceptibility. Second, chronic acoustic trauma is a well-recognised factor of early hearing loss. It is well established that individuals in occupations with work-related noise exposure (such as artillerymen, musicians, road workers and DJs) or who take part in certain leisure activities (such as hunting, clay-pigeon shooting, concert-going) have a greater risk of hearing loss (Honeth et al., 2015; Medina-Garin et al., 2016; Money et al., 2011; Schink et al., 2014). It is impossible to overstate the dangers of the prolonged or too loud daily acoustic exposure suffered (or actively sought) by adolescents and young adults from their frequent use of headphones and earphones. Exposure to higher noise levels means that people now lose their hearing earlier in life than in the past (WHO, 2013). Beyond prolonged or excessive noise exposure, childhood risk factors for hearing loss include exposure to viral or bacterial infections during pregnancy and birth delivery (e.g. rubella) or childhood (such as measles, mumps and meningitis and chronic otitis media) (WHO, 2013). A life course approach to hearing health is now being actively promoted (Davis et al., 2016).

Medical factors, such as diabetes mellitus (Martikainen et al., 2013), atherosclerosis and viral infection may have exacerbating effects. Whatever the factors involved, the final result is intracellular accumulation of free radicals, a well-known cause of (sensory) cell death.

Midlife prevention of age-related hearing decline is founded on careful protection of a limited auditory cell stock that is sadly sensitive to environmental aggression. It is mainly based on the management of the above extrinsic factors. This is considered further in the following sections.

### **Balance ability**

Balance disorder is becoming a major issue in developed countries (Barin & Dodson, 2011; Salzman, 2010; Tran Ba Huy, 2011; Harun et al., 2015), firstly because prevalence increases steadily with age, affecting a quarter to a third of the population older than 65 years and about half of those older than 85. Secondly, over and above the everyday nuisance, it is a major risk factor for iterative falls, with their devastating physical and financial consequences: 30% of adults older than 65 years fall at least once a year, and about 50% fall again, leading to hospital admission, restricted mobility, loss of independence and a financial burden averaging \$20 billion per year in the US. During midlife, there is a sharp increase in the prevalence of falls, based on evidence from British, Irish, Dutch and Australian cohort studies. The prevalence of falls over the preceding year increased from 8.7% in 40–44-year-olds to 29.9% in 60–64-year-olds in women, and from 14.7% in 45 to 49 year olds to 15.7% in 60–64-year-olds in men (Peeters et al., 2018). Midlife may be a sensitive life stage for preventive interventions.

Balance in humans involves a complex system including three peripheral sensory systems (vestibular, visual and proprioceptive), and central structures integrating peripheral sensory input

and transmitting appropriate commands to a select group of skeletal, oculomotor and somatic muscles. The outcome of this system should be an automatic, unconscious and instantaneous corporal response to spatial modifications accompanying movement, i.e., to stabilise posture and gaze.

With age, the whole balance system undergoes degenerative changes (Rosenhall & Rubin, 1975). In the vestibule, loss of hair cells, disintegration of otoconia, decrease in the number of primary vestibular neurons and shrinkage of vestibular nuclei have been extensively documented and attributed partly to microvascular changes. At the same time, the decline of visual performance described above limits visual preponderance, which increases with age, older adults increasingly relying on the visual system to stabilise their posture. Similarly, ageing of the muscles, joints and tendons impairs proprioceptive system performance. In addition, reduction in strength and contraction speed, along with fatigability of skeletal, somatic and oculomotor muscles, delays the reaction to postural disturbance. At the same time, the central structures (cerebellum, brainstem and cortical structures), which integrate and stratify all these peripheral sensory inputs, show progressive and irreversible changes, including demyelination and neuronal degeneration (Barin & Dodson, 2011; Salzman, 2010).

Age-related dizziness (also known as presbystasis) induces a variety of symptoms and signs. Firstly, difficulty walking, slower gait speed and shorter step length are universally reported by older individuals subject to dizziness. Secondly, constant fear of falling, anxiety, feeling unsafe and lightheadedness constitute a heavy emotional burden that comes with vestibular loss, restricting daily activities and causing social isolation. Thirdly, emerging literature suggests that difficulties in concentration and memory, leading to cognitive impairment, are associated with loss of balance (Barin & Dodson, 2011; Salzman, 2010; Tran Ba Huy, 2011; Harun et al., 2015).

### **Risk factors and prevention**

Peripheral vestibular disorders, including benign peripheral paroxysmal vertigo, Menière's disease, vestibular neuritis, ototoxic insult or any type of otologic pathology, may aggravate or decompensate a precarious and ageing balance system (Strupp & Brandt, 2013). Overweight, diabetes, atherosclerosis, cardiovascular diseases, osteoporosis, recent anaesthesia or confinement to bed may affect balance, from which older adults do not readily recover. The effects of sedatives, antidepressants, hypnotics, diuretics and anti-hypertensives can cumulate and directly impair residual physical capacity including balance; such iatrogenic effects are too often overlooked yet all too frequent.

Immediate environmental hazards that contribute to disorientation and increase the risk of falling are irregular flooring at home (rugs and carpets, steps, paving), insufficient lighting, and unsuitable footwear (such as high heels, foam soles absorbing proprioceptive sensation). More broadly, familial and social isolation can influence the risk of losing balance ability and

falls. These risks are also higher in those who have depressive symptoms (Anstey et al., 2008) and poorer cognitive function (Blodgett et al., 2018; Kuh et al., 2009; Tabbarah et al., 2002) and socioeconomic conditions throughout life (Syddall et al., 2009) (Birnie et al., 2011). Physical exercise, particularly structured exercise or strength training, has been associated with better balance ability and reduced falls risk in a number of RCTs (see for example (Okubo et al., 2017). Cognitive interventions also improve components of balance (Li et al., 2010), as does interactive dual training, which targets both cognitive and physical processes (Fraser et al., 2016; Schoene et al., 2015).

Prevention strategies of balance disorder and of its dramatic consequence, falls, have become a timely consideration in today's health care landscape (Khanuja et al., 2018). It includes analysis of the patient's environment and lifestyle, and thorough multidisciplinary screening for risk factors that worsen the deleterious side-effects of ageing (Barin & Dodson, 2011; Tran Ba Huy, 2011; Harun et al., 2015).

A physical examination to investigate the various systems involved in the maintenance of balance should include otoneurologic, ophthalmologic, neurologic and orthopaedic examinations and a general check-up; and a geriatric assessment after a first fall. These are considered in the following sections.

### ***Immune function, immunosenescence and infectious diseases***

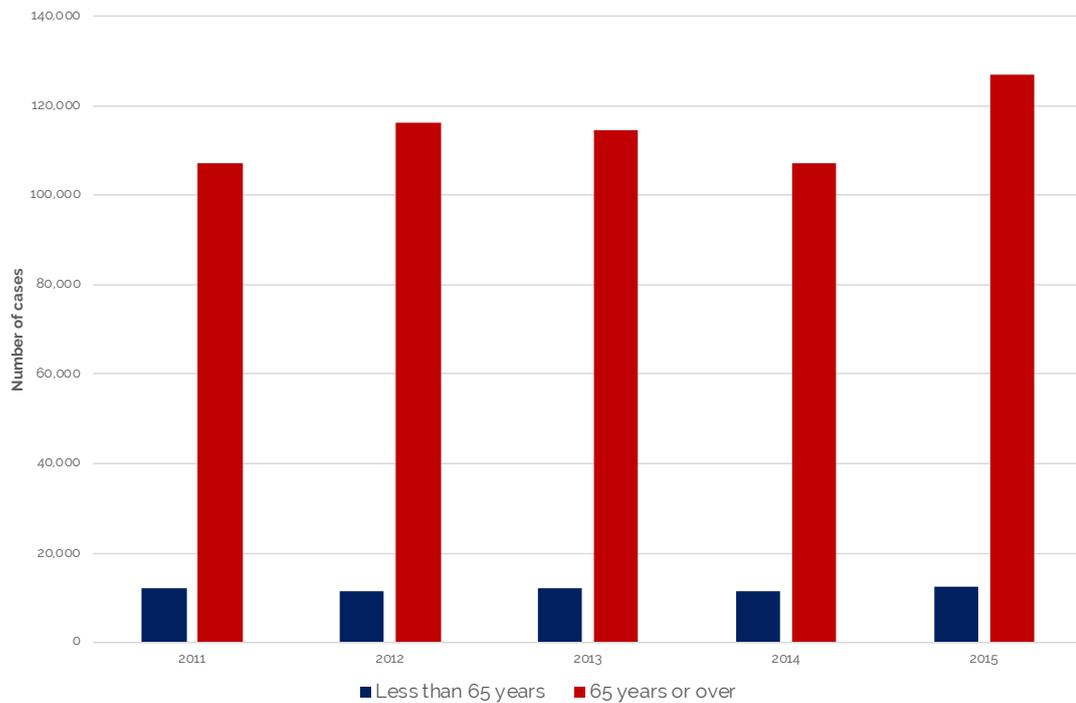
The immune system of the newborn is immature and protection against infections is provided by antibodies in the mother's milk, hence the importance of breastfeeding. The ability of the immune system to recognise, resist and remember specific pathogen exposure develops rapidly and is essentially complete by puberty. The adult therefore relies to a great extent on immune memory of common pathogens (or nowadays their counterparts in vaccines) encountered during childhood, and retains a set of so-called T cells that have not yet responded to an infectious agent (these are known as "naïve"). Naïve T cells are produced in the bone marrow, but require 'processing' in the thymus to achieve maturity. The thymus gland is very active in infancy and childhood, but almost absent in adulthood, so the production of naïve T cells is minimal in later life and absent in most people at old age. Adaptive immune memory acquired in early life is potentially maintained for a lifetime; however, the increase in life expectancy means that immune memory deterioration may make older adults more susceptible to pathogens that they have previously experienced as well as more susceptible to those that are new.

Current research is focusing on ways of dealing with the biological limitations of waning immune memory; the dysregulated interactions of components of the immune system with each other and with different organ systems in older individuals; and ensuring that new exposures can be combatted by the remaining naïve cells in older adults. There is little evidence that any of these phenomena are markedly different in different ethnic groups or among sexes, and therefore

interventions would be expected to be homogeneous across these groups. However, there is a great deal of inter-individual variation even within closely similar populations that will require personalised interventions. Some of this variation could be due to differences in gut microbiota, which are strongly influenced by ageing and diet.

Thus, infectious diseases in older adults are both more frequent and more severe than in younger adults, and older adults are more likely to respond poorly both to newly-encountered antigens and antigens re-encountered either as vaccines or live pathogens. Improved understanding of the mechanisms responsible for decreased immune competence is urgently required to reconstitute appropriate protective immunity. Older adults are particularly susceptible to newly-emerging or newly-encountered pathogens, and persistent herpes viruses such as Varicella Zoster (VZV) and Cytomegalovirus (CMV) also reactivate more frequently than in the young. These observations suggest some degree of immune compromise, which may be reflected in the distribution of immune cells and antibodies in the peripheral blood. There is a great deal of heterogeneity in disease susceptibility and response to vaccination in humans, and therefore it is essential to establish sets of immune biomarkers that reflect immune competence of the individual in this context. The use of such "immune signatures" to predict responsiveness to vaccination and susceptibility to infectious disease would allow better selection of prophylaxis and treatment options in older adults. Also, novel compounds are being developed to enhance the response of older adults to treatment (Mannick et al., 2014). Limited longitudinal studies of free-living human populations suggest that it is possible to establish individual immune signatures with predictive power for frailty and mortality. The definition of these biomarkers and their clinical correlates requires further research, preferably in longitudinal intervention studies to allow biomarkers to be aligned with clinical outcomes (Bertram et al., 2014). Immune signatures may differ according to birth cohort and country, creating a challenge for assessing immune ageing trajectories and their impact on morbidity and mortality (Pawelec, 2019).

Acute infections clearly also remain problematic in older people, especially viruses like influenza and pneumococcal pneumonia. Both are major public health problems (see Figure 20 and Figure 21). Influenza vaccine responses are poor, and older adults respond less well than younger adults to seasonal influenza vaccination; existing infections such as CMV may exacerbate the poor response. Despite respiratory disease caused by *Streptococcus pneumoniae* (*S. pneumoniae*) resulting in much morbidity and mortality, pneumococcal polysaccharide vaccines (PPVs) are less well investigated in the ageing context than influenza and their ability to prevent disease and death in older people is not clear. There is an opportunity to establish predictive immune biomarkers, taking CMV into account from the beginning.



**Figure 20.** Deaths from pneumonia in the EU (Eurostat).

With increasing mobility of ever-older people, responding to travel vaccines against pathogens such as Yellow Fever or West Nile Virus to which the individual has not yet been exposed poses a challenge. This is because these travel vaccines rely on the responsiveness of the very small number of aged naïve B and T cells still present. For example, there is currently some controversy concerning the wisdom of giving older adults the live attenuated Yellow Fever vaccine due to their perceived immune-compromised state. Given the variability between individuals, it would be very valuable also here to establish an immune signature that would be diagnostic for protective response capacity. Another increasingly important challenge is the re-emergence of tuberculosis, especially in poorer and more socioeconomically deprived areas. This is particularly important given the rapid acquisition of resistance to antibiotics, which is clearly a major problem in all areas of infectious disease policy worldwide.

## Prevention

The key factor is the protection afforded by the development of and adherence to vaccination schedules. The use of antibiotics or antiviral agents is less effective and more dangerous. A life course approach to vaccination has been recommended (Michel et al., 2009; Esposito et al., 2016; Centre, 2017). In childhood, parents need to fully take up the available vaccines for infectious agents for their children in order to establish immune memory in a safe and controlled manner. Older adults would benefit from the development of prophylactic vaccines for pathogens for which there is no vaccine yet, and for more effective therapeutic vaccines against agents that the patient is already infected with, especially if they can be tailored to immune signatures.

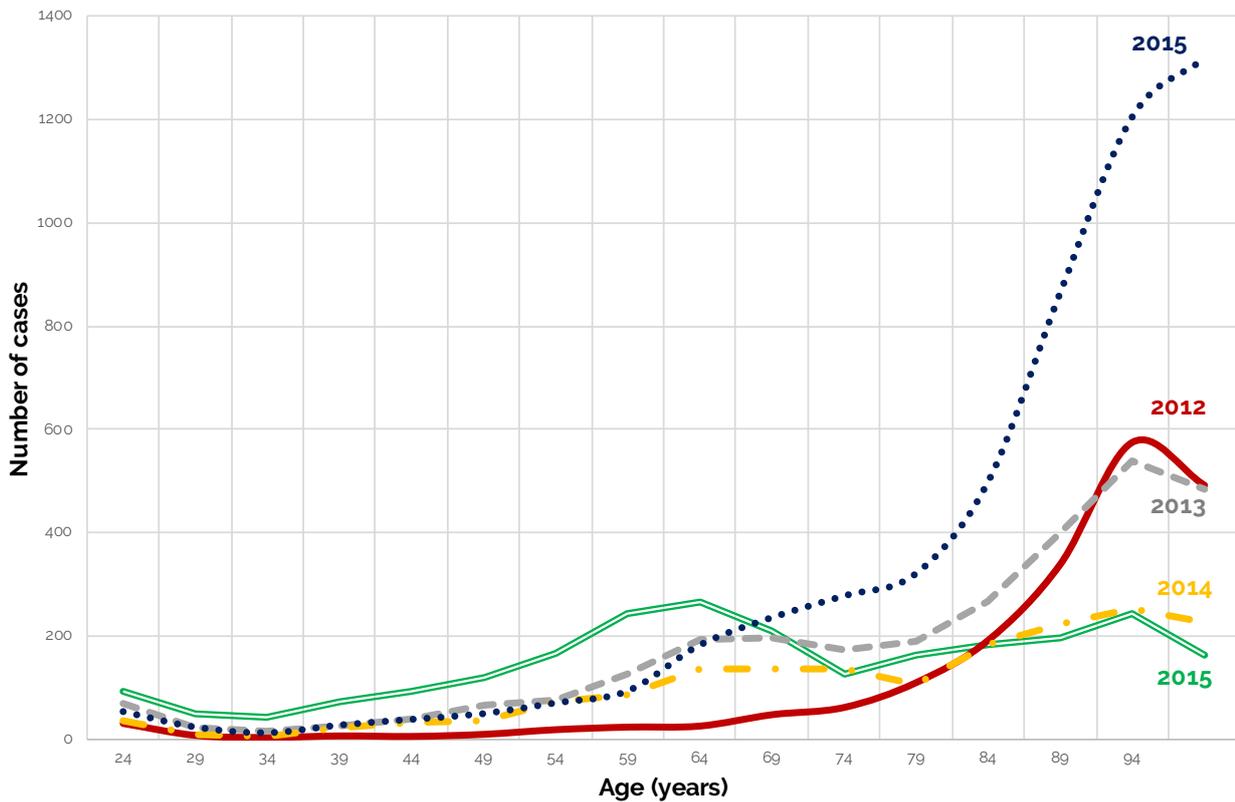


Figure 21. Deaths from influenza (including swine flu) in the EU (Eurostat).

## Cancers

The natural history of cancer is explained by the accumulation of sub-critical events at molecular level, leading to critical mass of mutations (Martincorena & Campbell, 2015). Thus, the increasing rate of cancer according to age is polynomial or exponential. A small shift in the curve, by reducing the rate of acquired mutations, would potentially be an effective preventive strategy, assuming that cancers could be delayed by around 20 years. This could be achieved with intervention on external risks such as lifestyle (Wu et al., 2016).

Data from the WHO mortality database shows that, in the EU, all cancers accounted for 30% of total deaths of men and 23% of total deaths in women at all ages in 2012 (Malvezzi et al., 2018). At 35–64 years, all cancers accounted for 35% of total deaths in men and 51% deaths in women. For men, lung cancer was the most common cancer (11%); for women it was breast cancer (11%) and lung cancer (10%). Between 1970 and 2012, overall cancer mortality rates declined for women and have been declining since 1988 for men. All cancers have shown decreases in mortality rates, albeit in variable amounts and timing, with the exceptions of pancreatic cancer and lung cancer (in women) (Malvezzi et al., 2018). For some cancers, such as stomach cancer and breast cancer, declines were predominantly seen in successive cohorts; declines in other cancers were due to both period and cohort effects, or predominantly to period effects (Malvezzi et al., 2018).

The EU cancer mortality trends contrast with incidence trends that still show increasing incidence rates for certain cancer sites such as thyroid, liver and kidney cancer (Ferlay et al., 2018). There are also strong regional variations in cancer incidence rates; variations are three- to four-fold in men and even greater in women (The Cancer Atlas, 2019; Ferlay et al., 2018). Current incidence and trends over 50 years reflect the different stages of the tobacco smoking epidemic in men and women from different countries. In most European countries, lung cancer rates in men are generally stable or decreasing, while they are still increasing in women. Overall, the number of cases is going up because of population ageing: In 2013, 2.8% of the EU population had cancer, with a slightly higher prevalence for women (2.9%) than for men (2.7%).

This difference in incidence and mortality rates means that more people are surviving cancer, and research is now highlighting the consequences of survival for patient reported outcomes, such as quality of life and the costs of health care (Smith et al., 2016). In Savage et al (2015), the average cost of cancer treatment was £3036 between 1995 and 1999; then at £20,233 between 2005 and 2009; and then at £ 35,383 between 2010 and 2014. The costs are still increasing, leading to the concept of financial toxicity (Zafar, 2016). Finding effective ways to prevent cancers will bring the biggest benefit for individuals and help to stem the rising costs of cancer treatments.

Cure rates vary by cancer site, which has implications for prevention priorities. For example, prevention is particularly important for lung cancers that have a cure rate of only 25%. Other cure rates are much higher — for example, for thyroid cancer it is 90% (De Angelis et al., 2014). Due to the increasing rate of cure (Torre et al., 2015), prevention of a second cancer needs to be considered. Interestingly, there is cross-fertilisation between prevention and care: diet and physical activity used to belong to the preventive field but are now used for increasing therapeutic efficacy (Schmid & Leitzmann, 2014). Conversely, drugs like Tamoxifen used as adjuvant therapy for breast cancer may be used (in the USA at least) for primary prevention (Robidoux et al., 1998).

### **Risk factors and prevention**

Increasing longevity is a major risk factor for cancers and the majority of cancer occurs in older adults (Fitzmaurice et al., 2015). However, cancer in midlife is a common cause of death (see above) and the years of lost life are inevitably higher (Brustugun et al., 2014).

Adult lifestyle makes an important contribution to the development of many cancers (Ferlay et al., 2013; Steliarova-Foucher et al., 2015; Ferlay et al., 2018). For example, the risk of common cancers such as lung cancer and breast cancer are modifiable by changes in lifestyle, with expected reductions of 20% and 80% respectively (Blot & Tarone, 2015). The population attributable fraction for cancers related to three main risk factors tobacco, overweight and

alcohol is close to 20% (30% in men and 10% in women) in an Australian cohort (Arriaga et al., 2017).

Challenge: Preventing or postponing cancer onset	
Cross-sectoral actions	<b>Education</b> <ul style="list-style-type: none"> <li>■ Lifelong health education on genetic background and corresponding susceptibility to toxic exposures, endocrine disruptors and individual behaviours</li> </ul>
	<b>Individual behaviour</b> <ul style="list-style-type: none"> <li>■ Control behavioural and lifestyle factors: obesity, alcohol, tobacco, sedentary lifestyle</li> <li>■ Control environmental risks: radiation, viruses, chemical and toxic agents</li> <li>■ Individual's values, preferences and priorities in life</li> </ul>
	<b>Possible targeted prevention</b> <ul style="list-style-type: none"> <li>■ Risk assessment: risky life conditions, occupation and family history</li> <li>■ Modifiable risk: environment control</li> <li>■ HPV &amp; vaccines to prevent virus-induced cancers</li> <li>■ Use classical anti-cancer medication for pharmaco-prevention</li> <li>■ Systematically genotype tumours (precision medicine)</li> </ul>
	<b>Technology</b> <ul style="list-style-type: none"> <li>■ Prevent some cancers through everyday technology: e.g. fridge use to decrease incidence of gastric cancers</li> <li>■ Mobile health app for primary prevention, currently mainly used in secondary prevention e.g. pulmonary cancer</li> </ul>
	<b>Society</b> <ul style="list-style-type: none"> <li>■ Sustainably control known and emerging risks: toxic particles, gases, viruses</li> <li>■ Monitor health impacts of indoor and outdoor pollution</li> <li>■ Screen for cancers (breast, colorectal, uterine cervix)</li> <li>■ Improve socioeconomic status of at-risk and ill populations</li> </ul>

**Table 10.** Challenge: Preventing or postponing cancer onset

Other, less important risk factors are occupational (for certain cancers, such as mesothelioma caused by asbestos or leukaemia caused by benzene), social and environmental (e.g. radiation and chemical exposures and viruses) (Collaborators, 2017). Absolute or relative constitutional genetic factors appear not to be important in terms of population attributable fraction, because few persons are in the higher risk categories. However, in the future, it is likely that more persons will be identified who have a somewhat increased genetic risk.

It should also be recognised that the risk of some cancers, such as cervical cancer, stomach cancer and breast cancer, are increased by exposures earlier in the life course. Examples include:

- exposure to HPV infection increasing the risk of cervical cancer
- exposure to *Helicobacter pylori* increasing the risk of stomach cancer
- exposure to diethylstilboestrol in utero raising the risk of breast and pancreatic cancers in exposed female offspring (Troisi et al., 2017)

- having breastfed reducing breast cancer risk (Weiss et al., 1997)

Less modifiable are reproductive factors associated with risk of breast cancer, such as early menarche age, null parity, late age at first live birth, a long reproductive interval index, and long contraceptive use duration (Al-Ajmi et al., 2018). It has been estimated that an early first live birth, lower reproductive interval index and increased number of children can contribute to a breast cancer risk reduction of up to 50% (Al-Ajmi et al., 2018); however, this creates an ethical dilemma between the availability of risk reduction (improving health) and individual and societal values.

Overall, cancer prevention in the EU will benefit most from a risk factor-based approach mainly focused on tobacco, weight control, increasing physical activity and reducing alcohol consumption. This is considered further in this report, along with more targeted approaches based on age (e.g. HPV vaccinations before sexual relationships) or for specific groups which are at increased risk genetically, occupationally, or in some other way.

### Policy options



Lifelong self-tracking of health can support citizens' engagement. Health care professionals could analyse the data collected to identify risk factors and symptoms of age-related disease as early as possible. Innovative technologies that capture changes in intrinsic capacities or monitor real-time exposure to risk (such as the level of functioning) may help to motivate individuals and to identify those with accelerated decline at an earlier stage.



The burden on society of the most common age-related diseases is growing due to many factors including demographic change. While specific policy actions are rightly taken on specific diseases, (for example, cancers, cardiovascular disease and diabetes), addressing the commonalities and determinants of all age-related diseases can be effective. This is especially important in terms of identifying and acting on early and midlife risk factors.



There are key knowledge gaps in understanding the role of risk factors for cognitive decline and dementia and for many other aspects of functional decline and age-related diseases.

## 2D. OPPORTUNITIES FOR HEALTHY AGEING: REINFORCING HEALTH PROMOTION AND TARGETED PREVENTIVE STRATEGIES

This section explores health promotion and targeted prevention strategies that the Working Group considers essential in midlife or earlier in the life course to improve the chance of healthy ageing in later life. The short timescale of this report limited comprehensive assessment (e.g. systematic review of intervention studies) of these strategies and so largely reflects assessment based on the experience of the Working Group experts. Health promotion consists of social and environmental interventions, such as health literacy campaigns, with the aim of enabling populations to gain more control over their health and improve it by adopting healthy lifestyle behaviours. Targeted prevention consists of strategies that focus on individuals or groups at highest risk of functional decline and specific age-related diseases (WHO, 2015b). Many of these age-related diseases share biological mechanisms and common risk factors, such as poorer socioeconomic conditions, lower educational level, physical inactivity, smoking, obesity, diabetes, hypertension and depression. Thus, tackling these risk factors may prove to be most efficient. For example, CVD prevention will also benefit cognitive and physical function.

Biological and functional biomarker age scores are increasingly being developed and refined to identify those most at risk because their biological or functional ages are older than their chronological age, and to facilitate targeted prevention. For example, an accelerated biomarker age may identify individuals who are metabolically compromised, or have been adversely affected by aggressive medical treatments, and should help tailor individual care.

The life course approach highlights when health promotion or targeted prevention may be most effective, as different strategies may work best at different life stages. In regard to targeting cardio-vascular health, for example, different phases of life require different strategies (Fuster, 2015). Compliance may be linked to an increasing sense of urgency as people age chronologically, functionally and biologically.

To structure what preventive strategies are best for whom, and when and how to motivate groups of individuals, the 4P framework (Flores et al., 2013) is helpful:

- **Predictive:** Identification of individual risks of developing certain diseases and functional disabilities based on the person's genetic profile and other personal information
- **Preventive:** Methods and treatments to avoid, reduce and monitor the risk of developing certain diseases
- **Personalised:** Clinical interventions based on the unique genetic, medical and environmental characteristics of each patient-citizen, and genomic profile of his or her diseases
- **Participatory:** Citizens are fully engaged in personal health management

Especially in the second half of life, due to the diverse nature of the ageing process, personal profiles (recorded by quantitative biomarkers other than genetics; i.e. the metabolome, gut microbiome, proteome) may have major impact on health, and interact with many smaller genetic influences.

In this section, strategies for health promotion and targeted prevention are grouped under four sub-headings:

- lifelong population-based strategies (population or individual based);
- strategies that encourage a healthy start to life (0–30 years);
- strategies for adults (30–50 years) that maintain capacities, restore function and delay disease onset;
- strategies for mature adults (over 50 years) for restoring capacity and functional ability, slowing the rate of functional decline and delaying disease onset and progression.

We use these broad age ranges with a cautionary note, as chronological age ranges may have little correspondence with biological and functional ageing. As further research refines indicators of biological and functional age, these may be increasingly used to identify the best individual-based approaches to healthy ageing.

### *Lifelong strategies for healthy ageing*

- Enact health and social policies to **combat poverty and social inequalities** at all life stages so that all European citizens have equal opportunities to age healthily. Many of the ageing outcomes are strongly socially patterned, with generally poorer outcomes associated with lower economic status (Centers for Disease Control and Prevention, 2016).
- **Regulate environmental exposures**, including air pollution and endocrine-disrupting chemicals, and work and leisure-related noise pollution.

- Adopt fiscal and regulatory approaches that facilitate **tobacco control and healthy diets** to reduce intake of sugar sweetened drinks and salty manufactured foods. These approaches are among the most effective means to curb the burden of metabolic disorders, cardiovascular diseases and cancers (WHO, 2019).
- Create sustainable health and social care systems for **health promotion, targeted prevention and integrated care** at all life stages. Screening programmes are essential for the early detection of disease, thereby reducing its burden. Targeted programmes for familial, geographic and ethnic risks raise awareness among potential at-risk groups and assist in the primary prevention of disease.
- Promote **lifelong learning and skills development**. Formal education in most countries often ends by the age of 24 years, and may end much sooner. With people living and working longer, investment in lifelong learning and skills development, and work-based educational and training programmes, can extend productive lives (Chen et al., 2018a). Broader engagement of older people in society, both in the workforce and through volunteering, can also be financially advantageous. These measures provide economic benefits directly through labour force participation, but also indirectly by improving health and cognitive function, and facilitate societal cohesion through a shared sense of purpose (Chen et al., 2018a). In a recent multidimensional analysis of countries' adaptation to societal ageing, which included a new Ageing Society Index, the high performance of the United States in the domain of productivity and engagement was considered to reflect the highest labour force participation rates at older ages, high effective retirement age, and high rates of volunteerism. These findings were likely driven by low unemployment rates and the adoption of flexibility in work hours and pension eligibility rules to reduce constraints to continued employment. In contrast, in Europe, 78% of people aged 55 years and above stop working altogether, citing the lack of opportunities for gradual retirement by reducing work hours (Eurobarometer, 2012). This multidimensional Ageing Society Index (Chen et al., 2018a) shows the needed shift from focusing on individuals and their immediate environments to a strategy that ensures that each society is successfully adapting to population ageing. Any 'new' index has to characterise a society as cohesive, with minimal tension and competition between generations and major sex or racial subgroups, productive with opportunities for effective engagement both within and outside the workforce, healthy, equitable, and secure (Macarthur Foundation Research Network on an Ageing Society, 2010). Importantly, all of these domains are mutable with effective public policies. The resulting index, which takes a broad view of ageing, builds on but does not duplicate prior efforts such as the Active Ageing Index (Zaidi et al., 2013).
- Adopt **health promotion and health literacy programmes** for the whole population. These should cover, for example, precise information on the risks of UV exposure for vision and skin health and improve public understanding of the risk and protective factors for chronic diseases such as dementia. Evidence suggests that people can identify a range of risk factors

for chronic diseases, such as dementia (Roberts et al., 2014; Vaportzis & Gow, 2018), but that there may be a disconnect between knowledge and behaviour (Vaportzis & Gow, 2018). As such, recommendations for improving public health education about risk factors may need to be combined with more specific actions at the individual level to support and enable behaviour change.

- Create a **lifelong self-tracking tool** to monitor health and to empower and engage all EU citizens in health management. Health booklets are already used to monitor growth and development in children. This concept should be extended to the whole of life and encompass parameters of adult health. The technology to enable lifelong tracking now appears possible. This proposal is elaborated in Chapter 4, page 190.

### *Strategies that encourage a healthy start to life (approximately 0–30 years)*

These strategies focus on parents, infants, children, adolescents and young adults, covering the period from conception, through growth and development to maturity.

- Improve **preconception care**. Societal advice on and greater provision of preconception care, benefiting young adults and their offspring (Fleming et al., 2018).
- Create programmes for infants, children and adolescents that **promote healthy ageing through education, safe lifestyles and behaviours**, as recommended by the recent WHO report (WHO, 2015b). The optimal period to motivate behaviour in favour of health may be as early as 3–5 years (Fuster, 2015). Good practice models include the Spanish 'Salud Integral' programme, a comprehensive health model for schools (Penalvo et al., 2015).
- Adopt **prenatal and postnatal strategies for optimal growth and development of intrinsic capacity**. This includes strategies to maximise cardio-metabolic, respiratory, musculoskeletal and cognitive potential in early life. For example, the importance of maximising peak bone mass is acknowledged (Gordon et al., 2017) and estimates suggest that 50% of chronic obstructive pulmonary disease is due to poor lung function from early life (Lange et al., 2015).
- **Monitor early development** for identification of children and families at risk of unhealthy ageing. This includes children with particularly low physical, cognitive, sensory and emotional capacities for more targeted approaches. Monitoring by parents and the health care system could benefit from m-health innovations (see Chapter 4, page 190).
- **Establish immune memory** in a safe and controlled environment. There should be a strong focus on maintaining effective immunity via a "life course vaccination programme" (Michel et al., 2017). It is of paramount importance that available vaccines for infectious agents are fully taken up by parents and grandparents; too often they are not completely vaccinated and thus can transmit infectious diseases to their young children (this is the case for pertussis and *Streptococcus pneumoniae*).

- Avoid radiation and **follow the protective regulatory rules** when exposed to radiation (x-ray, gamma ray, radioactivity and natural radiations) and radon gas.

### *Strategies for adults (approximately 30–50 years) that maintain capacities as long as possible after maturity, restore function and delay disease onset*

- **Monitor functional change, sub-clinical disease markers and behavioural risk factors** in individuals. The aim is to detect accelerated age-related decline and the early onset of disease rather than waiting for a critical clinical threshold to be reached. Such monitoring should include a simple examination of balance disorders (where necessary, screening for risk factors and comorbidities and recommending simple daily activities such as one-leg stance to improve balance). Monitoring could take place at the primary care level and be informed by self-managed life course health trackers that would also build scientific knowledge. Innovative technologies that capture changes in intrinsic capacities or monitor real-time exposure to risk (such as the level of physical activity) may help to motivate individuals and to identify those with accelerated decline at an earlier stage (see Chapter 4, page 190).
- Information on whether clinical thresholds for certain risk factors can be applied to all ages and ethnicities and both sexes is often lacking. **Further research is needed to establish meaningful thresholds** for the various population sub-groups.
- **Primary screening of certain conditions**, such as breast cancer and colorectal cancer, starts in this phase (e.g. stool samples collected and analysed for colorectal cancer) (Binefa et al., 2016).
- **Introduce preventive, lifestyle and tailored interventions** (depending on susceptibilities) for at-risk groups, and secondary cancer prevention. Good examples of effective lifestyle interventions are the Diabetes Prevention Programme (Centers for Disease Control and Prevention, 2018) and the million Hearts 2022 programme (US Department of Health and Human Services, 2017) for preventing cardiovascular disease in the US. Million Hearts 2022, a 5-year initiative, was launched in 2017 by the US Department of Health and Human Services to accelerate the implementation of effective strategies to improve cardiovascular health (Wall et al., 2018). During 2017–2021, Million Hearts 2022 priorities are to keep adults healthy through community-based strategies that reduce combustible tobacco use, sodium intake and physical inactivity, as well as optimising health care for those with and at risk for cardiovascular disease through clinical strategies that improve appropriate aspirin use, blood pressure control, cholesterol management, and tobacco cessation (Wall et al., 2018). Lifestyle intervention trials, particularly those involving physical activity, have generally shown improvement in muscle strength and physical function such as walking speed in older adults (Anton et al., 2015; Fielding et al., 2017; Cruz-Jentoft et al., 2014). However, there is wide individual variation in the benefits of physical activity that needs to be better understood, and

in the benefits of combining dietary and exercise interventions. To move forward with primary prevention, more information is needed about the effects of dietary interventions, especially dietary restriction, on healthy and overweight adults (Anton et al., 2015).

- **Screen and reduce cardio-metabolic risk factors**, benefiting not just cardiovascular disease but also cognition and brain health and physical function (Forman et al., 2017). Cardiovascular trials should include musculoskeletal and physical function as additional outcome measures.
- **Maintaining cognitive capacity for longer during adulthood** may be possible through lifelong learning, work complexity, high team responsibility and volunteer engagement (Valenzuela & Sachdev, 2006). It may also be through cognitive training, combining smart technologies, or non-invasive brain stimulation (Anton et al., 2015), which may have benefits for both cognitive and physical functions.
- **Screen for eye disorders**. Visual check-ups are important at this life phase. Measurement of ocular pressure and visual field monitoring appear to be cost-effective for early diagnosis, prevention or treatment (Boodhna & Crabb, 2016). The diagnosis of retinopathy relies on fundus examination, which should be systematically performed in adults over 45 years of age, especially in patients with diabetes mellitus because of their increased risk. Families at risk for age-related macular degeneration should receive genetic counselling in addition to preventive measures (Lechanteur et al., 2015).
- **Address the adult vaccines gap**, as part of a life course vaccination programme in order to maintain immunity to infections (including HPV for cervical cancer, if not yet received). The anti-vaccine movement represents a barrier to the progress that has been achieved through immunisation programmes.
- **Perform pharmacological interventions when appropriate**. Some are well-established (e.g. bisphosphonates, anti-hypertensive medications, statins), while others are more equivocal or of limited success. However, pharmacological treatment strategies remain expensive given the lifetime incidence of age-related diseases. Non-pharmacological interventions treatment (such as physical exercise, intellectual leisure activities and adequate intake of proteins) are beneficial alone or as a complement to pharmacological treatment.
- Avoid radiation and **follow the protective regulatory rules** when exposed to radiation (x-ray, gamma ray, radioactivity and natural radiations) and radon gas.
- Tertiary and secondary prevention directed at **managing and rehabilitating persons with diagnosed diseases**. Relatively common at this life stage are diabetes, cardiovascular disease, osteoarthritis and cancers.

*Strategies for mature adults (approximately over 50 years) to restore capacity or functional ability, slow the rate of functional decline, and delay disease onset or progression*

- Continue adult strategies for regular **monitoring of intrinsic capacities, disease markers and the emergence of new risk factors** to identify susceptible sub-groups with accelerated decline or disease progression. Remaining active and fit is particularly important in this life phase.
- Pay more attention to **assessing hearing loss**, which becomes common in this life phase, is a risk factor for cognitive decline, and can cause serious consequences for social life, increasing the risk of loneliness. Early prescription of hearing aids can dramatically improve functional abilities and wellbeing. At the present time, hearing aids are the only means of palliating the decline of auditory function. However, there are many barriers to this solution: high cost, inadequate national health and private insurance cover, the inconvenience of repeated consultations for fitting and adjustments, and, above all, psychological unwillingness to accept reality. From a public health perspective, efforts should be made to increase the affordability and accessibility of sound amplifier devices. Education and coaching by speech therapists on the use of communication strategies must be undertaken: e.g., speaking face-to-face, reducing background noise and speaking more slowly (Mamo et al., 2016).
- **Provide physical examinations for those with balance problems** at risk of falling, to investigate the various systems involved in the maintenance of balance.
- Tertiary and secondary prevention directed at **managing and rehabilitating persons with diagnosed diseases** and improving their quality of life. Increasingly common at this life stage are dementia, sarcopenia, COPD, and frailty.
- **Develop vaccinations to prevent infectious diseases** common in older people. As reflected in the interests of many companies, there are opportunities for using more effective and safe adjuvants or for enhancing vaccine response with pre-treatment, to compensate for the lower immune response of older people to vaccines and therefore lower vaccine effectiveness. The main public health issue here is to regulate predatory companies selling "anti-ageing" and "immune-strengthening" products to the gullible.
- Make **sarcopenia and frailty interventions** as they arise.

## Policy options



Promotion of healthy ageing needs to start early in life and continue across life, monitoring change in function over time, intervening to optimise peak function during development and where there is (accelerated) age-related decline, rather than waiting for a critical clinical threshold to be reached.



Health promotion programmes should stress that those who exercise, eat a healthy diet, maintain a normal weight and do not smoke have a higher level of capacity and a lower chance of decline as they grow older.



Member states should implement the most effective strategies for preventing obesity and encouraging a range of healthier lifestyles across the whole of life. A more equitable balance between health promotion, targeted intervention, and treatment is required. The fact that functional ageing is fundamental must be the basis for policy, and systematically included in any health and disease evaluation.

**Table 11.** Reinforcing health promotion for current and future old generations at the **individual** level

	Immunity and infection	Metabolism and diabetes	Cardiovascular	Respiratory	Musculoskeletal	Cognition	Mental	Sensory			Cancers	
	Education											
Basic school education												
Health literacy												
Planetary health education												
High technology education												
	Individual behaviour: healthy lifestyle											
Healthy diet (e.g. Mediterranean type)												
Regular physical activities												
Weight control												
Reduced calorie intake												
Limited or no alcohol												
	Individual within the life environment											
Safe, non-polluted environment												
Good working conditions												
Smoke-free environment												
Safe environmental and personal acoustic exposure (including ototoxic drugs)												
UV exposure												
Progressive glasses or contact lenses												
	Primary prevention: health promotion											
Lifelong self-tracking of health												
Midlife risk assessment												
Careful follow-up of appropriate lifestyle advice												
Regular medical controls												

(continued on opposite page)



Negative impact

**Table 11.** Reinforcing health promotion for current and future old generations at the **individual** level

(continued from opposite page)

	Immunity and infection	Metabolism and diabetes	Cardiovascular	Respiratory	Musculoskeletal	Cognition	Mental	Sensory			Cancers
								Vision	Hearing	Balance	
<b>Targeted prevention</b>											
Life course vaccine programme (including HPV)	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Prevention of malnutrition (undernutrition)	Low	Low	Low	Low	Low	Low	Low	Low	Low	High	Low
Prevention of malnutrition (overweight and obesity)	Low	High	High	Low	Low	Low	Low	Low	Low	Low	Low
Diabetes prevention programme	Low	Low	High	Low	Low	Low	Low	Low	Low	Low	Low
Cardiovascular score (risk factors)	Low	High	High	Low	Low	Low	Low	Low	Low	Low	Low
Cognitive stimulation and training	Low	Low	Low	Low	Low	High	Low	Low	Low	Low	Low
Pharmacological prevention	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Genotyping and precision medicine	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
<b>Technology</b>											
e-health user	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
m-health user	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Wearable devices, clothes	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
New non-invasive technology in care	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Robots in home care	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low



**Table 12.** Reinforcing health promotion for current and future old generations at the **society** level

	Immunity and infection	Metabolism and diabetes	Cardiovascular	Respiratory	Musculoskeletal	Cognition	Mental	Vision	Hearing	Balance	Cancers
<b>Society as a whole</b>											
Basic lifelong health education (starting at primary school)	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light
Address poverty and health inequalities	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light
Invest in a good start to life and build reserve	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Combat all forms of discrimination (ageism)	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light
Promote age-friendly cities and communities	Light	Light	Light	Light	Medium	Light	Light	Medium	Medium	Light	Light
Favour ageing in the home	Light	Light	Light	Light	Medium	Light	Light	Light	Light	Light	Light
Promote age-friendly care facilities (hospitals and long-term care)	Light	Light	Light	Light	Medium	Dark	Light	Light	Light	Light	Light
<b>Society and environment</b>											
Address risks, known (e.g. air, noise pollution) and emerging (e.g. viruses, endocrine disruptors, toxin alerts)	Light	Medium	Medium	Dark	Light	Light	Light	Light	Medium	Light	Dark
Regulate agro-industry	Light	Medium	Light	Light	Light	Light	Light	Light	Light	Light	Light
Promote 'one health'	Dark	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light
<b>Society and individual health</b>											
Media health advertisement campaigns	Dark	Dark	Dark	Light	Light	Light	Light	Dark	Dark	Light	Dark
Address known risks e.g. too salty manufactured food	Light	Light	Dark	Light	Light	Light	Light	Light	Light	Light	Light
Taxes on sugar-sweetened beverages	Light	Dark	Light	Light	Light	Light	Light	Light	Light	Light	Light
Taxes on tobacco	Light	Light	Light	Dark	Light	Light	Light	Light	Light	Light	Dark
<b>Society and health care systems</b>											
Prioritise prevention	Dark	Dark	Dark	Dark	Dark	Light	Light	Light	Light	Light	Dark
Improve care access	Light	Light	Light	Light	Light	Light	Light	Dark	Dark	Light	Dark
Improve care coordination	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light	Light





# Chapter 3. Optimising health and social care for older EU citizens

## INTRODUCTION

The approach to current and future challenges to public health and ageing is underpinned by the heterogeneity of ageing, the frequently shared risk factors for different outcomes, and the high prevalence of multimorbidity, necessitating a comprehensive multifactorial approach to assessment and management of older people.

Whereas many of the problems and challenges detailed in this report are not new, a number of features of ageing demography are rapidly changing, such as the magnitude of the problems; the rising prevalence of the oldest old; the rapidly changing societal structures such as smaller and more fragmented family units; the constituent of the health and social care labour force; the impact on pensions; and the rapidly changing cultural landscape in Europe.

The ageing population is not homogenous; significant variations in demographic, social and economic characteristics are commonplace. Therefore, when addressing policy issues, this heterogeneity and the contribution of social and economic factors to inequalities must be prioritised. Recognition of the success of the ageing population is highlighted by the '65 is the new 55' approach, which recognises that most of the age-related pressures on health and social care systems come from those in later old age, also the fastest growing demographic group.

In this chapter we adopt an 'out of the silo' approach, emphasising the common platforms and pathways shared by many of the challenges and opportunities of ageing. For example, the high prevalence of physical and mental multimorbidity coupled with care and social needs necessitates a comprehensive assessment and management strategy rather than individual speciality approach. The selected examples of care pathways are modelled on this approach, with specifics for individual conditions commonly encountered in the oldest old, e.g. malnutrition, frailty, sarcopenia, heart failure, falls and syncope, osteoporosis. The focus is on function, independent living and quality of life.

A public health approach is recommended, combining social and health care services and budgets for ease of access and reduction in duplication of services, given the frequent overlap between health and social care needs. New efficient models of health care provision should include social care considerations with internalisation of systems to deliver more efficiency i.e. single budget streams for health and social care, and seamless integrated discharge arrangements from the hospital sector to the community.

A further example of the 'out of the silo' approach is social prescribing coupled with other medication prescriptions to incorporate a holistic approach to therapeutic interventions, including access to physical activities and social engagement strategies in addition to traditional prescription of medications. The approach extends to interventions and risk factors: for example, risk factors for cardiovascular diseases are common to other outcomes such as cognitive disorders, falls, mental health and locomotor disorders. Interventions for one system will positively influence other systems. For example, physical exercise benefits cardiovascular fitness and cardiovascular disorders but also benefits metabolic disorders, mental health, bone health and cognition.

Therefore, the overarching care philosophy of the report is person-centred and relational-centred to ensure a fair, inclusive, sustainable health and social care system for all. It is important to appreciate older service users as full individuals rather than individuals being treated for particular conditions or sets of needs.

This chapter outlines the health and social status of today's older people, detailing options for solutions which incorporate, in addition to comprehensive care pathways, efficient models of service delivery which combine traditional approaches with new technologies and ensure functional ageing with as much independence as possible. Where institutional care is necessary, this should be in an environment which enhances quality of life as much as possible. Dignity, respect and quality of life should extend to end-of-life care.

### 3A. THE HEALTH CARE CHALLENGES

The health care challenges of today's older generation are diverse and complex, but they are also increasingly controllable, as beneficial interventions are developed, prioritised, and implemented not only concerning the individual but also at the level of system change. This is important because, while there is a major opportunity from increasing life expectancy, there is an associated challenge as healthy life expectancy is not fully keeping pace. There has been a call for coordinated action to address this gap (Beard et al., 2016).

The challenges associated with health care include the burden of individual long-term conditions that become more prevalent with increasing age — cardiovascular, neurological, metabolic, cancers and musculoskeletal disorders (Partridge et al., 2018). Current treatments convert many disorders into longer-term conditions. In addition, acute events such as infections are still frequent in patients suffering from age-related or treatment-related immune-depression, raising concerns about antimicrobial resistance (Giarratano et al., 2018).

Affective disorders including depression and anxiety are also common in later life, may result from functional impairment as well as cause it (John et al., 2019), and have a profound adverse impact on health as well as quality of life (Ferrari et al., 2013).

Geriatric syndromes have been referred to as "multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render [an older] person vulnerable to situational challenges" (Tinetti et al., 1995). Typically, geriatric syndromes are clinical conditions in older people which do not fit into discrete disease categories, including delirium, falls, dizziness and urinary incontinence. Newer geriatric syndromes now widely recognised include frailty, defined as multi-system impairment associated with increased vulnerability to stressors (Clegg et al., 2013), and sarcopenia, the age-related loss of skeletal muscle mass and strength (Sayer et al., 2013). These conditions represent multiple organ impairment (Inouye et al., 2007; Isaacs, 1992) and are common causes of loss of function.

Comorbidity and multimorbidity, although closely related to geriatric syndromes, are distinct clinical entities. Comorbidity is the co-existence of other conditions with an index condition that is the specific focus of attention. Multimorbidity is defined as the co-existence of two or more chronic conditions (The Academy of Medical Sciences UK, 2018) and the prevalence rises with advancing age.

Multimorbidity can be represented by the co-existence of two or more chronic conditions, each one of which is either:

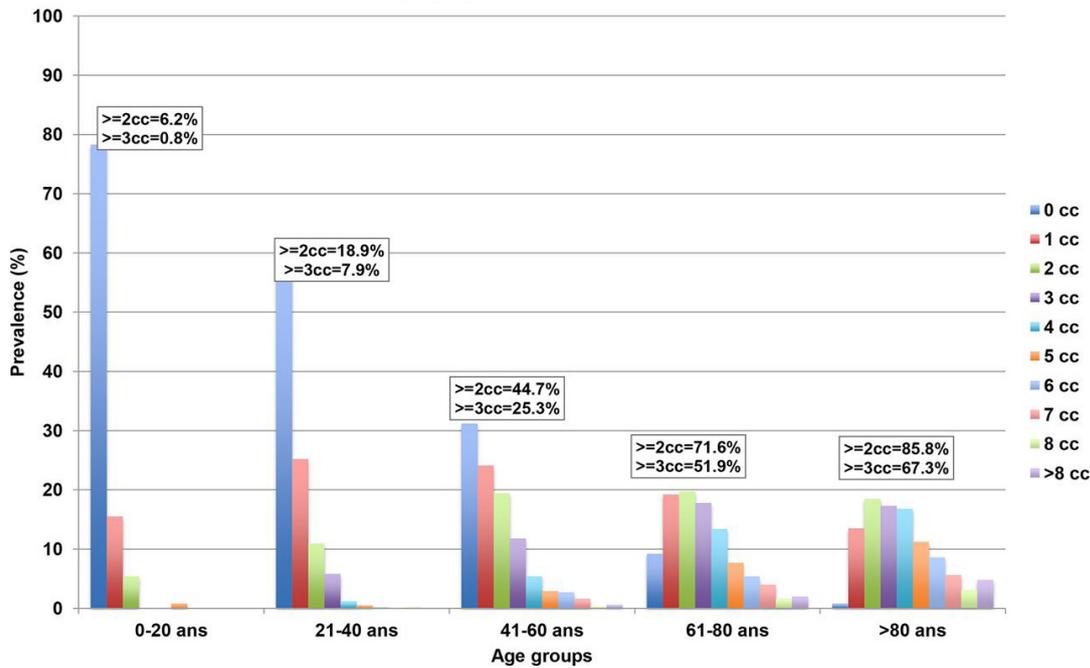
- a physical non-communicable disease of long duration, such as a cardiovascular disease or cancer;
- a mental health condition of long duration, such as a mood disorder or dementia;
- an infectious disease of long duration, such as HIV or hepatitis C.

Multimorbidity is further defined as the co-existence of several conditions where none is considered an index condition that is the specific focus of attention. The most important functional issues associated with multimorbidity in old adults are disability and dependency and impaired cognition (Maclullich et al., 2013; Mukaetova-Ladinska, 2018).

For older people, multimorbidity is the rule rather than the exception:

- Studies found that hypertension and arthritis are typically the most frequent combination of chronic diseases (Walker et al., 2016; Violan et al., 2014; Garin et al. 2016). However, despite a high prevalence, these may not be the most burdensome in terms of physical impact and quality of life.
- Having concurrent physical and mental health conditions is associated with poorer health-related quality of life, worse clinical outcomes and increased risk of premature mortality than having only physical conditions (Walker et al., 2016; Doherty & Gaughran, 2014).
- Furthermore, a UK study found that the co-existence of depression with another chronic condition was associated with increased financial cost per person relative to treating each of these conditions independently (Brilleman et al., 2013).

- Increased cost associated with certain combinations of conditions may also be age-dependent. For example, the same study found that the co-existence of diabetes and stroke was associated with increased cost (relative to each condition in isolation) among those aged 60 years and older. However, the same two conditions were associated with lower cost when presenting concurrently in individuals aged below the age of 60.
- Individuals with concurrent neurological or mental health conditions (including dementia, depression, anxiety and stroke) exhibited the greatest functional decline over time (Jackson et al., 2015).



**Figure 22.** Number of chronic conditions (CCs) by age group in a representative sample of 2904 patients reported by 118 general practitioners throughout Switzerland, and prevalence of multimorbidity in each age group (Excoffier et al., 2018).

Recognition of multimorbidity, and application of interventions to tackle all morbidities and shared risk factors, are preferred to a single disorder approach in older people (The Academy of Medical Sciences UK, 2018). There are a number of challenges in addressing multimorbidity: for example, treatment of one condition (i.e. cardiac disease) could raise the risk of a second (e.g., via polypharmacy), or one chronic condition could induce another (e.g., depression stemming from coping with another chronic condition).

Recognition of mutimorbidities also affords opportunities. For example, conditions may cluster within households, and thus identification of common and modifiable risk factors which lead to morbidities in multiple household members at different stages in the life course could influence the broader trend of health within households through preemptive action against risk factors beyond the primary patient.

While individual combinations of problems vary, the health care needs of most people with multimorbidity are similar: namely unconditional, personalised continuity of care from a small team of generalists whom they know and trust, linked to specialist and other services and resources as required (Barnett et al., 2012; Ong et al., 2016; Teh et al., 2018; Vetrano et al., 2018). Unfortunately, older people remain underserved by research on this topic, despite the burden of multimorbidity within this group being highest for both the patient and the health care system.

### ***Concluding remarks***

Recognition of multimorbidity and application of interventions to tackle all possible morbidities, including shared risk factors, is preferred to a single disorder approach in older people.

The major challenge of age-related diseases is functional loss. Health systems largely fail to measure function and yet it is the number one concern for patients and carries high care needs.

Continuity of care appears essential.

### **Policy options**



The high prevalence of physical and mental multimorbidity, coupled with care and social needs, means that we need a comprehensive assessment and management strategy, rather than an individual speciality approach.



It is beneficial to implement comprehensive care pathways efficient models of service delivery which combine traditional approaches with new technologies and ensure functional ageing with as much independence as possible.



The major challenge of age-related diseases is functional loss. Health systems largely fail to measure function and yet it is the number one concern for patients and carries high care needs.

## 3B. INTEGRATING AND EXPANDING ENVIRONMENTS AND COMMUNITIES FOR ALL AGES

### *Problem area*

In its guide to Age Friendly Cities in 2007 (WHO, 2007a), the WHO defined an age-friendly city as a place that "encourages active ageing by optimising opportunities for health, participation and security in order to enhance quality of life as people age". In practical terms, an age-friendly city adapts its structures and services to be accessible to, and inclusive of, older people with varying needs and capacities (Buffel et al., 2018; McCracken & Phillips, 2017; WHO, 2007a). For the purposes of this report, we refer as much as possible to an environment "suitable for all ages" so that the report does not reify ageism.

Along with recognising older people as contributors to the development of society, and advancing health and wellbeing into old age, the drive to ensure "enabling and supportive environments" is one of the three priority areas of the Madrid Plan of Action endorsed by the UN in 2002 (United Nations, 2002). Based upon a model of human functioning and capabilities (WHO, 2015b), the WHO's recent Global strategy and action plan on ageing and health (2016-2020) (WHO, 2016b) includes developing age-friendly environments as one of five strategic objectives with key actions aimed at fostering older people's autonomy, enabling older people's engagement, and promoting multi-sectoral action. As a holistic improvement and intervention framework, delivery challenges include:

- Addressing in a coherent fashion, the inter-connected, place-based, domains of action affecting the experiences of older people living in cities, towns and villages.
- Delivering these actions and innovations within a wider converging framework of regional spatial development, addressing additional and competing urban agendas such as sustainable cities, smart cities, green cities, healthy cities and creative cities.

### *First innovative interventions to favour environments and communities for all ages*

There are now over 700 members of the Global Network on Age-Friendly Cities and Communities (GNAFCC) worldwide, working with programmes spanning a broad range of scales across national, regional, city, county, municipal and neighbourhood levels (WHO). Innovative practices are shared in the Global Network of Age-Friendly Cities and Communities repository, aligned with the WHO themes addressing:

- outdoor spaces, the urban built environment and public realm;

- housing;
- mobility and transportation;
- civic participation and employment;
- social participation and leisure;
- respect, social inclusion and combating ageism;
- communications and information;
- community supports and health services.

Some examples of specific innovations include:

- Extending the timing of green pedestrian traffic lights to accommodate people who walk more slowly when crossing roads and streets (Crabtree et al., 2015).
- Installing more and better seating (with backs and arm-rests) along pedestrian routes and in parks and public spaces to accommodate people who need to rest more frequently, while also encouraging opportunities for greater social engagement (Yücel, 2013).
- The provision and access to toilets in public spaces and 'away from home' in publicly accessible buildings (Bichard & Hanson, 2009; Bichard & Knight, 2012).
- Rural and community transport to connect people living remotely with amenities and services centred in towns and cities (Breen, 2014).
- Liveable cities and neighbourhoods addressing sustainable, intergenerational communities that are inclusive, safe and secure for all (American Association of Retired Persons (AARP), 2018).

### *Encouraging implementation of innovations*

The interdisciplinary and multi-sectoral nature of age-friendly strategies and action plans calls for significant levels of collaborative working across local government agencies, health service providers, local industry and commerce, civic society organisations and community groups. Successful planning and implementation processes are dependent upon the active involvement of diverse older people, bringing a cross-section of experiences, priorities, contribution areas and a wealth of social capital to the table.

Examples of best practice in implementation include:

- The **Irish** programme provides support to all 31 county administrations in Ireland, based on a model of multi-stakeholder collaboration, older citizen participation and a shared local action agenda framed by the WHO guide (Age Friendly Ireland, 2014). This model is scalable and is now embedded in the replicable structures of Ireland's local government economic

and community planning processes (Government of Ireland, 2018a) and forms part of Ireland's national planning framework out to 2040 (Government of Ireland, 2018b). As such, the age-friendly communities and environments movement has an opportunity to effect a paradigm shift in local democracy and participatory governance through fostering a culture of engagement, empowerment and co-design that is at once innovative, creative, generative, evaluative and sustainable (Bond, 2015). While encouraging implementation takes on different forms in response to local contexts, spatial scales, ambitions and partnerships, there are some common, cyclical elements to most approaches and practices centred on initial assessments, developing commitments and plans of action, delivering on actions, evaluating and reporting, updating and recalibrating.

- In **New York**, the assessment process used a combination of community forums, focus groups and interviews to gather citizens' perspectives and aspirations. This was complemented with stakeholder inputs that spanned expert round-tables, Geographic Information System population data mapping, information requests, and self-assessments by relevant agencies. The result of this assessment process was a plan with 59 initiatives spanning community and civic participation, housing, public spaces and transport, and health and social services. To support delivery, the age-friendly team developed a series of guides and toolkits for architects and urban designers, arts and culture, businesses, colleges and universities, parks, pharmacies, transportation and walkability, urban planning, supermarkets and for primary care. The strong political commitment from the mayor's office provides a point for convergence of these implementation strands and an integrated environment for review and updating. The New York Academy of Medicine (2007) has been an important research and innovation partner to the programme.
- In the **UK**, the Age-Friendly Manchester initiative (Manchester City Council, 2017) adopted a similar assessment and co-creation approach. Manchester's programme is founded on a shift from a needs-based to a rights-based approach to inclusive access to the city. Part of Manchester's blueprint for encouraging implementation has been to produce an 'age-friendly charter of rights' for older people, and to encourage the public, private and NGO sectors to make 'pledges' or commitments to improve their products or services to make them more age-friendly. Advice and guidance are provided to organisations making pledges so that they are achievable and measurable, they are specific in relation to deliverables, there is clarity about who is responsible, and there is an understanding of how it will contribute to making the city age-friendly. Age-Friendly Manchester is supported by the Manchester Institute for Collaborative Research on Ageing (2018), where the teams are updating needs and asset assessments and exploring new sets of indicators.

Outside of initiatives anchored by public authorities at national, county, city or municipal levels, civic society organisations can play leading roles in encouraging implementation:

- In the **USA**, the American Association of Retired Persons (2019; founded in 1958) Liveable Community's initiative adopts a three-pronged approach to promoting liveable, age-friendly communities through engagement, volunteer education, and as an information resource.
- Across **Europe**, as an outcome of the European Innovation Partnership on Active and Healthy Ageing (2019), and based on the principles of the Dublin Declaration on Age-Friendly Cities and Communities in Europe 2013, the Covenant on Demographic Change (2018) is promoting actions towards an 'Age-Friendly Europe' through a network of regional and local authorities, civic society organisations, academic and research organisations, and industry.
- The recent Joint Statement from the Thematic Network on Smart Healthy Age-Friendly Environments (2018) addresses the local convergence of age-friendly, smart and healthy city drivers, and recognises that the Digital Single Market (European Commission, 2019a), the European Pillar on Social Rights (European Commission, 2017), the Sustainable Development Goals (United Nations, 2019); the EU Health Strategy (European Commission, 2007), and EU Health Policy Platform (European Commission, 2019b) are among many initiatives that must be aligned and harmonised to promote and deliver a more inclusive society that can support the health and wellbeing of older European citizens in their communities into the next decades.

### *Concluding remarks*

Following the UN (2002) Madrid Plan on Ageing (United Nations, 2002) and the WHO (2006a) initiative of Age Friendly Cities (WHO, 2006a), great progress has been made in easing the lives of older populations in more than 700 cities worldwide. Currently, numerous collaborative and innovative initiatives continue to promote more inclusive communities to support the integrated and active life of older European citizens in their communities, but further work remains to be done.

The policy landscape effecting the implementation of age-friendly environments and communities and the achievement of an 'age-friendly Europe' is both trans-sectoral and spatially hierarchical spanning European, national, regional and city to neighbourhood levels. Several common areas for action include:

- **Standardisation:** Achieve greater harmonisation of standards and guidelines as they affect the quality of the built environment particularly in relation to universal design and inclusive design spanning housing, the public realm and transportation.
- **Trans-sectoral collaboration capacity:** Promote regional and inter-regional programmes that can strengthen local capacities to build well-functioning multi-agency coalitions that can

address the integrated and transdisciplinary needs and requirements to support converging smart, healthy and age-friendly places.

- **Common monitoring and evaluation:** Informed by the WHO strategic objective to improve measurement, monitoring and research for healthy ageing, promote an evaluative culture for the design and implementation of multi-factorial, place-based, age-friendly environment innovations, through developing greater consensus on ways to measure, strengthening research capacities and incentives, and building and synthesising a 'place-oriented' evidence base.
- **Technology adoption and digital inclusion:** Enhance the take-up of technology-oriented solutions that empower older people to self-manage health and wellbeing through greater awareness, technical interoperability of devices and applications, and more integrated health, social and community-based pathways.
- **Alignment with global agenda:** Improve EU policy alignment with the global sustainable development agenda. From the UN to the WHO, and through UN Habitat, there is now a range of initiatives where the issue of ageing is considered within a broader human rights-based and citizenship-based approach, including combating ageism, which is still widespread.
- **Data:** Improve data for indicators and planning. There is still a lack of consistent, Europe-wide high spatial resolution, disaggregated data addressing older age groups, gender, health and wellbeing, and economic status that can support planning and community action at local, city and sub-regional scales.
- **Healthy ageing in all policies:** Encourage a cross-sectoral approach that promotes healthy ageing in all policies from local to European level, and encourage inter-sectoral responses to enhance healthy ageing, enable ageing in place and provide with greater social participation opportunities.

### Policy options



Local level policy, planning and procurement decisions are critical to delivering age-friendly communities. National and international political levels can act to provide financial and other incentives for smart community design and provide support and facilitate the sharing of best practice from communities that have experience of making the age-friendly transition.



There is a knowledge gap concerning the value of social engagement. It is thought that referral to non-clinical community and volunteer services may support the engagement of citizens, both in their own health and within their community.

### 3C. EASING MOBILITY AND DRIVING CONDITIONS

Mobility and access to transport are essential in order for older adults to retain autonomy, maintain physical fitness, stay integrated within their communities, and remain socially engaged. The car is the preferred mode of transportation by older people, with an increase in recent decades in the number of older adults who have driving licences and access to cars (Hjorthol et al., 2010). This is mainly attributable to an increase in the number of older female drivers (DaCoTa, 2012). By 2030, a quarter of all drivers will be aged 65 years or older (DaCoTa, 2012).

Access to a car has been associated with increased social engagement, quality of life and mental health. Driving, in particular, is associated with independence and a sense of control over one's life (Windsor et al., 2007). Conversely, driving cessation appears to increase symptoms of depression (Chihuri et al., 2016), cognitive decline (Choi et al., 2014) and functional limitations (Shimada et al., 2016). Therefore, older drivers must be supported to continue driving for as long as it is safe to do so.

Existing policies for renewing older people's driving licences differ between EU member states, with variable periods of licence renewal and diverse approaches to screening and assessment for determining fitness to drive. This is problematic when it comes to assessing the effectiveness of these approaches. Common procedures in place include age-based screening, mandatory or voluntary assessments and a requirement for medical screening (Polders et al., 2015). Evidence is lacking to support any safety benefits for age-based assessments; on the contrary, these assessments are associated with at best neutral outcomes and at worst adverse outcomes for older people (CONSOL, 2013). Imposing strict age-related screening likely increases societal and personal costs without safety benefits, and may result in premature driving cessation in women particularly (Siren & Haustein, 2014). There is evidence to support the effectiveness of alternate approaches to licensing regulations, including mandatory in-person licence renewal (Goodwin et al., 2015), referral of at-risk drivers (regardless of age) for a more comprehensive and multi-faceted assessment (Langford et al., 2006), and restricted licensing (Langford & Koppel, 2011). In the US, requiring an older driver to renew their licence in person has been associated with reduced fatal crash involvement rates for all age groups, with the greatest reduction seen for those aged 85 years and older (Goodwin et al., 2015).

Screening and assessment of at-risk drivers, rather than being based on age or presence of disease per se, should centre on how functional ability is impacted. Assessments of driving fitness should ideally be multifactorial; however, currently a lack of good evidence regarding the effectiveness of different screening and testing procedures is hampering the development and standardisation of detailed assessments (Polders et al., 2015), therefore a priority should be to facilitate further research into the predictors (e.g. sensory, cognitive, psychomotor and medical) of non-fitness to drive.

Implementing restrictions for older drivers is an approach to licence renewal that has proven efficacy and could be combined with comprehensive screening and assessment. These include restricting driving to specific times or limiting distance, requiring adaptive vehicle equipment or shortening the renewal cycle. Licensing restrictions reduce crash rates (Langford & Koppel, 2011) and gradual restrictions may be more acceptable to older adults and help ease the transition from full driving to eventual cessation of driving. The role of licensing agencies should include helping to ease this transition (Eby et al., 2008).

Evidence from the US and Canada supports the effectiveness of specific driving rehabilitation and refresher programmes (Betz et al., 2014; Korner-Bitensky et al., 2010). These comprise off-road (including education) and on-road components. Driving rehabilitation specialists — typically occupational therapists — carry out an assessment of fitness to drive and provide retraining as part such courses. However, this is rarely implemented in a standardised manner (Dickerson, 2013). There are also several barriers limiting uptake by drivers, including cost, lack of public awareness about the existence of such schemes, and lack of knowledge or willingness on the part of medical professionals to refer older drivers (Betz et al., 2014). Successful implementation and good uptake of retraining schemes requires initiatives at a national level to regulate training, increase awareness and engage various stakeholders so that incentives can be increased and costs can be reduced.

Application and standardisation of non-discriminatory policies and testing procedures across EU member states should be a key objective of initiatives in this area. The issue of restrictions on rental car hire for older people should also be addressed as part of a uniform policy change, to safeguard mobility between Member States and ensure compliance with their laws. Anecdotal evidence suggests that rental car policies differ markedly between EU countries, with many countries imposing widely varying upper age limits on rental.

Finally, progress in the development of autonomous vehicle technologies over the next few decades will benefit older drivers and thereby allow older adults to stay mobile for longer, by increasing safety and compensating for a decline in functional abilities. The latter is being achieved through the development of increasingly complex and sensitive advanced driver assistance systems, with vehicle sensors designed to monitor, for example, the driver's physiological or cognitive state (e.g. detection of drowsiness, distraction). The system can then

providing warnings, share control with the driver, or take full control of the car if necessary (Sentouh et al., 2014). However, there is currently poor regulation of autonomous vehicles and strict protocols must be developed for the testing of such vehicles. These include mandatory data reporting by manufacturers where situations have arisen during testing that could compromise safety, as well as the development of appropriate safeguards to ensure cybersecurity (Claybrook & Kildare, 2018). In addition, despite the rapid advancement of autonomous vehicles technologies, the rate of uptake is likely to be limited by the cost of these vehicles, at least in the short-to-medium term (Polders et al., 2015).

### *Concluding remarks*

In summary, the key points concerning older drivers in the EU raised here are:

- Non-discriminatory policies should be developed and standardised for:
  - screening and assessment approaches for fitness to drive;
  - licence renewal processes for older drivers;
  - car rentals between EU member states.
- Autonomous vehicles could benefit older drivers by increasing safety and maintaining mobility

### Policy options



Access to a car has been associated with increased social engagement, quality of life and mental health. Therefore, older drivers must be supported to continue driving for as long as it is safe to do so.



There is evidence to support the effectiveness of alternate approaches to licensing regulations, including mandatory in-person licence renewal; restricted licensing; and referral of at-risk drivers (regardless of age), for a more comprehensive and multi-faceted assessment.

### 3D. FAVOURING AGEING AT HOME

#### *Ageing at home*

Supporting older people to 'age in place' is a central concern of ageing policy. Ageing in place focuses on providing the necessary resources and assistance to enable older people to live with some level of independence at home or in the community for as long as possible, to avoid transferring to more costly long-term care or residential facilities (Heumann & Boldy, 1993; Horner & Boldy, 2008). As noted by Boldy et al (2011), it is important to distinguish between simply 'staying put' and 'ageing in place', with the latter implying a person is able to make an active and evolving decision to stay in their own home or community depending on their changing health and social care needs, preferences and available resources.

Ageing in place is generally a preferred option for older people, with a move to long-term care or a residential facility viewed as undesirable and an option of last resort (Stones & Gullifer, 2016; Wiles et al., 2012; Wilson, 2000). A large body of research has established that ageing in place affords stability and security and contributes to maintaining a sense of independence, self-reliance and empowerment (Coleman et al., 2016; Horner & Boldy, 2008; Stones & Gullifer, 2016; Wiles et al., 2012). Remaining in a familiar home and community environment may also enable people to more successfully adopt strategies for healthy ageing, provided that at least a minimum standard of housing quality is maintained and local resources such as transport and health care facilities are able to meet individual needs (Rosel, 2003; Sixsmith et al., 2014). Living in the community can further contribute to wellbeing and quality of life by helping people retain social connections and preserve an active social life (Horner & Boldy, 2008; Wiles et al., 2012). Sentimental objects such as photographs and familiar people and places also provide a link between the past and the present, fostering a sense of self-identity (Hidalgo & Hernández, 2001; Sixsmith et al., 2014; Stones & Gullifer, 2016).

Ageing in place is desirable as it affords opportunities for cost savings. Evidence in general shows that more appropriate and less costly care and support can be provided to older people who remain at home rather than in a residential facility (Chappell et al., 2004; Grabowski, 2006; Heumann & Boldy, 1993). Ageing in place may also offer advantages to service providers, by facilitating coordination of multiple care and support services for complex health and social care needs and enabling older people to remain more involved in decision making about their own care and support (Horner & Boldy, 2008).

Despite affording many benefits, Heumann and Boldy (1993) note that ageing in place nevertheless also has the potential to cause "great harm". For instance, an emphasis on ageing in place may encourage older people or their families to make decisions to remain at home when care in a residential facility may be necessary and more appropriate (Horner & Boldy, 2008). Furthermore, assistance from family or friends is often required to enable an older

person to remain living at home; delaying a move to institutional care may place a significant and unnecessary burden on informal carers (Horner & Boldy, 2008). Remaining at home may also result in social isolation and exclusion if appropriate social networks are not available or accessible (Horner & Boldy, 2008; Wiles et al., 2012). Additionally, ageing in place policies may have negative consequences if they are implemented at the expense of investing in developing a high quality long-term care system for those that will eventually need residential care (Heumann & Boldy, 1993).

Favouring ageing in the home environment seems to be an obvious win-win for both the health care system and the individual. Yet, what often is overlooked is ensuing loneliness in old age for those who live alone at home. Loneliness is defined as the subjective experience of distress in light of not meeting one's expectations for the quality or quantity of social relationships (Peplau & Perlman, 1982). It is distinguished from 'aloneness', which is the objective lack of social relations, characterised by social isolation (de Jong Gierveld et al., 2006; Russell et al., 2012).

- **Aloneness** is particularly high in old age as older adults often experience losses in their social environment. These may include the loss of a spouse, friends or family members (Lopez Doblas & Diaz Conde, 2018). Older adults also are more likely to retire and this may result in reduced contact with their social network, leading to social isolation and loneliness (Segel-Karpas et al., 2018). Many older adults also experience physical changes, such as reduced mobility or hearing or vision impairments that make social interactions more challenging (Qiu et al., 2010).
- Similar to aloneness, **loneliness** is highly prevalent in old age. But a meta-analysis has found a U-shaped association between age and loneliness (Pinquart & Sorensen, 2001). The rates of loneliness are high in late adolescence and among the oldest old (Luhmann & Hawkey, 2016). In a large survey conducted in 25 European countries, the prevalence of loneliness ranged between 34% among people over the age of 60 in Ukraine and 3% among those over 60 living in Denmark (Yang & Victor, 2011). Loneliness is higher in Mediterranean countries (10% lonely all of the time in Greece and 8% in France) compared with Northern European countries (1% in Switzerland, 2% in Denmark) (Sundstrom et al., 2009). Loneliness has been identified as an extreme stressor in later life which impacts health and even mortality (Luo et al., 2012).

New forms of care settings need to be developed which are decentralised and more self-organised by patients and their families, which allow patients to live together in small units and to contribute to everyday life routines for as long as possible and experience agency and purpose. This form of decentralised care setting is very important also for dementia patients.

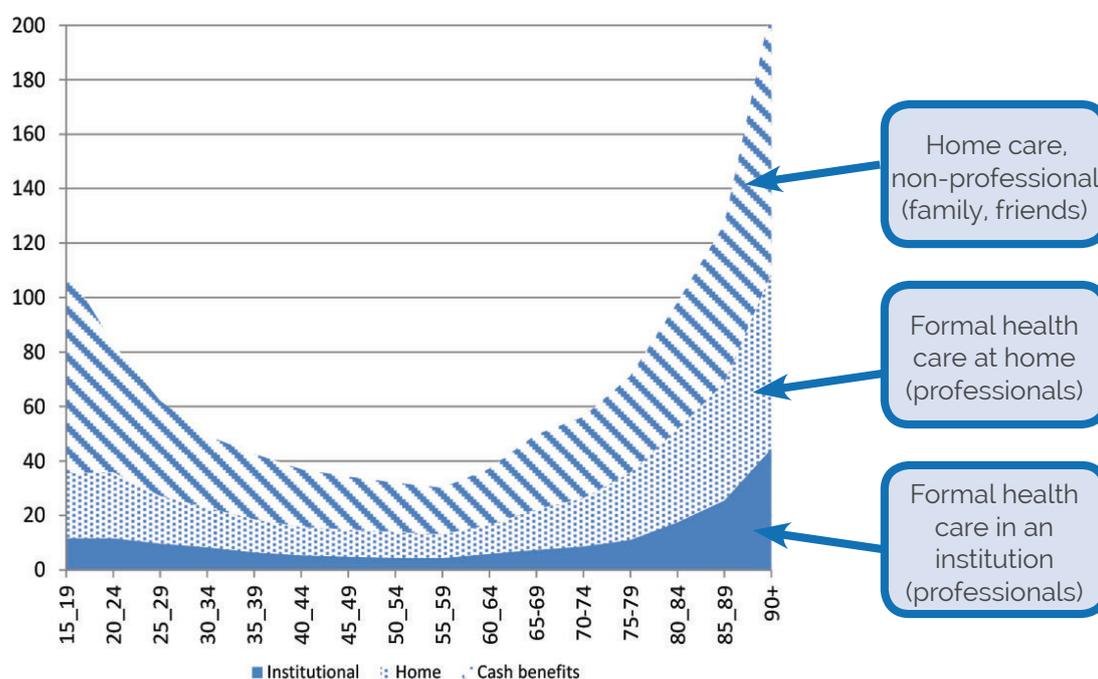
The provision of the necessary care and support to facilitate ageing in place varies according to national context, contributing to country-specific differences in the number of older people living at home and in residential facilities. Data from the Eurostat population and housing census

shows that across the region, 1.7% of people aged between 65 to 84 years lived in an institution (defined as 'health care institutions or institutions for retired or elderly persons') in 2011, with this figure reaching 12.6% for individuals aged over 85 years (Eurostat, 2018g). This share varies considerably across Member States, with over 20% of the population aged 85 years and over living in an institutional facility in Luxembourg, Malta and some parts of France, Germany, the Netherlands and Portugal, but this figure falling to below 2% in Bulgaria, Romania and some parts of Greece, Spain and Southern Italy (Eurostat, 2018g). Of course, while some of this variation is due to insufficient provision of formal long-term care, much will depend on social and cultural attitudes towards looking after older people and the ability of populations to provide informal care to family and friends.

### *Home care*

Home care, which is defined as delivering personal care and practical support to older people living in their own home, is one of several services that are offered to older people assessed as needing social care support. It is typically funded by health or social care services. Although the range and type of services within the theme of home care varies, it usually encompasses personal care (help to wash), support with the activities of daily living and help with essential domestic tasks. Home care services typically aid older people to stay independent and remain part of social and other activities.

The National Institute for Health and Care Excellence in the UK has a series of guidelines on home care. Recommendations include that the care is person-centred; offers support options; operates jointly with health and social care; ensures safety and safeguarding for those using home care services; and provides training and support for home care workers (National Institute for Health and Care Excellence, 2015).



**Figure 23.** Age related coverage of dependent population by age and type of care provided and costs, as a percentage of the population ([http://ec.europa.eu/economy\\_finance/publications/european\\_economy/2015/pdf/ee3\\_en.pdf](http://ec.europa.eu/economy_finance/publications/european_economy/2015/pdf/ee3_en.pdf)) with annotations added for this report.

It is difficult to establish how many older people with health and social care needs receive appropriate formal care at home to support ageing in place. This is due to an absence of comprehensive data on formal home care provision in many countries and a general fragmentation of long-term care funding and organisation that makes it challenging to decipher exactly what is spent on different care areas and on different age groups (European Commission, 2018a). Some insights can, however, be obtained from data from the European Commission’s Economic Policy Committee on the distribution of long-term care received by the dependent population in Europe. These data suggest that in the EU in 2016, approximately 10% of the dependent population aged 65 to 69 with long-term health or social care needs received home care, with 10% receiving care in an institutional setting and 30% granted cash benefits to purchase their own care or to reimburse informal or formal carers (European Commission, 2018a). Receipt of care in institutional settings compared to in the home was higher for those aged 85 to 89, with 30% receiving home care, 40% care in a residential facility and approximately 70% cash benefits. (As explained in the European Commission’s (2018a) ageing report, coverage may be above 100%, as some recipients may receive both cash and in-kind benefits.)

Undertaking cross-country comparisons of receipt of care for dependent older adults is complicated due to a lack of country-specific data by age group. However, if receipt of long-term care by all dependent individuals is considered, the majority of which is received by individuals aged over 60 years, we see large variations between countries. For instance, while over 40% of the dependent population in Belgium, Finland, the Netherlands and Norway receive home care, this falls to below 5% in Portugal and Poland (European Commission, 2018a).

### Home care resources available to older people

The level of home care resources available to older people living in their own home varies significantly from country to country, as does the method of delivering care at home. The level of demand from patients for home care also differs significantly across EU member states. Even the definition of what exactly constitutes home care differs (Genet et al., 2012). Generally, many types of home care services are available but often not very extensively. Relatively extensive services are available in Austria, Belgium, Denmark, the United Kingdom, Ireland, Luxembourg, the Netherlands, Norway and Sweden. In other countries, considerable needs remain unaddressed by formally provided services (Genet et al., 2012).

In order to age in place, older people must to some degree remain free of illness and disability or be provided with the necessary care and support to meet their health and social care needs. Many countries have therefore introduced initiatives to promote healthy ageing or innovative care models to support those with everyday functional limitations.

Actions targeting health promotion and prevention in older people who live in the community are increasingly prevalent. These interventions often focus on reducing falls, which are a leading cause of health complications and injuries among older people. One of the most successful and globally replicated fall prevention interventions is the Otago Exercise Programme from New Zealand (Thomas et al., 2010). The programme consists of muscle strengthening and balance training delivered by trained professionals in homes or other care settings and much research has shown it to be a cost-effective strategy in reducing falls and fall-related injuries, particularly for frail older people (Campbell et al., 1999; Campbell et al., 1997; Kyrдалen et al., 2014; Liu-Ambrose et al., 2008; Thomas et al., 2010). Another leading prevention strategy is the promotion of appropriate physical activity for older adults. Some initiatives that have successfully promoted physical activity in older populations include community-based exercise programmes, prescribing and monitoring of physical activity by primary care physicians or provision of pedometers to encourage walking (Croteau et al., 2004; King, 2001; Kolt et al., 2012). Much evidence has linked physical activity at older ages to lower hazard of disability and improved balance, mobility, cognition and wellbeing (de Vries et al., 2012; Kenfield & Stampfer, 2013).

Home visits are a principal strategy to facilitate ageing in place. A well known and successful model for providing home visits for adults with functional limitation is the Buurtzorg "neighbourhood care" nursing model that originated in the Netherlands in 2007. Under the Buurtzorg model, nurses work in small, self-managed teams to provide both medical treatment and social care support, with at least 60% of their time spent with patients (Gray et al., 2015; Kreitzer et al., 2015; Monsen & de Blok, 2013). The model supports care integration by encouraging nurses to work closely with informal carers and primary care providers as well as families and community resources. Evidence shows that care provided under the Buurtzorg model is of high quality and has led to fewer hospitalisations, lower number of care hours per

participant and lower rates of nursing home admissions compared to usual care (Buurtzorg Nederland, 2009; KPMG, 2015).

Satisfaction ratings among patients and nursing staff are also higher than for other home care models (Buurtzorg Nederland, 2009; Gray et al., 2015; KPMG, 2015; Monsen & de Blok, 2013). This success has seen several countries adopt the Buurtzorg model, including Japan, Norway, Sweden, the UK and USA, with adaptations made to meet country-specific needs (Gray et al., 2015; Kreitzer et al., 2015).

Home care can be delivered by two complementary care networks:

- an informal care network of non-professionals: spouse, family members and friends
- a formal care network of health care professionals (GPs/family doctors, nurses, aid-nurses, social workers and so on)

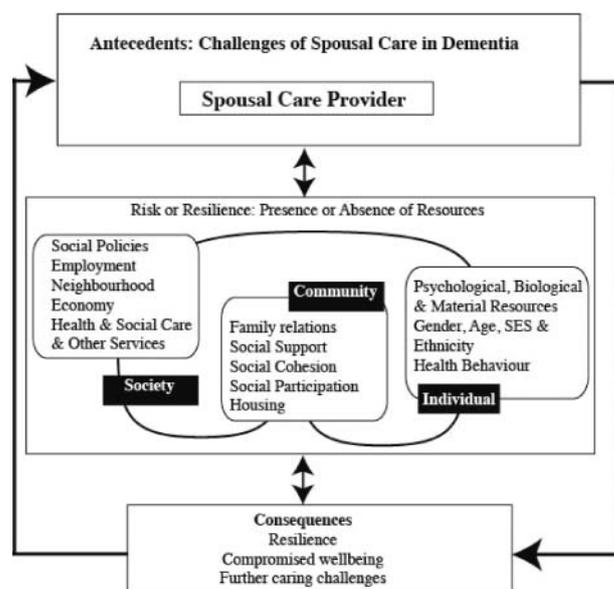
### Informal care networks

Informal caregiving is an essential part of care supply all over Europe, and older people in many countries prefer to receive help at home from their relatives, especially at early stages of care dependency (Mair et al., 2016). Depending on the setting, informal caregiving can heavily affect the life of carers with respect to work, family and social networks, as well as their health and wellbeing.

The majority of informal carers across Europe are between 55–65 years old (Colombo et al., 2011), and often in a potential “sandwich position” between older parents and younger children and grandchildren in need of support (Grundy & Henretta, 2006). Typically, spouses, adult daughters or daughters-in-law are the primary carers. They are often not in paid work (Bauer & Sousa-Poza, 2015) and have lower educational attainment (Colombo et al., 2011), and are among lower socioeconomic groups (Broese van Groenou et al., 2006). Older childless women (often also without partners) tend to compensate for a lack of support in older age by drawing on their broader social network and formal carers (Deindl & Brandt, 2017). Moreover, most people with dementia live in the community and depend on a family member for assistance (Kneebone & Martin, 2003). The National Dementia Strategy for England identifies family carers, 27% of whom are spouses in the United Kingdom, as “the most valuable resource for people with dementia”, with 600,000 family carers providing £8 billion (€10 billion) per annum of unpaid dementia care in the UK alone (Alzheimer’s Society, 2012).

Informal caregiving tasks and intensity also differ significantly between different care settings. Female carers provide more hours of care and care for a longer period (Yee & Schulz, 2000), spouses (of both sexes) more often provide care without any help from others (Litwin et al., 2014), and lower education is linked to more intensive caregiving (Colombo et al., 2011). In Southern

Europe, intensive support between older parents and adult children is more likely than in Northern Europe, where low-intensity support is much more common (Brandt, 2013).



**Figure 24.** Support networks of spousal care provider (Windle & Bennett, 2011, reproduced in Donnellan et al., 2017).

For Europe, results regarding physical health of informal carers are mixed, depending on the groups, indicators and contexts studied (e.g., Hiel et al., 2015). Informal caregiving for one's spouse seems to be especially detrimental (Pinquart & Sorensen, 2003). Caring for an individual with dementia is associated with depression (Schulz et al., 1995), anxiety (Cooper et al., 2007), greater risk of hypertension and heart disease, decreased immunity, and higher mortality (Mausbach et al., 2007; Schulz & Martire, 2004; Shaw et al., 1999). This psychological morbidity has been found to be most strongly associated with the coping strategies used by the carer, as well as demographic characteristics of the carer and neuropsychiatric symptoms and illness severity in the person with dementia (Cooper et al., 2008). Carers outside the household (often daughters) are more likely to be in better health. Care inside the household (mostly partners) is related to lower physical health and leads to a decline in mental health (Kaschowitz & Brandt, 2017).

Pinquart and Sorensen (2003) noted that most studies on informal and family carers centred on burden. However, burden is not the full story. While stress, at least initially, is common to adversity, carers are not homogeneous (Bonanno, 2004). Some family members might find caring entirely burdensome while others might find it life-enhancing; these carers are resilient (Windle & Bennett, 2012). Studies have also indicated that carers can identify positive aspects of their role (Brodaty & Donkin, 2009) and resilience within a caring role has been shown to be linked to factors such as perceived ability to cope, perceived control and social support (Dias et al., 2015; Harmell et al., 2011). Carers with higher perceived control, who favour challenge over stability, present with fewer depressive symptoms at follow-up (O'Rourke et al., 2010). Gaugler et al. (2007) found that high levels of resilience in dementia carers led to significantly less instances

of institutionalisation at three-year follow-up. They characterised these resilient carers as more accepting of support. However, the type of support is important; support may be detrimental if it creates feelings of over-dependence (Ingersoll-Dayton et al., 1997) or if it is not empathic.

### Formal home care networks

Formal home care workers are usually classified into two categories (Colombo et al., 2011; OECD/European Commission, 2013):

- paid nurses and rehabilitation staff such as occupational therapists and physiotherapists that provide home health care
- personal carers that provide social care and support to people who need assistance with activities of daily living

Delivery and financing of formal home care is therefore often split between health and social care depending on the type of service being received.

The formal home care workforce shares many commonalities across European countries. The majority of workers are personal carers rather than nurses or other health care staff (OECD, 2017a; OECD/European Commission, 2013). Home care workers are overwhelmingly women (over 80% of the workforce in most countries) of middle age, many of whom work part-time and have another job. Foreign-born individuals are also an important source of labour for the formal home care workforce (Colombo et al., 2011; OECD, 2017a; OECD/European Commission, 2013). In France and Austria, for example, 50% of all formal care workers are foreign-born, while migrants account for 70% and 23% of home care help in Greece and the UK, respectively (Colombo et al., 2011). In general, this work is undervalued and not recognised as skilled labour requiring training and qualifications.

In general, formal home care workers are low-skilled. Home care workers on average have fewer qualifications than formal care workers in institutions, while long-term care staff overall have lower qualifications than other health care workers (Colombo et al., 2011). Although some countries have made efforts to formalise training and education for formal home care workers, qualifications are often not required or enforced during recruitment, leaving workers in many countries under-skilled. As shown by Colombo et al. (2011), fewer than half of home care workers in Germany have relevant qualifications, while between 17% and 60% of all long-term care workers lack necessary qualifications in Australia, the Netherlands and the US.

Across Europe, formal home care workers are undervalued, salaries are low, working conditions are poor and the chance for career progression is limited (Colombo et al., 2011; National Audit Office, 2018; OECD/European Commission, 2013). These factors have contributed to low job satisfaction and high rates of staff turnover and staff vacancies. The UK, for example, is

experiencing a chronic shortage of long-term care workers, with a vacancy rate of 6.6% in 2016–17 and annual staff turnover of 27.8% (National Audit Office, 2018).

To reverse these trends, Member States have implemented a variety of strategies. In Germany and Finland, men and unemployed people respectively have been targeted to become formal carers, while salaries for long-term care workers have been significantly increased in Belgium, Denmark, France and Luxembourg (Muir, 2016). However, the impact of these initiatives is unclear, and it is uncertain if wage rises will be sustainable in the long run given the high labour intensiveness of long-term care.

Staff shortages across the region remain and are likely to be exacerbated by rising needs and reduced supply of both formal and informal care workers as a result of population ageing. If further efforts are not made to address issues related to staff shortages, to improve and standardise training and qualifications and to overcome poor working conditions, this will ultimately undermine the quality of long-term care that can be delivered in future.

### **Support for informal carers by health professionals**

Support by professionals as well as family and friends can reduce caregiving burden (Verbakel et al., 2016), whereas disagreement within the care network increases carer strain (Tolkacheva et al., 2011). Carers often reduce their leisure activities, experience more friction in their family life (Seltzer & Li, 2000), and see their (non-family) social contacts changing more often (Suitor & Pillemer, 1996), leading to shrinking networks (Clay et al., 2008).

Family carers are a vital determinant of positive outcomes for people with dementia. For example, having a co-resident carer exerts a 20-fold protective effect on risk of institutionalisation (Banerjee et al., 2003). Given that family carers of people with dementia are such an important resource, it is important to ensure that their own mental health and quality of life is satisfactory. Dementia carers have unique support needs (Roth et al., 2005): they are likely to suffer declines in the availability of people to provide informal support over time (Clay et al., 2008), and disengage from their existing social networks as they devote more time to caring as the disease progresses (Han et al., 2014; Hough et al., 2005).

Social exclusion is generally acknowledged as negative and is associated with the experiences of marginalised groups such as people with dementia, severe mental illness and informal carers. Reducing social exclusion and improving social inclusion are therefore policy priorities in countries such as England and Wales — leading to, for instance, the National Dementia Strategy for people living with dementia, the National Carers Strategy for unpaid informal carers, and strategies for people with mental health disorders.

The wellbeing gap between carers and non-carers is smaller in European countries which offer more generous formal care, whereas specific support measures for informal carers do not seem

to help to close the gap (Verbakel, 2014). Moreover, spousal carers' wellbeing is positively linked to the regional availability of formal care. Better wellbeing can be traced to higher perceived control of carers in regions with more formal care provision (Wagner & Brandt, 2018).

### *Developing financing models for ageing at home*

European countries spent on average 0.6% of their health care expenditures on curative home and rehabilitative home care and 3.5% on long-term nursing care at home (Genet et al., 2013). Figures on home care within the social care system (mostly domestic aid) are rarely available and statistics on private (out-of-pocket) home care expenditure are absent in many countries. National governments in most countries have developed a vision on home care, but these are neither detailed nor homogenous.

Although home care for health needs is usually funded through public sources or social health insurance, users in all countries of Europe are expected to pay for at least some share of their formal social home care costs (Costa-Font & Zigante, 2017; Robertson et al., 2014). The proportion of care paid for by individuals out-of-pocket is often large, with users commonly means-tested. The threshold for receiving financial assistance is frequently high. In England and Italy, for instance, co-payments are means-tested, with individuals covering up to 100% of social care costs (Costa-Font & Zigante, 2017). Other countries such as Sweden and Spain have introduced 'reserved amount' thresholds to limit co-payments, although individuals may still pay for up to 80% of long-term care needs, depending on personal financial circumstances (Costa-Font & Zigante, 2017; Robertson et al., 2014).

Home care that is not paid out-of-pocket is purchased by the central or local government in tax-funded systems or through social insurance funds. Home care purchased on behalf of users can be delivered in-kind through directly provided services, or through cash-for-care benefits where users are given cash to purchase their own social care services. Cash benefits can be provided in many forms, such as vouchers (e.g. Finland), home-care grants (e.g. Ireland), direct payments (e.g. England) or personal budgets (e.g. Netherlands) (Moran et al., 2013; Timonen et al., 2006). Although cash benefits enable users to pay for services and formal care workers directly, they can in some cases be used to reimburse informal carers. In most countries, uptake of cash-for-care benefits remains lower than direct in-kind provision of services (Timonen et al., 2006).

Specific attention should be devoted to the internalisation of costs and benefits in long-term care. As a principle, costs should match benefits within the same decision unit, such as a social insurance scheme, a government entity or a household. If benefits accrue largely outside the institution which bears the costs, there is no incentive for this institution to provide such services. Home care provides several examples.

If long-term care insurance covers professional help but not help from relatives, relatives have an incentive to underprovide home care. When professional care is only partially covered, there is an incentive to purchase less professional care. Both lead to worse health which will in turn generate more health insurance costs. The appropriate policy response is to have the health insurance support home care and to increase the coverage of professional care. This example also shows that internalisation is a matter of extent. Since home care will also be provided to some extent voluntarily as a matter of familial duty and altruism, coverage of costs does not need to be 100%. The other extreme, 0%, however, is also unlikely to be the right amount.

Home care is very strenuous. Carers need support (information, professional help, and vacation time). Often, such support is provided by social workers who are paid by municipalities. Again, costs and benefits are only partially internalised, since the resulting better health of both carer and care recipient benefits the health insurance while the municipality bears the costs. Health insurance funds should therefore subsidise municipalities. This does not necessarily have to be done directly, but could be achieved in a roundabout way, such as with block grants by the state or federal government charged to the health insurance, or subsidies to the carer enabling her to pay for services for which the municipality then charges a fee.

The European-level umbrella group Eurocarers, which represents informal carers, asserts that such care is crucial in health care systems but does not receive the recognition or financial support that it deserves:

“Due to demographic factors and developments in medical care and social support an increasing number of people require long-term care. Approximately 80% of this care is provided by spouses, relatives and friends. Without the work of these unpaid carers, formal care systems would be totally unsustainable, and many acute needs would remain unattended to. Yet carers receive little recognition for the valuable work they do. Policies to support them, although under development in many countries, are still far from adequate.”

(Eurocarers, 2019)

### *Concluding remarks*

The factors that influence the impact of informal care on carers' wellbeing are dependent on the balance between formal and informal support provided, the support setting and type, and the availability of long-term care in a country or region.

A mix of informal and formal support is essential for appropriate ageing in place, not only for care supply but also for the wellbeing of care receivers and carers. In order to encourage informal care, it is important to offer affordable and available support from formal care providers as alternatives for all social-economic groups. This enables an adequate care mix, facilitates the reconciliation of care, work and leisure, and thus increases care quality and reduces care burden for all parties involved.

## Policy options



Health and care professions need to be valued in all respects, starting with better education and remuneration, and including proper recognition of the role they play. The efforts of those workers on the front line of care are crucial in making the health and social care system work for old patients living at home.

## 3E. DEVELOPING CARE FACILITIES TO SUIT ALL AGES

### *Problem area*

With older patients accounting for an increasing proportion of hospital use in terms of outpatient visits, inpatient days and hospital discharges, there is a growing need to transform the physical design of hospitals so that they can provide a more supportive and therapeutic environment for patients, families and staff of all ages. The physical design of hospitals has recognised links to patient and staff outcomes in areas such as reduced staff stress and fatigue, increased effectiveness in delivering care, improved patient safety, and improved overall health care quality (Ulrich et al., 2004).

Studies on the positive impact of the design of the built environment on older people with dementia have tended to focus on long-term care settings (Marquardt et al., 2014). These highlight the differential impacts that environmental design factors (e.g. sensory ambience, visual connectivity, small-scale home-like personalisation and specialist care units) have upon patients' behaviours, cognition, functional abilities in daily activities, wellbeing and quality of life, social abilities, orientation and care outcomes. However, it should be noted that due to the medical and organisational complexity of hospitals, there are limits to the transferability of some of these findings across these settings (Büter, 2014). Future age-friendly hospital design may benefit from more systematic guidelines and tools based on the fusion of good inclusive hospital design with responsive design characteristics of newer care facilities for people with dementia, informed by inclusive principles, innovative practices, and end-user participatory approaches (Hignett, 2012).



**Figure 25.** An example of hospital signage from Mercer's Institute for Successful Ageing, a new (2016) clinical research facility at St. James's Hospital, Dublin. 'o' indicates ground floor and the graphics illustrate neurovascular services, specialist day hospital, general outpatient clinics, bone health and osteoporosis unit, memory clinic, falls and syncope unit and creative life unit.

In its all-age primary health centre guide, the WHO identifies vision, hearing, cognitive function and physical changes as areas of reduced functioning where a supportive environment can help older people, with or without a disability, to move about more independently, actively, safely and securely (WHO, 2008). Areas for sensitive environmental adaptation include lighting, acoustics, decor, orientation (signage), mobility (flooring, doors, ramps, stairs and lifts), and furniture and fittings. Accessible transport, assistive devices and personal assistance also form part of the physical environment domain.

Approaching design holistically is emerging as a common principle. An initial review of age-friendly hospital literature undertaken in Canada (Huang et al., 2011) suggested that, rather than

compartmentalising responses to distinct parts of a hospital, a set of guiding principles should be applied to hospitals as a whole, so that all older patients, family members and visitors and staff can benefit. St Olav's Hospital in Trondheim, Norway (Jensø & Haugen, 2004) is a leading example of a new breed of hospital which fuses a universal or inclusive design approach with a patient-focused care philosophy (Planetree, 2017), seeing the physical environment, technology, processes of care, and the emotional, social and behavioural environment as integrated elements.

While the development and commissioning of new hospitals can provide unique opportunities for innovation, architectural design to make existing hospitals more age-friendly requires transdisciplinary working in a complex operational environment, where improvements may span retrofit, refurbishment or minor works. Interventions may be as low-cost as labelling, signage, painting and art installations, through to high-cost spatial reorganisation and structural alterations.

At its core are the needs for:

- A paradigm shift in re-imagining hospitals as age-inclusive urban places intimately related to the neighbourhoods and communities they serve
- Patient-group, community, and staff engagement in processes of co-design to inform and guide the smooth spatial transformation of hospitals towards more inclusive, empowering and age-friendly places.

### *Innovations and developments*

There is a wide range of related, though currently unconnected, programmes and initiatives at various levels of maturity that can provide guidance to hospital managers to improve their facilities and make them more appropriate to the needs of older patients and their families. These include the environmental design aspects for person-centred care (Planetree, 2017), innovation for design and dignity and end-of-life care in hospitals (Foundation, 2014), the Beaumont Age-Friendly Hospital Framework (Age-friendly Ireland, 2014), and recent work applying a universal design approach to achieve dementia-friendly hospitals (Grey T. et al., 2018).

Closely related to the concepts of inclusive design and design for all, universal design is “the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability” (Centre for Excellence in Universal Design, 2014). Addressing design qualities from the urban environment to products and services, universal design is based on seven core principles which promote:

- **equitable use:** the design is useful to people with diverse abilities.

- **flexibility in use:** the design accommodates a wide range of individual preferences and abilities.
- **simple and intuitive use:** use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
- **perceptible information:** the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- **tolerance for error:** the design minimises hazards and the adverse consequences of accidental or unintended actions.
- **low physical effort:** the design can be used efficiently and comfortably and with a minimum of fatigue.
- **size and space for approach and use:** appropriate size and space is provided for approach, reach, manipulation, and use, regardless of user's body size, posture, or mobility.



**Figure 26.** An example of hospital signal from Mercer's Institute for Successful Ageing, a new (2016) clinical research facility at St. James's Hospital, Dublin. Note the large numbering: 2 indicates the second floor. Each floor is also colour-coded with bold colours.

The Dementia-friendly Hospital guideline (Grey T. et al., 2018) identifies areas where more universal design could contribute to improving the hospital experience of older people with dementia across the following spatial hierarchies from the public realm through to private spaces and services:

- Experiencing the hospital as a whole, including integration and interface with the community
- Site location, approach and entry to a hospital campus, including transportation

- Campus layout, including spatial organisation and external circulation
- Building layout(s), including entry, common spaces and services and the tissue of connectivity managed through internal horizontal and vertical circulation
- Key internal areas supporting clinical services, inpatient experience, outpatient experience, and experience in the emergency department and diagnostic and treatment areas
- Building components and elements, such as furniture, fittings, signage and equipment
- Technology for safety, care delivery, communication, and entertainment; the use of therapeutic technologies as part of the care process and assistive technologies to support patients, family members and staff
- A people-centred internal environment that softens the institutional setting and makes the hospital more welcoming, with careful use of lighting, heating and ventilation, and careful acoustic design and use of materials to create a supportive and therapeutic environment

### *Encouraging implementation of innovations*

The transferability, scalability and replicability of evidence-based policies and practices can be improved by the application of emerging 'implementation science' approaches (Bauer et al., 2015), where the focus is on fidelity and the challenge of practice adoption or adaptation into new situational contexts. In the realm of evidence-based design and design practice change, research is action-oriented and pragmatic, and needs to draw on methodologies and techniques that are holistic and transdisciplinary, spanning behaviour, health and wellbeing as well as site-specific sustainable design and creative practice (Niezabitowska, 2018). The dementia-friendly hospital innovation guidelines suggest that when exploring universal design across the hierarchical spatial levels that reflect a patient's journey, improvement teams should consider the following challenges and issues:

- **Engagement and participation:** Promote engagement with friends and family, staff and community; Provide space and supports for accompanying persons; promote a participatory design approach.
- **Provide a people-centred environment:** Soften the institutional environment; familiar or recognisable design that is easily understood and intuitive; facilitate personalisation and opportunities to add personal belongings.
- **Support patient safety and health:** Provide a safe environment through unobtrusive safety measures; support diet, nutrition and hydration; support meaningful physical and social activities including activities of daily living.
- **Balance sensory stimulation:** Optimise positive sensory stimulation and minimise negative stimulation; provide indoor and outdoor contact with nature, and access to the outdoors.

- **Support orientation and navigation:** Support orientation to date, time and location, and improve spatial cognition; provide good wayfinding that supports navigation; provide good visibility and visual access.
- **Adequate space to support the needs of a person with dementia:** Provide bays or single rooms with space for personal belongings and visitors; offer retreat spaces in multi-bed wards or communal areas in single-bed wards; provide space and supports for patient mobilisation and activities.
- **Appropriate use of technology:** Use technology appropriately for care delivery, safety, therapy, communication, and entertainment.

Since 2012, the European Innovation Partnership on Active and Healthy Ageing has been promoting innovation partnership as a means of achieving improved quality of life and health, improved health care system and service quality, effectiveness and sustainability, and increased innovation and competitiveness (European Innovation Partnership on Active and Healthy Ageing, 2012). While these types of initiatives are fostering the development, adoption, adaptation and application of age-friendly and dementia-friendly design principles and guidelines in housing and neighbourhoods throughout Europe, there would be significant value in forming an EU Task Group to focus on the pan-European development of age-friendly hospitals. Such an expert group could develop a more replicable toolkit and guidance for age-friendly hospital design that could be applied across the spectrum of environmental improvements, from easily implemented, low cost refits and renovations, through to more radical restructuring and new builds that are part of longer-term planning and design processes. Beyond tools and guidelines, such a group could drive a harmonised programme of actions to cover awareness, policy alignment, capacity and governance.

### *Concluding remarks*

A core set of evidence-based actions should be implemented that aim to reduce harm to older adults and avoid unwanted or duplicative care. The main goals of care are to improve residents' health, functional ability and wellbeing. Social cohesion and gender justice for residents, and also their formal carers, are major goals.

High-performing care teams need to focus on both measurable and intangible outcomes (such as dignity and wellbeing of residents). Rather than focusing on providing care where residents is seen primarily as a passive recipient of care, we should foster a community of people (residents and staff) that can be more actively engaged in mutually supporting each other.

## Policy options



Improving the design of hospitals and care facilities to make them age-friendly supports better outcomes for patients, family and health care workers alike. Conscientious design of new facilities, and effective retro-fitting of existing ones, does not necessarily have to be expensive it can start with something as simple as improved signage.



Strengthen relevant European networks that can promote and foster these on-going cultural and spatial transformations in residential and long-term care provision and settings, accelerating change throughout Europe.

## 3F. REDUCING EMERGENCY VISITS AND HOSPITAL ADMISSIONS

Older adults make up a greater proportion of all emergency department attendees than younger adults. Estimates vary, but the prevalence of adults aged 65 years and older in the emergency department is between about 12% and 25% (Fusco et al., 2014; Gruneir et al., 2011; Samaras et al., 2010). Older adults are also more likely to present with a higher level of emergency and require more test use.

- Falls are the main cause of emergency department attendance for older adults, accounting for between 15% and 30% of admissions (Samaras et al., 2010).
- It is estimated that delirium affects approximately 10% of older adults in the emergency department (McCabe & Kennelly, 2015) and 50% of patients with delirium in the emergency department may also have dementia.
- Chest pain and dyspnea are the principal complaints of up to 20% of older adult emergency department attendees.
- Adverse drug effects and interactions account for 11% of older adult emergency department visits (as compared with between 1% and 4% for younger adults).
- Abdominal pain or infections are the main complaint for up to 13% and 4%, of presentations, respectively (Samaras et al., 2010).

The older adult population has an increased risk of frequent emergency department use and have up to a fivefold greater chance of hospital admission (Legramante et al., 2016; Samaras et al., 2010). One review identified several clinical predictors of hospitalisation: falls history in the previous 12 months, atrial fibrillation, respiratory disease, cancer and leg ulceration. Increased age, male gender, living alone and poor mobility were also predictive of hospitalisation (Lyon et al., 2007). Other studies indicate that hospital admission typically occurs when an older person is experiencing some sort of crisis due to a combination of factors including exacerbation of a chronic condition, change in social circumstance or worsening of symptoms due to multimorbidity and frailty (Gjestsen et al., 2018).

Once hospitalised, there is considerable variation in length of stay for older adults, with age being the main driver. In the UK, the average length of stay for a person under 65 is approximately three days, but it is nine days for patients aged over 65, and as high as eleven days for adults aged 85 and older (Imison et al., 2012). Imison and colleagues also identified other patient-based factors, such as sex and health status; community resources and hospital-based factors such as rural location (accessibility); and internal processes as influencing the likelihood of admission and duration of stay (Imison et al., 2012).

In order to reduce emergency visits and hospital admissions, it is necessary to screen, diagnose and manage common geriatric syndromes and risk factors for syndromes as early as possible. Targeting the most frequent causes of emergency admissions of the older population and integrate them into care pathways is probably the best possible practice. For this reason, sarcopenia, frailty and falls and their orthopaedic consequences will be analysed, before focusing on heart failure care.

### *Sarcopenia*

Sarcopenia is a progressive and generalised skeletal muscle disorder that is associated with increased likelihood of adverse outcomes including falls, fractures, physical disability, and mortality (Writing Group for the European Working Group on Sarcopenia in Older People 2 et al., 2018). Although sarcopenia has long been associated with ageing and older people, the development of sarcopenia is now recognised to begin earlier in life (Sayer et al., 2008) and to have many contributing causes beyond ageing. Optimal care for people with sarcopenia is essential because the condition has high personal, social and economic burdens when untreated (Antunes et al., 2017; Mijnders et al., 2018).

The presence of sarcopenia increases risk for hospitalisation and increases cost of care during hospitalisation (Cawthon et al., 2017; Zhang et al., 2018). Incident (acute) sarcopenia during hospital stay is relatively common and predictive of adverse outcomes, not only in general medical settings, but also in critical care, surgical wards and patients with severe diseases (DeAndrade et al., 2018; Martone et al., 2017; Toptas et al., 2018). It is also a relevant predictive

factor of adverse outcomes for outpatients (Cawthon et al., 2017; Locquet et al., 2017; Tang et al., 2018).

Sarcopenia has recently been included the International Classification of Diseases ICD 10 (Chen et al., 2018b), but it is still far from being part of mainstream clinical practice (Vellas et al., 2018; Writing Group for the European Working Group on Sarcopenia in Older People 2 et al., 2018). Thus, pathways to screen, diagnose, and manage sarcopenia should be implemented in hospitals and primary care clinics in the near future, and some countries are already exploring how to do it and what the barriers are (Cesari et al., 2016; Falcon & Harris-Love, 2017; Reijnierse et al., 2017).

In 2018, a European initiative (European Working Group on Sarcopenia in Older People) proposed an algorithm for case-finding and diagnosing sarcopenia in clinical practice. A wide implementation of the clinical pathway proposed by these organisations would be a major step in reducing disability and other adverse outcomes in old age, and to improve treatment of most chronic conditions of adult and older Europeans:

For screening and diagnosis of sarcopenia, the European Working Group on Sarcopenia in Older People recommends following the pathway: Find Cases; Assess; Confirm; Severity (FACS).

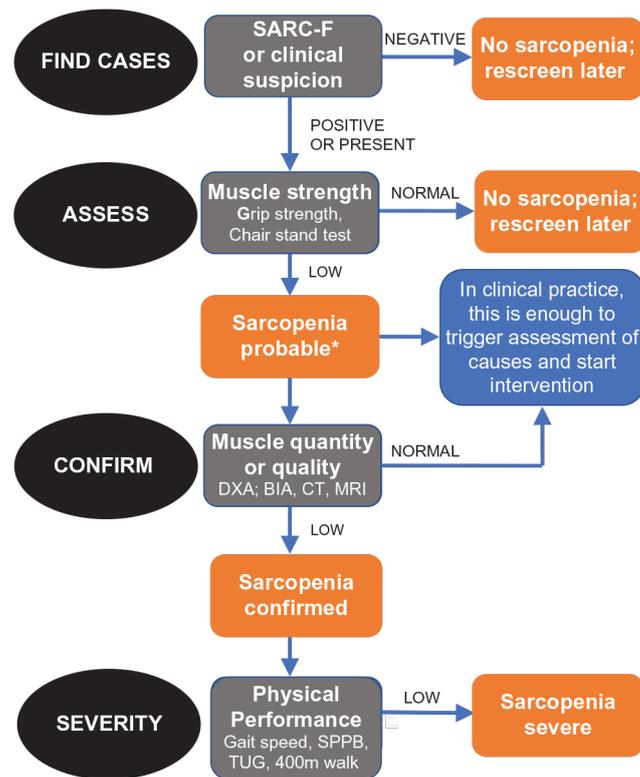
**Find Cases:** To identify individuals at risk for sarcopenia, EWGSOP advises use of the SARC-F questionnaire or clinical suspicion to find sarcopenia-associated symptoms.

**Assess:** To assess for evidence of sarcopenia, EWGSOP recommends use of grip strength or a chair stand measure with specific cut-off-points for each test. For special cases and for research studies, other methods for measurement of strength (knee flexion/extension) can be used.

**Confirm:** To confirm sarcopenia by detection of low muscle quantity and quality, DXA (dual-energy X-ray absorptiometry) is advised in clinical practice, and DXA, BIA (bio-impedance analysis), CT (computer tomography) or MRI (magnetic resonance imaging) in research studies.

**Severity:** Severity can be evaluated by performance measures; gait speed, SPPB (Short Physical Performance battery), TUG (Time Up and Go test), and 400m walk tests can be used.

(Writing Group for the European Working Group on Sarcopenia in Older People 2 et al., 2018)



**Figure 27.** European Working Group on Sarcopenia recommendations (Writing Group for the European Working Group on Sarcopenia in Older People 2 et al., 2018). Reproduced by permission of Oxford University Press on behalf of the British Geriatrics Society.

## Concluding remarks

Sarcopenia is a progressive and generalised skeletal muscle disorder that is associated with increased likelihood of adverse outcomes including falls, fractures, physical disability, and mortality. A wide implementation of the clinical sarcopenia pathway would be a major step in reducing disability and other adverse outcomes in old age, and would improve treatment outcomes of most chronic conditions.

## Frailty

Although the term “frailty” has often been used to characterise the most weak and dependent subset of older adults, the term has evolved in recent years. Frailty is now considered as a geriatric syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and causing vulnerability to adverse outcomes (Fried et al., 2001). This state of increased vulnerability distinguishes frailty from disability, is associated with ageing and has been linked to multiple adverse outcomes (incident disability, falls, hospitalisation, nursing home admission and mortality) (Vermeiren et al., 2016).

The power of using frailty to predict outcomes, initially described in general geriatric medicine, has recently been proven to extend to many other areas of medicine (Apostolo et al., 2017;

Handforth et al., 2015; Kim et al., 2016; Moskven et al., 2018; Tse et al., 2017; Wang et al., 2004). Although the exact tool to be used to identify frail older people is still controversial (Chang et al., 2018), it is becoming clear that characterisation of frailty allows for a better personalisation of complex, expensive treatments, reducing adverse outcomes and improving outcomes (Huisingh-Scheetz & Walston, 2017; Martin et al., 2018).

In the future, assessment of frailty on admission to hospital, irrespective of the condition or the admission department, will have to become standard practice, in order not only to predict outcomes, but also to tailor medical and surgical treatment to patient needs and to use multidisciplinary interventions to prevent disability as a result of hospitalisation (Sourdet et al., 2015). Also, detection of frailty may help in anticipating social needs after hospital discharge (Subbe et al., 2017). Detection of frailty should start in the emergency department (Elliott et al., 2017), as there is increasing evidence that such detection and the use of specific pathways for old frail patients may improve outcomes (Preston et al., 2018).

Changes should also include adapting the outcome measures used at present to assess the effects of hospitalisation by including some outcomes that are better fit to an old, frail population (Akpan et al., 2018). The power of using a more personalised frailty to predict outcomes could be harnessed to make health care interventions more targeted while understanding hospital and care demand to a greater extent in the older population.

### **Concluding remarks**

Frailty is a state of increased vulnerability which has to be distinguished from disability. Frailty is associated with ageing and has been link to multiple adverse outcomes (incident disability, falls, hospitalisation, nursing home admission and mortality). Detection of frailty should start in the emergency department, as there is increasing evidence that such detection and the use of specific pathways for older frail patients may improve outcomes.

### ***Falls***

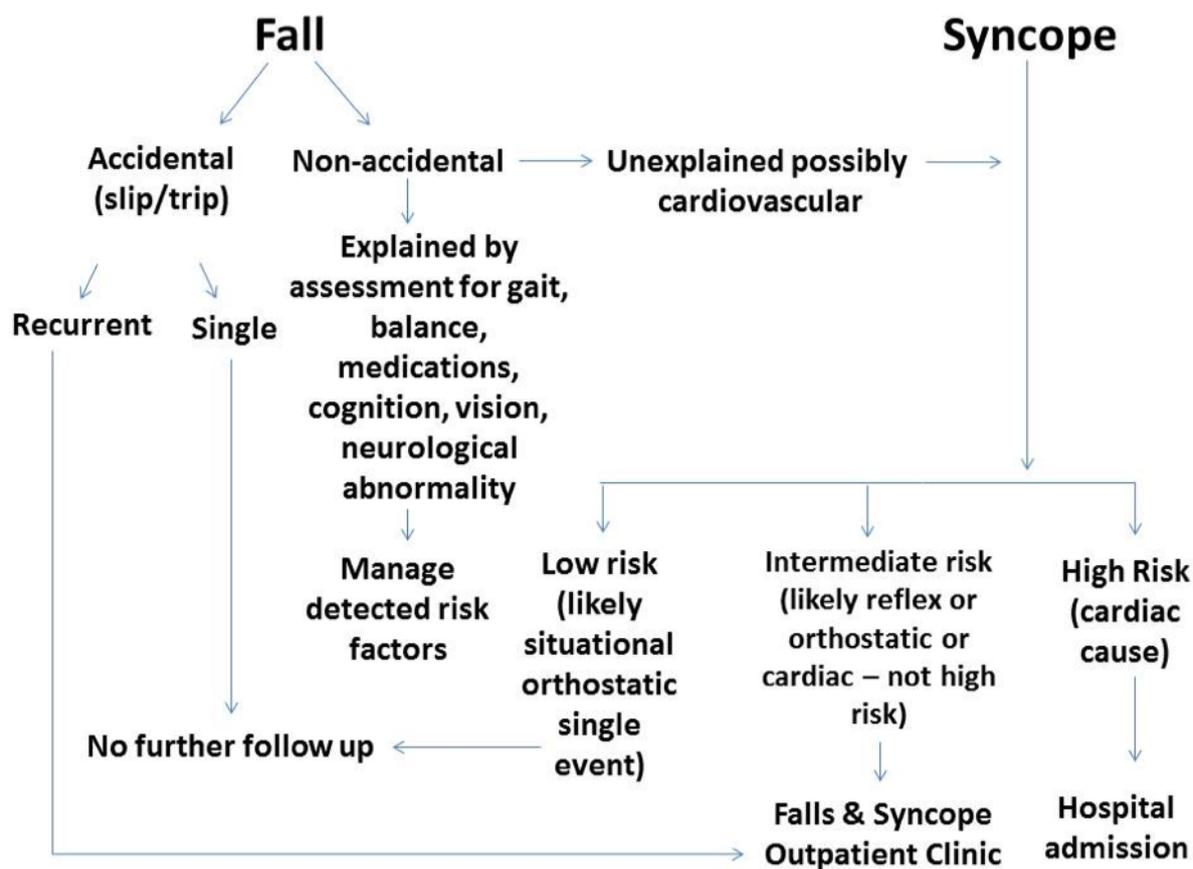
#### **Falls in the community**

Fall rates increase dramatically with advancing age and are the most common cause of fracture, including hip fracture, in older people. The annual prevalence of falls is 25% in 50–64-year-olds, 33% in 65–74-year-olds, and over 40% in people over 75 years. In one in five of these an injury occurs which necessitates hospital care, particularly in non-accidental events (Bhangu et al., 2017). Falls and syncope are one of the most common reasons for older people to attend the emergency department; across Europe, up to 50% of such patients are admitted to hospital. In countries where rigorous care pathways and risk stratification are applied, as few as 10% of falling patients are admitted to hospital (Sheldon et al., 2011).

Falls in older adults are recognised as a major health challenge as they are an important cause of injuries and impact on social participation, fear of falling and health service utilization (Collerton et al., 2012; Peeters et al., 2015; Stel et al., 2004). Falls frequently represent an evolving frailty state. If preventive measures are not taken in the immediate future, the numbers of injuries caused by falls is projected to be 100% higher by 2030, and related costs are projected to increase to unsustainable levels by 2042 (Kannus et al., 2007).

Early detection of modifiable risk factors will prevent falls and hence fractures. The most common risk factors are muscle weakness, impaired balance, polypharmacy, visual impairment, urinary incontinence and cognitive impairment. More recently, the important role of cardiovascular risk factors is recognised (cardiac arrhythmia or hypotension). These falls are frequently associated with transient loss of consciousness (syncope). 30% of older people who have syncope are unaware of loss of consciousness and present with falls (Parry & Kenny, 2005). Hence, recent guidelines recommend combined falls and syncope risk stratification and management (Brignole et al., 2018; Panel on Prevention of Falls in Older people, 2011).

A comprehensive geriatric assessment includes a focused fall history (history of falls and relevant risk factors, medication review); physical examination (gait, balance, mobility, neurologic function, muscle strength, cardiovascular status, visual acuity, feet and footwear); functional assessment (activities of daily living, patient's perceived function); and environmental assessment (home safety). The cardiovascular status assessment includes a history of prior cardiovascular disease, electrocardiogram, and lying and standing blood pressure. If a cardiac cause is suspected, further cardiac investigations are necessary. Low risk or intermediate risk patients can be assessed in dedicated falls and syncope units as per guidelines (Kenny et al., 2015). If patients are deemed at high risk, then they may require acute monitoring or hospital admission. Much of the assessment and management of falls and syncope can be nurse-led and physician supervised and delivered in an outpatient setting (dedicated falls and syncope unit). The most important step in risk stratification is to identify all possibly modifiable risk factors, and stratify for risk of cardiac event, further falls or syncope or death. Management is multifactorial, i.e., in most cases there are multiple possible risk factors for further events. Therefore, a multidisciplinary approach is necessary. Same-day assessment of fallers in an equipped facility with expertise in management of falls and syncope is the optimum care delivery model (Brignole et al., 2018; Kenny et al., 2015). Multiple component interventions reduce the rate of falls and risk of falling compared with usual care (Hopewell et al., 2018).



**Figure 28.** Care pathway for risk stratification of falls and syncope. Diagram modified from Guidelines by the American Geriatric Society 2011 (Panel on Prevention of Falls in Older people, 2011) and the European Society of Cardiology 2018 (<https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines>).

### Falls in care facilities and among hospital inpatients

Older people falling in care facilities, such as nursing homes, and hospitals are common events that may cause loss of independence, injuries, and sometimes death as a result of injury. Assessment and interventions are similar to those for falls in the community, with additional interventions for sensors and staff training. Interventions include exercise; reviews of drugs; evaluation of environment or assistive technologies including bed or chair alarms or the use of special (low/low) beds; social environment interventions that target staff members and changes in the organisational system; and knowledge interventions (Cameron et al., 2012; Guirguis-Blake et al., 2018). Interventions for falls prevention in hospital in patients is similar to care settings. Multifactorial interventions may reduce rate of falls in hospital in patients, although subgroup analysis suggests this may apply mostly to a subacute setting (Cameron et al., 2012).

There is moderate quality evidence (4512 participants, 4 studies) that vitamin D supplementation probably reduces the rate of falls (RaR 0.72, 95% CI 0.55 to 0.95;  $I^2 = 62\%$ ), but probably makes little or no difference to the risk of falling (RR 0.92, 95% CI 0.76 to 1.12;  $I^2 = 42\%$ ). The population included in these studies had low vitamin D levels. In care homes, vitamin D supplementation probably reduces the rate of falls but not the risk of falling. The effect of multifactorial

interventions on the rate of falls is minimal in these settings. In hospital, multifactorial interventions may reduce the rate of falls, although this may apply mostly to a subacute setting (Cameron et al., 2012).

### **Concluding remarks**

Fall rates increase dramatically with advancing age (annual prevalence: 40% in persons over 75 years) and are the most common cause of fracture, including hip fracture, in older adults.

The practice of multifactorial assessment for falls and syncope in a well-equipped facility by a trained staff is recommended because more than one possible cause may be present, including cognitive assessment, physical performance and cardiovascular assessment. Fall technologies should be employed as indicated for risk and fall detection.

Effective interventions for falls in care homes and nursing homes are lacking. Multi-component interventions reduce rate and risk of falls in the community.

### ***Osteoporosis and osteoporotic fractures***

Low-trauma fractures due to osteoporosis and reduced bone mass are an increasing challenge as Europe's population ages, given that the lifetime fracture risk is 1 in 3 for women and 1 in 5 for men (Hernlund et al., 2013). Across the 28 EU countries, an estimated 28 million people have osteoporosis, yet only about 20% are on appropriate treatment to reduce fracture risk (Hernlund et al., 2013). The International Osteoporosis Foundation has recently reported on fragility fractures in six European countries (France, Germany, Italy, Spain, Sweden, United Kingdom), where there are 2.6 million fractures annually. The associated costs in these countries are around €37.5 billion per year (Hernlund et al., 2013; International Osteoporosis Foundation, 2018). The projected costs by 2030 are of a 23% increase equating to €47 billion annually, which has the potential to cripple economies. Adding to that, the personal cost to the individual, carer strain, litigation costs to local authorities and so on will all rise accordingly.

However, this potential can be controlled and potentially reversed if preventive measures are taken. In adults at risk of fragility fracture, there is substantial evidence that osteoporosis drugs taken for 3–5 years can reduce fracture risk by as much as 70%, yet treatment rates even in those who have sustained a fragility fracture are low and appear to be falling (Hernlund et al., 2013). Reasons are many but adverse media and internet coverage may contribute, with many patients and even doctors fearing rare osteoporosis drug side-effects more than fractures (Jha et al., 2015). Health care systems in Europe must rise to this challenge, supporting education programmes that provide patients and their managing clinicians with balanced information. Though web-based fracture risk assessment tools are of proven use in refining fracture risk, enabling high-risk patients to be treated on clinical risk alone, there is limited access to bone

densitometry scanning in many countries, which hampers good osteoporosis care (Hernlund et al., 2013; Kanis et al., 2013; Lems & Raterman, 2017).

### **Concluding remarks**

Osteoporosis affects 28 million people in the EU; only about 20% are on appropriate treatment to reduce fracture risk, explaining the burden of fragility fractures. In adults at risk of fragility fracture, there is substantial evidence that osteoporosis drugs taken for 3–5 years can reduce fracture risk by as much as 70%.

### ***Fracture liaison services***

In those who have already sustained a fracture, there are clear benefits from use of well-defined clinical care pathways such as ortho-geriatric care of patients with a hip fracture (Giannoulis et al., 2016; Neuburger et al., 2015). These pathways reduce mortality after fracture. Pathways include attention to the prevention and management of delirium, screening and treatment of malnutrition, analysis of drug therapy or pain management, integration of an appropriate anaesthesia protocol, shortened delay for surgical procedures and a short rehabilitation circuit (Moyet et al., 2018).

A key strategy for an ageing population however is to reduce hip fracture numbers in the first place, given the serious morbidity and mortality excess associated with hip fracture (Neuburger et al., 2015). At least a third of those with a hip fracture have sustained a prior fragility fracture, so an increasing focus is now on 'fracture liaison services', which provide a coordinated approach to detecting and treating all fragility fracture types (International Osteoporosis Foundation, 2018). Carefully-structured services, coupled with falls and syncope services, improve treatment rates and reduce fracture numbers and associated costs (Brignole et al., 2018; Panel on Prevention of Falls in Older People, 2011; Walters et al., 2017). The positive impact on re-fracture rates, hospital length of stay, morbidity and mortality derived from national databases and audits have been demonstrated in several countries (Giannoulis et al., 2016; Neuburger et al., 2015).

Governments can influence hip fracture outcomes across Europe by supporting IT infrastructure for national databases which allow benchmarking and by rewarding good care via best practice tariffs which may improve care at the individual level (Neuburger et al., 2015; Oakley et al., 2017).

### **Concluding remarks**

Setting up fracture liaison services, which provide a coordinated approach to detecting and treating all fragility fracture types, will reduce the number of all types of fractures (especially hip fractures) throughout Europe and will contribute to reducing disability and health care costs.

## *Heart failure*

The incidence of heart failure increases with age, with a steep rise from 2% among middle-aged persons to up to 15% among octogenarians (Lloyd-Jones et al., 2002). Older chronic heart failure patients are more often female (50% vs. 35%;  $P < 0.0001$ ) and have higher rates of non-cardiovascular co-morbidities including chronic renal failure, anaemia and malignancy (Stein et al., 2012). In older adults hospitalised for heart failure, cognitive impairment is common (present in 47%) but only documented in half of the cases (22.7%) (Dodson et al., 2013).

There are currently clear gaps in delivery of guideline-based care (Cleland et al., 2003; Cowie et al., 2014; Ponikowski et al., 2014) and this is particularly true for older patients, for whom diagnosis is frequently delayed (All-Party Parliamentary Group on Heart Disease, 2016; Hancock et al., 2014) with inconsistent use of key diagnostic tests (Devroey & Van Casteren, 2011) such as echocardiogram and ECG.

Older patients leave hospital with substantial needs, no clear post-discharge follow-up to ensure adequate medication titration and home care need plans, and inadequate assessment of comorbid needs (All-Party Parliamentary Group on Heart Disease, 2016; Donkor et al., 2017; Mueller et al., 2017). For example, whereas all patients should see a heart failure specialist within two weeks of discharge (Ponikowski et al., 2016), in France, only one third see a cardiologist after discharge (Tuppin et al., 2013). Education and support for patients and their families is poor (Cancian et al., 2013; Jourdain & Juilliere, 2011) and palliative care and end-of-life care is poorly planned (Gadoud et al., 2014). Because of this, heart failure is the most common cause of unplanned admission of persons over 65 years (Cowie et al., 2014), whereas application of care pathway would achieve a 30% reduction in heart failure admissions.

### **Concluding remarks**

The incidence of heart failure increases with age, with a steep rise from 2% among middle-aged persons to up to 15% among octogenarians. The best model of care is a heart failure management programme: a package of person-centred care, which includes self-management support, rehabilitative and preventive care, routine reviews and escalation in the event of crisis and heart failure specialist and team working in collaboration with geriatrician at each opportunity in the heart failure journey (presentation, diagnosis, hospital discharge, and follow-up).

## Policy options



Implementing the identified care pathways for frailty, falls and syncope, osteoporosis, fracture, and heart failure can reduce the number of emergency visits and hospital admissions while contributing to a healthier later life. The care pathways are informed by leading medical experts and organisations and based upon high levels of in practice experience and process refinement.

The roll-out of Electronic Health Records will enable a greater oversight of a patient's social and health history including co-morbidity, which will boost the ability of health care professionals to take more targeted, clinically efficacious and co-ordinated interventions.

## 3G. REDUCING LENGTH OF STAY IN HOSPITAL

The geriatric team's work consists not only of curing acute diseases and caring for chronic diseases, but also avoiding over-long hospital stays which are always deleterious for old patients. For this reason, geriatricians increasingly focus their team activities on specific domains, which will be explored in the following pages. They include the practice of a comprehensive assessment, management of nutrition problems, reduction of polypharmacy and avoidance of inappropriate prescriptions, the fight against overuse of antibiotics and hospital-acquired infections, without neglecting the importance of early rehabilitation.

### *Comprehensive geriatric assessment (CGA)*

There are a number of prognostics tools, one of which is the Multidimensional Prognostic Index (MPI) (Gill et al., 2010). The MPI is the only CGA-based predictive tool using physical, cognitive, biological and social measures with good short-term and long-term discrimination and accuracy in hospital mortality and length of stay (Pilotto et al., 2008). A recent reflection paper published by the European Medicines Agency reported that while a complete evaluation of frailty to support its management requires a CGA, which is the 'gold standard' in clinical practice, "the MPI is able to extract information from CGA to categorise frailty in three subgroups with excellent prognostic value" (Committee for Medicinal Products for Human Use, 2018; Pilotto & Martin, 2018).

Despite clinical recommendations to incorporate patients' prognosis in clinical decisions (Royce et al., 2014; Schonberg et al., 2015), a recent observational study demonstrated that several barriers may limit the implementation of these recommendations: uncertainty in predicting prognosis, difficulty in discussing prognosis, and concern about patients' reactions (Schoenborn

et al., 2016). However, results from the MPI\_AGE European project demonstrated that the CGA-based MPI may be useful to evaluate whether specific treatments are cost-effective in older patients according to their individual prognostic profile, e.g. statins in secondary prevention of diabetes mellitus (Pilotto et al., 2015) or coronary artery disease (Pilotto et al., 2016b), anticoagulants in atrial fibrillation (Pilotto et al., 2016a) and anti-dementia drugs (Pilotto et al., 2018). Moreover, a study from France demonstrated that MPI was useful to evaluate mortality risk among older patients undergoing trans-catheter aortic valve implantation (TAVI) (Bureau et al., 2017), as subsequently confirmed in a multicentre international survey (Ungar et al., 2018). Very recently, a study from Germany reported that the CGA-based MPI was significantly associated with use of indicators of health care resources, including grade of care, length of hospital stay and discharge allocation (Meyer et al., 2018). The studies suggested that with full access to prognostic information derived from CGA-based predictive tools, physicians are better equipped to make clinical decisions that are aligned with their patients' needs in terms of safety and efficacy.

### Concluding remarks

Comprehensive geriatric assessment (CGA) allows optimising in-hospital clinical plans and developing tailored post-discharge care plans according to the real needs of the older patient. The implementation of a systematic CGA at hospital for admission of all older patients is consistently beneficial for several health outcomes, including decreased length of stay, institutionalisation rate, hospital readmission and mortality.

### Policy options



Teaching comprehensive geriatric assessment to all health care students and professionals is a demanding task and should be included in all academic and non-academic educational programmes for these students.

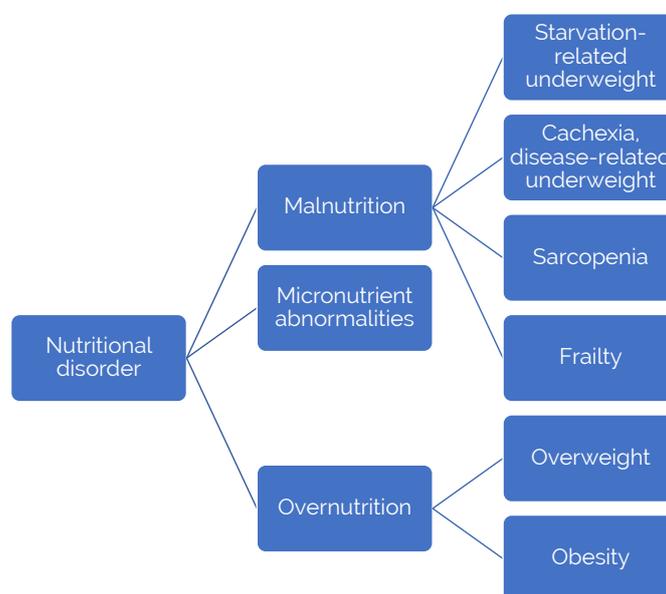
The clinical use of self-administered prognostic indices as screening tools, based on comprehensive geriatric assessment, should be implemented in clinical practice.

### *Nutrition care*

Ensuring proper nutrition for older adults is vital for encouraging healthier ageing, whether living at home, in a health care facility or long-term care setting. Nutritional disorder has a significant

impact on health, favouring loss of muscle strength and function, osteoporosis, frailty, fractures and exacerbating all geriatric syndromes as well as decreased wellbeing.

The most recent definition of nutritional disorder by the European Society for Clinical Nutrition and Metabolism (ESPEN) is illustrated by the figure below:



**Figure 29.** Definition of nutritional disorder (derived from Cederholm et al., 2015).

This section of the present report will focus on malnutrition, which was recently preferred to the term 'undernutrition' by the ESPEN group of experts (Cederholm et al., 2015).

Three scientifically demonstrated facts give support to our focus:

- Malnutrition is often undiagnosed in older adults, either in the home or in acute or chronic care settings.
- Malnutrition is commonly not treated.
- Malnutrition is the main cause of multiple and dramatic complications in the older population.

The concept and risk of malnutrition is based on four possible and independent criteria: unintentional weight loss, low body mass index, insufficient food intake, and low lean body mass. If any one of these criteria exists, it is necessary to perform nutritional assessment followed by medical diagnostics to identify the cause(s) of malnutrition.

Many European surveys published in peer review journals from 2010 to 2018 have confirmed that malnutrition is frequent in older adults living in very different care settings, including in the home. The reported prevalence and risk of malnutrition in older patients living at home is varied and high. Nine studies published during the period in question, mainly based on the use of the two most common forms of Mini Nutritional Assessment, showed that the prevalence of malnutrition

varied from 3% to 34% (Farre et al., 2014; Ferrari Bravo et al., 2018), while the risk of malnutrition varied from 21% to 58% (Ferrari Bravo et al., 2018; Kiesswetter et al., 2014).

When older adults living at home develop medical conditions or injuries that require hospitalisation, they are often found to be malnourished or at risk of malnutrition. A large European prevalence study performed at hospital admission revealed that 43.5% of older patients were malnourished and 33% at risk of malnutrition (Kaiser et al., 2010). It has also been reported that rates of malnutrition increase with age (Imoberdorf et al., 2010).

Malnutrition in hospital inpatients causes a range of adverse outcomes. These include a decrease in lean body mass, primarily skeletal muscle mass. Three days of bedrest in octogenarian patients provoke a loss of 1 kg of lean mass, which corresponds to a loss of 10% of the lower lean leg mass (Paddon-Jones et al., 2006). This causes longer immobility, increased risk of falls, a decrease in immune competence and a greater need for help when performing daily activities. Malnutrition resulted in a three-fold increase in the rate of *Clostridium difficile* infections in a recent prospective study performed in patients admitted for *Clostridium* epidemic in geriatric medicine wards at three acute hospitals in England (Behar et al., 2017). A meta-analysis of eight studies (4479 patients) demonstrated the link between vitamin D deficiency at a threshold concentration of <20 ng/mL and the risk of *Clostridium difficile* infection (Furuya-Kanamori et al., 2017). Reduced concentrations of vitamin D were also found to be associated with deterioration in mental health (Kvamme et al., 2011), treatment intolerance (Morley, 2012), and modified gastro-intestinal, cardiovascular, renal and respiratory functions, thus slowing down the recovery process. Those negative effects have been found to contribute to increased length of hospital stay in malnourished patients ( $p < .001$ ) (Kruizenga et al., 2016). New institutionalisations ( $p < .001$ ) and in-hospital mortality ( $p < .001$ ) also increased (O'Shea et al., 2017; Pavic et al., 2012).

As a result of this downward spiral caused by malnutrition, the total additional costs of managing patients with malnutrition have been estimated to be approximately four times higher for patients over 60 years of age compared with younger adult patients (Lim et al., 2012).

All older inpatients should be systematically screened at hospital attendance and admission for malnutrition. Although numerous screening tools exist, a hi-tech weight/height scale balance including a vectorial bio-impedance analysis able to determine body mass index and lean body mass (Bosy-Westphal et al., 2013) is currently considered the gold standard for diagnosing malnutrition (Cederholm et al., 2015).

Traditional screening or the use of high-tech scales will allow targeting appropriate interventions toward at-risk patients. Such interventions include better presentation of meals, increase in protein content, compensation for vitamin deficiencies, compensation of oral intakes with

fortified snacks or oral nutritional supplements, early mobilisation and rehabilitation. The goal of these is to:

- decrease complications
- maintain functional independence
- enhance rehabilitation
- increase quality of life
- reduce length of hospital stays and three-month readmission rates
- delay institutionalisation
- reduce hospital deaths
- cut health care costs

If malnutrition is not diagnosed and treated during hospitalisation, it is worse upon discharge in both medical and surgical patients of all ages, which compromises recovery outcomes. The comparison of malnutrition prevalence in older patients at hospital admission and discharge from the same hospital in Spain (n=1055; mean age 63 years) yielded alarming results (Alvarez-Hernandez et al., 2012). Among patients over 70 years of age, the malnutrition prevalence at hospital admission was 37% and at discharge 38.1%. This trend is even more important in surgical wards, which showed an increase in malnutrition of 2.7% at hospital discharge.

Such results, which unfortunately are the same globally (Freijer et al., 2013; Abizanda et al., 2016), raise an important question as to whether recommended lengths of hospitalisation are based on economic reasons or medical reasons to ensure an effective recovery. Patients struggle to recover from their infections or hip fractures if they suffer from persistent nutritional problems which hamper their recovery.

### **Benefits of enteral nutrition in malnourished patients**

Evidence in malnourished care home residents indicates that oral nutritional supplements improve quality of life and nutritional intake more effectively than dietary advice alone (Parsons et al., 2017) and moreover they are cost effective (Elia et al., 2018).

Postoperative enteral nutrition significantly reduced the rate of postoperative complications, decreased the length of hospital stay, with a favourable cost-benefit analysis in malnourished subjects (Abunnaja et al., 2013).

### **Concluding remarks**

Recognising and treating malnutrition enhances speed of recover of function and improves quality of life. Controlling nutritional issues during the pathway from home to hospital and

vice versa will significantly favour functional independence, allow ageing in the home, reduce inappropriate emergency visits and hospital or nursing home admissions.

The potential to increase quality of care and quality of life, and cut health care costs, is evident.

### Policy options



Malnutrition is mainly not diagnosed, remains untreated and leads to major health complications. All older inpatients should be systematically screened at hospital attendance and admission for malnutrition. Recognising and treating malnutrition enhances speed of recovery of function, avoids complications (such as falls, fractures and health care associated Infections) and improves quality of life.

## 3H. AVOIDING POLYPHARMACY AND INAPPROPRIATE DRUG PRESCRIPTIONS

Polypharmacy, defined as the use of multiple drugs or more than are medically necessary ( $n \geq 5$ ), is a growing concern for older adults (Maher et al., 2014). Polypharmacy is a safety problem, which concerns all patients of all age ranges, but more specifically the old population, whatever their place of living. Polypharmacy causes additional health problems from adverse drug effects and interactions, and increases direct and indirect health care costs as well as medication non-adherence (Perez-Jover et al., 2018).

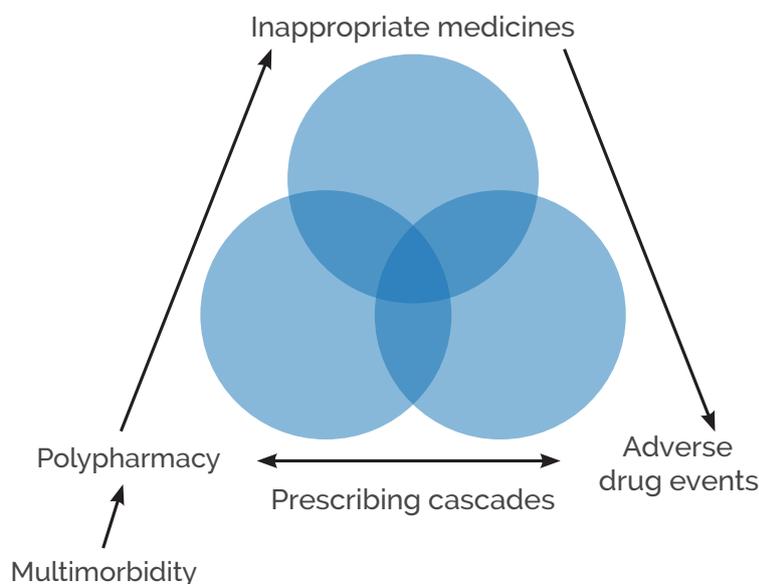
- In **Austria**, primary care patients over 75 years of age took an average of 9.1 drugs per day, and the risk of medication error is higher in this group than in groups taking fewer drugs (Koper et al., 2013)
- In **Italy**, 51.9% of older patients admitted to hospital took more than 5 different drugs; and 67% of them were discharged from the hospital ward with more than 5 different drugs.
- The average number of drugs prescribed to **French** nursing home residents was 6.9, and excessive polypharmacy concerned 21.1% of the residents ( $n = 6468$ ). (Herr et al., 2017).
- Polypharmacy explains why in **Spain**, people over 65 years were responsible for more than 30% of total medicine use and 73% of pharmaceutical expenditures, and represent 65% of all patients (Diz-Lois Martínez et al., 2012).

These figures explain why it is so important in geriatric medicine to reduce polypharmacy and indeed inappropriate drug prescriptions.

Prescribed drugs in older people are inappropriate when the risk of exposure to potential harm from medication is greater than the likelihood of benefit, when medication is prescribed at a dose that is not suitable for the condition in question, when medication is prescribed for too long or when cheaper alternatives are available. Such medications are referred to as potentially inappropriate medications. The other side of inappropriate prescribing is the omission of potentially beneficial medications for no valid reason; these instances are referred to as potential prescribing omissions. Together, the presence of potentially inappropriate medications and potential prescribing omissions represents inappropriate prescribing.

Inappropriate prescribing is highly relevant to older people. This is because inappropriate prescribing is the single greatest risk factor for adverse drug reactions which are particularly prevalent and present particular health hazards in frail older people with multimorbidity, i.e., multiple chronic medical conditions that are present simultaneously (O'Mahony, 2017). Multimorbidity is the cause of polypharmacy (Figure 30) and polypharmacy is, in turn, the single most important risk factor for inappropriate prescribing. Adverse drug reactions that older people experience from polypharmacy are commonly unrecognised and misdiagnosed as symptoms of a new condition for which even more medication is prescribed, so-called 'prescribing cascades' (Rochon & Gurwitz, 2017).

Potentially inappropriate medications are highly prevalent in older people in primary care (22%–40%), in hospital (33%–45%) and in nursing homes (60%–78%). Potential prescribing omissions are also highly prevalent among older people in primary care (22.7%–41.8%), in hospital (57.9%–63%) and in nursing homes (42.2%–85%) (O'Mahony et al., 2010; Morin et al., 2016; Tommelein et al., 2015). The presence of potentially inappropriate medications is a consistently strong predictor of adverse drug reactions in older people. Use of criteria developed to ascertain inappropriate prescribing — the "STOPP/START" criteria — as an intervention improves medication appropriateness, reduces adverse drug reactions, reduces drug cost, and lowers the risk of falls in older people.



**Figure 30.** Schematic diagram showing close relationships between multimorbidity, polypharmacy, inappropriate medications and adverse drug events. Unrecognised adverse drug events often lead to incorrect new diagnoses leading to further prescription medications, so-called 'prescribing cascades' (adapted from O'Mahony, 2017).

### *Electronic control of prescription quality*

Medication regimens in multimorbid older people are often complex for both patient and prescriber. Polypharmacy engenders inappropriate prescribing and has a negative effect on older patients' adherence with appropriate drug therapy. Over the past 25 years, numerous computerised systems have been developed and tested with the aim of optimising the appropriateness of older people's medication and minimising medication cost. Criteria for optimisation of older people's medication are numerous and therefore require computer support if they are to be deployed effectively in routine clinical practice.

Over the last 20 years, several studies have examined the efficacy of computerised interventions designed to improve medication appropriateness in older people, particularly those with multimorbid chronic illness with associated polypharmacy. Two recent systematic reviews (Cooper et al., 2015; Dalton et al., 2018) have addressed this issue in detail in older people and have drawn the following conclusions about routine use of computerised prescribing support for older people on multiple medications in whom inappropriate prescribing is highly prevalent in all care settings:

- Medication appropriateness is significantly and consistently improved in all care settings.
- Medication review carried out in this way is probably best conducted by pharmacists with suitable training and experience in geriatric pharmacotherapy. Physicians are less likely to carry out systematic assessment of older patients' multiple drug therapy.

There is a need for large-scale clinical trials to examine the effects of customised software systems on key clinical outcomes like hospitalisation, hospital length of stay, health care use, quality of life and mortality. Nevertheless, it is likely that well-designed software systems will improve at least some of these outcomes when assessed by clinical trials. The challenge in the future will be to integrate these software systems with patients' electronic medical records in such a way that potentially inappropriate medications and potential prescribing omissions are identified and highlighted quickly and accurately. However, implementation of potentially inappropriate medications and potential prescribing omission criteria will always require the clinical judgement of the prescriber.

### ***Appropriate care for older patients: regular review of medications***

Careful regular review of the medications consumed by older people with multimorbidity and polypharmacy is an essential part of high-quality medical care and a constituent of the CGA. This is because polypharmacy presents a constant risk of inappropriate medication, which in turn exposes older multimorbid people to drug-related problems of various kinds. However, the steady growth in the numbers of older people in all European populations means that most prescriptions for older people will be written by physicians who are not specialised in geriatric medicine. Therefore, the increasing challenge as the European population ages is to provide regular medication review for older people that minimises their exposure to adverse drug reactions.

Application of a structured pharmacist review of medication and subsequent prescriber adjustment of medication based on pharmacist advice is recommended. This can take place at time of comprehensive geriatric assessment (CGA) or at time of referral, and revised prescription at points of care transition (Manias & Hughes, 2015; Spinewine et al., 2012; Dalleur et al., 2014; O'Sullivan et al., 2016).

#### **Policy options**



It is clear that a high potential exists to both improve health care outcomes and reduce health care costs through improving training systems and patient education around prescription of medicines. This issue could be considered alongside the current debate on access to and availability of medicines at EU level.

### 3I. REDUCING HEALTH CARE-ASSOCIATED INFECTION

Health care-associated infection (HAI) is recognised as an important global health issue due to its association with increased morbidity, mortality and health costs, despite being largely preventable. The World Health Organisation defines HAI as "infection occurring in a patient during the process of care in a hospital or other health care facility which was not present or incubating at the time of admission" (WHO, 2019a). This term supersedes older terms including "nosocomial" and "hospital" infection, as it recognises that a significant proportion of HAI occurs in long-term care facilities such as residential and nursing homes. The care setting is a particularly important factor in the transmission of HAI to old patients and one that will become ever more significant in an ageing population.

A point prevalence study conducted by the European Centre for Disease Prevention and Control (2013) found that 5.7% of inpatients (all ages) in European hospitals were recorded as having at least one HAI, equating to over three million cases per year. The median age of the study population was 64 years, with 49% of patients being aged 65 and over (11% aged >80), demonstrating the importance of older people as an at-risk population. In the point prevalence study, 14% of HAI present on admission was categorised as originating in a location other than a hospital (European Centre for Disease Prevention and Control, 2013). This includes readmissions (either to the same or from a different hospital) as well as admissions from long-term care facilities.

It is estimated that approximately four million episodes of HAI occur in long-term care facilities in Europe annually (many of which are managed within the long-term care facilities setting), emphasising the significant burden of HAI in long-term care facilities, rivalling, if not exceeding, that of the acute care setting (European Centre for Disease Prevention and Control, 2014).

Due to increasing life expectancy, the number of older people requiring admission to hospital continues to increase and is therefore likely to drive up the proportion of inpatients for which they account. Increasing age in itself is a recognised risk factor for HAI (Ferreira et al., 2017) and specific risk factors for HAI in older people include being bedridden, length of stay, intravenous and urinary catheterisation and pressure ulcers (Reunes et al., 2011). Older people with these infections can also be challenging to manage: firstly, they may present atypically resulting in late diagnosis; secondly, they are prone to greater severity of infection, so may not respond to treatment as promptly or effectively as younger populations (Gavazzi & Krause, 2002; Zalacain et al., 2003).

The most important HAI among the elderly include pneumonia (HAP)/lower respiratory tract infection, urinary tract infections (often catheter-associated), gastrointestinal infections (specifically *Clostridium difficile*) and skin and soft tissue infections (Juthani-Mehta & Quagliarello,

2010). Key causative organisms of HAI are different to those causing disease in the community, often requiring different and sometimes prolonged treatment. Furthermore, there is an intrinsic link between HAI and antimicrobial resistance. These are thought to be synergistic in hospital settings, where HAI may drive antimicrobial resistance and therefore in turn the infections become more difficult to treat.

The economic burden is also difficult to measure (De Angelis et al., 2010), but a European Centre for Disease Prevention and Control report estimated that HAI accounts for approximately €7 billion per year (excluding indirect costs), predominantly due to prolonged hospital stays.

Key interventions to date have focused on improving infection prevention and control practices of health care workers, as they are recognised as the main source of transmission. These include hand hygiene (including hand washing and use of alcohol hand gels), personal protective equipment, isolation, and vaccination.

Given their association, policies should incorporate an integrated approach to HAI and antimicrobial resistance. Focus on infection prevention and control strategies is not only key to reducing incidence of HAI but will also contribute to reducing risk of antimicrobial resistance development, complementing antimicrobial stewardship (Dar et al., 2016).

Surveillance is regarded as a key component of control strategy for both HAI and antimicrobial resistance. Many European countries now have surveillance systems in place to enable monitoring of incidence of HAI. However, there is both paucity of data (Ewan et al., 2017; Lopez-Alcalde et al., 2015) and lack of publicly available information where data exists (Nunez-Nunez et al., 2018). Furthermore, a recent Cochrane review of improving adherence to standard precautions for control of HAI concluded that there was lack of standardisation of both interventions and outcome measures, meaning it is difficult to accurately evaluate effectiveness of infection prevention and control strategies (Moralejo et al., 2018).

Due to the unique environment within long-term care facilities, with many demographic and logistical differences to acute care, they are likely to require interventions specific to their setting. However, HAI in long-term care facilities is severely under-researched despite the burden likely being greater in long-term care facilities than acute care settings. For example, a recent Cochrane Review identified only one study that reviewed Methicillin-resistant *Staphylococcus aureus* (MRSA) infection control in nursing homes (Hughes et al., 2013). However, a recent randomised clinical trial of a multimodal targeted infection program in long-term care facilities showed promise and should encourage a trend towards further research (Mody et al., 2015).

HAI is already recognised as an important cause of preventable morbidity, mortality and costs in Europe. However, data are lacking in both quantity and quality (due to both heterogeneity and bias), which is an immediate barrier to improving infection prevention and control of HAI. There is a need for investment into high quality studies of HAI in both acute care and long-term

care facilities in order to develop effective interventions and control strategies. Furthermore, a standardised surveillance system requires implementation in order to accurately monitor HAI incidence and subsequently evaluate the impact of intervention.

### Policy options



To reduce as much as possible the length of hospital stays of old patients, adapt the hospital design (single, double, triple room; number of toilets per patient) and enhance hospital global hygiene policy.



Evaluate systematically the nutrition status (including vitamin D) of old patients at hospital admission and give nutritional support if needed.



Think of "one health" model and limit antibiotic use (in animals and humans); anti-microbial and anti-fungal resistance are worrying.



Improve infection prevention and control practices of health care workers: hand hygiene (including hand washing and use of alcohol hand gels), personal protective equipment, isolation, and vaccination.



Given their association, policies should incorporate an integrated approach to HAI and antimicrobial resistance. Focus on infection prevention and control strategies is not only key to reducing incidence of HAI but will also contribute to reducing risk of antimicrobial resistance development, complementing antimicrobial stewardship.

Health care associated infection is a major cause of increased length of stay and avoidable death that can be tackled through improved processes.

### 3J. PROMOTING INTERVENTIONS FOR EARLY REHABILITATION

Rehabilitation, defined as "a set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment" by the World Health Organisation (WHO, 2017b), is essential in geriatric care due to the straightforward relationship between disability and ageing as shown in the World Report on Disability (WHO, 2011c). As people get older, the problems in functioning also increase resulting in activity limitations and participation restrictions (WHO, 2011c). These need to be addressed by rehabilitation incorporating physical and rehabilitation medicine, which might be called "medicine of functioning" with the reference point as the International Classification of Functioning, Disability and Health (ICF) (WHO, 2011c), the overall objective of both rehabilitation and physical and rehabilitation medicine being optimising an individual's functioning at all ages (European Physical and Rehabilitation Medicine Bodies Alliance, 2018).

Rehabilitation includes:

- multicomponent exercises for those with mobility impairments
- cognitive rehabilitation, including cognitive stimulation, for those with problems in mental functions
- uro-gynaecological rehabilitation for those with urinary incontinence
- rehabilitation interventions for risk of falls are recommended within the context of integrated care for older people (WHO, 2017b)
- occupational therapy for activities of daily living training, exergaming and virtual reality systems, vestibular rehabilitation, tele-rehabilitation, psychosocial interventions for depressive symptoms, evidence-based physical rehabilitation medicine interventions including physical agents targeting pain relevant to comorbidities frequently encountered in older people
- interventions for home modifications (assistive devices, technical aids, and other tools)
- assistive technologies including computer-based and smart technologies along with self-management educational interventions including nutrition to meet the needs of the specific individual and carer support (Oral et al., 2017)

Rehabilitation services for older people can be provided in various settings including hospitals (inpatient or day-clinic rehabilitation), rehabilitation centres, home, community and long-term

care facilities. Specialised inpatient rehabilitation for geriatric patients has been shown to be potentially beneficial in improving functioning outcomes as well as preventing nursing home admissions and reducing mortality (Bachmann et al., 2010).

Regarding long-term care residents, evidence suggests that disability may be reduced by rehabilitation interventions aiming to maintain or improve physical function in individuals aged over 60 years living in long-term care facilities, albeit with quite small effects (Crocker et al., 2013).

Assistive technologies are commonplace in rehabilitation. However, there is a need for robust research for evidence of efficacy and harms of a variety of new technologies (Giustini et al., 2014). Future transdisciplinary research involving relevant scientific disciplines, academic and non-academic stakeholders shows promise in greater use of technological innovations in ageing (Grigorovich et al., 2018).

The insufficient number of rehabilitation professionals can be considered as a current barrier to strengthen and extend rehabilitation (WHO, 2017a). The number of physical rehabilitation physicians in Europe varies across countries, ranging between 0.23 and 13.46 per 100,000 inhabitants in 2017 (European Physical and Rehabilitation Medicine Bodies Alliance, 2018). The number of other rehabilitation professionals such as physical therapists and occupational therapists are below the level needed in most countries (WHO, 2017a).

### Policy options



The skilled training and integration of physical rehabilitation workforce within community, hospitals and long-term care supports enhanced health outcomes and reduced institutionalisation.

## 3K. PREVENTING HOSPITAL READMISSIONS AND DELAYING NURSING HOME ADMISSIONS

### *Preventing hospital readmissions*

A systematic review of interventions for reducing hospital readmission at 30 days which included 42 trials (some extended period of follow-up to 90 days or beyond), found that multi-component interventions which involved more individuals in care delivery and supporting capacity for self-care were 1.3 times more effective than other interventions (Leppin et al., 2014). Interventions

supporting the capacity for self-care involved assessing the impact of comorbidities, functional status, carer capabilities, socioeconomic factors, and patient and carer goals for care. The most successful interventions also coordinated care across inpatient to outpatient settings and typically involved patient home visits and reported cost savings.

Another review of randomised controlled trials in the US (Kripalani et al., 2014) also found that interventions needed to be multifaceted to successfully reduce readmission rates. Successful interventions included using an advanced practice nurse who meets with patient and carer in hospital, performs a needs assessment and provides complete discharge planning including education and coordination of post-discharge services, followed by home visits (Naylor et al., 1999); and the Care Transitions Intervention, which employs a nurse transition coach who educates patients on how best to navigate their own care. The latter model emphasises four aspects: medication self-management, a patient-owned health record, follow-up with a primary care provider or specialist, and awareness of red flags (Coleman et al., 2006). This intervention was successful in reducing both 30-day and 90-day readmission rates.

The various multicomponent initiatives have in common that they bridge hospital and post-discharge periods with dedicated personnel, patient-centred instructions and follow-up. Evidence suggests that the greater the number of domains included in the interventions the greater the success in reducing readmissions (Burke & Coleman, 2013).

### *Delaying nursing home admissions*

There is evidence that providing home health services delays the transition from community living into a nursing home (Segelman et al., 2017; Young et al., 2015). These home health services range from help with home management tasks, activities of daily living, to administration of medications (Young et al., 2015), with the aim being to promote independence by improving or slowing the progression of disability to delay nursing home admission (Rantz et al., 2005).

#### **Policy options**



Bridging community care, hospital and post-discharge periods with dedicated personnel, patient-centred instructions and follow-up with comprehensive, multidomain interventions prevent re-admission.

## 3L. ENCOURAGING MORE AGE-FRIENDLY LONG-TERM CARE FACILITIES

### *Importance of living conditions within the institution*

Long-term care services may be provided in a variety of settings, including home care, institutional (nursing homes and hospitals), or residential care, which can be internally or externally provided, sometimes under mixed forms (assisted living arrangements other than nursing homes, sheltered housing, etc.) (OECD, 2005). Formal care and informal care services coexist in many of these institutions, either complementing or substituting for each other and depending on the type of dependency of residents. For residents of long-term institutions to have a good quality of life, an environment is required where they can have a stimulating and homely environment, good medical and psychological support, and adequate nutritional intake.

### *De-institutionalising of institutions*

Moving into a residential care facility requires a great deal of adjustment to a lifestyle and environment entirely different from that of one's previous life. A sense of home in residents is important for their quality of life. It is influenced by three main themes (Rijnaard et al., 2016; van Hoof et al., 2016):

- **psychological factors**, including a sense of acknowledgement, preservation of one's values and habits, feeling in control and coping)
- **social factors**, including interaction and relationship with staff, other residents, family, friends and pets
- **the built environment**, including private space, public space, personal belongings, technology, look and feel, outdoors and location

This feeling of home is important to help retain a sense of autonomy, security and wellbeing. Good medical and personal care, respect for residents and friendly staff have also been shown to be important for the meaning of home (Jaye et al., 2016; Board & McCormack, 2018). The carer's perceptions and attitudes need to shift from task-orientated to person-centred care (Klaassens & Meijering, 2015). For dementia sufferers in particular, the design and organisation of care homes should be according to the needs of residents and family careers rather than according to the priorities of staff and managers (Popham & Orrell, 2012).

### *Person-centred care*

The rights of older people often appear to diminish with age. In the case of old people with cognitive impairment, disability or physical or mental illness, the rights of autonomy, dignity and

respect face even a greater threat (Cox & Pardasani, 2017). To address this, several philosophical approaches have been integrated into health and long-term care practices with older people. One such approach is represented by the concept of person-centred care.

'Person-centred care' is broadly defined as knowing the person through interpersonal relationship, and addressing his or her needs and preferences beyond the clinical or medical demands (American Geriatrics Society Expert Panel on Person-Centered Care, 2016). Other terms, such as patient-centred care, person-directed care, resident focus or relational care roughly address a similar approach, stressing the 'how' over the 'what' (Fazio et al., 2018). A recent systematic review concluded that the most common elements of person-centred care include coordination, integration, and focus of care, which is multidisciplinary, involves family and fictive kin, and emphasises the individual person and his or her family as significant outcomes (Kogan et al., 2016). The overall idea is that relationship, dignity, respect and autonomy are of major importance for older adults' health and wellbeing. Such an approach allows old people to maintain their personhood and citizenship, which possibly incorporates both rights and responsibilities.

### *Adequate nutrition*

Malnutrition is now recognised as a 'geriatric syndrome' and is common in institutionalised residents with a prevalence of up to 50% in some studies. Poor food and fluid intake and malnutrition are endemic in older people in long-term institutions. It is important that policymakers, managers and staff in these institutions are proactive in improving nutrition for their residents, and this issue has also been identified as an important area for research in the future (Keller et al., 2015).

Risk factors for malnutrition include conditions affecting appetite, dietary intake, oral health, and nutrient absorption as well as increasing comorbidities. The syndrome is associated with adverse outcomes, including infection risk (such as pneumonia), falls, pressure sores, reduced quality of life, hospitalisation, increased mortality and health care costs (Agarwal et al 2016). Conditions such as sarcopenia (loss of muscle mass, strength and performance), frailty and wasting syndrome (cachexia) can result from protein-energy malnutrition.

A range of screening tools is available for identification of malnutrition, although further research is required to identify the most appropriate method in care homes (van Bokhorst-de van der Schueren et al., 2014). Earlier identification of nutritional problems in a resident or in the whole long-term care facility needs food and nutrition interventions to improve outcomes and quality of life. Identifying the problem will allow the food service to be changed, food improvement to be favoured, the dining environment to be modified, staff to be trained and feeding assistance to be allowed (Abbott et al., 2013).

Malnutrition in nursing homes is also associated with pressure sores (Van Lancker et al., 2012) and poor oral health (including dental status) and thus ensuring good dentition and appropriate wearing of dentures are important in maintaining satisfactory intake of calories (Sadamori et al., 2012). Dysphagia is a complicating factor in this group of residents (Namasivayam & Steele, 2015), which needs modifying of the food texture to improve food intake (Austbø Holteng et al., 2017). Residents with dementia are at particularly high risk of malnutrition.

Fortification of foods, variety in menus, frequent low volume nutrient-dense and energy-dense small meals, and snacks and oral nutritional supplements are recommended. (Nieuwenhuizen et al., 2010; Stange et al., 2013). Oral liquid nutritional supplements can improve nutritional status and help prevent weight loss (Hines et al., 2010). Adequate vitamin D supplements (LeBlanc et al., 2015) and appropriate oral supplementation are often recommended for residents in long-term care facilities (Hsieh et al., 2010; Rondanelli et al., 2011).

There are important ethical issues and dilemmas regarding the appropriateness of enteral feeding in dementia sufferers in nursing homes (Paccagnella et al., 2016).

### ***Variety in stimulation, leisure and social engagement in long-term care facilities***

Despite living in care home facilities, some older people can become isolated, with limited opportunities for social engagement. As a consequence, their quality of life can suffer and psychological and physical consequences can develop, including depression, worsening cognitive impairment and frailty.

Proactive interventions are therefore required to improve engagement, physical and cognitive stimulation and leisure activities. Physical training to improve strength, balance or function can improve functional performance and quality of life (Weening-Dijksterhuis et al., 2011). There is accumulating evidence for variations of Yoga and Tai-Chi in improving several outcomes, including mood, cognition and sleep quality. Psychosocial interventions empowering care staff to encourage lifestyle engagement and a range of leisure activities can benefit residents including alleviating depression (Cheng et al., 2012) and reducing cognitive impairment progression (Cheng et al., 2014). Studies of cognitive stimulation, reminiscence therapy, music therapy, group treatment, movement stimulation, multimodal activation therapy, meaningful activity and positive staff engagement have shown potential in improving outcomes in residents including those with dementia. Such activities should be encouraged and care staff empowered and trained to deliver them.

### ***Avoiding inappropriate transfers to emergency rooms***

Changing demography has resulted in increasing transfers of frail older people to emergency departments worldwide, including from long-term institutions. Such transfers often result in iatrogenic complications, morbidity, stress and anxiety as well as excessive cost, and some of these transfers are potentially avoidable (Marshall et al., 2015). The nature of the acute change in health, resources available in the care homes, and the resident's or family's preference are some of the factors influencing the decision to initiate transfer (Trahan et al., 2016).

Some schemes have shown that interventions could potentially reduce avoidable transfers to emergency departments. A programme including a set of tools and transfer-avoiding strategies halved transfers (Aizen et al., 2014), and a Canadian "Care by Design" programme that allowed increased access and quality of care from family physicians reduced unnecessary transfers (Marshall et al., 2015).

Falls are also a common reason for transfers of residents to hospital. The incidence of falls in care homes has been reported as 1.7 falls per person-year compared to 0.65 falls per person-year for community-dwelling older people (Rubenstein, 2006), and a Canadian study showed 62% of residents fell over at least once over the course of one year in residential care facilities (Kennedy et al., 2015). A recent Cochrane review has shown that there is a lack of high quality randomised controlled trials on interventions to reduce falls in this environment. There was some evidence that vitamin D prescriptions reduced the rate of falls in care homes. Some selected trials have shown a reduction in fall rates for individualised multifactorial interventions, although the meta-analyses were not conclusive overall for multifactorial interventions. The review recommended an urgent need for better quality trials to close this research gap, particularly with regards to supervised exercise programs, and interventions targeting staff, organisational systems, assistive technologies, medication review and the social environment (Cameron et al., 2018).

More and more old adults die in long-term care facilities. To avoid the last-minute transfer of dying patients to the emergency department, the care facility team needs to be better trained in palliative care and advance care planning.

### ***Health care professionals working in long-term care***

Worldwide changing demography has resulted in increasing number of frail, disabled and demented older people living in long-term care institutions. Age-friendly long-term care leadership must be committed to addressing ageism and social cohesion among residents and professional staff members. Health care professionals working in long-term care must benefit from appropriate multidisciplinary training so that they can acquire the scope of competencies needed to provide care improving residents' health and functional ability and wellbeing.

### *Concluding remarks*

Age-friendly long-term care leadership must be committed to addressing ageism. Social cohesion and gender justice for residents, and also their formal carers, are major goals.

Implementing a core set of evidence-based actions aims to reduce harm to older adults and avoid unwanted or duplicative care. The main goals of the care are improving residents' health and functional ability and wellbeing; favouring reliable use of evidence-based care; helping residents to establish advanced care planning and identifying surrogate decision markers; and regularly updating previous information and wishes.

A better social and professional recognition of long-term care workers is needed to reduce high staff turnover. Specific multidisciplinary training of health professionals is essential to enable them to fulfil with their daily duties and adequately care for acute or end of life patients (see below), while focusing on both measurable and intangible (dignity and wellbeing of residents) outcomes.

## 3M. DEVELOPING PALLIATIVE MEDICINE AND CARE CULTURE

In Europe, three quarters of all death occur at the age of 65 years or older, and more frequently in long-term care (Prsic & Teno, 2017). Many older people are now dying from chronic debilitating conditions, such as end-stage organ failure and dementia. Although most deaths occur among older people, there is relatively little attention to their specific needs toward the end of life (WHO, 2011b). Palliative care is predominantly afforded to patients with cancer, but even in the field of oncology its provision tends to be insufficient, is often limited to end-of-life care and is not integrated into standard care pathways. Moreover, cancer patients aged 85 years and older are more likely to die from other diseases than from cancer, and the rising incidence of dementia has considerably increased the strain on the service.

Alleviation of suffering must be a fundamental goal of health systems, in addition to and complementary to the extension and preservation of life. Evidence suggests that older people, especially people with dementia, have unmet needs, underdiagnosed and undertreated pain (Feast et al., 2018); are subjected to burdensome transitions to acute care hospitals in the last few days of life; and may too often die miserably in intensive care, bound to a mechanical ventilator (Gavrin, 2007). Older people with multiple health problems are at risk of receiving unnecessary treatments and procedures and are not referred to hospice care until the very last few days. Particularly problematic is the destiny of people with advanced dementia and of those living in long-term care facilities (Beerens et al., 2013).

Palliative care continues to be treated as a silo, operating on its own terms often as a non-integrated part of treatment, and is limited to end-of-life care in the hospice environment.

(Dumanovsky et al., 2016). To better meet the needs of older people, access to palliative care should include people with diseases other than cancer and who have multimorbidity. Palliative care should be for everybody, in any care setting, and not limited to the last days of life.

There is some evidence that some specific palliative care models are applicable, work well, are well received, and are cost-efficient (Pautex et al., 2010). These are:

- hospital-based with mobile teams for consultation, with or without an in-hospital dedicated unit with beds
- embedded in homecare services
- provided in nursing homes as an added service

It is clear, however, that a sustainable integration of palliative care requires policies and programmes that are culturally sensitive and respectful of each country's differences, and thus are adapted to local settings.

Who should be in charge of palliative medicine: the generalist or a specialist in palliative care? While there remains room to distinguish even the representative skill sets for primary and specialist palliative care, the basic management of symptoms and the basic elements for discussing about prognosis and goal of treatment should be part of all physicians' job requirements. To this end, there are available sets of prognostic indicators — either generic indicators of severity or progression, or disease-specific indicators — to correctly identify patients with advanced chronic conditions for a progressive palliative care approach (Amblas-Novellas et al., 2016).

### *Concluding remarks*

Palliative care as a medical discipline has been one of the major advances in modern medicine. The area had previously been seriously neglected, but now forms a major part of patient care.

The de-institutionalisation of long-term care institutions is beneficial as it is associated with improved physical and mental health outcomes for resident patients, with improved engagement and job satisfaction for long-term care workers.

### **Policy options**



Integrating palliative care into the health care system is essential to take more seriously the alleviation of the burden of pain, suffering, and severe distress

associated with life-threatening or life-limiting conditions. Systematic integration of a universal access to palliative care and the implementation of these interventions will strengthen the overall performance of any health system.

### *Promoting advance care planning initiatives*

Advance care planning, or 'living wills', provide patients with an opportunity to consider, discuss, and plan their future care with their health professionals (both GPs and nurses) and inform their closest relatives of their end-of-life wishes. The goal is to enable a "dignified end of life", in the event of decisional incapacity (Barnes & Yaffe, 2011).

About two thirds of older patients had views about end of life (becoming care dependent, suffering from physical or mental deterioration, dying alone, etc.) and appreciated it if their family practitioner initiated a conversation on the subject. Unfortunately, less than a quarter of physicians and even fewer nurses have enough knowledge, experience and skills to deal with end-of-life discussion (De Vleminck et al., 2017; Silva et al., 2014).

Application of discussions is influenced by a mixture of religious beliefs, attitudes toward death and specifically one's own death. The role of proxies as decision-makers is uncertain. End-of-life decisions, treatment refusal and 'do not resuscitate' policies are complex. The complexity is even greater among vulnerable populations including insufficiently informed individuals, such as ethnic minorities and patients with limited health literacy (Vyshka & Kruja, 2011). Another frequent problem is the considerable reluctance of health care professionals to initiate advance care planning discussions as early as possible in patients with pre-dementia (van der Steen et al., 2016).

Whatever the context, it was proven that patients benefiting from palliative care or advance care planning are less likely to receive cardio-pulmonary resuscitation or burdensome, unnecessary medical treatments, they enjoy a reduced length of hospital stay and significantly smaller number of end-of-life transfers to emergency wards, regardless of whether their place of residence is at home or in a nursing home (Abel et al., 2013; Bouwstra et al., 2015).

### *Concluding remarks*

The de-institutionalisation of long-term care institutions is beneficial as it is associated with improved physical and mental health outcomes for resident patients, with improved engagement and job satisfaction for long-term care workers.

## Policy options



Advance care planning or a "living will", which state the patient's wishes and preferences for the purpose of preserving dignity and autonomy at the end of life, should be a part of the public health agenda and integrated into all health professionals' training programmes.



Informal and family carers must be better supported including training, provision of necessary equipment and respite care. Training health care professionals is essential to early identify elder abuse and engage clear and fair reporting and whistleblowing procedures. There may be lessons that can be transferred from the area of child protection policy.

## 3N. COMBATING ELDER ABUSE

Elder abuse is a single or repeated act, or lack of appropriate action, occurring within any relationship where there is an expectation of trust, which causes harm or distress to an older person. This type of violence constitutes a violation of human rights and includes physical, sexual, psychological, and emotional abuse; financial and material abuse; abandonment; neglect; and serious loss of dignity and respect (WHO, 2018a).

### *Prevalence of elder abuse*

Around 1 in 6 older people experience some form of abuse, a figure higher than previously estimated and predicted to rise as populations age worldwide. A study supported by WHO and published in the Lancet Global Health found that almost 16% of people aged 60 years and older were subjected to either psychological abuse (11.6%), financial abuse (6.8%), neglect (4.2%), physical abuse (2.6%) or sexual abuse (0.9%) (Yon et al., 2017).

There are numerous risk factors that increase the likelihood of an older person becoming a victim of elder abuse, including (Hildreth et al., 2011):

- memory problems (such as dementia)
- mental illness, either long-standing or recent

- physical disabilities
- depression, loneliness, or lack of social support
- abuse of alcohol or other substances
- taking prescribed medications that impair judgement
- being verbally or physically combative with the carer
- having a shared living situation
- informal or formal carers' stress

Elder abuse can take place in both institutional and community settings. As such, some aspects of the problem can be addressed through institutional rules and processes for health and care institutions. Other aspects of elder abuse are societal and related to the way that older people are treated within society. Examples include ageist stereotypes where older adults are depicted as frail, weak and dependent, and changes in the bonds between generations of a family.

### ***Relevant considerations and options***

It is crucial to proactively identify situations where abuse is suspected to be taking place, in order that steps can be taken to liberate those at risk from their abusers. Raising awareness for opportunistic screening, for example in the emergency room, is recommended.

At EU level, the most notable elderly abuse-related activity in recent years was the Daphne-EUSTaCEA programme (European Association for Directors and Providers of Long-Term Care Services for the Elderly, 2016), focused on the abuse of elderly women. It was coordinated by AGE Platform Europe and funded by the European Commission. The project had the following outcomes, intended to launch a call for action on abuse against older women, and to share best practice that EU Member States can use to tackle it:

- eleven national workshops
- development of a European Charter
- development of a good practice guide

The Swedish Agency for Health Technology Assessment and Assessment of Social Services published systematic reviews on major geriatric topics highlighting lack of evidence, knowledge gaps and low-quality research on the oldest patient group (SBU, 2013). Publications on urinary incontinence, pressure ulcers (SBU, 2014), depression (SBU, 2015) and fractures management (SBU, 2017) indicate clearly that high quality research is needed to favour the development of good practice guidelines. In the absence of scientifically-based guidelines, the SBU suggested that in many instances care that older people receive may be sub-optimal.

### *Concluding remarks*

In violation of human rights, elder abuse in multiple forms (financial, psychological and physical) all too frequently affect the most vulnerable population at home or in institutions. This linked to a general change in societal attitudes to the elderly, who are often seen as being just a vulnerable burden which represents an overall cost to society.

### **Policy options**



Informal and family carers must be better supported, including training, provision of necessary equipment and respite care. Training health care professionals is essential to early identify elder abuse and engage clear and fair reporting and whistleblowing procedures.





# Chapter 4. The use of technology to promote healthy ageing

Health care technologies offer an opportunity to address some of the health care challenges of the 21st century. Telemedicine, smartphone apps, and biosensors for remote diagnosis and monitoring, with a focus on prevention, will bring major improvements in patient outcomes. Health care technology and other innovative solutions can be harnessed to promote health, maintain functional ability, compress morbidity across the life course and extend healthy life expectancy.

However, it is critical that adoption any new health care technology is based on scientific evidence and that such technologies should redress, not reinforce, health care inequalities. If adequate training is provided on the integration of new health care technologies and on the interpretation of data from these solutions, such technologies have the potential to counterbalance some of the shortfall in health care workforce in future years.

## 4A. TELEMEDICINE, DIGITAL MEDICINE, WEARABLE SENSORS, MOBILE AND WIRELESS TECHNOLOGIES

The WHO (2016a) defines telemedicine as the provision of clinical care and preventive care from a distance using telecommunication and information technology, including text, audio and video consultation. Telemedicine has been used to overcome distance barriers and to improve access to medical services that would often not be consistently available in distant rural communities. In the UK, the Royal College of Physicians has recommended consultations via the telephone and video consultations in order to cope with increased health care demands (Royal College of Physicians, 2018). In a recent study evaluating online consultation system for use in primary care, it was found that online consultation improved access for some patients, but that in its current form, it was not perceived by practices as creating sufficient efficiencies to warrant financial investment (Farr et al., 2018).

A 2017 report from the Joint Action to Support the e-health Network, entitled 'EU state of play on telemedicine services and uptake recommendations', found that adoption of telemedicine services across Europe has been uneven, and services represent less than 10% of total health care services in Europe (Joint Action to support the e-health Network, 2017).

The term "digital products and services" refers to products that are intended for use in the diagnosis, prevention, monitoring and treatment of a disease, condition or syndrome" (Topol et

al., 2019). This definition encompasses a range of technologies, including telemedicine but also smartphone apps, wearable devices, software used in clinical settings (such as e-prescribing) and point-of-care tests.

Wearable sensors and devices have evolved as key technical tools which may dramatically revolutionise the next generation of health care solutions and have become health innovation drivers (Steinhubl et al., 2013). The miniaturisation of sensors and devices has generated new health care solutions (Kher, 2016). By employing mobile and wireless technologies, smartphone apps and wearable devices are transforming 'traditional' health care services and enhancing health outcomes, health quality and health equity (WHO, 2011a). Smartphone apps and wearable devices are also included in the domain of m-health (Istepanian & Woodward, 2016). m-health can assist in the detection and prevention of age-related diseases, leading towards healthier ageing and healthier societies (Vital Wave Consulting, 2009). Existing m-health technologies have already shown their potential for improving care, self-management, self-efficacy, behaviour promotion and medication adherence (Changizi & Kaveh, 2017). More than 50% of intervention studies on m-health relating to healthy eating (McCarroll et al., 2017) or obesity and diabetes prevention (Wang et al., 2017) report positive effects based on primary outcomes. A similar trend of alcohol and substance abuse prevention via m-health tools is also emerging (Kazemi et al., 2017).

m-health is still at an early stage of development in many countries (Marcolino et al., 2018). Clinical evidence has yet to emerge for many existing or near future solutions (Istepanian & Woodward, 2016). However, most importantly, m-health has yet to achieve industry-wide deployment of functional, sustainable products and services that consistently meet financial, quality, and patient satisfaction benchmarks (Slovensky & Malvey, 2017). A major risk to the future perception of m-health is the proliferation of off-the-shelf devices whose scientific foundation is questionable (Slovensky & Malvey, 2017).

However, the availability of wearable technologies such as pedometers, smart watches, fitness trackers and other types of wearable sensors tracking physical activity provide one measure of a healthy lifestyle. Other wearables can record and track blood pressure and temperature. Combined with health promotion and early preventive strategies, such measures may enable younger European generations to have a healthier later life. Their use and generated data may also increase public awareness that some risk factors associated with age-related functional decline are modifiable by lifestyle choices at all life stages. Lifelong self-tracking of health may offer a new approach for early diagnosis and early interventions (see example later in this section).

Health care technologies such as smartphone apps and wearable devices are also important facilitators of ageing in place. Wearable technologies, as well as home-based technologies, promote the development of integrated closed-loop care and therapeutic systems. The use

of such devices has been recognised by other disciplines of medicine, specifically neurology (Espay et al., 2016), for their potential to:

- enhance tailoring of symptomatic therapy
- identify objective biomarkers to improve longitudinal tracking of impairments in clinical care and research
- encourage the adoption of clinico-pathophysiologic phenotyping and early detection of critical health milestones
- improve subgroup targeting of patients for treatments

People are living longer, and overall population levels are increasing (Department of Economic and Social Affairs, 2017), but the required medical support personnel and health care methodologies are resulting in cost deficits and health personnel shortages. Health care technologies such as telemedicine, smartphone apps and wearable devices have the potential to address some of these challenges. As mentioned above, scientific evaluation and evidence of the clinical benefit as well as sustainable economic models need to be realised first. Also required is a health care workforce that is trained to incorporate and interpret data derived from these new technologies. The NHS in the UK has recently published an extensive report on preparing the health care workforce take advantage of new health care technologies, through training and education (Topol et al., 2019). This report concludes that the adoption of new technologies should enable staff gain more time to care, promoting deeper interaction with patients. This may be most important for older patients.

## 4B. LIFELONG SELF-TRACKING OF HEALTH

Health booklets can be used to monitor growth and development in children, providing useful information on height, weight, immunisations and other common health issues to both carers (parents or guardians) and care providers (midwives, nurses, GPs and paediatricians).

We propose the creation of a lifelong self-tracking tool to monitor health, which would be kept by every adult throughout early, mid- and older adulthood. Its availability in two different formats, a paper booklet and a smartphone app, will allow an adaptation to the level of technology literacy of the end user. This lifelong self-tracking of health tool would contain information on key health parameters routinely updated by the individual's care providers at primary care centres and hospitals.

Such information may include:

- **Anthropometric data:** height, weight, waist circumference, body mass index, etc.
- **Functional abilities:** physical and cognitive basic tests and measurements (average number of steps taken per day, balance test, normal/rapid gait speed, etc.

- **Vaccinations:** flu, pneumococcus, tetanus, etc.
- **Vital signs** (especially important for individuals with wearable devices): blood pressure, pulse rate, cardiac rhythm, respiration rate, etc.

The parameters mentioned above are examples of what could be encompassed; the exact set of parameters, the format of the tool requires development and adoption by the European health service authorities.

Our proposal is based on two arguments:

- **Life course approach to health:** The basic finding in this domain is that health at a specific point in time is not based on exposure to risk factors at that time, but over the life course. At present, delivery of health care is based on a current snapshot of key health parameters, however, integrating all recorded changes over time will enable care to be more appropriate and of a higher quality. Functional decline will be detected earlier, allowing for personalised primary prevention or intervention to delay or postpone age-related disability.
- **Prevention:** It is increasingly clear that functioning and lifestyle factors are important components used to tackle the increasing burden of chronic diseases. Changes in key measurements can help alert individuals (and their health care providers) to increased risk of certain diseases before their onset. For example, changes in waist circumference may be associated with ischemic heart disease, whereas important functional ability changes may reveal a risk of sarcopenia, sarcopenic obesity, frailty and falls.

The proposed long-term and individualised monitoring of key health markers will facilitate primary prevention. As is the case with any smartphone app, advice on the use of the tool and interpretation of data should be regularly updated, acknowledgement of functional progress should be notified, and alerts should be delivered in the case of significant changes

Thus, by combining the use of the tool with proper medical advice, potential decline would be detected earlier, and primary prevention or early interventions may then be implemented, stopping or even reversing the decline, for example from frailty to pre-frailty or from pre-frailty to robustness.

Our proposal is that this lifelong self-tracker of health would be held by the individual or authorised person, ensuring data protection and privacy. The data included in the proposed health booklets or smartphone apps regarding a particular individual are intended to be under the individual's control as a tool for health self-management and only if he or she agrees to include the information collected by health care providers. Development of the tool would naturally take into consideration the relevant legal (such as data protection regulation) and ethical issues, to ensure all necessary approvals.

In European countries where universal medical records already exist, this information could be regularly downloaded or transferred to complete medical data recordings. For example, Denmark's personal health care card is updated with each medical consultation and hospitalisation, and could also include the parameters regularly updated in the proposed self-tracker tool. Combined tools of self-management and management of health information by professionals will allow for a better and earlier targeted primary prevention or treatment intervention in order to delay or postpone age-related disability.

### Policy options



New technologies have high potential but often come along with complex legal and ethical challenges. Policy should be tailored for health applications, as distinct from consumer products, to take account of the specific needs of patients.



There is a knowledge gap in terms of assessing cost-effectiveness of digital technologies, which are needed to drive uptake and build business cases for investment.

## 4C. AGEING IN PLACE

Adoption of appropriate technologies can be an important facilitator of ageing in place and can play a significant role in the independence of older individuals. These technologies cover a multitude of devices and smartphone apps that serve a range of purposes. They may be used to promote healthy and active ageing or help people with functional limitations complete everyday tasks. The most common examples include text telephones, hearing aids or speech recognition software for people with sensory or visual impairments, as well as scooters or motorised wheelchairs for people with mobility difficulties. Other examples include wearable battery-operated emergency alert systems, which detect falls and summon help.

Wearables provide a level of security to the older person, improving their safety at home. Use of these devices and aids has been shown to improve quality of life and health outcomes for older people and to support independent living. However, little evidence is available to date on cost-effectiveness (Khosravi & Ghapanchi, 2016).

Other important assistive technologies include automated pill dispensers or memory prompts on smartphones or tablets that provide reminders to those with cognitive impairments to take medicines. While there are few studies on their effectiveness or economic benefits, some studies suggest these devices improve medication adherence (Paterson et al., 2017). A series of recent randomised controlled trial studies have shown that reminders sent via text message can encourage people to successfully improve health behaviours. Studies find that text message-based reminders have led to improvements in remembering to take diabetes drugs (Vervloet et al., 2012), following HIV treatment regimens (Pop-Eleches et al.), and adhering to asthma treatment (Strandbygaard et al.), among others.

Important issues for conventional assistive technology use by older adults include its impact on and emotional adjustment regarding self-image, the need for individualised follow-up and close collaboration with the social network of the older individuals due to the significant influence of sociocultural context (Larsen et al., 2018). Multidisciplinary research involving relevant scientific disciplines, academic and non-academic stakeholders show promise in greater use of technological innovations in ageing (Grigorovich et al., 2018).

Tablet and computer-based technologies have been developed to slow disease progression. For example, some computerised brain-training programmes have reported a slowing in cognitive decline. A number of randomised control trials have found that participants in different brain-training programmes displayed improved reasoning, speed and memory and less decline when completing instrumental activities of daily living (IADL) compared to controls (Rebok et al., 2014; Shah et al., 2017).

Delivery of health care services by health professionals based on remote monitoring can be used to provide timely assessments, support and advice to older people at home. Yet, while research suggest these systems may effectively improve care management for older adults with chronic health conditions (Flodgren et al., 2015; Salisbury et al., 2017), evidence on cost-effectiveness is mixed (Henderson et al., 2013; Mistry, 2012).

### *Home enhancements*

One objective of ageing in place is to create a safe zone at home, so that the older person's functional, physical, medical and social needs are maintained through monitoring and management of health and wellbeing (Carretero, 2015; Institute of Mechanical Engineers, 2018). The viability of technology in the home to meet these needs must be balanced with the older person's declining physical and cognitive health. These systems are only useful if coupled with support services so that closed loop care can be provided. Viable systems require the deployment of basic medical and social support services for monitoring and maintaining physical and psychological wellbeing, safety, accessibility and mobility.

Common devices such as mobile phones, tablets or ordinary telephones can be linked through an ICT system that monitors the environment or health of an individual (e.g. by monitoring toilet visits) and sends alerts when necessary (Carretero, 2015; Institute of Mechanical Engineers, 2018). Given that smart homes are a relatively recent development, it is perhaps unsurprising that there are scarce studies on their cost effectiveness and potential to prolong ageing in place.

Technologies to promote ageing in place come in different forms, but one distinction that can be made is whether they are active or passive:

- **Active** home monitoring devices capture vital signs, weight or symptoms and report them to a remote provider or a home health care agency. Active systems require an individual to operate them, whether they are hardware or software in nature.
- **Passive** monitoring technologies include wearables, such as fitness bands tracking physical activity (steps taken), door movement sensors that track activity within the home but also include bed sensors that capture restlessness, sleep interruptions, or heart rate and respiration during sleep.

The use of technology to adapt housing is a critical component of ageing in place strategies. Adapted housing solutions can include installation of practical technology to make everyday tasks easier, such as placing ramps at front doors, anti-slip mats or grab-bars in showers and baths to assist bathing and improve upkeep of good hygiene standards, or use of toilets with adaptable height settings (Carretero, 2015; Powell et al., 2017). Evidence suggests these types of aids and devices can prevent falls and reduce accident rates and can lead to improved quality of life and health outcomes (Powell et al., 2017).

Technologies can also be introduced to create 'smart homes', where sensors and automated systems perform various tasks such as switching electrical appliances and lighting and heating systems on or off when prompted, or automatically if left on accidentally (Carretero, 2015; Institute of Mechanical Engineers, 2018; Liu et al., 2016).

### ***Social connectedness***

ICT-based technologies can help promote social connectedness. Evidence shows that provision of mobility devices can help older people maintain an active social life and enhances access to local resources (Pettersson et al., 2016; Sund et al., 2015). Social networks may also provide a means for older people to create or maintain social connections and an active lifestyle.

Technologies such as tablets and smartphones for social connectivity and emotional health tend to focus on older adults' interactions with their family but can also be useful for carers, whether in the form of paid professional assistance or unpaid family, friends or neighbours, as well as with the broader community. These technologies may provide social engagement or access to information but also employment and volunteer opportunities.

Technology can encourage or facilitate social interactions and emotional contact either in person or via virtual communities, and can delay declines in mental wellbeing. Although poor mental health in later life, including anxiety and depression, can be prevalent as a result of genetics, social isolation, stressful or traumatic life events, subjective indicators demonstrate that an increased sense of purpose and meaning in life can extend longevity (Selwyn et al., 2015).

**Policy options**



The use of new technologies, including monitoring systems, can support citizens to age in place and improve social inclusion but they must facilitate the connection to health and care professionals in case of need.

**4D. ACCEPTANCE BY OLDER PEOPLE**

Developing technical solutions for home monitoring requires consideration of both the older person and their care provider (formal or informal).

One factor affecting whether technologies are actually used by older people is how well they can be incorporated into the person’s daily life. Technology must be adaptable to individual lifestyles and foster individual health goals; those that are too obtrusive are less accepted.

Acceptance can only be assessed through better design, including human factors engineering, as well as usability testing with older people as integral members of the design, development and testing process.

Data privacy is very relevant to the acceptance of technology by older adults. Who has access to the information generated from technology is an important consideration for technology users of all ages? Appropriately designed systems share data only on vital signs or passive activity of the individual rather than infringing on privacy, such as recording data from cameras positioned around the home.

Technology uptake varies substantially between older people. Knowledge, affordability, ease of use, functionality, personal preferences and concerns over privacy all influence whether or not an older adult may engage with technologies that can support them to remain living at home (Peek et al., 2016; Yusif et al., 2016).

The issue of acceptance will become more acute as wearable devices become increasingly hidden through integration into fabrics and textiles. While the data recording and monitoring becomes significantly unobtrusive if the clothing itself is the sensor, there needs to be a

reminder to the older person and care providers that data is being recorded when wearing the garment. Informed consent is crucial, and easy-to-understand explanations must be given.

Current user capacities for smart devices should not be extrapolated to the future. Current older people that use smart devices have only learned to use them in old age. Future older people may have been using smart devices their whole life, but technology will continually evolve and thus usability will always remain an important concern.

### Policy options



It is important to establish patient informed consent for use of new technologies, which necessitates an explanation of how has access to their data and how it will be used.



Current user capacities for smart devices should not be extrapolated to the future. Current older people that use smart devices have only learned to use them in old age. Future older people may have been using smart devices their whole life, but technology will continually evolve and thus usability will always remain an important concern.

## 4E. GLOBAL EFFICIENCY AND PROVEN OUTCOMES

Some remote monitoring health models of care have shown clear benefits for patients with chronic disease, specifically those that incorporate patients and family members into the care team (Darkins et al., 2008). These models of care, which frequently involve remote patient monitoring, show promise in getting and maintaining patients to achieve their health care goal and, in some cases, lowering the incidence of avoidable hospitalisations and re-hospitalisations for patients with chronic conditions (Bartolini & McNeill, 2012; Sorknaes et al., 2013; Polisena et al., 2010; Boutwell & Hwu, 2009). Other models have not been able to demonstrate significant improvements (Sorknaes et al., 2013).

In Europe, but also in the US, technologies for remote homecare have been shown to be effective in small-scale studies of patients with chronic diseases, but adoption of these technical

solutions remains limited (Wootton, 2012; Zanaboni & Wootton, 2012; Lindeman, 2010). There are several obstacles to achieving widespread adoption:

- acceptance of technologies by patients and clinicians
- economically sustainable reimbursement systems
- interoperability between electronic patient record systems
- financial and technical capability to incorporate bandwidth-heavy telemedicine programs into primary care centres, clinics, and small hospitals and into the home

There have been no reported large studies that have explored the efficiency of home care delivery that has been supported by technologies in older adult cohorts.

## 4F. REGULATION AND CERTIFICATION

New types of standardisation and collaboration projects are needed to cope efficiently with the rapidly growing new industry of health-based smartphone apps, wearables and in-home health care technologies. This lack of standardisation has made it difficult to integrate data into electronic patient record systems in primary care centres.

In order to stabilise and accelerate the industrialisation of wearable electronic devices and technologies, the International Electro-technical Commission's Technical Committee 124 "Wearable electronic devices and technologies" is developing standards in this area. However, it will need strong liaisons and collaborations with other bodies to fully standardise such devices. The focus on standardisation must also encompass the transmission, processing and storage of the data generated from the wearables or from device in the home. With the increasing use of cloud-based systems, standards to ensure data privacy and security are urgently required.

As new technologies are constantly being developed, based on different hardware and software platforms, there is a need to have a standardised assessment process so that scientific evidence is generated to inform both the public but also health care agencies of which devices and systems work and which do not. Interoperability of hardware technologies and health care services is also lacking.

In 2014, an analysis was undertaken of the use of ICT for health delivery and e-health policy initiatives within 27 EU Member States. This influenced the development of an e-health roadmap that reflected national, regional, and local conditions focusing on technical imperatives but also including personalised telemedicine solutions (Currie & Seddon, 2014). An updated communication was published in 2018 (European Commission, 2019).

As health care monitoring in the home is envisaged to play a greater role in health care delivery to older adults, it is increasingly important to develop a strong evidence base of successful,

innovative solutions that can lead to scalable and sustainable home health care programmes. The Transatlantic Tele-health Research Network (Broderick et al., 2017) has developed a multinational research agenda to provide a uniform framework for identifying and rapidly replicating best practices, while concurrently fostering global collaboration in the development and rigorous testing of new and emerging telemedicine and health care technologies. The agenda incorporates health care parameters across traditional modes of care for the benefit of providers, companies, policymakers, and the international research community:

### **Transatlantic Telehealth Research Network research agenda**

(Broderick et al., 2017)

#### **Patient**

- Assessment of personal engagement in own health through the use of telehealth technologies (quantified self)
- Self-determination and motivation with regard to the use of new telehealth technologies
- Health literacy, eHealth literacy, technology literacy, contributions to design features of technology, and interaction with telehealth technologies
- Patient-to-patient interventions

#### **Home**

- Integration of smart home telehealth technologies (wellness and health devices and software, Internet of Things)

#### **Health care professionals**

- Communication for and between providers and patients (telehealth through mobile, wearable, and remote monitoring)
- Telehealth training and education, including designing communities of knowledge and practice
- Health system design, organization, and practice
- Cross-sector integration using telehealth technologies (Accountable Care Organizations, bundled care, medical homes)
- Telehealth in redesign of chronic disease management
- Adoption of telehealth programs in clinical practice

#### **Technologies**

- Use of self-tracking technologies

- Design of user-friendly technologies
- Development of sensor technologies for detection of fluid in the body, sleep patterns, etc

**Data systems and infrastructure**

- Integration of telehealth devices with electronic health records and cloud databases
- Integration of personal health records data and telehealth devices and systems

**Data analytics**

- Algorithms for multimodel data platforms, devices, and sources
- Innovative data analytic approaches for integrating data for precision medicine, including predictive, personalized, and customized analytics

**Development of new telehealth technologies**

- Assessing mobile, intelligent, and individualized telehealth technologies
- Enhancing the matching of patient preferences and telehealth use
- Anticipation of telehealth innovations still to be invented
- International telehealth technology standards

**Research methods**

- Multidisciplinary assessment of the effectiveness of new telehealth services
- Advances in tracking, data transmission, and storage of telehealth data (real-time analytics vs store-and-forward)
- Rapid cycle design evaluation vs traditional randomized controlled trials

**Financing**

- Assessing innovative payment and reimbursement systems, especially in the emerging value-based health care environment
- Global variations in financing and paying for telehealth

**Privacy and security policy**

- Addressing different cultures of privacy (ethical issues) for patients
- Enhancing telehealth data security (given advances in mobile, wearable, and cloud-based system configurations)

- Local, regional, and international regulatory requirements (licensing, guidelines, standards)

### Public policy

- Telehealth across state and international borders
- Professional licensing and standards
- Variation in intergovernmental and international telehealth policies and financing

This model outlines an approach whereby the public and private sectors can address gaps in technologies, monitoring and health provision, in order to maximise the potential for ageing at home. A global approach is critical, especially when it comes to interoperability.

### Policy options



The development of health care technologies must incorporate trustworthiness (privacy, security, safety, acceptability) and cost-effectiveness. The focus must be on designing age-friendly systems, relevant for all ages. As a principle of design, the older person should be considered as a partner of the design team from the outset, thus ensuring the system has high levels of usability but also privacy and security. Such an approach would also limit uptake of technologies being promoted without adequate science underpinning their use. Older people are particularly vulnerable to such scams and a trusted development network or certification would foster public reassurance.

Digital technologies, especially those on the borderline with consumer or wellness products, are a challenge to regulate. Appropriate uptake of technology is predicated on health care professionals being able to trust that products and services are safe. Clinical evidence, in line with that expected for similar medicines or medical devices, should be presented when the product claims demand it.

## 4G. REIMBURSEMENT AND HEALTH ECONOMICS

While technology plays a crucial role enabling ageing in place, uptake varies substantially between older people and between EU member states. Assisting health care provision using remote technology has rapidly increased in recent years, as new products are developed and consumer demand for instant access to health care increases. Indeed, the telemedicine market is expected to grow to \$113.1 billion by 2025, at an estimated compound annual growth rate of

18.8%. It is expected that at least 7 million patients in the US will access telemedicine services in 2018, a sharp increase from 2013, when the estimated number of tele-health patients was less than 350,000.

Despite this momentous growth, reimbursement continues to be a key obstacle for telemedicine providers. However, in the US, reimbursement rules by various health care providers are slowly expanding to cover more telemedicine services.

Reimbursement for equipment varies across EU states. In the UK, assistive technology and equipment for social (not health) care needs are paid for by local authorities, when items cost less than £1000. More expensive equipment is funded on a means-tested basis and according to local funding criteria. These items can be provided directly to patients, or, in some local authorities, purchased through personal budgets. In order for personal budgets to be used to purchase equipment, local authorities must be satisfied that an item is necessary to help support social care needs and will help improve specified outcomes. Personal budgets cannot cover assistive technologies or equipment items that are eligible for funding from health care budgets or housing allowances (NHS). This demonstrates the importance of funding and reimbursement schemes being flexible to both new technologies and the needs of the individual.

In cost-effectiveness analyses in health care, Quality-Adjusted Life Years are often used as an outcome measure of effectiveness. However, there is an ongoing debate concerning the appropriateness of the use of this metric for decision-making in care of older adults. The World Economic Forum has reported on the case for investment in, and integration of, innovative technologies for health by financial services institutions. It includes recommendations for collaboration across the public, private and social sectors to ensure the prosperity of current and future generations of older adults and peace of mind for their children (Global Agenda Council on Ageing, 2016).

Continued increases in the cost of health care are driving stakeholder interest in reimbursement. Investment in new health care technologies is heavily dependent on whether there is coverage, coding and reimbursement. Payers increasingly expect new technologies to demonstrate better outcomes at equal or lower costs before investment. More hospitals are establishing value analysis committees to evaluate all new products prior to entering a hospital or clinic setting. Physicians are interested in products that help them meet quality metrics imposed by government and private payers. Perhaps most importantly, patients are becoming more educated and prefer interventions that improve quality of life at the lowest cost possible.

Most importantly, reimbursement assessment for new technologies should be conducted as early in the product design and development phase as possible. Such an assessment is a snapshot of the existing coding, coverage and payment landscape for a particular product.

It informs potential innovators what reimbursement challenges and opportunities exist for adoption of the product under consideration.

As discussed above, there has been a rapidly growing consumer market of digital medicine technologies, including smartphone health and wellness apps and health-centred wearable devices. This has been a result of the surge in use of connected devices known as the Internet of Things. The advantage of this rapidly growing consumer market is that the cost of devices will continue to reduce while devices and systems reimbursement become more technically advanced.

There is the potential to prescribe devices and apps which may provide information to support clinical decision-making and accelerate hospital discharge. The challenge for the acute hospital system, but also the longer care of older adults at home, is to put processes in place to ensure data from these devices are assessed for validity, that consent to access the data is appropriate, that storage of the data is correctly managed including consideration of whether or not there are implications for the national electronic health record system.

The private sector needs clearer guidance on what exactly is expected by health care systems, in terms of data collected, quality of that data, data privacy and security as well as financial reimbursement schemes. Otherwise the development of technologies with no health based scientific evidence for their use will continue to increase.

### Policy options



There is a great deal of interest around digital technologies, but little widespread investment. A major hurdle is that existing reimbursement pathways designed for medicines, medical devices and surgical interventions do not facilitate the effective assessment and hence uptake of digital technology. They may need to be adapted and tailored.

## 4H. INTEGRATED DIAGNOSTICS AND DATA SCIENCE

The use of data science in the diagnosis of disease and management of health care has significantly expanded over the past decade. The applications of machine learning (artificial intelligence, AI) algorithms within the field of ageing research offer tremendous opportunities. Such methods applied to data acquired at a single time point and to data acquired longitudinally

can be employed to generate predictors of disease and offer new possibilities to early interventions. AI-derived biomarkers of ageing enable a holistic view of biological processes and allow for development of new methods to build causal models, extracting the most important features and identifying biological targets and mechanisms. These novel methods can be combined into a unified, seamless end-to-end biomarker development, target identification, drug discovery and real-world evidence pipeline that may help accelerate and improve pharmaceutical research and development practices (Zavoronkov et al., 2019).

Machine learning and big data analytics is considered one of the transformative drivers underway for intelligent health care delivery systems (Istepanian & Al-Anzi, 2018). New datasets, both structured and unstructured, are beginning to appear that contain formal and informal medical knowledge as well as health data. The outcomes are clear: AI will in future perform full, descriptive, diagnostic, predictive and prescriptive analytics — paving a new “path” to healthier ageing for future older adults.

However, machine learning algorithms are currently far from being useable in the delivery of safe health care. They can provide decision support, rather than taking a lead in decision making. Algorithms applied to data from wearables are typically designed for people in perfect health. People with comorbidities require devices that measure, and account for, relevant parameters, and the patients and doctors receiving the data need to be trained in correctly interpreting and using it.

### Policy options



Artificial intelligence offers tremendous potential for improving standards of diagnosis and care. While AI is a policy priority across several sectors, the ethical, legal and technical approaches must be tailored for an effective application to delivery of health care.

## 4I. UNIQUE ELECTRONIC HEALTH RECORD: INTEROPERABILITY, LEGAL AND ETHICAL ASPECTS IN EU COUNTRIES

In Europe, clinical documentation is increasingly carried out in electronic health record systems, with huge amounts of data stored in electronic format. Many European countries have invested in national e-health infrastructures, which are progressively communicating increasing volumes

of electronic health record data to support continuity of care and public health programmes: systems are defined (mostly by law) in Denmark, Finland, Israel and the UK (to a limited degree).

The technical capacity to roll out electronic health record systems already exists. However, the technical base, systems linking records, and data collected currently differ in content and formal description across countries and frequently within one country. Standards are not defined at a government level.

A unique electronic medical record within the European Union will improve patient care in several ways. As mobility between EU countries becomes more common, access to medical records in another country will likely have an impact on citizens' health.

One of the major hurdles to adoption of electronic health records in a Member State is finding an agreement across medical disciplines on the minimum data content of the electronic record. At EU level, in order to facilitate the Directive on Patient Rights in Cross-Border Health Care (European Commission, 2011), it has been proposed that a summary of a patient's health record could be presented as an extract (European Commission, 2010). The use of different languages for an electronic health record, and potential difficulties to understand the record by health care professionals in contact with a patient, represent a challenge to widespread coordinated use at European level. The European Commission announced in October 2018 that a recommendation to establish a European Electronic Health Record is part of its work programme for 2019 (European Commission, 2018b).

A European electronic health record system could contribute to the flexibility of older people to travel or live abroad and still receive somewhat co-ordinated care. Analysis of clinical data present in electronic health records across European countries will assist health authorities to propose evidence-based public health measures, as well as promote the discovery of new knowledge about diseases and effective treatments.

As the society ages, the EU will have a more heterogeneous population. To maximise the use of the electronic health record system, medical records should:

- have a common language with a minimum database that can be transferred easily from one setting to the next, so the person carries the most relevant social, functional (comprehensive geriatric assessment) and medical data between hospitals, countries or settings (including nursing homes or long-term care)
- assess treatment effectiveness and outcomes, as well as longitudinal patient monitoring
- ease recruiting of the required number of patients, with specific inclusion and exclusion criteria, for clinical studies. This is particularly the case for older people (under-representation of frail older patients in clinical trials is commonplace)

- enhance cross-country studies, improve hypothesis testing and early detection of safety risks in different health care systems across the EU

The EU project "Electronic health records for clinical research" has developed a platform that can utilise de-identified data from hospital systems, in compliance with the ethical, regulatory and data protection policies of the EU General Data Protection Regulation (Council of the European Union & European Parliament, 2016) and additional requirements of each participating country. The project could enable a scalable and flexible approach to reusing electronic health record data, which can bring safe and effective innovative medicines more quickly to the market and enrich medical research and knowledge.

Nevertheless, there are many obstacles that have to be addressed. These include:

- guarantees of patient privacy and confidentiality
- unification of legislation related to health in each country
- data storage and centralisation
- differences in clinical practices across the EU of recording data or treatment

These challenges must be carefully considered as the European Commission develops its European electronic health record proposal in 2019.

### Policy options



It is recognised that transition to an electronic health record is highly challenging within health systems, and even more so to coordinate them at EU level. The benefits of coordination, not only for receiving care abroad, make it well worth the attempt to find an agreement across social and medical disciplines on the minimum data content of the electronic record.

## 4J. EXAMPLES OF THE USE OF TECHNOLOGIES IN CARE OF OLDER PEOPLE

### *Technologies for falls*

Technologies are increasingly employed in the detection of falls risk factors (heart rate and rhythm), detection of falls and detection of an individual lying on the ground after a fall. Technologies can be wearable, implantable (e.g. loop recorder) or ambient in nature.

Technologies are further classified by whether they detect falls automatically or need to be activated.

Wearable technologies encompass two different types of hardware: inertial sensors (e.g., tri-axial accelerometer) and locating systems (GPS), or a combination of both. Ambient technologies include vision sensors (e.g., cameras), sound sensors (e.g., microphones), radar sensors (e.g. Doppler radar), infrared sensors and pressure sensors (e.g., floor sensors), or a combination of them (Lapierre et al., 2018).

Technologies that need to be activated include wall-mounted systems (e.g., warning cord) and wearable systems (e.g., wristwatch or pendant alarms linked to a 24/7 call centre). Limitations of such technologies are common: if an older adult is unconscious, confused or cognitively impaired or injured, he or she cannot activate such alarms. Moreover, 80% of older adults do not use their alarm button after a fall, due to difficulty in activating it, or for fear of disturbing carers (Fleming & Brayne, 2008; Tinetti et al., 1993). Automatic fall detection technologies (e.g., accelerometers) and implantable fall detection technologies may address this issue by detecting a fall and automatically sending an alert to a carer or a call centre. The perception of older adults toward automatic fall detection technologies is favourable (Hawley-Hague et al., 2014).

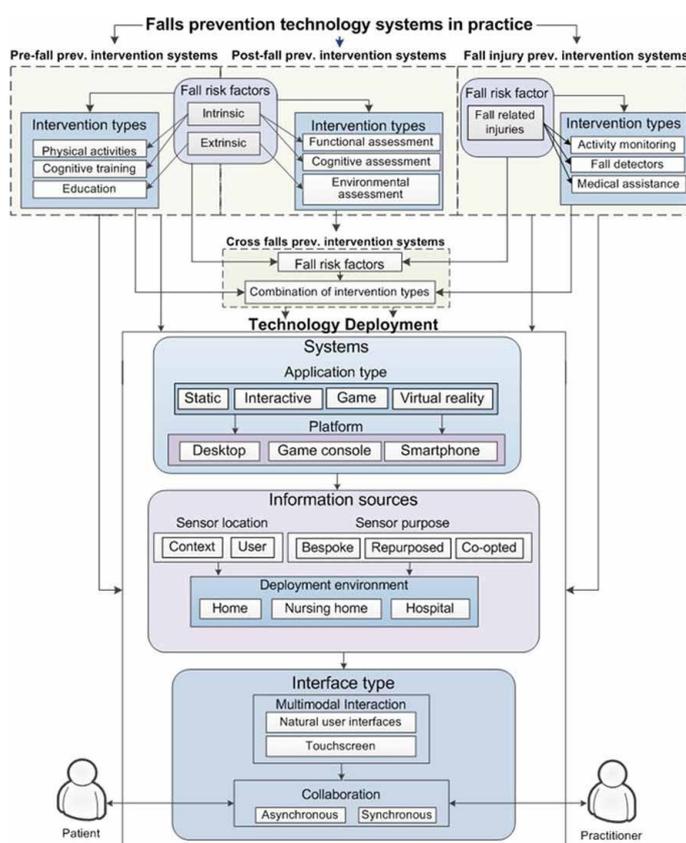


Figure 31. Falls prevention technology (Hamm et al., 2016).

*Assistive robotics*

In recent decades, assistive robotics has become a theme of research and development. The main benefit of implementing robotics is the potential to automate tasks that are often viewed as mundane or repetitive. Use of robotics has become very common in minimally invasive surgery, specifically in orthopaedic and neurosurgical procedures, and the scope of robotics in health care is expanding.

Dahl & Boulos (2014) provide an overview of current and potential applications of robotics in health and social care. This report classified robotic systems by applications and tasks, experiences, capabilities, commercialisation and platforms. Issues for successful implementation of robotics in health and social care include personalisation, user safety, reliability, robustness, sustainability, usability and user acceptance, ethical concerns, cost effectiveness, impact on the health workforce shortage and issues of liability.

Abdi et al. (2018) report on studies using socially assistive robots in the care of older adults. They identified five roles for such robots: affective therapy, cognitive training, social facilitators, companionship and physiological therapy. Besides technical challenges, the rise of assistive robotics poses ethical and sociological questions. Regulations and standards being developed focus on education and dissemination initiatives including robo-ethics and, in particular, on human-robot interaction and human dignity in assistive situations (Torras, 2016; Torras, 2018). The objective of these guidelines for students and professionals (robot designers, manufacturers and programmers) are also valuable for end users and the general public. There are other challenges with robotics in social care including acceptance and user-centred design, social impacts and issues of autonomy and control (Share & Pender, 2018).

Key needs are to recognise human intentions and build a user model so as to personalise robot skills to match the degree of mobility and user preferences (Riek, 2017). An open issue shared with other types of robots is their need to semantically 'understand' situations, instead of just reacting to them in a mere perception-action association. Several European projects address these and related technical challenges of assistive robotics (Tzovaras, 2015; European Commission, 2018d).

**Policy options**



Two areas where pilot projects are beneficial, based upon existing evidence, are technology to prevent falls and assistive robotics. Such projects should try and

identify ethical issues to address through policy before wider adoption in society in future.

## 4K. CONCLUDING REMARKS

The deployment of health care technologies will expand in the next decades and can address some of Europe's health care challenges. While these can assist in the detection and diagnosis of disease, they can also be harnessed to promote health, maintain functional ability, and extend healthy life expectancy.

Including older individuals and the health care workforce as partners in the design of health care technologies will help to offset some of the usability, data privacy and interoperability issues that are currently a concern. With increased training and education on the integration of new health care technologies and on the interpretation of data from these solutions, health care technologies have the potential to counterbalance some of the shortfall in health care workforce in future years.

### Policy options



It is vital that adoption of any new health care technology is based on scientific evidence and that such technology should redress not reinforce health care inequalities.





# Chapter 5. Intensifying skilled health workforce training

This chapter first identifies the current and near-future shortages in the health care workforce in the EU and then explores the many specific and interconnected challenges in addressing these shortages, bearing in mind that “without a health workforce, no care is possible” (Campbell et al., 2013). The increasing rate of population ageing in the EU highlights how this problem needs urgent attention from all EU policymakers and stakeholders as well as a concerted action plan from European ministries of education, health, finances and labour.

Solving the problem of workforce shortages starts with youth as well as the general public and the media, and requires changing the overall negative perception of ageing. A change in mindset is needed to improve how health care professions are valued and to drive a more ethical recruitment of health care professionals, free of discrimination on the basis of age, gender or race. In addition, education of health care professionals must be transformed by incorporating adopting vibrant and attractive training programmes and must be accompanied by the prospect of better working conditions. Acting quickly and over the long term on the aforementioned issues is essential to provide the substantially increased number of skilled health and social care professionals needed in order to care for the ageing population of the EU.

## 5A. ESTIMATING AND UNDERSTANDING THE LACK OF HEALTH AND SOCIAL CARE WORKERS IN THE EU

The health workforce embodies “all people engaged in actions whose primary intent is to enhance health” (WHO, 2016b) and includes (Eurostat, 2018e, 2018f; Skills Panorama, 2018):

- Health care professionals (physicians, nurses, midwives, paramedical practitioners, dentists, pharmacists and veterinarians), who constitute 29.6% of the total EU health workforce.
  - In 2016, there were 18 million physicians in the EU; of these, 38% were aged over 55 years, and 49% were women.
  - The number of nurses varies widely among EU countries; in Luxembourg there is 1 nurse for every 86 inhabitants, while in Romania there is one nurse for every 1526 inhabitants.
- Associate health care professionals (medical, laboratory and radiology technicians, as well as community health workers), who represent 26.6% of the total EU health workforce.

- Care workers (mainly health care assistants supervised by health professionals or associate professionals), who, together with daily logistical support (cleaning staff, ambulance drivers, etc.), correspond to 28.9% of the EU health workforce.
- Allied health professionals (administrators, lawyers, librarians, curators, architects, engineers, urban planners, etc.), who make up another 14.9% of the EU health workforce.

It is interesting to note that, in 2017, health professionals in the EU totalled 6.44 million, of which 5.3 million of these were health and social workers; moreover, only 1.8% were working in education (Skills Panorama, 2019b). Meanwhile, 70% of European health care budgets are allocated to salaries and other expenses directly related to health workforce employees (European Commission, 2008)

Among OECD countries, the increase in health workforce numbers between 2000 and 2014 reached 48%, while the agriculture and industry sectors lost a significant number of workers (James, 2016). Despite this huge increase, the estimated shortage of health care professionals in 2020 at the EU level was estimated in 2012 to reach almost 1 million; similar shortage rates concerning physicians, nurses and associated health professionals were also predicted (Insight, 2012). It was demonstrated that a close relationship exists between health workforce staffing and health outcomes, specifically in high-income settings (DeLuca & Soucat, 2013).

Health care is a complex and human resource-intensive sector. To ensure and sustain health care, a large, effective and skilled health workforce is required, not just to fulfil both the current and future needs and expectations of the population, but also to adapt to the evolving health care services provided in the EU (WHO, 2016a).

Without urgent, major and multi-targeted efforts, the shortage in the EU health workforce will continue to increase. According to WHO calculations of aggregate density, based on the number of physicians, nurses and midwives needed for every 1,000 inhabitants, in 2030 the deficit of health care professionals in Europe (51 countries) will reach 4.1 million, broken down into 0.6 million physicians, 2.3 million nurses and midwives, and 1.2 million dentists, pharmacists and associated health specialists/care providers (WHO, 2016a).

The factors shaping the health workforce crisis are well defined. In particular, three interconnected groups of factors influence health workforce robustness:

- Internal factors directly related to health care professionals themselves, who have grown older and have become overburdened and overstressed by increasingly difficult working conditions, changes in care delivery models, and skill mismatches, often without opportunities for lifelong learning or career advancement. Moreover, they often experience undervalued social status and difficulties trying to adapt their lifelong practice to new administrative constraints, leading to burn-out and professional attrition.

- Other internal factors, linked to changes in patient profiles: patients are older, requiring more complex, holistic care as they suffer from chronic diseases, multimorbidity, and loss of physical independence and autonomy. Finally, their care demands and expectations have risen considerably. Aged multimorbid patients with chronic diseases, frailty or disability and polypharmacy require a holistic care strategy consisting of coordinated and integrated care that includes polypharmacy management and emerging technology (Busetto, Luijckx, Calciolari, González Ortiz, & Vrijhoef, 2017) (Rogers et al., 2018).
- External factors closely related to the financial and management constraints of health care systems, which have planned insufficiently for the strong impact of new technology in daily care and have underestimated the need for the continuing education of their employees.

All these factors raise the difficult question of how to retain the health care workforce and improve its robustness to meet current and future needs.

## 5B. ADDRESSING THE SHORTAGE OF THE HEALTH WORKFORCE: RECRUITMENT CHALLENGES

To assure the highest possible quality of care, an optimum quantity of skilled health workers is required, which necessitates developing multiple long-term initiatives, keeping in mind that nurse accreditation takes 3–4 years of training, while general practitioners need 6–7 years of mandatory training, and specialists even more.

EU capacity-building and policy action aimed at the health workforce depends, at the national level, on the collaboration among the ministries of health, education, labour and finances of member states. Their synergic actions first need to raise sufficient funds and establish public-private partnerships for job creation, eliminating gender inequities and promoting youth employment (High-Level Commission on Health Employment and Economic Growth, 2016).

In addition, transnational collaboration will be required to rethink and adjust health services to adapt them to the new needs of the population, the mobility of health professionals and the integration of technological progresses in care delivery. In any case, careful monitoring of the health labour market is essential for adjusting and evaluating the long-term action needed (High-Level Commission on Health Employment and Economic Growth, 2016).

- Without a doubt, the initial steps for building a robust health workforce must begin in schools; the 'whole school, whole community and whole child model' demonstrated that acting on multiple educational components, from health education to health services and environment and family–community engagements, is essential for young students to develop and maintain healthy behaviours, even up to 15 years after their involvement in such

comprehensive programmes (Michael, Merlo, Basch, Wentzel, & Wechsler, 2015). However, these programmes failed to demonstrate that participating students will orient their career toward health care professions.

- School teachers and counsellors in elementary and middle schools must recognise the value of students who tend to the needs of others and exhibit academic excellence and enthusiasm for combining knowledge with specialised skills. Once these students have been identified, the potential benefits of exploring the health workforce should be suggested to them. Waiting until high school to expose students to health care professions may be too late. In any case, early exposure to health care responsibilities is a vital step in career choice, development and sustainability (Williams, 2018).
- In parallel, family members and the general public should be informed of the current evolution in health care systems and the great career opportunities that lie in this multi-component and promising domain.
- The main determinants of choosing a career in health care are, for general practitioners in the UK, firstly, personal social engagement with a holistic approach to health, as well as a lifestyle oriented toward a life-work balance. This choice is favoured by the medical curriculum of training programmes, which focus on general or family medicine practice. As mentioned earlier, the quality and duration of initial exposure to general practice, as well as the relationships with general practitioner colleagues, have a strong influence on final career decisions (Marchand & Peckham, 2017). As reported below, these criteria are similar for other health care professions, including nursing.
- Whichever the health care profession, although career choice and training is a key period, initial employment is also a decisive period, as multiple negative factors may intervene. A survey conducted among 23,000 nurses in medical and surgical wards in 10 European countries showed that 33% of nurses intended to change jobs within the next year, while 9% intended to permanently leave the profession (Heinen et al., 2013). Such results have dramatic consequences: the quality of the care provided by nurses suffering from burnout was proven to be deleterious to patient health, resulting in a higher rate of pressure ulcers, nosocomial infections and in-hospital mortality. Institutions employing nurses suffering from burnout witnessed much higher costs than those that would have been needed to improve the working conditions of their health care workers (Buchan & Catton, 2018).
- The ideal way to divert health care attrition (approximately 10% per year) driven by worker dissatisfaction is to improve the health care system itself. Reforming health service delivery appears essential to increase both the recruitment and retention of health care workers. The reform of health care services must:
  - prioritise health promotion and disease prevention;

- optimise scopes of practice, including task shifting, or the rational distribution of tasks among health care workforce teams, to allow for accessibility, equity and good quality health care services;
- build stronger linkages between health and social sectors;
- favour lifelong learning
- propose career paths with prospects for advancement.

(High-Level Commission on Health Employment and Economic Growth, 2016).

- Migration of health care workers is not the solution. Often frustrated by a weak health system infrastructure and poor living conditions in their home countries, health care workers who choose to migrate to higher income countries are attracted by the promise of higher salaries and better working conditions. Nevertheless, the loss of health care professionals from poor to rich countries is associated with high costs for the poor countries (DeLuca & Soucat, 2013). For these reasons, WHO made important efforts to promote single international standards in the attempt to regulate the worldwide migration flow of health care professionals. Not surprisingly, the recognition of foreign health care credentials appears to be the best way to monitor the international migration of health care professionals (WHO, 2014).

## 5C. ADDRESSING THE SHORTAGE OF THE HEALTH WORKFORCE: EDUCATIONAL CHALLENGES

### *Training and support of non-professional carers*

Informal caregiving is an essential part of care supply all over Europe, as older adults in many countries prefer to receive help at home from their relatives, especially in early stages of care dependency (Mair, Quinones, & Pasha, 2016).

The majority of informal carers across Europe are between 55–65 years old (Colombo et al., 2011), and often in a potential "sandwich position" between older parents and younger children and grandchildren in need of support (Grundy & Henretta, 2006). Typically, spouses, adult daughters or daughters-in-law are the primary carers. Older childless women (often also without partners) tend to compensate for a lack of support in older age by drawing on their broader social network and formal carers (Deindl & Brandt, 2017).

Informal carers assume many different responsibilities in providing care support for ill or older family members. They coordinate logistics, care management, advocacy, medical interpretation, and medical decision-making, performing many functions that professional care workers perform on a paid basis (Phillips et al., 2016).

There is a need to provide care-specific information to informal carers. Unfortunately, existing print-based carer education materials often fail to adequately match the health literacy skills and information needs of their target audience. Patient associations are very useful for sharing practical information with informal carers. Individualised, structured multicomponent interventions have shown to be a promising approach to relieve the burden of informal carers for people with dementia (Berwig et al., 2017). Exchanges and collaboration with health care professionals are also highly recommended, as well as education in health care technology, which can support in-home care.

Moreover, in order to encourage informal care, it is important to make affordable formal care alternatives available to all socioeconomic groups, which would enable an adequate care mix and facilitate the reconciliation of care, work and leisure (offering much-needed rest to carers), thereby increasing care quality and reducing care burden for all parties involved (Brandt, 2013).

### *Training of health care professionals*

Geriatric medicine is a meta-discipline that transcends and informs all other medical disciplines (Tinetti, 2016). Its knowledge base and principles should guide all health care and allied professionals involved in caring for older adults. Over the past decades, several important social and health care system changes have occurred due to the introduction of new technology, including the Internet of Things, smartphones and wearable devices. New concepts in care, such as value-based and population-based health care, consider each individual as a consumer and decision-maker in every care opportunity available. Despite these changing trends in care, unfortunately health care education has not changed (Simpson, Leipzig, & Sauvigne, 2017).

Bearing in mind that ageing represents a major EU health care priority, evidence-based geriatric education must move forward quickly to increase global health literacy, offer attractive education and training, streamline workforce planning and staffing, and improve performance management and working conditions (WHO, 2006). Addressing these domains in a comprehensive manner offers the opportunity to overcome the traditionally fragmented health care workforce approach and to fully harness the synergies of human resource interventions to thereby favour integrating health care systems across the EU.

### **Perception of ageing and care for older patients**

The most urgent need is to effect a major change in the perception of ageing and care for older patients in all health care professional schools (medical, nursing, dentistry, pharmacy, physiotherapy and social work, among others).

The previous chapters highlight how ageing is an inescapable process and how patient profiles change with age. Furthermore, as explained earlier, population ageing is a trend that will

continue to increase over the next several decades. In light of such conditions, the fact that many European health care schools, some of which are highly recognised, do not provide any training in geriatrics is a major omission. Moreover, even when undergraduate training programmes in geriatrics exist, they are often limited in hours and discredited by medical specialists who, notably, increasingly perform geriatric assessment to enhance the quality of their clinical decisions affecting aged patients. This occurs not so much in internal medicine, but increasingly in cardiology, cardio-surgery and orthopaedics.

The Geriatric Medicine Section of the Union of European Medical Specialists compiled the curricular contents used in European health care schools and performed a modified consensus Delphi process to develop a European undergraduate programme in Geriatric Medicine, which has been widely endorsed by many European countries (Masud et al., 2014). The curriculum outlines ten broad learning domains:

- Graduates should respect patients regardless of their age.
- Graduates should know about and understand normal and abnormal structure and function, including the natural history of human diseases, the body's defence mechanisms, disease presentation and responses to illness.
- Graduates should know about common medical conditions in older people.
- Graduates should have the special skills needed to conduct a history and perform an assessment in an older patient.
- Graduates should know about and understand the principles of treatment including the effective and safe use of medicines as a basis for prescription.
- Graduates should recognise the importance of responses to illness, providing support for recovery and reducing or managing impairments, disabilities and handicaps.
- Graduates should know about and understand the main ethical and legal issues in the international and national context in which they will encounter them.
- Graduates should know about, understand and respect the roles and expertise of other health and social care professionals.
- Graduates should know about care of older patients in different settings.
- Graduates should know about specific aspects relevant for health and social care for older persons in their region/country.

These recommendations for undergraduate medical programmes could easily be applied in other health care professional schooling programmes (for nurses, pharmacists, dentists, social workers, and others). A universal programme in geriatrics bringing medical students together with students from different health care professional schools would prove to be an excellent option for building competencies in an interdisciplinary way. One of the difficulties in

implementing these recommendations is that often the professors themselves lack practical clinical experience in geriatrics, and their knowledge is not sufficiently updated in the domains they teach; this is especially true in rapidly evolving fields, such as sarcopenia, frailty, early diagnosis of dementia, etc.

### **Lack of academic resources**

The lack of faculty and academic resources in geriatrics and gerontology must be addressed urgently.

In many EU countries, there is still a lack of available faculty and resources in geriatrics and gerontology to support sustainable health education with dynamic, attractive and updated curriculums. This shortcoming was partially addressed in the 1990s by the initiative of a few academic leaders who decided to 'train the future leaders in geriatric medicine in Europe' by breaking with traditional classroom teaching and offering hands-on training that built on well-defined learning objectives and incorporated the use of technological support tools (Michel, 1997). Fortunately, this initiative is still successful in Europe and continues to expand worldwide (Michel & Cha, 2015).

This programme was a precursor of later training in geriatrics, with great impact on not just health universities and schools but also on associated professional schools, in fields such as architecture, design, engineering, urban planning and management. Training in the field of ageing needs a well-balanced education that goes beyond academic knowledge and skills to also develop aptitudes for listening to and understanding the life priorities and needs of older adults, without prejudice. Mutual respect of professional competencies is absolutely essential to create synergies among multidisciplinary care teams. Interpersonal and communication skills are fundamental, as well as the ability to cooperate in flexible, competency-driven hierarchies, along with a willingness to continuously grow and update skills and knowledge.

An interesting policy option worth exploring is to formalise and support European geriatric medicine, both politically and financially. More efforts at the academic level are needed to engage general practitioners in continuing education in geriatric medicine and to actively involve younger generations in developing new approaches to caring for current and future aged adults.

### **New teaching techniques**

New teaching techniques need to be transversal and interactive. Training platforms offering case simulation to learn technical gestures on mannequins represent a first practical model that does not involve any risk for patients. Several different models are used in simulation centres that, through the repetition of gestures, teach the implementation of technical skills in the context of more comprehensive care. The results of a recent meta-analysis of 40 evaluation studies

suggest that simulation-based nursing educational interventions have strongly positive effects, particularly in the psychomotor domain. However, these need to be complemented by other more traditional educational interventions (Kim, Park, & Shin, 2016).

Training platforms involving virtual patients are interactive computer simulations that are increasingly used as learning activities in modern health care education, especially in teaching clinical decision making (Dafli et al., 2015). The shortage of geriatrician faculties, the declining lengths of inpatient hospital stays, and the increasing emphasis on competency-based learning argue for the further exploration of the role of virtual patients in geriatrics education. Virtual patients are case-based computer programs that combine textual information with multimedia elements, such as audio, graphics and animation (Tan, Mulhausen, Smith, & Ruiz, 2010). Virtual patient activities have been shown to enhance student performance during clinic visits, and students felt that virtual patients realistically simulated real patients (Taglieri, Crosby, Zimmerman, Schneider, & Patel, 2017).

Complex case simulation scenarios, followed by rigorous debriefings, contribute to patient safety, health care worker wellbeing and quality of care. Global analysis applying knowledge, skills and attitudes helps determine the major characteristics of the tasks to be simulated; for example, assessment of uncontrolled chronic pain in an aged patient implicates optimal timing of prescription of adequate medications and follow-up of outcomes when implemented in a relevant learning setting (Dieckmann & Krage, 2013). This learning model could greatly benefit geriatric medicine, where it has gone unharnessed until now. A preliminary application in clinical pharmacy yielded relatively positive results (Gustafsson, Englund, & Gallego, 2017).

When compared with no intervention, virtual patients were found to be superior, with large effect sizes seen in knowledge, clinical reasoning, and other skills. However, when compared with non-computer instruction (other simulations, standardised patients, lectures, written materials, etc.), the effect sizes of studies employing were found to be much smaller for outcomes such as satisfaction, knowledge, clinical reasoning, and other skills (Cook, Erwin, & Triola, 2010). The paucity of cost comparisons between real patients and virtual patients does not enable any conclusions to be drawn yet.

### **Information and communication technology**

The use of ICT effectively complements traditional education.

Distance-learning involves internet delivery of education using a wide variety of instructional designs, including synchronous and asynchronous formats (tele-teaching, video transmission, and teaching methods based on information and communication technology, including Massive Open Online Courses (MOOCS) and Small Private Online Open Courses (SPOOCS) (Wong, Greenhalgh, & Pawson, 2010). Many studies indicate that internetbased learning can be just as

effective as more traditional forms of education and training (WHO, 2017). However, a recent WHO-funded review of internet-based training for health care professionals found that engaging learners in an online course from start to finish is a far bigger challenge than developing on-line course design and content (WHO, 2017).

Blended teaching activities consist of a combination of self-directed learning methods entailing traditional knowledge transfer including both e-learning and classroom teaching. It facilitates learning content uptake at all stages of life-long learning. Predefining the overall topics and learning objectives, as well as detailed objectives for all learning phases, is mandatory for blended learning training to be effective. The combination of self-directed and face-to-face learning may be supported and enhanced by patient feedback for students. Integrating MOOCs into a traditional teaching activity is not so easy and involves specific requirements and training of leaders (de Jong et al., 2019). Predefining the overall and detailed learning objectives for each professional profile and for each phase of education is mandatory for sustainable educational training, in addition to the regular evaluation of support materials. The need for regularly updating course contents is exemplified by the 2010 definition of sarcopenia, which became outdated when a new definition and diagnostic criteria were published in November 2018 (Cruz-Jentoft et al., 2019).

Training health professionals in the use of algorithms for machine learning and big data can improve decision making and coordinated care. Artificial intelligence can generate relevant scientific knowledge but must be applied with operational clarity for collecting data linked with online devices while protecting personal data and understanding the rights of patients and other ethical concerns. A good example is a supervised machine-learning method that determines a "Disease State index" allowing for the prevention of dementia 10 years before its onset (Pekkala et al., 2017), or the prediction of cancer survival rate based on the measurement of normal gait speed (Sasani et al., 2019).

### **Multidisciplinary scenarios**

The use of multidisciplinary scenarios is the best and most attractive way to train geriatric teams. Geriatric care is characterised as teamwork, which is the only way of providing integrated care to aged patients. Health care professionals need to be deployed in an efficient manner that adequately shares responsibility and accountability for clinical processes and care outcomes. Geriatricians who lead and coordinate multidisciplinary teams need to define educational requirements, choose a variety of teaching methodologies, enhance competencies, and favour inter-professional work without forgetting to promote career pathways. It is the only way to prepare the next generation of health care professionals so that they may adapt their knowledge to the future care needs of patients. The only way to achieve these goals is to favour the training of different categories of health care professionals. (WHO, 2013)

Multidisciplinary scenarios and role-play training are useful for students, resident doctors and health care professionals to learn to work together to face various practical situations, for example:

- Adopting the right attitude for responding to clinical situations, e.g. when a pager message is received while on call during a nursing home rotation. The effectiveness of structured role-playing didactic sessions for different learners (geriatric medicine fellows, family medicine residents and faculty, and nurse practitioner students) has been demonstrated for all players involved (Yuasa et al., 2013).
- Developing a tactful, clear and empathetic style of communication when delivering bad news (for example, in the case of an Alzheimer's disease diagnosis or at the end of life of an aged cancer patient). Multidisciplinary training aims at developing skills with authentic, real-life applications and improves the ability to speak in terms that both patient and family members can understand. These exercises allow for the discussion of ethical questions regarding autonomy, dignity and respect of the patient through shared decisions, taking into account the patient's life priorities, fears and expectations (Spear, Guillen, Elliott, Roettger, & Zukowsky, 2013).

Co-construction of shared learning between patients and professionals is desirable and appreciated. Sharing and understanding patient experiences is an important contribution to training health care professionals. Thus, co-teaching joins patients and health care professionals to learn together and exchange points of view, feelings and expectations of each other. Such innovative programmes must pedagogically address the questions of specific objectives and characteristics of the integrated education of health care workers and patients. Research on standard and validated methods to obtain and harness the value of patient experiences should be developed and assessed (van de Pol et al., 2017).

These new multidisciplinary training methods emerge as the most effective tools for building a solid team capable of delivering the best quality care possible to older adult patients with complex medico-psycho-social conditions.

### **Alignment with previously trained professionals**

Alignment is needed between new models of care and previously trained health care professionals.

The high rate of burnout and attrition among health care professionals is often linked to their dissatisfaction or frustration with the health care system in which they work. Alignment between the hopes and wishes of the health workforce is often in discordance with increasingly compulsory administrative burdens and constant economic constraints. National, regional and local health care administrations are not always aware of the numerous changes that health

care professionals have had to face during the last few decades: older, complex and dependent patients with increasing consumer demands; spectacular advances in medical and scientific knowledge; the introduction of high technology in daily care; the development of new treatment methods; and the reinforcement of health promotion.

These rapid and continuous changes in the role of health care professionals strongly necessitate the need for a lifelong learning programme with regular and mandatory re-certification, at least every five years.

**Figure 32.** *Fig ??: Alignment between new models of care and previously trained health care professionals (Prof. Jean-Pierre Michel, designed for the TFA report)*

The patient needs and demands of today are more and more specific. Complementary training enabling task shifting is essential, allowing for career advancement. Among the numerous other training opportunities possible in geriatrics, two are briefly described below.

### **Training of long-term care workforce**

Long-term care for all ages is based on the existing geriatric care model, which includes: leadership committed to combating ageism, reliable use of evidence-based care in favour of advanced care planning, and identification of surrogate decision makers. Furthermore, it includes regular evaluation of staff members who are specifically trained and proficient in the care of older adults, and, finally, high-performing care teams focused on measurable outcomes.

Older adults accessing long-term care wards should expect a minimum level of knowledge from all their providers, and not just from those who provide direct, hands-on care. Care often focuses merely on the “basic needs of residents” rather than on their individual preferences so as to ensure wellbeing, a meaningful life and respect. This may, for instance, be achieved by introducing variety in daily activities and offering stimulating and diverse environments. Moreover, long-term care staff members would benefit from cultural competency training. Specific long-term care issues are often lacking in classical education programmes for physicians and nurses, such as elder abuse identification, mouth care, pressure-ulcer prevention and management and coping mechanisms for dealing with behavioural and/or psychological disorders in demented patients, etc.

The earliest possible integration of such long-term care challenges and more attractive transversal training programmes, with multidisciplinary case simulations and greater overall involvement of nurse practitioners in medical and nursing education, are urgently needed (Donaldson & Vacha-Haase, 2016).

## Training in palliative medicine and end-of-life care

Over the past few decades, the majority of aged populations have experienced prolonged burdensome chronic diseases and functional decline at the end of life, necessitating increased long-term care. This explains why older adults die more frequently in institutional settings, despite their preference for dying at home (Fleming et al., 2017). These changing patterns preceding death in older adults require a shift in approaches to care at the end of life (Prsic & Teno, 2017).

Integrating palliative care education into all health care systems is essential to respond more effectively to alleviate the burden of pain, suffering, and severe distress associated with life-threatening or life-limiting conditions. A recent survey demonstrated the need for all health care professionals to improve management of pain and other physical and psychological symptoms in the final hours and days of life, cope with requests to hasten death, handle vital prognosis, address spiritual needs, and, in general, better manage the final hours and days of life (Carroll, Weisbrod, O'Connor, & Quill, 2018).

## 5D. ADDRESSING THE SHORTAGE OF THE HEALTH WORKFORCE: SUSTAINABILITY AND RETENTION

As discussed earlier, the factors that influence the retention of health care workers are complex and interrelated. They are shaped by:

- cultural and educational roots
- family background
- financial rewards often linked to the potential benefits of continuing education in institutions where career advancement is possible
- employment organisation and human resources management, which play a role even more important than clinical infrastructure
- recognition and appreciation of the work performed, as well as the possibility of task sharing and shifting, often in close relation with mentoring and relationships with colleagues on the team (WHO, 2010).

What appears clear is that worker retention depends on a set of individual factors and choices or preferences. Care organisations can only propose a range of administrative options or interventions: financial incentives, flexibility of working hours, career ladder, lifelong education, etc. Closing the gap between the internal and external factors is left to the management team who plays essential roles for retaining the health workforce.

'Magnet' hospitals and care facilities (Buchan & Catton, 2018), in which health care organisations, encompassing both administrative and health professionals, attract and retain highly qualified health professionals and care workers, thus allowing for the best quality-price ratio possible, are based on the criteria of:

- supportive and participatory management
- adequate staffing
- flexible working schedules
- clinical career opportunities
- professional autonomy and responsibility
- in-service continuing education

This section has prioritised many of the workforce problems common to health care institutions in all EU countries, over the important topic of geographical regions that are underserved in terms of health care. Personal and family choices undoubtedly interact with professional decisions. Cultural roots within regions also must be considered, as well as 'pre-service' education, requiring health care candidates to evaluate whether they have the sufficient personal skills and attributes (confidentiality and communication abilities) to cope with the balance between work and leisure that awaits them and, at the same time, to serve the care demands of the local community. These points are critical, as very often regions that are underserved in terms of health care have the poorest community infrastructures and are neglected by central governments.

## 5E. ATTESTING TO THE ROLE OF THE HEALTH WORKFORCE AS THE CENTRE OF ROBUST HEALTH SYSTEMS

Several strands of evidence demonstrate the truth of the WHO statement that "the health workforce is the backbone of strong, resilient health systems" (High-Level Commission on Health Employment and Economic Growth, 2016):

- Good health contributes to economic growth; one extra year of life expectancy was shown to raise steady-state GDP by about 4% (Bloom, Canning, & Sevilla, 2004)
- Investments in health systems enhance inclusive economic growth, including job creation; an additional 2% GDP investment in education, health and social service has increased overall employment rates by 2.4 to 6.1% (International Trade Union Confederation, 2016).

- Expenditures on health are associated with productivity gains in other sectors; health sector development has had a greater effect on manufacturing than financial development itself (Rajan & Zingales, 1998)

For all of those reasons, recruiting, developing and maintaining a skilled health care workforce needs a strong political boost, including coordinated actions among the ministries of health, education, labour and finances of all EU member states. A new and improved alignment between the needs, demands and expectations of the ageing population, and an adequate number of skilled health professionals responsible for their care, are absolutely essential.

Changes in the perception of ageing must take place immediately, beginning in primary school and continuing through associated professional education in fields such as architecture, engineering and urban planning, without neglecting the crucial and positive impact that the media may have.

Public perception of ageing constitutes a major priority, keeping in mind that, overall, Europe (51 countries) will suffer from a deficit of 4.1 million health workers by 2030. To address this impressive challenge, public and private partnerships must be quickly established to develop vibrant, blended and sustainable inter-professional workforce education programmes with personalised support, lifelong learning, certifications and re-certifications. Furthermore, an attractive career ladder and appropriate opportunities for easing the burden of the underserved regions in all EU countries are desperately needed.

## 5F. CONCLUSION

Health care corresponds to a complex and human resource-intensive sector. An adequate number of skilled health professionals is needed to assure an optimum functioning of health care services. However, the health workforce in Europe is currently facing a shortage linked to multiple factors, including the ageing of health care professionals, the new needs and expectations of a growing number of aged patients with complex conditions, and difficulties in adapting to new health care services, including increasing high technology in management and care delivery. Currently, the EU is lacking almost 1 million health care workers, a trend that will exponentially worsen until 2030, when a shortage of almost 4.1 million health care professionals is expected in the whole Europe. Multiple strategies are required to overcome this crisis:

**Policy options**



Without urgent, major and multi-targeted efforts, the shortage in the EU health workforce will continue to increase. The attractiveness of a career in health and social care for older people is in serious need of a boost to drive an improvement in quality and satisfaction while tackling shortages. A new and improved alignment between the needs, demands and expectations of the ageing population, and an adequate number of skilled health professionals responsible for their care, is essential.



Health education should start as early as possible, ideally at primary school, given that many habits are formed at a young age that impact our health in later life; especially concerning nutrition and exercise.



The most urgent need is to effect a major change in the perception of ageing and care for older patients in all health care professional schools (medical, nursing, dentistry, pharmacy, physiotherapy and social work, among others).

Transnational collaboration will be required to rethink and adjust health services to adapt them to the new needs of the population, the mobility of health professionals and the integration of technological progresses in care delivery.

New teaching techniques need to be transversal (medical, dentistry, pharmacy and nurses), interactive and make use of e-learning to a greater extent.

All health care workers should receive an education in gerontology considering the increasing frequency of exposure to older patients.



A lifelong learning approach to training and education of health care and long-term care workers should be put in place as well as the clear establishment of career

ladders. Learning can be targeted where appropriate such as updated training for GPs on prevention to ensure that public information campaigns and advice offered to citizens is up to date.

# Conclusions

Following a period of remarkable demographic transition in Europe, characterised by increased life expectancy, decreased fertility and sweeping changes in societal and economic structures, the ageing of European populations now demands immediate attention from EU policymakers, in order to improve the prospects of current and future ageing for EU citizens. From a broad scientific perspective on public health, the present Evidence Review Report has provided the most scientifically solid arguments available to help policymakers answer the following questions:

- How can public health policy best organise efficient prevention, control and treatment of early and midlife risk factors, to ensure that people have good functional ability when they enter old age?
- What measures are needed to enable health care systems to face the challenges posed by the current generation of aged adults?

In its response to the aforementioned questions, the report highlights various evidences, from which the following main conclusions can be drawn:

- Although common processes of ageing appear to be involved in the aetiology of many diseases, aged populations exhibit high heterogeneity. The functional approach to ageing considers both the various individual determinants of health and the surrounding life circumstances of each individual and their interactions. For this reason, “healthy ageing” as used by the World Health Organisation, which aims to develop and maintain functional ability, serves as a good goal.
- A life course approach, which identifies opportunities throughout life to reduce the risk of chronic clinical conditions and age-related disability, proves particularly useful. To counter the widening gap in health outcomes over time, comprehensive preventive interventions early in life should be complemented with others at each point of the life cycle; midlife emerges as a period of particular importance.
- Ageism (age-based stereotypes, prejudice, and discrimination) and adultism (the power that the older generations have over the younger generations) are key issues to tackle, bearing in mind the growing population of older people in the EU. Fighting against age discrimination implies actions at different levels and by different players, including laws and regulations at both national and European levels.

- The all-important concept of costs constrained and the internalisation of costs and benefits are essential when developing health and social care policy. In this sense, the potential benefits of preventive measures must be considered in the long term.
- Certain global environmental health challenges and lifetime risk factors are common to many aspects of healthy ageing and age-related diseases, and many of these risk factors are modifiable through intervention, although individual responses may vary. Thus, health promotion and preventive strategies need to be assessed for their effectiveness on multiple rather than single outcomes, or targeted towards risk factors or protective factors that have a wide breadth of effect.
- Health education and health promotion programmes focused on diet, exercise and lifestyle are key for reaching a more equitable balance between health promotion, targeted intervention, and treatment. Furthermore, such programmes shift the balance of individual and societal responsibilities in achieving healthy ageing.
- Health care systems need to effectively measure function in order to prevent its loss during ageing, which would also lessen multimorbidity, a major challenge facing older people. This would also help reduce the utilisation of health services, as well as hospital admissions and stays. The application in acute care settings of a geriatric model of care, with comprehensive geriatric assessment, nutritional intervention, reduction of polypharmacy and inappropriate drug prescriptions, would prove effective in improving outcomes over the long term.
- Ageing at home is, for many, vastly preferred over long-term care institutions. However, its success depends on many things: collaboration between informal (not professional) and formal (professional) care networks; all-age communities that support the integrated and active lives of aged citizens; non-discriminatory policies for older drivers; and appropriate financing models.
- Long-term care institutions emerge as a more attractive alternative if they are properly 'de-institutionalised' to deliver patient-centred care in friendly surroundings. Developing a palliative care culture in all care facilities is fundamental, and advance care planning may be an effective way to avoid unnecessary transfer to emergency wards.
- Technology will play a revolutionary role in the care delivery systems of the future, and new tools, such as those enabling the lifelong tracking of functional health, can help detect and diagnose disease, maintain functional ability and improve healthy life expectancy. However, the adoption of any new health care technology must be based on scientific evidence, must address concerns about usability, data privacy and interoperability and must not reinforce health care inequalities.
- Overcoming the increasing shortage of skilled health care professionals in Europe is needed to meet the health and social care needs of current and future aged populations, and it requires collaboration among ministries of education, health, finances and labour, as well as

the private sector. Geriatric care will benefit from promoting health care education early and throughout primary and secondary schooling, including principles of geriatric medicine in all health care professional education programmes to favour multidisciplinary training, and introducing new technology, blended teaching, online learning, virtual patients and case simulations in health care education.





## Annex 1: Working Group members

- Professor Jean-Pierre Michel, Geneva University (France, Switzerland), **Chair**
- Professor Diana Kuh, University College London (United Kingdom), **Vice-Chair**
- Professor Rose Anne Kenny, Trinity College Dublin (Ireland), **Vice-Chair**
- Professor Richard Reilly, Trinity College, The University of Dublin (Ireland), **Vice-Chair**
- Professor Liat Ayalon, Bar Ilan University (Israel)
- Professor Axel Boersch-Supan, Max Planck Institute for Social Law and Social Policy (Germany)
- Professor Jacques Bringer, Université de Montpellier (France)
- Professor Alfonso Cruz Jentoft, Hospital Universitario Ramón y Cajal (Spain)
- Associate Professor Giovanni Gambassi, Università Cattolica del Sacro Cuore (Italy)
- Associate Professor Alan J. Gow, Heriot-Watt University (United Kingdom)
- Professor Tomasz Grodzicki, Jagiellonian University Medical College (Poland)
- Professor Lenka Lhotska, Czech Technical University in Prague (Czech Republic)
- Dr. Ekaterina L. Markova, Institute for the Study of the Societies and Knowledge (Bulgaria)
- Professor Rytis Maskeliunas, Kauno Technologijos Universitetas (Lithuania)
- Professor Carlo Patrono, Catholic University School of Medicine (Italy)
- Professor Lene Juel Rasmussen, University of Copenhagen (Denmark)
- Prof. Regina Roller-Wirnsberger, Medical University of Graz (Austria)
- Professor Archana Singh-Manoux, INSERM (France)
- Professor P. Eline Slagboom, Leiden University Medical Centre (The Netherlands)
- Professor Anne Pieter van der Mei, Maastricht University (The Netherlands)
- Professor Leo J.G. van Wissen, Netherlands Interdisciplinary Demographic Institute NIDI, University of Groningen, (The Netherlands)
- Professor Jose Vina, University of Valencia (Spain)

*Professor Graham Watt, University of Glasgow (United Kingdom) opted to withdraw his name from the working group due to his dissent concerning certain omissions in the topics covered.*



## Annex 2: External contributing experts

In the drafting process of this report, the Working Group Chair and Vice-Chairs identified certain areas of expertise for which the Working Group could benefit from external advice. Therefore, it was decided to invite external (to the Working Group) contributing experts with expertise and scientific excellence in the identified areas to contribute to writing certain sections.

- Rodd Bond, Netwell CASALA Reserch Centre, Dundalk Institute of Technology (Ireland)
- Professor Jean Bousquet, University of Montpellier (France)
- Professor Martina Brandt, TU Dortmund (Germany)
- Dr. Sophie Brooks, London School of Hygiene and Tropical Medicine (United Kingdom)
- Dr Eileen Burns, Leeds Teaching Hospitals NHS Trust (United Kingdom)
- Associate Professor Matteo Cesari, Università di Milano (Italy)
- Dr. Jonathan Cylus, European Observatory on Health Systems and Policies, London School of Economics & Political Science and London School of Hygiene and Tropical Medicine (United Kingdom)
- Dr. Frances Dockery, Beaumont Hospital (Ireland)
- Professor François Eisinger, Institut Paoli-Calmettes (France)
- Judith Kaschowitz, TU Dortmund (Germany)
- Professor Tahir Masud, Nottingham University Hospitals NHS Trust (United Kingdom)
- Associate Professor Jochen O. Mierau, University of Groningen — Aletta Jacobs School of Public Health (The Netherlands)
- Professor Ursula Müller-Werdan, Charité — Universitätsmedizin Berlin (Germany)
- Professor Denis O'Mahony, University College Cork (Ireland)
- Professor Aydan Oral, Istanbul University (Turkey)
- Professeur André Laurent Parodi, Président honoraire de l'Académie nationale de Médecine et de l'Académie vétérinaire de France (France)
- Professor Graham Pawelec, University of Tübingen (Germany)
- Professor Alberto Pilotto, University of Bari (Italy)
- Professor Emma Reynis, University of Stirling (United Kingdom)
- Professor Nils-Eric Sahlin, Lund University (Sweden)
- Professor Avan Aihie Sayer, Newcastle University (United Kingdom)
- Professor Matthias Schwannauer, The University of Edinburgh (United Kingdom)
- Professor Stephen Stansfeld, Queen Mary University of London (United Kingdom)
- Professor Timo E Strandberg, University of Helsinki, University of Oulu, Center for Life Course Health Research (Finland)
- Professor Carme Torras, Institut de Robòtica i Informàtica Industrial (CSIC-UPC) (Spain)
- Professor Patrice Tran Ba Huy, La Société Française d'ORL (France)
- Dr. Melanie Wagner, Max Planck Institute for Social Law and Social Policy (Germany)
- Gemma Williams, European Observatory on Health Systems and Policies (United Kingdom)



## Annex 3: Discussion workshop and participants

A key milestone during preparation of this report was a one-day expert workshop that took place on 7 December 2018 in Brussels. This workshop brought together the SAPEA Working Group members and external experts. The aim of this workshop was to discuss and review the key findings of the SAPEA report, and to identify points to prioritise in SAPEA's report and in the Scientific Opinion of the European Commission's Group of Chief Scientific Advisors. The workshop participants discussed the draft report in terms of the feasibility and practical applicability of its conclusions to transforming the future of ageing.

The experts were provided with some guiding questions (see below) and the draft report in advance of the workshop to familiarise themselves with the content. They were asked to address questions raised in the draft report, areas of disagreement, relevant points that may have been omitted, inaccuracies that required correction, and evidence which may have been missed in the literature presented.

In total, there were 37 participants at the workshop, with twelve external experts invited and selected based on their applied knowledge and experience in this field. A workshop report is available at [sapea.info/ageing](http://sapea.info/ageing).

### *Guiding questions for external experts*

General remarks:

- Does the report/section answer the question in the scoping paper?
- Does it use the appropriate and up-to-date evidence?
- Are there any gaps in terms of the evidence that is covered within the selected topics?
- Are there any crucial omissions in terms of the selected topics?
- Is the report accessible to a wide audience, especially to policy-makers?

Remarks linked to the policy options:

- Are the options presented sufficiently backed up by scientific evidence?
- Can the options presented be implemented at policy level?
- At what scale can the options presented be implemented? At EU level? National levels? And within what timeframe?

- Are there important trade-offs to consider?
- Could part of what is proposed from a scientific evidence perspective be more feasible and desirable? Are some options more feasible and desirable than others?

The SAPEA Working Group took into account the comments made and reshaped the report in light of them.

### ***Workshop participants***

- Dr. Edvard Beem, Joint Programming Initiative on More Years Better Lives (The Netherlands)
- Ms. Marta Beck-Domzalska, Eurostat, European Commission
- Professor Ilaria Bellantuono, Sheffield University (UK)
- Dr. Mirko de Melis, Medtronic
- Mr. Maarten Eisema, University of Groningen (The Netherlands)
- Professor Chris Hankin, ACM Europe Council, Imperial College London (UK)
- Ms. Barbara Kerstiens, DG Research and Innovation, Unit E4: Noncommunicable diseases and the challenge of healthy ageing, European Commission
- Professor Pierre Lefebvre, University of Liège (Belgium)
- Professor Stefania Maggi, Italian National Council for Research (Italy)
- Mr. Ettore Marchetti, DG EMPL, Unit C.2: Modernisation of social protection systems, European Commission
- Dr. Jochen Mierau, University of Groningen (The Netherlands)
- Professor Christine Milligan, Lancaster University (UK)
- Ms. Birgit Morlion, DG CNECT, Unit H3: eHealth, Wellbeing and Ageing, European Commission
- Professor Ursula Müller-Werdan, Charité Hospital, Berlin (Germany)
- Dr. Amalia Munoz Pineiro, Joint Research Centre, European Commission
- Ms. Anne Sophie Parent, AGE Platform EU (Belgium)
- Professor José Manuel Ribera Casado, Spanish Academy of Medicine, Universidad Complutense de Madrid (Spain)
- Professor John Rowe, Columbia University (USA)

The following experts did not attend the workshop but provided helpful written feedback on the draft report:

- Professor Clemens Tesch-Römer, German Centre of Gerontology (Germany)
- Professor Alan Walker, University of Sheffield (United Kingdom)



## Annex 4: Glossary of terms

Amino acids	Amino acids are the building blocks of proteins. A large proportion of cells, muscles and tissue is made up of amino acids, meaning they carry out many important bodily functions, such as giving cells their structure. They also play a key role in the transport and the storage of nutrients. Amino acids have an influence on the function of organs, glands, tendons and arteries. They are furthermore essential for healing wounds and repairing tissue, especially in the muscles, bones, skin and hair as well as for the removal of all kinds of waste deposits produced in connection with the metabolism.
Amyloid cascade hypothesis	This hypothesis posits that the deposition of the amyloid- peptide in the brain is a central event in Alzheimer's disease pathology
Anaemia	A deficiency of red blood cells or haemoglobin in the blood, resulting in pallor and weariness
Androgen Deprivation Therapy	Also called androgen suppression therapy. It is an antihormone therapy mainly used in treating prostate cancer.
Anorexia	Anorexia nervosa is a psychiatric illness characterised by maintaining a low body weight, caloric restriction, and body dissatisfaction. Often times, people suffering from anorexia experience a distorted body image, seeing themselves as overweight even when they are significantly underweight. Anorexia nervosa can also be accompanied by binge eating and purging.
Antihypertensives	Antihypertensive drugs comprise several classes of compound with the therapeutic intention of preventing, controlling, or treating hypertension.
Apolipoprotein E (ApoE)	A class of proteins involved in the metabolism of fats in the body. It is important in Alzheimer's disease and cardiovascular disease.
Arrhythmia	An arrhythmia describes an irregular heartbeat — the heart may beat too fast, too slowly, too early, or irregularly
Atherosclerosis	A disease in which plaque builds up inside the arteries. Arteries are blood vessels that carry oxygen-rich blood to the heart and other parts of the body.
Atrial fibrillation	An irregular and often rapid heart rate that can increase the risk of stroke, heart failure and other heart-related complications.
Benign paroxysmal positional vertigo	Benign paroxysmal positional vertigo (BPPV) is one of the most common causes of vertigo — the sudden sensation of spinning or that the inside of the head is spinning. Benign paroxysmal positional vertigo causes brief episodes of mild to intense dizziness. Benign paroxysmal positional vertigo is usually triggered by specific changes in the position of the head.
Benzene	Benzene is a colourless, sweet-smelling chemical that can be derived from natural gas, crude oil, or coal. Benzene is primarily used as a feedstock to make other industrial chemicals. Benzene is also used as a solvent in the chemical and pharmaceutical industries.
Beta carotene	The yellow/orange pigment that gives vegetables and fruits their rich colours.
Beta-hydroxy-beta-methylbutyrate (HMB)	Beta-hydroxy beta-methylbutyrate (HMB), a metabolite of the essential amino acid leucine, is one of the latest dietary supplements promoted to enhance gains in strength and lean body mass associated with resistance training. Unlike anabolic hormones that induce muscle hypertrophy by increasing muscle protein synthesis, HMB is claimed to influence strength and lean body mass by acting as an anticatabolic agent, minimising protein breakdown and damage to cells that may occur with intense exercise.
Biliary tract	Refers to the liver, gall bladder and bile ducts, and how they work together to make, store and secrete bile.
Bioimpedance	Bioimpedance characterises the electrical properties of the body (or other biomaterials), e.g. to what extent the body is a good conductor for electric currents. Bioimpedance is a measure of how well the body impedes electric current flow. Fat has high resistivity, blood lower resistivity.
Bisphenol A	An industrial chemical compound C <sub>15</sub> H <sub>16</sub> O <sub>2</sub> that is a component especially of hard plastics (such as polycarbonate) and epoxy resins.

Blue Zones	Specific geographic areas where an extraordinary number of people live long and healthy lives. Inhabitants in these areas routinely live to 100 and beyond.
Bronchial hyperreactivity	A state characterised by easily triggered bronchospasm (contraction of the bronchioles or small airways). It is a hallmark of asthma and also occurs frequently in people with COPD.
Bronchopulmonary dysplasia	Bronchopulmonary dysplasia (BPD) is a form of chronic lung disease that affects new-borns (mostly premature) and infants. It results from damage to the lungs caused by mechanical ventilation (respirator) and long-term use of oxygen. Most infants recover from BPD, but some may have long-term breathing difficulty.
Cachexia	Cachexia is a "wasting" disorder that causes extreme weight loss and muscle wasting, and can include loss of body fat. This syndrome affects people who are in the late stages of serious diseases like cancer, HIV or AIDS, COPD, kidney disease, and congestive heart failure (CHF).
cardiometabolic	Concerning both heart disease and metabolic disorders such as diabetes
Cardiopulmonary Resuscitation (CPR)	Cardiopulmonary resuscitation (CPR) is an emergency technique used to help someone whose heart and/or breathing has stopped.
Cardiovascular	1: of, relating to, or involving the heart and blood vessels; 2: used, designed, or performed to cause a temporary increase in heart rate.
Cardiovascular disease	Cardiovascular disease (CVD) is a class of diseases that involve the heart or blood vessels.
Cerebrospinal fluid	Is a clear, colourless body fluid found in the brain and spinal cord. It is produced by the specialised ependymal cells in the choroid plexuses of the ventricles of the brain, and absorbed in the arachnoid granulations.
Cerebrovascular disease	Cerebrovascular disease refers to a group of conditions that can lead to a cerebrovascular event, such as a stroke. These events affect the blood vessels and blood supply to the brain.
Chronic otitis media	Chronic otitis media is a chronic infection of the middle ear cavity. It is caused by an ongoing inflammatory response within the middle ear, and is typically associated with unresolved and resistant bacterial infections.
Clostridium	A group of anaerobic bacteria (bacteria that thrive in the absence of oxygen). There are 100+ species of Clostridium.
Clostridium difficile	Clostridium difficile, also known as C. difficile or C. diff, is bacteria that can infect the bowel and cause diarrhoea. The infection most commonly affects people who have recently been treated with antibiotics. It can spread easily to others. C. difficile infections are unpleasant and can sometimes cause serious bowel problems, but they can usually be treated with another course of antibiotics.
Cytomegalovirus (CMV)	Cytomegalovirus (CMV) is a common virus that can infect almost anyone. Once infected, the body retains the virus for life but it remains asymptomatic. CMV is cause for concern in pregnant or immunocompromised persons. A woman who develops an active CMV infection during pregnancy can pass the virus to her baby, who might then experience signs and symptoms. For people with compromised immunity, especially due to organ transplantation, CMV infection can be fatal. CMV spreads from person to person through body fluids, such as blood, saliva, urine, semen and breast milk. There's no cure for the virus. However, medications can help treat new-borns and people with weak immune systems.
Demyelination	Myelin is an insulating material coating parts of most nerve cells. When it's worn away or damaged, nerves can deteriorate, causing problems in the brain and throughout the body. Damage to myelin around nerves is called demyelination.
Diabetes mellitus	Diabetes mellitus (or diabetes) is a chronic, lifelong condition that affects the body's ability to use the energy found in food. There are three major types of diabetes: type 1 diabetes, type 2 diabetes, and gestational diabetes.
Diethylstilbestrol	Diethylstilbestrol, or DES, is a synthetic (man-made) form of the female hormone oestrogen.
Diuretics	Diuretics, also called water pills, are medications designed to increase the amount of water and salt expelled from the body as urine. There are three types of prescription diuretics. They're often prescribed to help treat high blood pressure, but they're used for other conditions as well.
Dual Energy X-ray Absorptiometry (DXA)	Dual X-ray Absorptometry. A technique for scanning bone and measuring bone mineral density (BMD). DXA is relatively easy to perform and the amount of radiation exposure is considered low. DXA is also called dual energy X-ray absorptometry or DEXA.
Dyslipidaemia	Refers to unhealthy levels of one or more kinds of lipid (fat) in the blood. Dyslipidaemia usually means that low-density lipoprotein (LDL) levels or triglycerides are too high. It can also mean high-density lipoprotein (HDL) levels are too low.

Dysphagia	Difficulty swallowing (dysphagia) means it takes more time and effort to move food or liquid from the mouth to the stomach. Dysphagia may also be associated with pain. In some cases, swallowing may be impossible. Persistent dysphagia may indicate a serious medical condition requiring treatment. Dysphagia can occur at any age, but is more common in older adults.
Dyspnoea	Shortness of breath can be a symptom of health problems, often related to heart or lung disease.
Epigenetics	Epigenetics involves genetic control by factors other than an individual's DNA sequence. Epigenetic changes can switch genes on or off and determine which proteins are transcribed.
Epigenome	A multitude of chemical compounds that can tell the genome what to do. The human genome is the complete assembly of DNA (deoxyribonucleic acid)-about 3 billion base pairs — that makes each individual unique.
Etiologic/ aetiology	Assigning or seeking to assign a cause
Focal cerebral ischemia	Occurs when a blood clot has blocked a cerebral vessel. Focal cerebral ischemia reduces blood flow to the particular brain region, increasing the risk of cell death to that area. It can be either caused by thrombosis or embolism.
Gait speed	Also known as walking speed. Gait speed is a quick, inexpensive, reliable measure of functional capacity with well-documented predictive value for major health-related outcomes.
Gastrointestinal Infection	Gastrointestinal infections are viral, bacterial or parasitic infections that cause gastroenteritis, an inflammation of the gastrointestinal tract involving both the stomach and the small intestine. Symptoms include diarrhoea, vomiting, and abdominal pain.
Gerontology	Gerontology is the study of the social, cultural, psychological, cognitive, and biological aspects of ageing.
Gestational hypertension	Also referred to as pregnancy induced hypertension. It is characterised by high blood pressure during pregnancy.
Glaucoma	A disease that damages the eye's optic nerve. It usually happens when fluid builds up in the front part of the eye and increases the pressure.
Helicobacter pylori	Helicobacter pylori (H. pylori) is a type of bacteria that can cause ulcers in stomach lining or the upper part of the small intestine. For some people, an infection can lead to stomach cancer.
Homeostatis	Any self-regulating process by which biological systems tend to maintain stability while adjusting to conditions that are optimal for survival.
Human papillomavirus (HPV)	HPV is a group of more than 150 related viruses. HPV is named for the warts (papillomas) some HPV types can cause. Some other HPV types can lead to cancer. Men and women can get cancer of mouth/ throat, and anus/rectum caused by HPV infections. Men can also get penile HPV cancer. In women, HPV infection can also cause cervical, vaginal, and vulvar HPV cancers. Vaccines can prevent infection with the types of HPV that most commonly cause cancer.
Husbandry	The cultivation or production of plants or animals or the scientific control and management of a branch of farming and especially of domestic animals
Hyperglycaemia	High blood sugar (glucose) level
Hypoperfusion	Decreased blood flow through an organ
Hypotension	Low blood pressure
hypothalamic pituitary adrenal (HPA) axis	The HPA axis is responsible for the neuroendocrine adaptation component of the stress response.
Hypothalamic-pituitary-gonadal (HPG) axis	The HPG axis plays a critical part in the development and regulation of a number of the body's systems, such as the reproductive and immune systems. Fluctuations in this axis cause changes in the hormones produced by each gland and have various local and systemic effects on the body.
Hypoxia	Lack of oxygen
Iatrogenic	Induced inadvertently by a physician or surgeon or by medical treatment or diagnostic procedures
Immunosenescence	Refers to the gradual deterioration of the immune system brought on by natural age advancement. It involves both the host's capacity to respond to infections and the development of long-term immune memory, especially by vaccination.

Ischemic	A condition in which there is insufficient blood flow to one of the body's organs, most often caused by an atherosclerotic plaque in the artery supplying that organ. An organ subjected to ischemia is referred to as being ischemic.
K4Care	An integrated knowledge-based intelligent technology is being made available to help in the management and provision of health care services to chronically ill patients anytime and anywhere through the Web. The K4CARE project involved the joint effort of 4 technological institutions and 7 health care centres. This consortium combined experiences of old and new EU countries to define a new health care model for care of elderly people. New knowledge-based ICT technologies were researched, developed and integrated in a final product that implements the health care model as a web platform. This is a validated prototype that optimises the safe management of the care of chronically ill patients at home.
Leucine	Leucine is one of nine essential amino acids in humans (provided by food), Leucine is important for protein synthesis and many metabolic functions. Leucine contributes to regulation of blood-sugar levels; growth and repair of muscle and bone tissue; growth hormone production; and wound healing. Leucine also prevents breakdown of muscle proteins after trauma or severe stress and may be beneficial for individuals with phenylketonuria. Leucine is available in many foods and deficiency is rare.
Macrophysical	Of or relating to the physics of bodies and phenomena on a macroscopic scale.
Macrovascular ischemic disease	Involves changes to the small blood vessels in the brain. Changes to these vessels can damage white matter — the brain tissue that contains nerve fibres and serves as the connection point to other parts of the brain.
Malignancy	A term for diseases in which abnormal cells divide without control and can invade nearby tissues. Malignant cells can also spread to other parts of the body through the blood and lymph systems. There are several main types of malignancy. Carcinoma is a malignancy that begins in the skin or in tissues that line or cover internal organs. Sarcoma is a malignancy that begins in bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue. Leukaemia is a malignancy that starts in blood-forming tissue, such as the bone marrow, and causes large numbers of abnormal blood cells to be produced and enter the blood. Lymphoma and multiple myeloma are malignancies that begin in the cells of the immune system. Central nervous system cancers are malignancies that begin in the tissues of the brain and spinal cord. Also called cancer.
Meniere's disease	Meniere's disease is a disorder of the inner ear that can lead to dizzy spells (vertigo) and hearing loss. In most cases, Meniere's disease affects only one ear. Meniere's disease can occur at any age, but it usually starts between young and middle-aged adulthood. It's considered a chronic condition, but various treatments can help relieve symptoms and minimize the long-term impact on life.
Meningitis	Meningitis is a rare infection that affects the delicate membranes — called meninges — that cover the brain and spinal cord.
Mesothelioma	Malignant mesothelioma is a type of cancer that occurs in the thin layer of tissue that covers the majority of the internal organs (mesothelium). Mesothelioma is an aggressive and deadly form of cancer. Doctors divide mesothelioma into different types based on what part of the mesothelium is affected. Mesothelioma most often affects the tissue that surrounds the lungs (pleura). This type is called pleural mesothelioma. Other, rarer types of mesothelioma affect tissue in the abdomen (peritoneal mesothelioma), around the heart and around the testicles.
Methicillin-resistant Staphylococcus aureus (MRSA)	Methicillin-resistant Staphylococcus aureus (MRSA) infection is caused by a type of Staphylococcus ('staph') bacteria that has become resistant to many of the antibiotics used to treat ordinary staph infections. Most MRSA infections occur in people who have been in hospitals or other health care settings, such as nursing homes and dialysis centres. When it occurs in these settings, it's known as health care-associated MRSA (HA-MRSA). HA-MRSA infections typically are associated with invasive procedures or devices, such as surgeries, intravenous tubing or artificial joints.
Microangiopathy	Disease of the capillaries (very small blood vessels), in which the capillary walls become so thick and weak that they bleed, leak protein, and slow the flow of blood.
Microbiome	A community of microorganisms (such as bacteria, fungi, and viruses) that inhabit a particular environment and especially the collection of microorganisms living in or on the human body
Microvascular complications	Include cardiovascular diseases such as heart attacks, strokes and insufficiency in blood flow to legs.

Mitochondrial Disease	Result from failures of the mitochondria, specialized compartments present in every cell of the body (except red blood cells). Mitochondria are responsible for creating more than 90% of the energy needed by the body to sustain life and support organ function. When they fail, less and less energy is generated within the cell. Cell injury and even cell death follow. If this process is repeated throughout the body, whole organ systems begin to fail.
Muscular deconditioning	The loss of muscle tone and endurance due to chronic disease, immobility, or loss of function.
Myopia	Near-sightedness.
Naive B cell	A naive B cell is a B cell that has not been exposed to an antigen. Once exposed to an antigen, the naive B cell either becomes a memory B cell or a plasma cell that secretes antibodies specific to the antigen that was originally bound. Plasma cells do not last long in the circulation, this is in contrast to memory cells that last for very long periods of time. Memory cells do not secrete antibody until activated by their specific antigen.
Naive T cell	T cell that has differentiated in bone marrow. The thymus produces progenitor cells, which mature into T-cells (thymus-derived cells). The body uses T-cells help destroy infected or cancerous cells. T-cells created by the thymus also help other organs in the immune system grow properly.
Nematode	Also known as roundworms. They occur as parasites in animals and plants or as free-living forms in soil, fresh water and marine environments.
Nephrovascular	Relating to the blood vessels of the kidney
Neurovascular	Of, relating to, or involving both nerves and blood vessels
Nonsteroidal anti-inflammatory drugs	Are a drug class that reduce pain, decrease fever, prevent blood clots and, in higher doses, decrease inflammation. Side-effects depend on the specific drug, but largely include an increased risk of gastrointestinal ulcers and bleeds, heart attack and kidney disease.
Nosocomial	Originating or taking place in a hospital, acquired in a hospital, especially in reference to an infection. The common usage of the term "nosocomial" is now synonymous with hospital-acquired. Nosocomial infections are infections that have been caught in a hospital and are potentially caused by organisms that are resistant to antibiotics. A nosocomial infection is specifically one that was not present or incubating prior to the patient's being admitted to the hospital, but occurring within 72 hours after admittance to the hospital.
Nutraceutical	The term "nutraceutical" is used to describe these medicinally or nutritionally functional foods. Nutraceuticals, which have also been called medical foods, designer foods, phytochemicals, functional foods and nutritional supplements, include such everyday products as "bio" yoghurts and fortified breakfast cereals, as well as vitamins, herbal remedies and even genetically modified foods and supplements.
Nutrient sensing	A cell's ability to recognise and respond to fuel substrates such as glucose.
Oncology	The branch of science that deals with tumours and cancers.
Organ of Corti	The Organ of Corti is the sensitive element in the inner ear and can be thought of as the body's microphone. It is situated on the basilar membrane in one of the three compartments of the Cochlea. It contains four rows of hair cells which protrude from its surface. Above them is the tectoral membrane which can move in response to pressure variations in the fluid-filled tympanic and vestibular canals. There are some 16,000 -20,000 of the hair cells distributed along the basilar membrane which follows the spiral of the cochlea.
Osteoarthritis	Osteoarthritis is the most common form of arthritis. It is a degenerative joint disease that involves thinning or destruction of the smooth cartilage that covers the ends of bones, as well as changes to the bone underlying the joint cartilage. Osteoarthritis produces pain, stiffness and reduced movement of the affected joint, which ultimately affects one's ability to do physical activities, reducing quality of life.
Osteoporosis	Osteoporosis is a bone disease. The word "osteoporosis" literally means porous bones. It is a bone disorder characterised by decreased bone strength as a result of reduced bone quantity and quality. A person with osteoporosis has an increased risk of breaking a bone (fracturing) easily.
Otoconia	Small crystals of calcium carbonate in the saccule and utricle of the ear that under the influence of acceleration in a straight-line cause stimulation of the hair cells by their movement relative to the gelatinous supporting substrate containing the embedded cilia of the hair cells

Oxidative Stress	Oxidative stress is well known to be involved in the pathogenesis of lifestyle-related diseases, including atherosclerosis, hypertension, diabetes mellitus, ischemic diseases, and malignancies. Oxidative stress has been defined as harmful because oxygen free radicals attack biological molecules such as lipids, proteins, and DNA. However, oxidative stress also has a useful role in physiologic adaptation and in the regulation of intracellular signal transduction.
Palliative care	Palliative care is specialized medical care for people living with a serious illness. This type of care is focused on relief from the symptoms and stress of a serious illness. The goal is to improve quality of life for both the patient and the family. Palliative care is provided by a specially-trained team of doctors, nurses and other specialists who work together with a patient's other doctors to provide an extra layer of support. It is appropriate at any age and at any stage in a serious illness, and it can be provided along with curative treatment.
Pathophysiology	the functional changes that accompany a particular syndrome or disease
Phototoxicity	Phototoxicity is defined as a toxic response from a substance applied to the body which is either elicited or increased (apparent at lower dose levels) after subsequent exposure to light, or that is induced by skin irradiation after systemic administration of a substance.
Phthalate	Phthalate or phthalate esters are esters of phthalic acid. They are mainly used as plasticizers, i.e., substances added to plastics to increase their flexibility, transparency, durability, and longevity. They are used primarily to soften polyvinyl chloride (PVC).
Pneumococcal Pneumonia	There are many types of pneumonia, and the most common type of bacterial pneumonia is called pneumococcal pneumonia. Pneumococcal pneumonia is caused by bacteria that live in the upper respiratory tract and can be spread through coughing. Common symptoms of pneumococcal pneumonia include high fever, excessive sweating and shaking chills, coughing, difficulty breathing, shortness of breath and chest pain. Certain symptoms, such as cough and fatigue, can appear without warning and may last for weeks, or longer. In severe cases, pneumococcal pneumonia may necessitate hospitalisation and result in death.
Pneumococcus	Pneumococcus ( <i>Streptococcus pneumoniae</i> ) is a bacterium that causes human diseases such as pneumonia, sinusitis, otitis media, and meningitis. Pneumococci normally occur in the upper respiratory tract.
Pneumonia	Pneumonia is an infection that inflames the lungs' air sacs (alveoli). The air sacs may fill up with fluid or pus, causing symptoms such as a cough, fever, chills and trouble breathing.
Polymedication	The administration of many drugs at the same time or the administration of an excessive number of drugs
Population Attributable Fraction (PAF)	The contribution of a risk factor to a disease or a death is quantified using the population attributable fraction (PAF). PAF is the proportional reduction in population disease or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario (e.g. no tobacco use). Many diseases are caused by multiple risk factors, and individual risk factors may interact in their impact on overall risk of disease. As a result, PAFs for individual risk factors often overlap and add up to more than 100%.
Population attributable risk	The Population Attributable Risk (or Population Attributable Fraction) indicates the number (or proportion) of cases that would not occur in a population if the factor were eliminated (e.g. how many lives would be saved if people no longer smoked?)
Postmitotic	A mature cell that is no longer capable of undergoing mitosis (a part of the cell cycle when replicated chromosomes are separated into two new nuclei)
Presbyastasis	The loss of vestibular and balance functions associated with ageing
Presbycusis	Age-related hearing loss
Presenteeism	Working while sick
Proprioception/ proprioceptive	The process in which nerve endings in the muscles and joints are stimulated when the body moves, so that a person is aware of their body's position
Proteostasis	Protein homeostasis or 'proteostasis' is the process that regulates proteins within the cell in order to maintain the health of both the cellular proteome and the organism itself.
Psychomotor	Relating to, or characterising movements of the body associated with mental activity
Psychotropic drugs	Psychotropic drugs are medications that affect the central nervous system, changing how the brain processes information, such as altering mood, thoughts, perceptions, emotions, and behaviours.

Retinopathy	Retinopathy means disease of the retina. There are several types of retinopathy, but all involve disease of the small retinal blood vessels.
Sarcopenia	The decline of skeletal muscle tissue with age. It is one of the most important causes of functional decline and loss of independence in older adults.
Senile miosis	A reduction in the size of a person's pupil in old age
STRC	Stereocilin is a protein that in humans is encoded by the STRC gene. This gene encodes a protein that is associated with the hair bundle of the sensory hair cells in the inner ear. The hair bundle is composed of stiff microvilli called stereocilia and is involved with mechanoreception of sound waves. Mutations in this gene cause autosomal recessive non-syndromic deafness.
Tamoxifen	Tamoxifen is the oldest and most-prescribed selective oestrogen receptor modulator (SERM) and is used for treatment of: women and men diagnosed with hormone-receptor-positive, early-stage breast cancer after surgery (or possibly chemotherapy and radiation) to reduce the risk of the cancer coming back (recurring); women and men diagnosed with advanced-stage or metastatic hormone-receptor-positive disease; reduce breast cancer risk in women who haven't been diagnosed but are at higher-than-average risk for the disease.
Telomere	The natural end of a eukaryotic chromosome composed of a usually repetitive DNA sequence and serving to stabilise the chromosome
Tetanus	Tetanus is a serious disease caused by a bacterial toxin that affects our nervous system, leading to painful muscle contractions, particularly of the jaw and neck muscles. Tetanus can interfere with the ability to breathe and can be life-threatening. Tetanus is commonly known as "lockjaw." Thanks to the tetanus vaccine, cases of tetanus are rare in the developed world. There's no cure for tetanus. Treatment focuses on managing complications until the effects of the tetanus toxin resolve.
Thymus	The thymus is part of the lymphatic system, along with the tonsils, adenoids and spleen, and is also part of the endocrine system. The thymus produces progenitor cells, which mature into T-cells (thymus-derived cells). The body uses T-cells help destroy infected or cancerous cells. T-cells created by the thymus also help other organs in the immune system grow properly.
Tinnitus	Tinnitus is an awareness of sound in the ears or head which is not from an external source. There are many different types of tinnitus sounds. Common descriptions are that it is a hiss, whistle, whirr, ring or buzz. Occasionally, it can be segments of music. The pitch can be high or low and the level can vary over time.
Triaxial Accelerometers	Triaxial accelerometers are intended for simultaneous measurement of vibration in three perpendicular axes.
Triglycerides	A type of fat found in the blood, the most common type of fat in the body. Triglycerides are necessary for health but in excess amounts, they may be harmful and may increase the risk of heart disease.
Urogynaecology	Female pelvic medicine is a new designation for the established field of urogynaecology. An urogynecologist cares for women with pelvic floor disorders in a blend of gynaecology and reconstructive surgery.
Varicella Zoster Virus (VZV)	A type of herpesvirus that causes chicken pox. After initial infection with varicella zoster virus (VZV), the inactive (latent) form of the virus can remain in the body. If the latent virus becomes active again, it can cause shingles.
Vestibular	Relating to empty spaces in the body that are entrances to passages or other spaces
Vestibular Neuritis	Vestibular neuritis is a disorder that affects the nerve of the inner ear called the vestibulocochlear nerve. The disorder may cause a person to experience such symptoms as sudden, severe vertigo (spinning/swaying sensation), dizziness, balance difficulties, nausea, vomiting, and concentration difficulties.
West Nile virus	West Nile virus (WNV) is a mosquito-borne disease. There are no vaccines to prevent or medications to treat WNV in people. Fortunately, most people infected with WNV do not feel sick. About 1 in 5 people who are infected develop a fever and other symptoms. About 1 out of 150 infected people develop a serious, sometimes fatal, illness.
Yellow fever	Yellow fever is an acute viral haemorrhagic disease transmitted by infected mosquitoes. The "yellow" in the name refers to the jaundice that affects some patients. Symptoms of yellow fever include fever, headache, jaundice, muscle pain, nausea, vomiting and fatigue. A small proportion of patients who contract the virus develop severe symptoms and approximately half of those die within 7 to 10 days. The virus is endemic in tropical areas of Africa and Central and South America. Large epidemics of yellow fever occur when infected people introduce the virus into heavily populated areas with high mosquito density and where most people have little or no immunity, due to lack of vaccination. In these conditions, infected mosquitoes transmit the virus from person to person.



## Annex 5: List of abbreviations

AARP	American Association of Retired Persons
ACP	Advanced Care Planning
AD	Alzheimer's Disease
ADAS	Advanced Driver Assistance System
ADL	Activities of Daily Living
ADR	Adverse Drug Reaction
AF	Atrial Fibrillation
AFH	Age-Friendly Hospital
AFM	Age-Friendly Manchester
AI	Artificial Intelligence
AMD	Age-Related Macular Degeneration
AMR	Antimicrobial Resistance
APMS	Adult Psychiatric Morbidity Survey
APP	Application Software
AREDS	Age-Related Eye Disease Study
AV	Autonomous Vehicle
BCoDE	Burden of Communicable Diseases in Europe
BIA	Bioelectrical Impedance Analysis
BMD	Bone Mineral Density
BMI	Body Mass Index
BP	Blood Pressure
CFAS	Cognitive Function and Ageing Study
CGA	Comprehensive Geriatric Assessment
CIRS-G	Cumulative Illness Rating Scale – Geriatrics
CKD	Chronic Kidney Disease
CKD	Chronic Kidney Disease
CMD	Common Mental Disorder
CMV	Cytomegalovirus
CNECT	Communications Networks, Content and Technology
COPD	Chronic Obstructive Pulmonary Disease
CRD	Chronic Respiratory Disease
CSF	Cerebrospinal Fluid

CSOs	Civic Society Organisations
CTI	Care Transitions Intervention
CV	Cardiovascular
CVD	Cardiovascular Disease
DALYs	Disability-Adjusted Life Years
DASH	Diet Approaches to Stop Hypertension
DFH	Dementia Friendly Hospital
DG	Directorate General
DG ECFIN	Directorate-General for Economic and Financial Affairs
DNR	Do Not Resuscitate
DRSs	Driving Rehabilitation Specialists
DU	Universal Design
DXA	Dual Energy X-Ray Absorptiometry
EBD	Evidence Based Design
ECDC	European Centre for Diseases Control
ECG	Electrocardiogram
ECG	Electrocardiography
ED	Emergency Department
EDCs	Endocrine-Disrupting Chemicals
EGE	European Group on Ethics in Science and New Technologies
EHR	Electronic Health Record
EIP-on-AHA	European Innovation Partnership on Active and Healthy Ageing
EMA	European Medicine Agency
ERR	Evidence Review Report
ESC	European Society of Cardiology
ESPEN	European Society for Clinical Nutrition and Metabolism
ESPEN	European Society for Clinical Nutrition and Metabolism
EU	European Union
EVASG	Escmid Vaccine Study Group
EWGSOP	European Working Group on Sarcopenia in Older People
F-A-C-S	Find Cases-Assess-Confirm-Severity
FEV1	Forced Expiratory Pressure In 1 Second
FINGER	Finnish Geriatric Intervention Study
FLS	Fracture Liaison Services
GD	General Director
GDP	Growth Domestic Product
GDPR	General Data Protection Regulation
GIS	Geographic Information System

GLOW	Global Longitudinal Study of Osteoporosis in Women
GNAFCC	Global Network on Age-Friendly Cities and Communities
GP	General Practitioner
GPS	Global Positioning System
HAI	Health care-Associated Infection
HAP	Hospital-Acquired Pneumonia
HCI	Human-Computer Interaction
HCW	Health care Workers
HF	Heart Failure
HIV	Human Immunodeficiency Virus
HMSO	Her Majesty's Stationery Office
HPA	Hypothalamic Pituitary Adrenal
HPG	Hypothalamic–Pituitary–Gonadal
HPV	Human Papillomavirus
HR-pQCT	High Resolution Peripheral Quantitative Computed Tomography
IADL	Instrumental Activities of Daily Living
ICF	International Classification of Functioning, Disability and Health
ICT	Information and Communication Technology
IDF	International Diabetes Federation
IEEE	Institute of Electrical and Electronics Engineers
IOF	International Osteoporosis Foundation
IoT	Internet of Things
IP	Inappropriate Prescription
IPC	Infection Prevention and Control
K4Care	Knowledge-Based Home-Care Eservices for An Ageing Europe
KSA	Knowledge, Skills and Attitudes
LCT	Long-Term Care
LRTI	Lower Respiratory Tract Infection
LTC	Long-Term Care
LTCF	Long-Term Care Facilities
m-health	Mobile and Wireless Technologies
MICRA	Manchester Institute for Collaborative Research on Ageing
MPI	Multidimensional Prognostic Index
MRSA	Methicillin-Resistant Staphylococcus Aureus
mTOR	Mechanistic Target of Rapamycin
mTOR	The Mammalian Target of Rapamycin
NGO	Non-Governmental Organisation
NHANES	National Health and Nutrition Examination Survey

NHS	National Health Service
NIA	National Institute on Ageing
NIH	Us National Institutes of Health
NSAIDs	Nonsteroidal Anti-Inflammatory Drugs
OA	Osteoarthritis
OECD	Organisation for Economic Co-Operation and Development
ONS	Oral Nutritional Supplements
PAF	Population Attributable Fraction
PAR	Population Attributable Risk
PDGF-AA	Platelet-Derived Growth Factor
PIM's	Potentially Inappropriate Medications
PPO's	Potential Prescribing Omissions
PPS	Point Prevalence Study
PPV	Pneumococcal Pneumonia Vaccines
pQCT	Quantitative Computed Tomography
PRM	Physical and Rehabilitation Medicine
RCT	Randomised Controlled Trial
SAPEA	Science Advice for Policy by European Academies
SARC-F	Questionnaire for Rapid Assessment of Sarcopenia Status
SBU	Swedish Agency for Health Technology Assessment and Assessment of Social Services
SCOPE	The Scorecard for Osteoporosis in Europe
SHARE	Survey of Health, Ageing and Retirement in Europe
SPPB	Short Physical Performance Battery
TAVI	Transcatheter Aortic Valve Implantation
TFA	Trans Fatty Acids
TFR	Total Fertility Rate
TILDA	The Irish Longitudinal Study on Ageing
TTRN	Transatlantic Telehealth Research Network
TUG	Timed Up and Go Test
UEMS	European Union of Medical Specialists
UEMS-GMS	European Union of Medical Specialists – Geriatric Medicine Section
UN	United Nations
UTI	Urinary Tract Infection
VP	Virtual Patient
VZV	Varcella Zoster Virus
WHO	World Health Organisation



# Annex 6: Acknowledgements

SAPEA wishes to thank the following people for their valued contribution and support in the production of this report.

## **European Commission Chief Scientific Advisors**

Professor Pearl Dykstra

## **SAPEA board**

Professor George Griffin (FEAM)

Professor Sierd Cloetingh (Academia Europaea)

## **Peer reviewers**

Professor Matthias Barton, University of Zurich (Switzerland)

Professor Linda Partridge, University College London (United Kingdom)

Professor Kieran Walsh, National University of Ireland Galway (Ireland)

Professor Rudi Westendorp, University of Copenhagen (Denmark)

Professor Hans Wildiers, University Hospital Leuven (Belgium)

Professor Rainer Winkelmann, University of Zurich (Switzerland)

Professor Rene Amalberti, Haute Autorité de Santé (France)

Professor David Phillips, Lingnan University, Hong Kong (United Kingdom)

Professor Jesus Angel Fernández Tresguerres Hernández, Universidad Complutense de Madrid (Spain)

One anonymous reviewer

## **SAPEA staff**

Hamed Mobasser (Lead Scientific Policy Officer)

Dr Nina Hobbhahn

Dr Céline Tschirhart

Hannah Whittle

Louise Edwards

Antoine Blonce

Esther Dorado Ladera

Dr Jacqueline Whyte

Toby Wardman

Robert Vogt

Agnieszka Pietruczuk

Laurence Legros (FEAM)

Katharina Nordhaus (Leopoldina)

Rudolf Hielscher

## **European Commission Scientific Advice Mechanism Unit**

Dr Johannes Klumpers

Dr Maurizio Salvi

Dr Iphigenia Pottaki

Dr Sigrid Weiland

## **Literature review**

Delyth Morris, Health Library, University Library Service Cardiff University

## **Contract staff**

Steven Bridges, Scientific Writing

Kimberly Katte, Scientific Writing

Dr Joanne Feeney, Research Analysis



# Annex 7: Systematic literature search method report

## *Scope*

Systematic literature searches were designed and run in the Medline database, and additionally in Web of Science if it was a social science topic, using a combination of Subject Heading and keyword searching. Subject Heading searching makes use of the National Library of Medicine's controlled vocabulary thesaurus, finding articles in Medline using indexing. Subject heading searches can be identified in the search strategies. Here, 'exp' indicates that the searched Subject Heading was 'exploded' and therefore finds articles indexed with this term or narrower terms. The subject heading searches were supplemented by textword searching (.tw.), which identifies where the searched word or phrase is within the title and abstract of the articles in Medline. Textword searches can be identified in the search strategies.

## **Relevant subjects**

Searches were designed in collaboration with Working Group members for a range of different topics relating to an ageing population. In total 39 searches were undertaken on topics including:

- interventions for various conditions such as asthma and COPD, cardiovascular disease, dementia etc.
- prevention of balance disorder, hearing loss and vision deficiency
- epidemiology of depression, sensory ageing and cardiovascular disease
- health literacy in varying populations
- varying topics related to undernutrition
- varying topics related to care homes

## **Relevant types of study**

Where requested and appropriate, searches were limited to randomised controlled trials and observational studies using tested SIGN search filters, to review papers using BMJ Best Practice search filters, and to policy documents only using the search filter outlined below:

1. exp Policy/
2. exp Public Policy/
3. exp Health Policy/
4. (policy or policies or policymaker\*).tw.

5. (government\* adj3 (intervention\* or legislat\* or directive\* or policy or policies)).tw.
6. Guideline\*.tw.
7. OR/1-6

## Geographical limits

Where requested and appropriate, a European search filter was applied to searches. The search filter used in these instances is outlined below. This filter would identify any studies which specifically reference one or several European countries, either mentioned in the title/abstract or indexed using Subject Headings.

- |                              |                                |                                 |                             |
|------------------------------|--------------------------------|---------------------------------|-----------------------------|
| 1. exp European Union/       | 17. exp Estonia/               | 32. (Italy or Italian*).tw.     | 47. exp Romania/            |
| 2. European union.tw.        | 18. Estonia*.tw.               | 33. exp Latvia/                 | 48. Romania*.tw.            |
| 3. exp Austria/              | 19. exp Finland/               | 34. Latvia*.tw.                 | 49. exp Slovakia/           |
| 4. Austria*.tw.              | 20. (Finland or Finnish).tw.   | 35. exp Lithuania/              | 50. Slovakia*.tw.           |
| 5. exp Belgium/              | 21. exp France/                | 36. Lithuania*.tw.              | 51. exp Slovenia/           |
| 6. belgi*.tw.                | 22. (France of French).tw.     | 37. exp Luxembourg/             | 52. Slovenia*.tw.           |
| 7. exp Bulgaria/             | 23. exp German/                | 38. Luxembourg*.tw.             | 53. exp Spain/              |
| 8. Bulgari*.tw.              | 24. German*.tw.                | 39. exp Malta/                  | 54. (Spain or Spanish).tw.  |
| 9. exp Croatia/              | 25. exp Greece/                | 40. (Malta or Maltese).tw.      | 55. exp Sweden/             |
| 10. Croatia*.tw.             | 26. (Greece of Greek*).tw.     | 41. exp Netherlands/            | 56. (Sweden or Swedish).tw. |
| 11. exp Cyprus/              | 27. exp Hungary/               | 42. (Netherlands or Dutch).tw.  | 57. exp United Kingdom/     |
| 12. (Cyprus or Cypriot*).tw. | 28. (Hungary or Hungarian).tw. | 43. exp Polish/                 | 58. United Kingdom.tw.      |
| 13. exp Czech Republic/      |                                | 44. (Poland or Polish).tw.      | 59. Great Britain.tw.       |
| 14. Czech*.tw.               | 29. exp Ireland/               | 45. exp Portugal/               | 60. British.tw.             |
| 15. exp Denmark/             | 30. (Ireland or Irish).tw.     | 46. (Portugal or Portugese).tw. | 61. Britain.tw.             |
| 16. (Denmark or Danish).tw.  | 31. exp Italy/                 |                                 | 62. Or/1-61                 |

## Language

All searches were limited to English language studies only. The English language filter was applied using the predefined Ovid Medline limit.

## Date of publication

All searches were limited to articles from 2010 to current (unless stated otherwise in Table 13).

## Method

All searches were undertaken using the same search strategy defining the ageing population (unless stated otherwise in Table 13). The search used to define and identify the ageing population was:

- |                     |                    |
|---------------------|--------------------|
| 1. exp Aged/        | 8. exp Geriatrics/ |
| 2. aged.tw.         | 9. Geriatric*.tw.  |
| 3. exp Ageing/      | 10. Or/1-7         |
| 4. ageing.tw.       |                    |
| 5. ageing.tw.       |                    |
| 6. elderly.tw.      |                    |
| 7. older adult*.tw. |                    |

For each of the 39 research questions, this search strategy was used to define the population. A further search strategy was then applied relating to each specific research question. Table 13 outlines the search strategies for each of the 39 searches, which were combined with the ageing population search.

**Table 13.** Search terms used per topic, listed in alphabetical order. Exp = Subject Heading 'exploded' to include narrower indexed terms; tw = textword searching (title and abstract); adj2 = adjacency searching within 2 words; adj3 = adjacency searching within 3 words; RCT = randomised controlled trial. Number of results are pre-sifting for relevant articles.

### Advanced Care Planning

(Medline, 202 results)

1. exp Advanced Care Planning/
2. advance\* care plan\*.tw.
3. OR/1-2
4. 3 AND ageing population AND EU filter

### Asthma and COPD interventions

(Medline, 79 results)

1. exp Asthma/
2. exp Pulmonary Disease, Chronic Obstructive/
3. COPD.tw.
4. Asthma\*.tw.
5. OR/1-5
6. Intervention\*.tw.
7. exp Smoking Cessation/
8. ((stop\* or ceas\*) adj3 smok\*).tw.
9. exp Adrenal Cortez Hormones/
10. (adrenal cortex hormone\* or corticosteroid\*).tw.
11. Beta2-mimetic.tw.
12. OR/6-11
13. 5 AND 12 AND ageing population AND EU filter AND policy filter AND RCTs/ Observational studies filters

### Balance disorder prevention

(Medline, 25 results)

1. Balance disorder\*.tw.
2. (balance\* adj3 problem\*).tw.
3. OR/1-2
4. prevent\*.tw.
5. exp Health Diet/
6. ((healthy or balanced) adj2 diet\*).tw.
7. OR/4-6
8. 3 AND 7 AND ageing population

### Cardiovascular disease burden

(Medline, 629 results)

1. Coronary Syndrome/
2. acute coronary syndrome\*.tw.
3. exp Stroke/
4. ischemic stroke\*.tw.
5. exp Myocardial Infarction/
6. myocardial infarction\*.tw.
7. atherosclerotic stroke\*.tw.
8. OR/1-9
9. exp "Global burden of disease"/
10. burden\*.tw.
11. OR/11-12
12. 10 AND 14 AND ageing population AND EU filter AND RCTs/Observational studies filters

### Cardiovascular disease epidemiology

(Medline, 402 results)

1. exp Cardiovascular Diseases/
2. cardiovascular disease\*.tw.
3. exp Acute Coronary Syndrome/
4. acute coronary syndrome\*.tw.
5. exp Stroke/
6. ischemic stroke\*.tw.
7. thrombotic stroke\*.tw.
8. exp Myocardial Infarction/
9. myocardial infarction\*.tw.

10. atherosclerotic stroke\*.tw.
11. OR/1-10
12. exp Epidemiology/
13. epidemiology.tw.
14. OR/12-13
15. 11 AND 14 AND EU filter AND RCTs/ Observational studies filters

### Cardiovascular disease interventions

(Medline, 331 results)

1. exp Cardiovascular Diseases/
2. cardiovascular disease\*.tw.
3. exp Coronary Artery Disease/
4. coronary artery disease\*.tw.
5. exp Myocardial Infarction/
6. myocardial infarction\*.tw.
7. exp Heart Failure/
8. heart failure\*.tw.
9. OR/1-8
10. Intervention\*.tw.
11. exp Smoking Cessation/
12. smoking cessation.tw.
13. ((stop\* or ceas\*) adj3 smok\*).tw.
14. exp Exercise/
15. exercise\*.tw.
16. physical activ\*.tw.
17. exp Weight Loss/
18. (weight adj3 los\*).tw.
19. exp Diet, Mediterranean/
20. Mediterranean diet\*.tw.
21. exp Vegetables/
22. (vegetable\* or vegetarian\*).tw.
23. exp Fatty Acids, Omega-3/
24. omega 3.tw.
25. omega3.tw.
26. omega 6.tw.
27. omega6.tw.
28. OR/10-27
29. 9 AND 28 AND ageing population AND EU filter AND policy filter AND RCTs/ Observational studies filters

### Dementia interventions

(Medline, 77 results)

1. exp Dementia/
2. dementia.tw.
3. exp Alzheimer Disease/
4. exp Cognitive Dysfunction/
5. (cognitiv\* adj3 impair\*).tw.
6. Alzheimer\*.tw.
7. (cognitiv\* adj3 declin\*).tw.
8. OR/1-7
9. Intervention\*.tw.
10. exp Education/
11. educat\*.tw.
12. exp Employment/
13. employ\*.tw.
14. job\*.tw.
15. exp Cognitive Reserve/
16. cognitive reserve\*.tw.
17. brain reserve\*.tw.
18. (memor\* adj3 stimulat\*).tw.
19. (cogniti\* adj3 revalidat\*).tw.
20. exp Exercise/
21. exercis\*.tw.
22. physical activit\*.tw.
23. exp Tai Ji/
24. tai chi.tw.

25. social activit\*.tw.
26. leisure activ\*.tw.
27. exp Dancing/
28. danc\*.tw.
29. exp Diet, Mediterranean/
30. Mediterranean diet\*.tw.
31. exp Olive Oil/
32. olive oil.tw.
33. exp Dietary Supplements/
34. dietary supplement\*.tw.
35. oral nutritional supplement\*.tw.
36. nutritional supplement\*.tw.
37. souvenaid.tw.
38. finger.tw.
39. mapt.tw.
40. prediva.tw.
41. statin\*.tw.
42. nsaid\*.tw.
43. exp Anti-Inflammatory Agents, Non-Steroidal/
44. ginko biloba.tw.
45. exp Vitamin B 12/
46. vitamin b12.tw.
47. vitamin b 12.tw.
48. exp Adaptation, Psychological/
49. coping behaviour\*.tw.
50. coping behavior\*.tw.
51. (safe\* adj3 home\*).tw.
52. Modif\* adj3 environ\*).tw.
53. Companion robot\*.tw.
54. OR/9-53
55. 8 AND 54 AND ageing population AND EU filter AND policy filter AND RCTs/ Observational studies filters

### Depression epidemiology

(Medline, 249 results)

1. exp Depression/
2. depress\*.tw.
3. Depressive disorder/ or depression, postpartum/ or depressive disorder, major/ or depressive disorder, treatment-resistant/ or dysthymic disorder/
4. Dysthymi\*.tw.
5. OR/1-4
6. Epidemiology.tw.
7. exp Epidemiology/
8. (life adj3 course).tw.
9. OR/6-8
10. 5 AND 9 AND Review filter

### Diabetes interventions

(Medline, 158 results)

1. exp Diabetes Mellitus/
2. diabetes.tw.
3. OR/1-2
4. Intervention\*.tw.
5. exp Diet, Mediterranean/
6. Mediterranean diet\*.tw.
7. exp Dietary Approaches To Stop Hypertension/
8. dietary approaches to stop hypertension.tw.
9. DASH diet\*.tw.
10. (lower\* adj3 lipid\*).tw.
11. exp Blood Pressure/
12. blood pressure.tw.
13. aspirin\*.tw.
14. exp Aspirin/

15. acetylsalicylic acid\*.tw.
16. exp Exercise/
17. exercis\*.tw.
18. physical activ\*.tw.
19. exp Weight Loss/
20. (weight adj3 los\*).tw.
21. exp Wound Healing/
22. ((wound\* adj3 (manage\* or car\* or heal\*)).tw.
23. ((foot or feet) adj3 car\*).tw.
24. exp Oral Hygiene/
25. ((oral or dental or mouth) adj4 (car\* or hygien\*)).tw.
26. ( tax\* adj3 (sugar\* or drink\* or beverage\*)).tw.
27. OR/4-26
28. 3 AND 27 AND ageing population AND EU filter AND policy filter AND RCTs/ Observational studies filters

### Global Health education (Medline, 4 results)

1. exp Global Health/
2. exp Health Education/
3. 1 and 2
4. (global health adj3 educat\*).tw.
5. 3 OR 4
6. 5 AND ageing population AND Review filter
7. Limit to 2013 — Current

### Global Health education and health care professionals (Medline, 9 results)

1. exp Health Personnel/
2. (health professional\* or health personnel).tw.
3. OR/1-2
4. exp Global Health/
5. exp Health Education/
6. 4 AND 5
7. (global health adj3 educat\*).tw.
8. OR/6-7
9. 8 AND Review filter
10. Limit to 2013 — Current

### Global Health education and medical students (Medline, 3 results)

1. exp Students, Medical/
2. (medical adj3 (student\* or undergraduate\*)).tw.
3. 1 OR 2
4. exp Global Health/
5. exp Health Education/
6. 4 AND 5
7. (global health adj3 educat\*).tw.
8. 6 OR 7
9. 3 AND 8 AND Review filter
10. Limit to 2013 — Current

### Global Health education and young people (Medline, 20 results)

1. exp Young Adult/
2. (young adult\* or young person\* or young people).tw.
3. 1 OR 2
4. exp Global Health/
5. exp Health Education/
6. 4 AND 5
7. (global health adj3 educat\*).tw.
8. 6 OR 7
9. 7 AND Review filter
10. Limit to 2013 — Current

### Health literacy (Medline, 85 results)

1. exp Health Literacy/
2. (health literate or health literacy).tw.
3. OR/1-2
4. 3 AND ageing population AND Review filter

5. Limit 4 to 2013 — Current

### Health literacy and health care professionals (Medline, 79 results)

1. exp Health Personnel/
2. (health professional\* or health personnel).tw.
3. OR/1-2
4. exp Health Literacy/
5. (health literate or health literacy).tw.
6. OR/4-5
7. 3 AND 6 AND Review filter
8. Limit 7 to 2013 — Current

### Health literacy and medical students (Medline, 3 results)

1. exp Students, Medical/
2. (medical adj3 (student\* or undergraduate\*)).tw.
3. OR/1-2
4. exp Health Literacy/
5. (health literate or health literacy).tw.
6. OR/4-5
7. 3 AND 6 AND Review filter
8. Limit 7 to 2013 — Current

### Health literacy and young people (Medline, 71 results)

1. exp Young Adult/
2. (young adult\* or young person\* or young people).tw.
3. exp Adolescent/
4. adolescen\*.tw.
5. teen\*.tw.
6. OR/1-5
7. exp Health Literacy/
8. (health literate or health literacy).tw.
9. OR/7-8
10. 6 AND 9 AND Review filter
11. Limit 10 to 2013 — Current

### Hearing loss prevention (Medline, 24 results)

1. exp Hearing Loss/
2. ((hear or hearing) adj3 los\*).tw.
3. ((hear or hearing) adj3 deficien\*).tw.
4. OR/1-3
5. Prevent\*.tw.
6. exp Ear Protective Devices/
7. (ear\* adj3 protect\*).tw.
8. ((avoid\* or expos\*) adj3 (loud music or loud noise\*)).tw.
9. Noise cancelling headphone\*.tw.
10. Noise cancelling earphone\*.tw.
11. OR/5-10
12. 4 AND 11 AND ageing population AND EU filter AND RCTs/observational studies/ review filters

### Keeping older people in care homes stimulated (Medline, 83 results; Web of Science, 427 results)

1. Care home\*.tw.
2. Nursing home\*.tw.
3. exp Nursing Homes/
4. Assisted Living Facilities/
5. Residential home\*.tw.
6. exp Homes for the Aged/
7. OR/1-6
8. Activ\* provi\*.tw.
9. Activit\* coordinator\*.tw.
10. Meaningful activ\*.tw.
11. Leisure activ\*.tw.
12. Exercise class\*.tw.
13. Physical\* exercis\*.tw.
14. exp Yoga/
15. yoga.tw.
16. chair yoga.tw.
17. exp Tai Ji/
18. tai ji.tw.

19. tai chi.tw.
20. craft\*.tw.
21. puzzle\*.tw.
22. jigsaw\*.tw.
23. hand massage\*.tw.
24. music class\*.tw.
25. singing class\*.tw.
26. singing group\*.tw.
27. choir\*.tw.
28. active listen\*.tw.
29. (cognitiv\* adj3 stimulat\*).tw.
30. Engagement intervention\*.tw.
31. ((engage\* or stimulat\*) adj3 activit\*).tw.
32. OR/8-31
33. exp Apathy/
34. intervention\*.tw.
35. 33 AND 34
36. 32 OR 35
37. 7 AND 36 AND ageing population AND RCTs/Observational studies/Review filter

### Kidney vascular interventions (Medline, 54 results)

1. exp Renal Insufficiency, Chronic/
2. chronic renal insufficien\*.tw.
3. chronic kidney disease\*.tw.
4. chronic renal disease\*.tw.
5. OR/1-4
6. Intervention\*.tw.
7. exp Blood Glucose/
8. exp Insulin/
9. blood glucose.tw.
10. insulin.tw.
11. glycemic control.tw.
12. exp Blood Pressure/
13. blood pressure.tw.
14. hypoglycemic control.tw.
15. exp Diet, Sodium-Restricted/
16. ((sodium restrict\* or low salt\* or salt restrict\*) adj3 diet\*).tw.
17. exp Diabetes Mellitus/
18. diabetes.tw.
19. hydrat\*.tw.
20. OR/6-19
21. 5 AND 20 AND ageing population AND EU filter AND RCTs/Observational studies AND policy filter

### Making care homes more homely (Medline, 27 results; Web of Science, 44 results)

1. exp Nursing Homes/
2. exp Homes for the Aged/
3. exp Assisted Living Facilities/
4. nursing home\*.tw.
5. care home\*.tw.
6. residential home\*.tw.
7. OR/1-6
8. Homely.tw.
9. Home-lie.tw.
10. Homeliness.tw.
11. Sense of home.tw.
12. (nostalgic adj2 décor).tw.
13. (familiar\* adj2 (esthetic\* or aesthetic\*)).tw.
14. High contrast colo?r\*.tw.
15. Natural light\*.tw.
16. High luminance light\*.tw.
17. Intelligent light system\*.tw.
18. (discreet adj2 furniture).tw.
19. Interior design.tw.
20. OR/8-19
21. 7 AND 20 AND ageing population

### Measure of disability (Medline, 1684 results)

1. Disabil\*.tw.
2. exp Frailty/
3. exp Frail Elderly/
4. frail\*.tw.
5. vulnerabl\*.tw.
6. (impair\* adj3 capab\*).tw.
7. (limited adj3 capacit\*).tw.
8. (limited adj3 capab\*).tw.
9. (functional\* adj3 impair\*).tw.
10. exp Cognitive Dysfunction/

11. (cognitiv\* adj3 (dysfunction or impair\*))\*tw.
12. Psychiatric disorder\*.tw.
13. exp "Activities of Daily Living" / activities of daily living.tw.
14. (limit\* adj3 activit\*).tw.
15. (restrict\* adj3 participat\*).tw.
16. OR/1-16
17. exp Disability Evaluation / (measure\* adj2 method\*).tw.
18. (measure\* adj3 (disabilit\* or frail\*))\*tw.
19. (evaluat\* adj3 disabil\*).tw.
20. Short performance physical battery.tw.
21. Frailty assessment method\*.tw.
22. Frieds frailty phenotype.tw.
23. Frailty index.tw.
24. Study of osteoporotic fractures index.tw.
25. Edmonton frailty scale.tw.
26. "fatigue resistance ambulation and loss of weight index".tw.
27. Clinical frailty scale.tw.
28. Multidimensional prognostic index.tw.
29. Tilburg frailty indicator.tw.
30. Prisma-7.tw.
31. Groningen frailty indicator.tw.
32. Sherbrooke postal questionnaire.tw.
33. Gerontopole frailty screening tool.tw.
34. Kihon checklist.tw.
35. OR/18-36
36. 17 AND 37 AND ageing population AND Review filter

### Mobility interventions

(Medline, 142 results)

1. exp Walking Speed / (walk\* adj3 speed\*).tw.
2. (gait adj3 speed\*).tw.
3. (physical\* adj3 (perform\* or function\*))\*tw.
4. (function\* adj3 (capacit\* or ageing or ageing))\*tw.
5. Mobilit\*.tw.
6. Locomoto\*.tw.
7. exp Accidental Falls / (fall or falls or falling).tw.
8. OR/1-9
9. Intervention\*.tw.
10. Chair stand\*.tw.
11. Chair rise\*.tw.
12. TUG test.tw.
13. "timed up and go".tw.
14. (strength\* adj3 test\*).tw.
15. (flexibil\* adj3 (test\* or exercis\*))\*tw.
16. exp Walkers / (walking aid\* or walker\*).tw.
17. exp Exercise / exercis\*.tw.
18. physical\* activ\*.tw.
19. exp Physical Therapy Modalities / physical therap\*.tw.
20. ((chang\* or modif\*) adj3 (home\* or house\*))\*tw.
21. ((chang\* or modif\*) adj3 (footwear or shoe\*))\*tw.
22. exp Vitamin D / vitamin d.tw.
23. (cataract\* adj3 (surg\* or operat\*))\*tw.
24. OR/11-29
25. 10 AND 30 AND ageing population AND EU filter AND observational studies / review filter and policy filter

### Muscle strength interventions

(Medline, 12 results)

1. exp Muscle Strength / (muscl\* adj3 strength\*).tw.
2. exp Hand Strength / ((hand\* or grip\*) adj3 strength\*).tw.
3. OR/1-4
4. Intervention\*.tw.
5. exp Exercise / exercis\*.tw.
6. physical\* activ\*.tw.
7. OR/6-9
8. 5 AND 10 AND ageing population AND EU filter AND observational studies / review filters AND policy filter

### Musculoskeletal interventions

(Medline, 75 results)

1. exp Musculoskeletal Diseases / exp Musculoskeletal Pain / musculoskeletal disease\*.tw.
2. exp Bone Density / bone dens\*.tw.
3. bone mass\*.tw.
4. OR/1-6
5. Intervention\*.tw.
6. Bisphosphonate\*.tw.
7. exp Strontium / strontium.tw.
8. exp Vitamin D / vitamin d.tw.
9. exp Calcium / calcium.tw.
10. cathepsin k.tw.
11. exp Denosumab / denosumab.tw.
12. exp Exercise / exercis\*.tw.
13. physical\* activ\*.tw.
14. exp Hydrotherapy / hydrotherap\*.tw.
15. OR/8-23
16. 7 AND 24 AND ageing population AND EU filter AND observational studies / review filter AND policy filter

### Neurovascular interventions

(Medline, 88 results)

1. Neurovascular disease\*.tw.
2. exp Stroke / stroke\*.tw.
3. exp Ischemic Attack, Transient / transient ischemic attack\*.tw.
4. exp Carotid Stenosis / carotid stenosis.tw.
5. exp Dementia, Vascular / vascular dementia.tw.
6. mixed dementia.tw.
7. OR/1-10
8. Intervention\*.tw.
9. exp Blood Pressure / blood pressure.tw.
10. exp Aspirin / aspirin.tw.
11. acetylsalicylic acid.tw.
12. exp Diet, Sodium-Restricted / ((sodium restrict\* or low salt\* or salt restrict\*) adj3 diet\*).tw.
13. exp Exercise / exercis\*.tw.
14. physical activ\*.tw.
15. exp Diet, Mediterranean / Mediterranean diet\*.tw.
16. exp Dietary Approaches To Stop Hypertension / dietary approaches to stop hypertension.tw.
17. DASH diet\*.tw.
18. Mid diet.tw.
19. OR/12-28
20. 11 AND 30 AND ageing population AND EU filter AND RCTs/observational studies filter AND policy filter

### Nutritional status of patients in nursing homes

(Medline, 322 results)

1. exp Malnutrition / malnutrition.tw.
2. nutrition\*.tw.
3. OR/1-3
4. exp Nursing Homes / exp Homes for the Aged / exp Assisted Living Facilities / nursing home\*.tw.
5. care home\*.tw.
6. residential home\*.tw.
7. OR/5-10
8. 4 AND 11 AND ageing population AND RCTs/observational studies/review filter

### Obesity interventions

(Medline, 66 results)

1. exp Obesity / obes\*.tw.
2. overweight\*.tw.
3. OR/1-3
4. Intervention\*.tw.
5. exp Exercise / exercis\*.tw.
6. physical\* activ\*.tw.
7. (weight adj3 los\*).tw.
8. exp Bariatric Surgery / (bariatric adj3 (surg\* or operat\*))\*tw.
9. OR/5-11
10. 4 AND 12 AND ageing population AND EU filter AND RCTs/Observational studies filter

### Osteoarthritis interventions

(Medline, 19 results)

1. exp Osteoarthritis / osteoarthritis.tw.
2. OR/1-2
3. Intervention\*.tw.
4. exp Weight Loss / ((los\* or reduc\*) adj3 weight).tw.
5. exp Micronutrients / micronutrient\*.tw.
6. exp Vitamin D / vitamin d.tw.
7. exp Antioxidants / antioxidant\*.tw.
8. exp Smoking / smoking.tw.
9. exp Occupational Diseases / ((occupation\* or work\* or employ\*) adj3 (condition\* or disease\*))\*tw.
10. exp Swimming / (aquatic exercis\* or swim\* or water aerobics).tw.
11. Aerobic\*.tw.
12. exp Resistance Training / (resistance training or strength training).tw.
13. exp Hydrotherapy / hydrotherap\*.tw.
14. exp Tai Ji / tai chi.tw.
15. exp Yoga / yoga.tw.
16. exp Stem Cells / stem cell\*.tw.
17. OR/4-29
18. 3 AND 30 AND ageing population AND EU filter AND RCTs/Observational studies filter AND policy filter

### Osteoporosis interventions

(Medline, 37 results)

1. exp Osteoporosis / osteoporosis.tw.
2. OR/1-2
3. Intervention\*.tw.
4. exp Smoking Cessation / ((stop\* or ceas\*) adj3 smok\*).tw.
5. exp Exercise / exercis\*.tw.
6. physical\* activ\*.tw.
7. exp Resistance Training / ((strength or resistance or balance) adj3 training).tw.
8. exp Dietary Proteins / (protein\* adj3 diet\*).tw.
9. exp Vitamin D / vitamin d.tw.
10. exp Calcium / calcium.tw.
11. OR/4-17
12. 3 AND 18 AND ageing population AND EU filter AND RCTs/observational studies filter AND policy filter

## Sarcopenia interventions

(Medline, 10 results)

1. exp Sarcopenia/
2. sarcopenia.tw.
3. OR/1-2
4. exp Social Class/  
(social status\* or social class\* or socioeconomic status\* or socioeconomic status\*).tw.
5. exp Exercise/  
exercis\*.tw.
6. physical\* activ\*.tw.
7. exp Resistance Training/  
(resistance or strength) adj3 training).tw.
8. exp Dietary Proteins/  
(protein\* adj3 (diet\* or intak\*)).tw.
9. ((adequate or good) adj3 (nutrition\* or diet\*)).tw.
10. exp Leucine/  
Leucine.tw.
11. Beta methyl butyrate.tw.
12. Beta hydroxyl.tw.
13. OR/4-17
14. 3 AND 18 AND ageing population AND RCTs/observational studies filter AND policy filter

## Sensory ageing epidemiology

(Medline, 47 results)

1. (sens\* adj3 (ageing or ageing or aged)).tw.
2. exp Hearing Loss/  
(hear or hearing) adj3 (los\* or deficien\*).tw.
3. exp Deafness/  
deaf\*.tw.
4. ((eyesight or vision or visual) adj3 (los\* or deficien\*)).tw.
5. Balance disorder\*.tw.
6. (balanc\* adj3 problem\*).tw.
7. exp Vertigo/  
OR/1-10
8. exp Epidemiology/  
epidemiology.tw.
9. (life adj3 course).tw.
10. OR/11-13
11. 10 AND 14 AND EU filter

## Sensory interventions

(Medline, 13 results)

1. exp Macular Degeneration/  
macular degenera\*.tw.
2. exp Hearing Loss/  
(hearing adj3 los\*).tw.
3. exp Presbycusis/  
OR/1-5
4. Intervention\*.tw.
5. exp Diabetes Mellitus/  
diabet\*.tw.
6. exp Blood Glucose/  
blood glucose.tw.
7. exp Insulin/  
insulin.tw.
8. glycemic control.tw.
9. exp Blood Pressure/  
blood pressure.tw.
10. exp Vitamin A/  
vitamin a.tw.

19. vitamin c.tw.
20. exp Vitamin E/  
vitamin e.tw.
21. exp Selenium/  
selenium.tw.
22. exp Zinc/  
zinc.tw.
23. exp Smoking Cessation/  
(stop\* or ceas\*) adj3 smok\*).tw.
24. exp Sunscreening Agents/  
(sun or UVA or UVB) adj3 protect\*).tw.
25. exp Fatty Acids, Omega-3/  
omega 3.tw.
26. omega3.tw.
27. (sensory adj3 stimul\*).tw.
28. (sensory adj3 activ\*).tw.
29. exp Mindfulness/  
mindfulness.tw.
30. exp Noise/  
noise.tw.
31. exp Hearing Loss, Noise-Induced/  
chronic acoustic trauma.tw.
32. music concert\*.tw.
33. ((headphone\* or head phone\*) adj3 music\*).tw.
34. exp "Drug-Related Side-effects and Adverse Reactions"/  
drug toxicit\*.tw.
35. OR/7-44
36. 6 AND 45 AND ageing population AND EU filter AND RCTs/observational studies filter AND policy

## Undernutrition and hospital admissions

(Medline, 182 results)

1. exp Hospitalisation/  
(hospital\* adj3 admission\*).tw.
2. Hospitalisation\*.tw.
3. Hospitalisation\*.tw.
4. OR/1-4
5. exp Malnutrition/  
malnutrition.tw.
6. undernutrition.tw.
7. under nutrition.tw.
8. OR/6-9
9. 5 AND 10 AND EU filter

## Undernutrition and hospital discharge

(Medline, 36 results)

1. exp Patient Discharge/  
(patient\* adj3 discharg\*).tw.
2. (hospital\* adj3 discharg\*).tw.
3. OR/1-3
4. exp Malnutrition/  
malnutrition.tw.
5. undernutrition.tw.
6. under nutrition.tw.
7. OR/5-8
8. 4 AND 10 AND ageing population AND EU filter

## Undernutrition and independent living

(Medline, 99 results)

1. exp Independent Living/

2. (independent\* adj3 (living or live)).tw.
3. Community dwelling.tw.
4. OR/1-3
5. exp Malnutrition/  
malnutrition.tw.
6. undernutrition.tw.
7. under nutrition.tw.
8. OR/5-8
9. 4 AND 9 AND EU filter

## Undernutrition and nursing homes

(Medline, 146 results)

1. exp Nursing Homes/  
nursing home\*.tw.
2. OR/1-2
3. exp Malnutrition/  
malnutrition.tw.
4. undernutrition.tw.
5. under nutrition.tw.
6. OR/4-7
7. 3 AND 8 AND ageing population AND EU filter

## Unnecessary transfers of older patients to emergency departments

(Medline, 19 results)

1. exp Nursing Homes/  
exp Homes for the Aged/  
exp Assisted Living Facilities/  
nursing home\*.tw.
2. care home\*.tw.
3. residential home\*.tw.
4. OR/1-6
5. "accident and emergency".tw.
6. A&e.tw.
7. exp Emergency Service, Hospital/  
emergency department\*.tw.
8. emergency room\*.tw.
9. OR/8-12
10. ((avoid\* or unnecessary) adj3 (transfer\* or admission\* or admit\*)).tw.
11. 7 AND 13 AND 14 AND ageing population

## Vision deficiency prevention

(Medline, 22 results)

1. ((eyesight or vision or visual) adj3 (los\* or deficien\*)).tw.
2. Prevent\*.tw.
3. exp Healthy Diet/  
(healthy or balance) adj2 diet\*).tw.
4. exp Vitamin A/  
vitamin a.tw.
5. exp Fatty Acids, Omega-3/  
omega 3.tw.
6. ((regular\* or frequent\* or annual\*) adj3 eye exam\*).tw.
7. exp Smoking Cessation/  
smoking cessation.tw.
8. ((stop\* or ceas\*) adj3 smok\*).tw.
9. exp Eye Protection Devices/  
sunglasses.tw.
10. OR/2-14
11. 1 AND 15 AND ageing population AND EU filter AND observational studies/review filter



# References

- Abbott, R. A., Whear, R., Thompson-Coon, J., Ukoumunne, O. C., Rogers, M., Bethel, A., ... Stein, K. (2013). Effectiveness of mealtime interventions on nutritional outcomes for the elderly living in residential care: A systematic review and meta-analysis. *Ageing Research Reviews*, 12(4), 967-981. doi:10.1016/j.arr.2013.06.002
- Abdi, J., Al-Hindawi, A., Ng, T., & Vizcaychipi, M. P. (2018). Scoping review on the use of socially assistive robot technology in elderly care. *BMJ Open*, 8(2), e018815. doi:10.1136/bmjopen-2017-018815
- Abel, J., Pring, A., Rich, A., Malik, T., & Verne, J. (2013). The impact of advance care planning of place of death, a hospice retrospective cohort study. *BMJ Supportive & Palliative Care*, 3(2), 168-173. doi:10.1136/bmjspcare-2012-000327
- Abizanda, P., Sinclair, A., Barcons, N., Lizan, L., & Rodriguez-Manas, L. (2016). Costs of malnutrition in institutionalized and community-dwelling older adults: A systematic review. *Journal of the American Medical Directors Association*, 17(1), 17-23. doi:10.1016/j.jamda.2015.07.005
- Abunnaja, S., Cuviallo, A., & Sanchez, J. A. (2013). Enteral and parenteral nutrition in the perioperative period: State of the art. *Nutrients*, 5(2), 608-623. doi:10.3390/nu5020608
- Adam, S., Bonsang, E., Germain, S., & Perelman, S. (2007). Retirement and cognitive reserve: A stochastic frontier approach applied to survey data. *CREPP*, 2007/04(02), 1-25.
- Age-friendly Ireland. (2014). Beaumont hospital embarks on journey to become the first age friendly hospital in Ireland. Retrieved from <http://agefriendlyireland.ie/beamont-hospital-embarks-on-journey-to-become-the-first-age-friendly-hospital-in-ireland/>
- Agree, E. M., & Glaser, K. (2009). Demography of informal caregiving. In P. Uhlenberg (Ed.), *International handbook of population aging* (pp. 647-668). Dordrecht: Springer Netherlands.
- Ahn, J., Dik, B. J., & Hornback, R. (2017). The experience of career change driven by a sense of calling: An interpretative phenomenological analysis approach. *Journal of Vocational Behavior*, 102, 48-62. doi:10.1016/j.jvb.2017.07.003
- Aizen, E., Hindawi, E., Shahla, H., & Elyounes, A. A. (2014). The effect of an intervention on rates of nursing home residents transfers to emergency departments. *Harefuah*, 153(2), 83-86.
- Akpan, A., Roberts, C., Bandeen-Roche, K., Batty, B., Bausewein, C., Bell, D., ... Banerjee, J. (2018). Standard set of health outcome measures for older persons. *BMC Geriatrics*, 18:36, 1-10. doi:10.1186/s12877-017-0701-3
- Al-Ajmi, K., Lophatananon, A., Yuille, M., Ollier, W., & Muir, K. R. (2018). Review of non-clinical risk models to aid prevention of breast cancer. *Cancer Causes Control*, 29(10), 967-986. doi:10.1007/s10552-018-1072-6
- Al-Bashaireh, A. M., Haddad, L. G., Weaver, M., Kelly, D. L., Chengguo, X., & Yoon, S. (2018). The effect of tobacco smoking on musculoskeletal health: A systematic review. *Journal of Environmental and Public Health*, 2018, 4184190-4184190. doi:10.1155/2018/4184190
- Albers, M. W., Gilmore, G. C., Kaye, J., Murphy, C., Wingfield, A., Bennett, D. A., ... Zhang, L. I. (2015). At the interface of sensory and motor dysfunctions and Alzheimer's disease. *Alzheimer's & Dementia*, 11(1), 70-98. doi:10.1016/j.jalz.2014.04.514
- Albertini, M. (2016). Ageing and family solidarity in Europe : Patterns and driving factors of intergenerational support. Retrieved from <http://documents.worldbank.org/curated/en/499921467989468345/Ageing-and-family-solidarity-in-Europe-patterns-and-driving-factors-of-intergenerational-support>
- Albertini, M., Kohli, M., & Vogel, C. (2007). Intergenerational transfers of time and money in European families: Common patterns – different regimes? *Journal of European Social Policy*, 17(4), 319-334. doi:10.1177/0958928707081068
- All-Party Parliamentary Group on Heart Disease. (2016). Focus on heart failure: 10 recommendations to improve care and transform lives. Retrieved from <https://www.bhf.org.uk/-/media/files/campaigning/appg-on-heart-disease-focus-on-heart-failure-report.pdf>
- Allinson, J. P., Hardy, R., Donaldson, G. C., Shaheen, S. O., Kuh, D., & Wedzicha, J. A. (2017). Combined impact of smoking and early-life exposures on adult lung function trajectories. *American Journal of Respiratory and Critical Care Medicine*, 196(8), 1021-1030. doi:10.1164/rccm.201703-0506OC
- Almond, D., Currie, J., & Duque, V. (2017). Childhood circumstances and adult outcomes: Act II. *Journal of Economic Literature*, 56(4), 1360-1446. doi:10.1257/jel.20171164
- Alvarez-Hernandez, J., Planas Vila, M., Leon-Sanz, M., Garcia de Lorenzo, A., Celaya-Perez, S., Garcia-Lorda, P., ... Sarto Guerri, B. (2012). Prevalence and costs of malnutrition in hospitalized patients; the predyces study. *Nutricion Hospitalaria*, 27(4), 1049-1059. doi:10.3305/nh.2012.27.4.5986
- Alzheimer's Disease International. (2015). World Alzheimer report 2015. The global impact of dementia: An analysis of prevalence, incidence, cost and trends. Retrieved from <https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf>
- Alzheimer's Society. (2012). Dementia 2012: A national challenge. Retrieved from [Alzheimers.org.uk/dementia2012](http://Alzheimers.org.uk/dementia2012)
- Ambblas-Novellas, J., Murray, S. A., Espauella, J., Martori, J. C., Oller, R., Martinez-Munoz, M., ... Gomez-Batiste, X. (2016). Identifying patients with advanced chronic conditions for a progressive palliative care approach: A cross-sectional study of prognostic indicators related to end-of-life trajectories. *BMJ Open*, 6(9), e012340. doi:10.1136/bmjopen-2016-012340

- American Association of Retired Persons. (2019). Livable communities. Retrieved from <https://www.aarp.org/livable-communities/about/>
- American Association of Retired Persons (AARP). (2018). Roadmap to liveability - strategies and solutions that make a community great for people of all ages. Retrieved from [www.AARP.org/livabilityRoadmap](http://www.AARP.org/livabilityRoadmap)
- American Diabetes Association. (2017). Prevention or delay of type 2 diabetes. *Diabetes Care*, 40 (Suppl. 1), 44-47. doi:10.2337/dc17-S008
- American Diabetes Association. (2018). Improving care and promoting health in populations: Standards of medical care in diabetes. *Diabetes Care*, 41(1), 7-12. doi:10.2337/dc18-S001
- American Geriatrics Society Expert Panel on Person-Centered Care. (2016). Person-centered care: A definition and essential elements. *Journal of the American Geriatrics Society*, 64(1), 15-18. doi:10.1111/jgs.13866
- Amieva, H., Ouvrard, C., Giulioli, C., Meillon, C., Rullier, L., & Dartigues, J. F. (2015). Self-reported hearing loss, hearing aids, and cognitive decline in elderly adults: A 25-year study. *Journal of the American Geriatrics Society*, 63(10), 2099-2104. doi:10.1111/jgs.13649
- Andersen, S. L., Sebastiani, P., Dworkis, D. A., Feldman, L., & Perls, T. T. (2012). Health span approximates life span among many supercentenarians: Compression of morbidity at the approximate limit of life span. *The Journals of Gerontology: Series A*, 67(4), 395-405. doi:10.1093/gerona/glr223
- Angelini, V., Mierau, J. O., & Howdon, D. D. H. (2018). Childhood socioeconomic status and late-adulthood mental health: Results from the survey on health, ageing and retirement in Europe. *The Journals of Gerontology: Series B*, 74(1), 95-104. doi:10.1093/geronb/gby028
- Angus, J., & Reeve, P. (2006). Ageism: A threat to 'aging well' in the 21st century. *Journal of Applied Gerontology*, 25(2), 137-152. doi:10.1177/0733464805285745
- Anstey, K. J., Burns, R., von Sanden, C., & Luszcz, M. A. (2008). Psychological well-being is an independent predictor of falling in an 8-year follow-up of older adults. *The Journals of Gerontology: Series B*, 63(4), P249-P257. doi:10.1093/geronb/63.4.P249
- Anton, S. D., Woods, A. J., Ashizawa, T., Barb, D., Buford, T. W., Carter, C. S., ... Pahor, M. (2015). Successful aging: Advancing the science of physical independence in older adults. *Ageing Research Reviews*, 24(Pt B), 304-327. doi:10.1016/j.arr.2015.09.005
- Antunes, A. C., Araujo, D. A., Verissimo, M. T., & Amaral, T. F. (2017). Sarcopenia and hospitalisation costs in older adults: A cross-sectional study. *Nutrition & Dietetics*, 74(1), 46-50. doi:10.1111/1747-0080.12287
- Apostolo, J., Cooke, R., Bobrowicz-Campos, E., Santana, S., Marcucci, M., Cano, A., ... Holland, C. (2017). Predicting risk and outcomes for frail older adults: An umbrella review of frailty screening tools. *JBIG Database of Systematic Reviews and Implementation Reports*, 15(4), 1154-1208. doi:10.11124/jbisrir-2016-003018
- Apostolo, J., Queiros, P., Rodrigues, M., Castro, I., & Cardoso, D. (2015). The effectiveness of nonpharmacological interventions in older adults with depressive disorders: A systematic review. *JBIG Database of Systematic Reviews and Implementation Reports*, 13(6), 220-278. doi:10.11124/jbisrir-2015-1718
- Arné, J. L., Duffier, J. L., Hamard, H., Legall, J. R., Legent, F., & Nicolas, G. (2013). La prise en charge des soins ophtalmologiques en France. *Bulletin de L'Académie Nationale de Médecine*, 137, 1051-1053.
- Arriaga, M. E., Vajdic, C. M., Canfell, K., MacInnis, R., Hull, P., Magliano, D. J., ... Laaksonen, M. A. (2017). The burden of cancer attributable to modifiable risk factors: The Australian cancer-PAF cohort consortium. *BMJ Open*, 7(6), e016178. doi:10.1136/bmjopen-2017-016178
- Ash, A. S., Kroll-Desrosiers, A. R., Hoaglin, D. C., Christensen, K., Fang, H., & Perls, T. T. (2015). Are members of long-lived families healthier than their equally long-lived peers? Evidence from the long life family study. *The Journals of Gerontology: Series A*, 70(8), 971-976. doi:10.1093/gerona/glv015
- Attias-Donfut, C., Ogg, J., & Wolff, F.-C. (2005). European patterns of intergenerational financial and time transfers. *European Journal of Ageing*, 2(3), 161-173. doi:10.1007/s10433-005-0008-7
- Austbø Holteng, L. B., Frøiland, C. T., Corbett, A., & Testad, I. (2017). Care staff perspective on use of texture modified food in care home residents with dysphagia and dementia. *Annals of Palliative Medicine*, 6(4), 310-318.
- Ayalon, L. (2013). Feelings towards older vs. Younger adults: Results from the European social survey. *Educational Gerontology*, 39(12), 888-901. doi:10.1080/03601277.2013.767620
- Ayalon, L. (2014). Perceived age, gender, and racial/ethnic discrimination in Europe: Results from the European social survey. *Educational Gerontology*, 40(7), 499-517. doi:10.1080/03601277.2013.845490
- Ayalon, L. (2015). Perceptions of old age and aging in the continuing care retirement community. *International Psychogeriatrics*, 27(4), 611-620. doi:10.1017/s1041610214002415
- Ayalon, L. (2016). Satisfaction with aging results in reduced risk for falling. *International Psychogeriatrics*, 28(5), 741-747. doi:10.1017/s1041610215001969
- Ayalon, L. (2018). Loneliness and anxiety about aging in adult day care centers and continuing care retirement communities. *Innovation in Aging*, 2(2). doi:10.1093/geroni/igy021
- Ayalon, L., & Tesch-Römer, C. (2018). Contemporary perspectives on ageism. Springer International Publishing. Retrieved from <https://link.springer.com/book/10.1007/978-3-319-73820-8>
- Bachmann, S., Finger, C., Huss, A., Egger, M., Stuck, A. E., & Clough-Gorr, K. M. (2010). Inpatient rehabilitation specifically designed for geriatric patients: Systematic review and meta-analysis of randomised controlled trials. *BMJ (Clinical Research Edition)*, 340, c1718. doi:10.1136/bmj.c1718

- Baigent, C., Blackwell, L., Collins, R., Emberson, J., Godwin, J., Peto, R., ... Zanchetti, A. (2009). Aspirin in the primary and secondary prevention of vascular disease: Collaborative meta-analysis of individual participant data from randomised trials. *Lancet*, 373(9678), 1849-1860. doi:10.1016/s0140-6736(09)60503-1
- Baird, J., Kurshid, M. A., Kim, M., Harvey, N., Dennison, E., & Cooper, C. (2011). Does birthweight predict bone mass in adulthood? A systematic review and meta-analysis. *Osteoporosis International*, 22(5), 1323-1334. doi:10.1007/s00198-010-1344-9
- Banerjee, S., Murray, J., Foley, B., Atkins, L., Schneider, J., & Mann, A. (2003). Predictors of institutionalisation in people with dementia. *Journal of Neurology, Neurosurgery, and Psychiatry*, 74(9), 1315-1316. doi:10.1136/jnnp.74.9.1315
- Banks, E., Reeves, G. K., Beral, V., Balkwill, A., Liu, B., & Roddam, A. (2009). Hip fracture incidence in relation to age, menopausal status, and age at menopause: Prospective analysis. *PLoS Medicine*, 6(11), e1000181. doi:10.1371/journal.pmed.1000181
- Banzi, R., Camaioni, P., Tettamanti, M., Bertele, V., & Lucca, U. (2016). Older patients are still under-represented in clinical trials of Alzheimer's disease. *Alzheimer's Research & Therapy*, 8, 32-32. doi:10.1186/s13195-016-0201-2
- Barin, K., & Dodson, E. E. (2011). Dizziness in the elderly. *Otolaryngologic Clinics of North America*, 44(2), 437-454. doi:10.1016/j.otc.2011.01.013
- Barnes, D. E., & Yaffe, K. (2011). The projected effect of risk factor reduction on Alzheimer's disease prevalence. *The Lancet Neurology*, 10(9), 819-828. doi:10.1016/s1474-4422(11)70072-2
- Barnes, P. J. (2017). Senescence in COPD and its comorbidities. *Annual Review of Physiology*, 79, 517-539. doi:10.1146/annurev-physiol-022516-034314
- Barnes, P. J., Burney, P. G., Silverman, E. K., Celli, B. R., Vestbo, J., Wedzicha, J. A., & Wouters, E. F. (2015). Chronic obstructive pulmonary disease. *Nature Reviews Disease Primers*, 1, 15076. doi:10.1038/nrdp.2015.76
- Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Epidemiology of multimorbidity and implications for health care, research, and medical education: A cross-sectional study. *Lancet*, 380(9836), 37-43. doi:10.1016/s0140-6736(12)60240-2
- Barrett, R., Kuzawa, C., McDade, T., & Armelagos, G. (1998). Emerging and re-emerging infectious diseases: The third epidemiologic transition. *Annual Review of Anthropology*, 27(1), 247-271.
- Bartolini, E., & McNeill, N. (2012). Getting to value: Eleven chronic disease technologies to watch. Retrieved from [https://www.nehi.net/writable/publication\\_files/file/getting\\_to\\_value\\_eleven\\_chronic\\_disease\\_technologies\\_to\\_watch.pdf](https://www.nehi.net/writable/publication_files/file/getting_to_value_eleven_chronic_disease_technologies_to_watch.pdf)
- Barzilay, N., Crandall, J. P., Kritchevsky, S. B., & Espeland, M. A. (2016). Metformin as a tool to target aging. *Cell Metabolism*, 23(6), 1060-1065. doi:10.1016/j.cmet.2016.05.011
- Bateman, R. J., Xiong, C., Benzinger, T. L. S., Fagan, A. M., Goate, A., Fox, N. C., ... Morris, J. C. (2012). Clinical and biomarker changes in dominantly inherited Alzheimer's disease. *The New England Journal of Medicine*, 367(9), 795-804. doi:10.1056/NEJMoa1202753
- Bauer, J. M., & Sousa-Poza, A. (2015). Impacts of informal caregiving on caregiver employment, health, and family. *Journal of Population Ageing*, 8(3), 113-145. doi:10.1007/s12062-015-9116-0
- Bauer, M. S., Damschroder, L., Hagedorn, H., Smith, J., & Kilbourne, A. M. (2015). An introduction to implementation science for the non-specialist. *BMC Psychology*, 3:32, 1-12. doi:10.1186/s40359-015-0089-9
- Bauer, U. E., Briss, P. A., Goodman, R. A., & Bowman, B. A. (2014). Prevention of chronic disease in the 21st century: Elimination of the leading preventable causes of premature death and disability in the USA. *Lancet*, 384(9937), 45-52. doi:10.1016/s0140-6736(14)60648-6
- Baum, F., Popay, J., Delany-Crowe, T., Freeman, T., Musolino, C., Alvarez-Dardet, C., ... & Bishai, D. M. (2018). Punching above their weight: A network to understand broader determinants of increasing life expectancy. *International Journal for Equity in Health*, 12(1), 117. doi:10.1186/s12939-018-0832-y
- Baumgart, M., Snyder, H. M., Carrillo, M. C., Fazio, S., Kim, H., & Johns, H. (2015). Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A population-based perspective. *Alzheimer's & Dementia*, 11(6), 718-726. doi:10.1016/j.jalz.2015.05.016
- Beal, B. (2016). Feedback fears for the 'me, me, me' generation: How to tread carefully in dishing out criticism. *Human Resource Management International Digest*, 24(6), 27-29. doi:10.1108/HRMID-05-2016-0076
- Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., ... Chatterji, S. (2016). The world report on ageing and health: A policy framework for healthy ageing. *Lancet*, 387(10033), 2145-2154. doi:10.1016/S0140-6736(15)00516-4
- Beerens, H. C., Zwakhalen, S. M., Verbeek, H., Ruwaard, D., & Hamers, J. P. (2013). Factors associated with quality of life of people with dementia in long-term care facilities: A systematic review. *International Journal of Nursing Studies*, 50(9), 1259-1270. doi:10.1016/j.ijnurstu.2013.02.005
- Behar, L., Chadwick, D., Dunne, A., Jones, C. I., Proctor, C., Rajkumar, C., ... Llewelyn, M. J. (2017). Toxigenic clostridium difficile colonization among hospitalised adults; risk factors and impact on survival. *Journal of Infection*, 75(1), 20-25. doi:10.1016/j.jinf.2017.04.006
- Ben-Shlomo, Y., Cooper, R., & Kuh, D. (2016). The last two decades of life course epidemiology, and its relevance for research on ageing. *International Journal of Epidemiology*, 45(4), 973-988. doi:10.1093/ije/dyw096
- Bergman, A., Heindel, J. J., Jobling, S., Kidd, K. A., & Zoeller, R. T. e. (2013). State of the science of endocrine disrupting chemicals 2012. Retrieved from <https://www.who.int/ceh/publications/endocrine/en/>
- Bertram, L., Bockenhoff, A., Demuth, I., Duzel, S., Eckardt, R., Li, S. C., ... Steinhagen-Thiessen, E. (2014). Cohort profile: The Berlin ageing study II (BASE-II). *International Journal of Epidemiology*, 43(3), 703-712. doi:10.1093/ije/dyt018

- Betz, M. E., Dickerson, A., Coolman, T., Schold Davis, E., Jones, J., & Schwartz, R. (2014). Driving rehabilitation programs for older drivers in the United States. *Occupational Therapy in Health Care*, 28(3), 306-317. doi:10.3109/07380577.2014.908336
- Bhangu, J., King-Kallimanis, B. L., Donoghue, O. A., Carroll, L., & Kenny, R. A. (2017). Falls, non-accidental falls and syncope in community-dwelling adults aged 50 years and older: Implications for cardiovascular assessment. *PLOS ONE*, 12(7), e0180997. doi:10.1371/journal.pone.0180997
- Bhatnagar, P., Wickramasinghe, K., Wilkins, E., & Townsend, N. (2016). Trends in the epidemiology of cardiovascular disease in the UK. *Heart*, 102(24), 1945-1952. doi:10.1136/heartjnl-2016-309573
- Bichard, J.-A., & Hanson, J. (2009). Inclusive design of 'away from home' toilets. In R. Cooper, G. Evans, & C. Boyko (Eds.), *Designing sustainable cities* (pp. 86-108). Sussex, UK: Wiley-Blackwell.
- Bichard, J.-A., & Knight, G. (2012). Improving public services through open data: Public toilets. *Proceedings of the Institution of Civil Engineers - Municipal Engineer*, 165(3), 157-165. doi:10.1680/muen.12.00017
- Binefa, G., Garcia, M., Mila, N., Fernandez, E., Rodriguez-Moranta, F., Gonzalo, N., ... Moreno, V. (2016). Colorectal cancer screening programme in Spain: Results of key performance indicators after five rounds (2000-2012). *Scientific Reports*, 6, 19532. doi:10.1038/srep19532
- Birnie, K., Cooper, R., Martin, R. M., Kuh, D., Sayer, A. A., Alvarado, B. E., ... on behalf of the, H. s. t. (2011). Childhood socioeconomic position and objectively measured physical capability levels in adulthood: A systematic review and meta-analysis. *PLOS ONE*, 6(1), e15564. doi:10.1371/journal.pone.0015564
- Blagojevic, M., Jinks, C., Jeffery, A., & Jordan, K. P. (2010). Risk factors for onset of osteoarthritis of the knee in older adults: A systematic review and meta-analysis. *Osteoarthritis and Cartilage*, 18(1), 24-33. doi:10.1016/j.joca.2009.08.010
- Blodgett, J. M., Kuh, D., Hardy, R., Davis, D. H. J., & Cooper, R. (2018). Childhood cognition and age-related change in standing balance performance from mid to later life: Findings from a British birth cohort. *The Journals of Gerontology: Series A*. doi:10.1093/gerona/gly275
- Blot, W. J., & Tarone, R. E. (2015). Doll and peto's quantitative estimates of cancer risks: Holding generally true for 35 years. *Journal of the National Cancer Institute*, 107(4). doi:10.1093/jnci/djv044
- Board, M., & McCormack, B. (2018). Exploring the meaning of home and its implications for the care of older people. *Journal of Clinical Nursing*, 27(15-16), 3070-3080. doi:10.1111/jocn.14495
- Bolam, K. A., van Uffelen, J. G., & Taaffe, D. R. (2013). The effect of physical exercise on bone density in middle-aged and older men: A systematic review. *Osteoporosis International*, 24(11), 2749-2762. doi:10.1007/s00198-013-2346-1
- Boldy, D., Grenade, L., Lewin, G., Karol, E., & Burton, E. (2011). Older people's decisions regarding 'ageing in place': A western Australian case study. *Australasian Journal on Ageing*, 30(3), 136-142. doi:10.1111/j.1741-6612.2010.00469.x
- Bonanno, G. A. (2004). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? *American Psychologist*, 59(1), 20-28. doi:10.1037/0003-066x.59.1.20
- Bond, R. (2015). Sustainable age-friendly communities and environments: Towards a capabilities approach for older persons – a European perspective. Paper presented at the 2nd International Conference on Deepening Democracy - Local Governments and Rights-Based Development: Local Governments and Rights of the Aged. Kerala, India.
- Bongaarts, J., & Feeney, G. (1998). On the quantum and tempo of fertility. *Population and Development Review*, 24(2), 271-291. doi:10.2307/2807974
- Bonjour, J. P., & Chevalley, T. (2014). Pubertal timing, bone acquisition, and risk of fracture throughout life. *Endocrine Reviews*, 35(5), 820-847. doi:10.1210/er.2014-1007
- Bonsang, E., Adam, S., & Perelman, S. (2012). Does retirement affect cognitive functioning? *Journal of Health Economics*, 31(3), 490-501. doi:10.1016/j.jhealeco.2012.03.005
- Boodhna, T., & Crabb, D. P. (2016). More frequent, more costly? Health economic modelling aspects of monitoring glaucoma patients in England. *BMC Health Services Research*, 16:611, 1-13. doi:10.1186/s12913-016-1849-9
- Börsch-Supan, A., Härtl, K., & Leite, D. N. (2016). Chapter 13 - social security and public insurance. In J. Piggott & A. Woodland (Eds.), *Handbook of the economics of population aging* (Vol. 1, pp. 781-863). North-Holland: Elsevier.
- Börsch-Supan, A., Ludwig, A., & Winter, J. (2002). Ageing and international capital flows. In A. J. Auerbach & H. Herrmann (Eds.), *Ageing, financial markets and monetary policy* (pp. 55-83). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Börsch-Supan, A., & Schuth, M. (2014). Early retirement, mental health, and social networks. In D. A. Wise (Ed.), *Discoveries in the economics of aging* (pp. 225-250). Chicago: University of Chicago Press.
- Bosy-Westphal, A., Schautz, B., Later, W., Kehayias, J. J., Gallagher, D., & Muller, M. J. (2013). What makes a BIA equation unique? Validity of eight-electrode multifrequency BIA to estimate body composition in a healthy adult population. *European Journal of Clinical Nutrition*, 67 (Suppl. 1), S14-21. doi:10.1038/ejcn.2012.160
- Bouchama, A., Dehbi, M., Mohamed, G., Matthies, F., Shoukri, M., & Menne, B. (2007). Prognostic factors in heat wave related deaths: A meta-analysis. *Archives of Internal Medicine*, 167(20), 2170-2176. doi:10.1001/archinte.167.20.ira70009
- Boulet, L. P., FitzGerald, J. M., & Reddel, H. K. (2015). The revised 2014 GINA strategy report: Opportunities for change. *Current Opinion in Pulmonary Medicine*, 21(1), 1-7. doi:10.1097/mcp.0000000000000125
- Bousquet, J., Anto, J. M., Berkouk, K., Gergen, P., Antunes, J. P., Auge, P., ... Zins, M. (2015). Developmental determinants in non-communicable chronic diseases and ageing. *Thorax*, 70(6), 595-597. doi:10.1136/thoraxjnl-2014-206304

- Bousquet, J., Bewick, M., Cano, A., Eklund, P., Fico, G., Goswami, N., ... de Oliveira-Alves, B. (2017). Building bridges for innovation in ageing: Synergies between action groups of the EIP on AHA. *The Journal of Nutrition, Health and Aging*, 21(1), 92-104. doi:10.1007/s12603-016-0803-1
- Boutwell, A., & Hwu, S. (2009). Effective interventions to reduce rehospitalizations: A survey of the published evidence. Retrieved from [http://www.breecollaborative.org/wp-content/uploads/bree\\_readmissions\\_background\\_reading.pdf](http://www.breecollaborative.org/wp-content/uploads/bree_readmissions_background_reading.pdf)
- Bouwstra, H., Smalbrugge, M., & Hertogh, C. M. (2015). Physician treatment orders in Dutch nursing homes. *Journal of the American Medical Directors Association*, 16(8), 715.e711-715.e715. doi:10.1016/j.jamda.2015.05.018
- Bowdish, D. M. E. (2018). The aging lung: Is lung health good health for older adults? *Chest*. doi:10.1016/j.chest.2018.09.003
- Bozic, T., Mestrovic, T., Profozic, Z., & Profozic, V. (2017). The role of occupational medicine in assessing work limitation: A cross-sectional study on construction workers over a five-year period in Croatia. *Work*, 58(4), 439-446. doi:10.3233/wor-172644
- Brandsma, C. A., de Vries, M., Costa, R., Woldhuis, R. R., Konigshoff, M., & Timens, W. (2017). Lung ageing and COPD: Is there a role for ageing in abnormal tissue repair? *European Respiratory Review*, 26(146). doi:10.1183/16000617.0073-2017
- Brandt, M. (2013). Intergenerational help and public assistance in Europe: A case of specialization? *European Societies*, 15(1), 26-56. doi:10.1080/14616696.2012.726733
- Breen, C. (2014). Public and community transport for older people in rural Ireland, north and south. Retrieved from <https://www.cardi.ie/publications/>
- Brignole, M., Moya, A., de Lange, F. J., Deharo, J. C., Elliott, P. M., Fanciulli, A., ... van Dijk, J. G. (2018). 2018 ESC guidelines for the diagnosis and management of syncope. *European Heart Journal*, 39(21), 1883-1948. doi:10.1093/eurheartj/ehy037
- Brilleman, S. L., Purdy, S., Salisbury, C., Windmeijer, F., Gravelle, H., & Hollinghurst, S. (2013). Implications of comorbidity for primary care costs in the UK: A retrospective observational study. *British Journal of General Practice*, 63(609), e274-e282. doi:10.3399/bjgp13X665242
- Brodsky, H., & Donkin, M. (2009). Family caregivers of people with dementia. *Dialogues in Clinical Neuroscience*, 11(2), 217-228.
- Broderick, A., Lindeman, D., Dinesen, B. I., Kidholm, K., Spindler, H., Catz, S. L., & Baik, G. (2017). Telehealth innovation: Current directions and future opportunities. Retrieved from <https://cdw-prod.adobecqms.net/content/dam/cdw/on-domain-cdwg/PDF/telehealth-innovation-current-directions-future-opportunities.pdf>
- Broese van Groenou, M., Glaser, K., Tomassini, C., & Jacobs, T. (2006). Socio-economic status differences in older people's use of informal and formal help: A comparison of four European countries. *Ageing and Society*, 26(5), 745-766. doi:10.1017/S0144686X06005241
- Brook, R. D., Rajagopalan, S., Pope, C. A., 3rd, Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., ... Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation*, 121(21), 2331-2378. doi:10.1161/CIR.0b013e3181d8bece1
- Brookmeyer, R., Johnson, E., Ziegler-Graham, K., & Arrighi, H. M. (2007). Forecasting the global burden of Alzheimer's disease. *Alzheimer's & Dementia*, 3(3), 186-191. doi:10.1016/j.jalz.2007.04.381
- Brooks, J. M., Titus, A. J., Bruce, M. L., Orzechowski, N. M., Mackenzie, T. A., Bartels, S. J., & Batsis, J. A. (2018). Depression and handgrip strength among U.S. adults aged 60 years and older from NHANES 2011-2014. *The Journal of Nutrition, Health and Aging*, 22(8), 938-943. doi:10.1007/s12603-018-1041-5
- Brustugun, O. T., Møller, B., & Helland, Å. (2014). Years of life lost as a measure of cancer burden on a national level. *British Journal of Cancer*, 111, 1014. doi:10.1038/bjc.2014.364
- Buffel, T., Handler, S., & Phillipson, C. (Eds.). (2018). *Age-friendly cities and communities: A global perspective* (1 ed.): Bristol University Press.
- Bureau, M. L., Liuu, E., Christiaens, L., Pilotto, A., Mergy, J., Bellarbre, F., ... Paccalin, M. (2017). Using a multidimensional prognostic index (MPI) based on comprehensive geriatric assessment (CGA) to predict mortality in elderly undergoing transcatheter aortic valve implantation. *International Journal of Cardiology*, 236, 381-386. doi:10.1016/j.ijcard.2017.02.048
- Burke, R. E., & Coleman, E. A. (2013). Interventions to decrease hospital readmissions: Keys for cost-effectiveness. *JAMA Internal Medicine*, 173(8), 695-698. doi:10.1001/jamainternmed.2013.171
- Burn, K., & Szoek, C. (2015). Is grandparenting a form of social engagement that benefits cognition in ageing? *Maturitas*, 80(2), 122-125. doi:10.1016/j.maturitas.2014.10.017
- Büter, K. (2014). Dementia friendly hospital architecture - what lessons can be learnt from long term care facilities. In G. Marquardt & A. Viehweger (Eds.), *Architecture for people with dementia. Planning principles, practices and future challenges*. Dresden, Germany: TU Dresden.
- Buurtzorg Nederland. (2009). Social business case buurtzorg Nederland (in Dutch). Retrieved from <https://transitiepraktijk.nl/files/maatschappelijke%20business%20case%20buurtzorg.pdf>
- Buyschaert, M., Bordier, L., Bauduceau, B., Buyschaert, M., Le Floch, J.-P., Verny, C., & Doucet, J. (2015). Cognitive dysfunction in elderly diabetic patients: What we learned more in recent literature. *Médecine des Maladies Métaboliques* 32, 47-52. doi:10.1016/S1957-2557(15)30010-9
- Caillaud, D., Lemoigne, F., Carré, P., Escamilla, R., Chanez, P., Burgel, P.-R., ... Roche, N. J. B. P. H. (2012). Association between occupational exposure and the clinical characteristics of COPD. *BMC Public Health*, 12:302, 1-7. doi:10.1186/1471-2458-12-302
- Caliendo, M., & Schmidl, R. (2016). Youth unemployment and active labor market policies in Europe. *IZA Journal of Labor Policy*, 5(1), 1. doi:10.1186/s40173-016-0057-x

- Calvin, C. M., Deary, I. J., Fenton, C., Roberts, B. A., Der, G., Leckenby, N., & Batty, G. D. (2011). Intelligence in youth and all-cause-mortality: Systematic review with meta-analysis. *International Journal of Epidemiology*, 40(3), 626-644. doi:10.1093/ije/dyq190
- Calvo, E., Sarkisian, N., & Tamborini, C. R. (2013). Causal effects of retirement timing on subjective physical and emotional health. *The Journals of Gerontology: Series B*, 68(1), 73-84. doi:10.1093/geronb/gbs097
- Cameron, I. D., Dyer, S. M., Panagoda, C. E., Murray, G. R., Hill, K. D., Cumming, R. G., & Kerse, N. (2018). Interventions for preventing falls in older people in care facilities and hospitals. *The Cochrane Database of Systematic Reviews (CDSR)*, 9(Cd005465). doi:10.1002/14651858.CD005465.pub4
- Cameron, I. D., Gillespie, L. D., Robertson, M. C., Murray, G. R., Hill, K. D., Cumming, R. G., & Kerse, N. (2012). Interventions for preventing falls in older people in care facilities and hospitals. *The Cochrane Database of Systematic Reviews (CDSR)*, 12, Cd005465. doi:10.1002/14651858.CD005465.pub3
- Campbell, A. J., Robertson, M. C., Gardner, M. M., Norton, R. N., & Buchner, D. M. (1999). Falls prevention over 2 years: A randomized controlled trial in women 80 years and older. *Age and Ageing*, 28(6), 513-518.
- Campbell, A. J., Robertson, M. C., Gardner, M. M., Norton, R. N., Tilyard, M. W., & Buchner, D. M. (1997). Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *The BMJ (Clinical Research Edition)*, 315(7115), 1065-1069.
- Cancian, M., Battaggia, A., Celebrano, M., Del Zotti, F., Novelletto, B. F., Michieli, R., ... Toffanin, R. (2013). The care for chronic heart failure by general practitioners. Results from a clinical audit in Italy. *European Journal of General Practice*, 19(1), 3-10. doi:10.3109/13814788.2012.717925
- Caputo, F., Vignoli, T., Leggio, L., Addolorato, G., Zoli, G., & Bernardi, M. (2012). Alcohol use disorders in the elderly: A brief overview from epidemiology to treatment options. *Experimental Gerontology*, 47(6), 411-416. doi:10.1016/j.exger.2012.03.019
- Carretero, S. (2015). Technology-enabled services for older people living at home independently: Lessons for public long-term care authorities in the eu member states. Luxembourg: European Commission.
- Castro-Costa, E., Dewey, M., Stewart, R., Banerjee, S., Huppert, F., Mendonca-Lima, C., ... Prince, M. (2007). Prevalence of depressive symptoms and syndromes in later life in ten European countries: The SHARE study. *British Journal of Psychiatry*, 191, 393-401. doi:10.1192/bjp.bp.107.036772
- Cauley, J. A., Chalhoub, D., Kassem, A. M., & Fuleihan Gel, H. (2014). Geographic and ethnic disparities in osteoporotic fractures. *Nature Reviews Endocrinology*, 10(6), 338-351. doi:10.1038/nrendo.2014.51
- Cawthon, P. M., Lui, L. Y., Taylor, B. C., McCulloch, C. E., Cauley, J. A., Lapidus, J., ... Ensrud, K. E. (2017). Clinical definitions of sarcopenia and risk of hospitalization in community-dwelling older men: The osteoporotic fractures in men study. *The Journals of Gerontology: Series A*, 72(10), 1383-1389. doi:10.1093/gerona/glw327
- Cederholm, T., Bosaeus, I., Barazzoni, R., Bauer, J., Van Gossum, A., Klek, S., ... Singer, P. (2015). Diagnostic criteria for malnutrition - an ESPEN consensus statement. *Clinical Nutrition*, 34(3), 335-340. doi:10.1016/j.clnu.2015.03.001
- Centers for Disease Control and Prevention. (2016). Strategies for reducing health disparities 2016. Retrieved from <https://www.cdc.gov/minorityhealth/strategies2016/index.html>
- Centers for Disease Control and Prevention. (2018). National Diabetes Prevention Program. Retrieved from <https://www.cdc.gov/diabetes/prevention/index.html>
- Centre for Excellence in Universal Design (2014). What is universal design. Retrieved from <http://universaldesign.ie/What-is-Universal-Design/>
- Cesari, M., Nobili, A., & Vitale, G. (2016). Frailty and sarcopenia: From theory to clinical implementation and public health relevance. *European Journal of Internal Medicine*, 35, 1-9. doi:10.1016/j.ejim.2016.07.021
- Chang, S. F., Lin, H. C., & Cheng, C. L. (2018). The relationship of frailty and hospitalization among older people: Evidence from a meta-analysis. *Journal of Nursing Scholarship*, 50(4), 383-391. doi:10.1111/jnu.12397
- Changizi, M., & Kaveh, M. H. (2017). Effectiveness of the mHealth technology in improvement of healthy behaviors in an elderly population-a systematic review. *The Journal of mHealth*, 3, 51. doi:10.21037/mhealth.2017.08.06
- Chapko, D., McCormack, R., Black, C., Staff, R., & Murray, A. (2018). Life-course determinants of cognitive reserve (CR) in cognitive aging and dementia - a systematic literature review. *Aging and Mental Health*, 22(8), 915-926. doi:10.1080/13607863.2017.1348471
- Chappell, N. L., Dlott, B. H., Hollander, M. J., Miller, J. A., & McWilliam, C. (2004). Comparative costs of home care and residential care. *The Gerontologist*, 44(3), 389-400.
- Chen, C., Goldman, D. P., Zissimopoulos, J., & Rowe, J. W. (2018a). Multidimensional comparison of countries' adaptation to societal aging. *Proceedings of the National Academy of Sciences of the United States of America*, 115(37), 9169-9174. doi:10.1073/pnas.1806260115
- Chen, W. Z., Chen, X. D., Ma, L. L., Zhang, F. M., Lin, J., Zhuang, C. L., ... Chen, X. X. (2018b). Impact of visceral obesity and sarcopenia on short-term outcomes after colorectal cancer surgery. *Digestive Diseases and Sciences*, 63(6), 1620-1630. doi:10.1007/s10620-018-5019-2
- Chene, G., Beiser, A., Au, R., Preis, S. R., Wolf, P. A., Dufouil, C., & Seshadri, S. (2015). Gender and incidence of dementia in the Framingham heart study from mid-adult life. *Alzheimer's & Dementia*, 11(3), 310-320. doi:10.1016/j.jalz.2013.10.005
- Cheng, S.-T., Chow, P. K., Song, Y.-Q., Yu, E. C. S., & Lam, J. H. M. (2014). Can leisure activities slow dementia progression in nursing home residents? A cluster-randomized controlled trial. *International Psychogeriatrics*, 26(4), 637-643. doi:10.1017/S1041610213002524

- Cheng, S. T., Chow, P. K., Yu, E. C., & Chan, A. C. (2012). Leisure activities alleviate depressive symptoms in nursing home residents with very mild or mild dementia. *The American Journal of Geriatric Psychiatry*, 20(10), 904-908. doi:10.1097/JGP.0b013e3182423988
- Chihuri, S., Mielenz, T. J., DiMaggio, C. J., Betz, M. E., DiGuseppi, C., Jones, V. C., & Li, G. (2016). Driving cessation and health outcomes in older adults. *Journal of the American Geriatrics Society*, 64(2), 332-341. doi:10.1111/jgs.13931
- Childs, B. G., Gluscevic, M., Baker, D. J., Laberge, R. M., Marquess, D., Dananberg, J., & van Deursen, J. M. (2017). Senescent cells: An emerging target for diseases of ageing. *Nature Reviews Drug Discovery*, 16(10), 718-735. doi:10.1038/nrd.2017.116
- Choi, M., Lohman, M. C., & Mezuk, B. (2014). Trajectories of cognitive decline by driving mobility: Evidence from the health and retirement study. *International Journal of Geriatric Psychiatry*, 29(5), 447-453. doi:10.1002/gps.4024
- Christensen, K., McGue, M., Petersen, I., Jeune, B., & Vaupel, J. W. (2008). Exceptional longevity does not result in excessive levels of disability. *Proceedings of the National Academy of Sciences of the United States of America*, 105(36), 13274-13279. doi:10.1073/pnas.0804931105
- Christensen, K., Thinggaard, M., Oksuzyan, A., Steenstrup, T., Andersen-Ranberg, K., Jeune, B., ... Vaupel, J. W. (2013). Physical and cognitive functioning of people older than 90 years: A comparison of two Danish cohorts born 10 years apart. *Lancet*, 382(9903), 1507-1513. doi:10.1016/s0140-6736(13)60777-1
- Clark, C., Caldwell, T., Power, C., & Stansfeld, S. A. (2010). Does the influence of childhood adversity on psychopathology persist across the lifecourse? A 45-year prospective epidemiologic study. *Annals of Epidemiology*, 20(5), 385-394. doi:10.1016/j.annepidem.2010.02.008
- Clark, C., Smuk, M., Lain, D., Stansfeld, S. A., Carr, E., Head, J., & Vickerstaff, S. (2017). Impact of childhood and adulthood psychological health on labour force participation and exit in later life. *Psychological Medicine*, 47(9), 1597-1608.
- Clark, R. I., & Walker, D. W. (2018). Role of gut microbiota in aging-related health decline: Insights from invertebrate models. *Cell Mol Life Sci*, 75(1), 93-101. doi:10.1007/s00018-017-2671-1
- Clay, O. J., Roth, D. L., Wadley, V. G., & Haley, W. E. (2008). Changes in social support and their impact on psychosocial outcome over a 5-year period for African American and white dementia caregivers. *International Journal of Geriatric Psychiatry*, 23(8), 857-862. doi:10.1002/gps.1996
- Claybrook, J., & Kildare, S. (2018). Autonomous vehicles: No driver...no regulation? *Science*, 361(6397), 36-37. doi:10.1126/science.aau2715
- Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). Frailty in elderly people. *Lancet*, 381(9868), 752-762. doi:10.1016/s0140-6736(12)62167-9
- Cleland, J. G., Swedberg, K., Follath, F., Komajda, M., Cohen-Solal, A., Aguilar, J. C., ... Mason, J. (2003). The euroheart failure survey programme – a survey on the quality of care among patients with heart failure in Europe. Part 1: Patient characteristics and diagnosis. *European Heart Journal*, 24(5), 442-463.
- Clemons, T. E., Rankin, M. W., & McBee, W. L. (2006). Cognitive impairment in the age-related eye disease study: Areds report no. 16. *Archives of Ophthalmology*, 124(4), 537-543. doi:10.1001/archoph.124.4.537
- Clifford, A., Lang, L., Chen, R., Anstey, K. J., & Seaton, A. (2016). Exposure to air pollution and cognitive functioning across the life course – a systematic literature review. *Environmental Research*, 147, 383-398. doi:10.1016/j.envres.2016.01.018
- Clouston, S. A., Brewster, P., Kuh, D., Richards, M., Cooper, R., Hardy, R., ... Hofer, S. M. (2013). The dynamic relationship between physical function and cognition in longitudinal aging cohorts. *Epidemiologic Reviews*, 35, 33-50. doi:10.1093/epirev/mxs004
- Coe, N. B., von Gaudecker, H. M., Lindeboom, M., & Maurer, J. (2012). The effect of retirement on cognitive functioning. *Health Economics*, 21(8), 913-927. doi:10.1002/hec.1771
- Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., ... Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the global burden of diseases study 2015. *Lancet*, 389(10082), 1907-1918. doi:10.1016/s0140-6736(17)30505-6
- Coile, C., & Gruber, J. (2001). Social security incentives for retirement. In D. A. Wise (Ed.), *Themes in the economics of aging* (pp. 311 - 354). London: University of Chicago Press.
- Coleman, E. A., Parry, C., Chalmers, S., & Min, S. J. (2006). The care transitions intervention: Results of a randomized controlled trial. *Archives of Internal Medicine*, 166(17), 1822-1828. doi:10.1001/archinte.166.17.1822
- Coleman, T., Kearns, R. A., & Wiles, J. (2016). Older adults' experiences of home maintenance issues and opportunities to maintain ageing in place. *Housing Studies*, 31(8), 964-983. doi:10.1080/02673037.2016.1164834
- Collerton, J., Kingston, A., Bond, J., Davies, K., Eccles, M. P., Jagger, C., ... Newton, J. L. (2012). The personal and health service impact of falls in 85 year olds: Cross-sectional findings from the newcastle 85+ cohort study. *PLOS ONE*, 7(3), e33078. doi:10.1371/journal.pone.0033078
- Colombo, F., Llana-Nozal, A., Mercier, J., & Tjadens, F. (2011). *Help wanted? Providing and paying for long-term care*. Paris: OECD Publishing.
- Commission/EACEA/Eurydice, E. (2019). *Compulsory education in Europe - 2018/19. Eurydice facts and figures*. Retrieved from <https://publications.europa.eu/en/publication-detail/-/publication/4569ca0c-caa7-11e8-9424-01aa75ed71a1/language-en/format-PDF>
- Committee for Medicinal Products for Human Use (CHMP). (2018). *Reflection paper on physical frailty: Instruments for baseline characterisation of older populations in clinical trials (EMA/CHMP/778709/2015)*. Retrieved from [https://www.ema.europa.eu/en/documents/other/reflection-paper-physical-frailty\\_en.pdf](https://www.ema.europa.eu/en/documents/other/reflection-paper-physical-frailty_en.pdf)

ema.europa.eu/documents/scientific-guideline/reflection-paper-physical-frailty-instruments-baseline-characterisation-older-populations-clinical\_en.pdf

- Compston, J. E., Flahive, J., Hosmer, D. W., Watts, N. B., Siris, E. S., Silverman, S., ... Adachi, J. D. (2014). Relationship of weight, height, and body mass index with fracture risk at different sites in postmenopausal women: The global longitudinal study of osteoporosis in women (GLOW). *Journal of Bone and Mineral Research*, 29(2), 487-493. doi:10.1002/jbmr.2051
- CONSOL. (2013). Driver licensing legislation. Retrieved from [http://www.consolproject.eu/attachments/article/16/CONSOL%20Report\\_WP5.1\\_final.pdf](http://www.consolproject.eu/attachments/article/16/CONSOL%20Report_WP5.1_final.pdf)
- Cooper, C., Balamurali, T. B., & Livingston, G. (2007). A systematic review of the prevalence and covariates of anxiety in caregivers of people with dementia. *International Psychogeriatrics*, 19(2), 175-195. doi:10.1017/s1041610206004297
- Cooper, C., Katona, C., Orrell, M., & Livingston, G. (2008). Coping strategies, anxiety and depression in caregivers of people with Alzheimer's disease. *International Journal of Geriatric Psychiatry*, 23(9), 929-936. doi:10.1002/gps.2007
- Cooper, J. A., Cadogan, C. A., Patterson, S. M., Kerse, N., Bradley, M. C., Ryan, C., & Hughes, C. M. (2015). Interventions to improve the appropriate use of polypharmacy in older people: A cochrane systematic review. *BMJ Open*, 5(12), e009235. doi:10.1136/bmjopen-2015-009235
- Cooper, R., Hardy, R., Sayer, A. A., & Kuh, D. (2014). A life course approach to physical capability. In R. C. Diana Kuh, Rebecca Hardy, Marcus Richards, and Yoav Ben-Shlomo (Ed.), *A life course approach to healthy ageing*. Oxford Oxford University Press.
- Cooper, R., Kuh, D., Cooper, C., Gale, C. R., Lawlor, D. A., Matthews, F., & Hardy, R. (2011). Objective measures of physical capability and subsequent health: A systematic review. *Age and Ageing*, 40(1), 14-23. doi:10.1093/ageing/afq117
- Cooper, R., Kuh, D., Hardy, R., & Mortality Review Group. (2010). Objectively measured physical capability levels and mortality: Systematic review and meta-analysis. *BMJ (Clinical Research Edition)*, 341, c4467. doi:10.1136/bmj.c4467
- Cooper, R., Muniz-Terrera, G., & Kuh, D. (2016). Associations of behavioural risk factors and health status with changes in physical capability over 10 years of follow-up: The MRC national survey of health and development. *BMJ Open*, 6(4), e009962. doi:10.1136/bmjopen-2015-009962
- Cooper, R., Richards, M., & Kuh, D. (2017). Childhood cognitive ability and age-related changes in physical capability from midlife: Findings from a British birth cohort study. *Psychosomatic Medicine*, 79(7), 785-791. doi:10.1097/PSY.0000000000000482
- Costa-Font, J., & Zigante, V. (2017). Building implicit partnerships? Financial long term care entitlements in Europe. *LEQS*, No. 125. doi:10.2139/ssrn.3052190
- Council of the European Union and European Parliament (2016). Regulation (EU) 2016/679 (General Data Protection Regulation). Brussels, Belgium. Retrieved from <https://publications.europa.eu/en/publication-detail/-/publication/3e485e15-11bd-11e6-baga-01aa75ed71a1/language-en>
- Covenant on Demographic Change. (2018). Towards an age-friendly Europe. Retrieved from [https://www.agefriendlyEurope.org/sites/default/files/Covenant\\_brochure.pdf](https://www.agefriendlyEurope.org/sites/default/files/Covenant_brochure.pdf)
- Cowie, M. R., Anker, S. D., Cleland, J. G. F., Felker, G. M., Filippatos, G., Jaarsma, T., ... Lopez-Sendon, J. (2014). Improving care for patients with acute heart failure: Before, during and after hospitalization. *ESC Heart Fail*, 1(2), 110-145. doi:10.1002/ehf2.12021
- Cox, C., & Pardasani, M. (2017). Aging and human rights: A rights-based approach to social work with older adults. *Journal of Human Rights and Social Work*, 2(3), 98-106. doi:10.1007/s41134-017-0037-0
- Crabtree, M., Lodge, C., & Emmerson, P. (2015). A review of pedestrian walking speeds and time needed to cross the road. Retrieved from <https://trl.co.uk/reports/PPR700>
- Crews, J. E., Chou, C. F., Sekar, S., & Saaddine, J. B. (2017). The prevalence of chronic conditions and poor health among people with and without vision impairment, aged >/=65 years, 2010-2014. *American Journal of Ophthalmology*, 182, 18-30. doi:10.1016/j.ajo.2017.06.038
- Crocker, T., Forster, A., Young, J., Brown, L., Ozer, S., Smith, J., ... Greenwood, D. C. (2013). Physical rehabilitation for older people in long-term care. *The Cochrane Database of Systematic Reviews (CDSR)*, (2). doi:10.1002/14651858.CD004294.pub3
- Cronin-Golomb, A., Gilmore, G. C., Neargarder, S., Morrison, S. R., & Laudate, T. M. (2007). Enhanced stimulus strength improves visual cognition in aging and Alzheimer's disease. *Cortex*, 43(7), 952-966.
- Croteau, K. A., Richeson, N. E., Vines, S. W., & Jones, D. B. (2004). Effects of a pedometer-based physical activity program on older adults' mobility-related self-efficacy and physical performance. *Activities, Adaptation & Aging*, 28(2), 19-33. doi:10.1300/J016v28n02\_02
- Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyere, O., Cederholm, T., ... Zamboni, M. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing*, 48(1), 16-31. doi:10.1093/ageing/afy169
- Cruz-Jentoft, A. J., Carpena-Ruiz, M., Montero-Errasquin, B., Sanchez-Castellano, C., & Sanchez-Garcia, E. (2013). Exclusion of older adults from ongoing clinical trials about type 2 diabetes mellitus. *Journal of the American Geriatrics Society*, 61(5), 734-738. doi:10.1111/jgs.12215
- Cruz-Jentoft, A. J., Landi, F., Schneider, S. M., Zuniga, C., Arai, H., Boirie, Y., ... Cederholm, T. (2014). Prevalence of and interventions for sarcopenia in ageing adults: A systematic review. Report of the international sarcopenia initiative (EWGSOP and IWGS). *Age and Ageing*, 43(6), 748-759. doi:10.1093/ageing/afu115
- Cukierman-Yaffe, T., Gerstein, H. C., & Williamson, J. D. e. a. (2009). Action to control cardiovascular risk in diabetes-memory in diabetes (accord-mind) investigators. *Diabetes Care* 32, 221-226.

- Cukierman, T., Gerstein, H. C., & Williamson, J. D. (2005). Cognitive decline and dementia in diabetes – systematic overview of prospective observational studies. *Diabetologia*, 48(12), 2460-2469. doi:10.1007/s00125-005-0023-4
- Cumberland, P. M., & Rahi, J. S. (2016). Visual function, social position, and health and life chances: The UK biobank study. *JAMA Ophthalmology*, 134(9), 959-966. doi:10.1001/jamaophthalmol.2016.1778
- Cummings, J. L., Morstorf, T., & Zhong, K. (2014). Alzheimer's disease drug-development pipeline: Few candidates, frequent failures. *Alzheimer's Research & Therapy*, 6(4), 37. doi: 10.1186/alzrt269
- Currie, W. L., & Seddon, J. J. M. (2014). A cross-national analysis of eHealth in the European Union: Some policy and research directions. *Information & Management*, 51(6), 783-797. doi:10.1016/j.im.2014.04.004
- DaCoTa. (2012). Older drivers. Retrieved from [http://safetyknowsys.swov.nl/safety\\_issues/Older-drivers.html](http://safetyknowsys.swov.nl/safety_issues/Older-drivers.html)
- Dahl, T. S., & Boulos, M. N. K. (2014). Robots in health and social care: A complementary technology to home care and telehealthcare? *Robotics*, 3(1), 1. doi: 10.3390/robotics3010001
- Dalleur, O., Boland, B., Losseau, C., Henrard, S., Wouters, D., Speybroeck, N., ... Spinewine, A. (2014). Reduction of potentially inappropriate medications using the stopp criteria in frail older inpatients: A randomised controlled study. *Drugs & Aging*, 31(4), 291-298. doi:10.1007/s40266-014-0157-5
- Dalton, K., O'Brien, G., O'Mahony, D., & Byrne, S. (2018). Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: A systematic review and meta-analysis. *Age and Ageing*, 47(5), 670-678. doi:10.1093/ageing/afy086
- Dar, O. A., Hasan, R., Schlundt, J., Harbarth, S., Caleo, G., Dar, F. K., ... Heymann, D. L. (2016). Exploring the evidence base for national and regional policy interventions to combat resistance. *Lancet*, 387(10015), 285-295. doi:10.1016/s0140-6736(15)00520-6
- Darkins, A., Ryan, P., Kobb, R., Foster, L., Edmonson, E., Wakefield, B., & Lancaster, A. E. (2008). Care coordination/home telehealth: The systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. *Telemedicine and e-health*, 14(10), 1118-1126. doi:10.1089/tmj.2008.0021
- Dartigues, J. F., & Feart, C. (2011). Risk factors for Alzheimer disease: Aging beyond age? *Neurology*, 77(3), 206-207. doi:10.1212/WNL.ob013e31822550af
- Daskalopoulou, C., Stubbs, B., Kralj, C., Koukounari, A., Prince, M., & Prina, A. M. (2017). Physical activity and healthy ageing: A systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews*, 38, 6-17. doi:10.1016/j.arr.2017.06.003
- Daskalopoulou, C., Stubbs, B., Kralj, C., Koukounari, A., Prince, M., & Prina, A. M. (2018). Associations of smoking and alcohol consumption with healthy ageing: A systematic review and meta-analysis of longitudinal studies. *BMJ Open*, 8(4), e019540. doi:10.1136/bmjopen-2017-019540
- Davey, J., & Glasgow, K. (2006). Positive ageing - A critical analysis. *Policy Quarterly*, 2, 21-27. doi: 10.26686/pq.v2i4.4209
- Davis, A., McMahon, C. M., Pichora-Fuller, K. M., Russ, S., Lin, F., Olusanya, B. O., ... Tremblay, K. L. (2016). Aging and hearing health: The life-course approach. *The Gerontologist*, 56 (Suppl. 2), S256-267. doi:10.1093/geront/gnw033
- Day, F. R., Elks, C. E., Murray, A., Ong, K. K., & Perry, J. R. (2015). Puberty timing associated with diabetes, cardiovascular disease and also diverse health outcomes in men and women: The UK Biobank study. *Scientific Reports*, 5, 11208. doi:10.1038/srep11208
- De Angelis, G., Murthy, A., Beyersmann, J., & Harbarth, S. (2010). Estimating the impact of healthcare-associated infections on length of stay and costs. *Clinical Microbiology and Infection*, 16(12), 1729-1735. doi:10.1111/j.1469-0691.2010.03332.x
- De Angelis, R., Sant, M., Coleman, M. P., Francisci, S., Baili, P., Pierannunzio, D., ... Capocaccia, R. (2014). Cancer survival in Europe 1999-2007 by country and age: Results of EUROCARE-5 – a population-based study. *The Lancet Oncology*, 15(1), 23-34. doi:10.1016/s1470-2045(13)70546-1
- de Jong Gierveld, J., van Tilburg, T., & Dykstra, P. A. (2006). Loneliness and social isolation. In A. L. Vangelisti & D. Perlman (Eds.), *The Cambridge handbook of personal relationships* (pp. 485-500). Cambridge: Cambridge University Press.
- de Jong, P. G., Pickering, J. D., Hendriks, R. A., Swinnerton, B. J., Goshtasbpour, F., & Reinders, M. E. (2019). Twelve tips for integrating massive open online course content into classroom teaching. *Medical Teacher*, 1-5. doi:10.1080/0142159X.2019.1571569
- de Rezende, L. F., Rey-Lopez, J. P., Matsudo, V. K., & do Carmo Luiz, O. (2014). Sedentary behavior and health outcomes among older adults: A systematic review. *BMC Public Health*, 14:333, 1-9. doi:10.1186/1471-2458-14-333
- De Vleminck, A., Pype, P., Batteuw, D., & Demeyere, T. (2017). Do non-terminally ill adults want to discuss the end of life with their family physician? An explorative mixed-method study on patients' preferences and family physicians' views in Belgium. *Family Practice*, 35(4), 495-502. doi:10.1093/fampra/cmz125
- de Vries, N. M., van Ravensberg, C. D., Hobbelen, J. S., Olde Rikkert, M. G., Staal, J. B., & Nijhuis-van der Sanden, M. W. (2012). Effects of physical exercise therapy on mobility, physical functioning, physical activity and quality of life in community-dwelling older adults with impaired mobility, physical disability and/or multi-morbidity: A meta-analysis. *Ageing Research Reviews*, 11(1), 136-149. doi:10.1016/j.arr.2011.11.002
- DeAndrade, J., Pedersen, M., Garcia, L., & Nau, P. (2018). Sarcopenia is a risk factor for complications and an independent predictor of hospital length of stay in trauma patients. *The Journal of Surgical Research*, 221, 161-166. doi:10.1016/j.jss.2017.08.018

- Deary, I. J., Corley, J., Gow, A. J., Harris, S. E., Houlihan, L. M., Marioni, R. E., ... Starr, J. M. (2009). Age-associated cognitive decline. *British Medical Bulletin*, 92, 135-152. doi:10.1093/bmb/ldp033
- Deelen, J., van den Akker, E. B., Trompet, S., van Heemst, D., Mooijaart, S. P., Slagboom, P. E., & Beekman, M. (2016). Employing biomarkers of healthy ageing for leveraging genetic studies into human longevity. *Experimental Gerontology*, 82, 166-174. doi:10.1016/j.exger.2016.06.013
- Deindl, C., & Brandt, M. (2017). Support networks of childless older people: Informal and formal support in Europe. *Ageing and Society*, 37(8), 1543-1567. doi:10.1017/S0144686X16000416
- den Ouden, M. E., Schuurmans, M. J., Arts, I. E., & van der Schouw, Y. T. (2011). Physical performance characteristics related to disability in older persons: A systematic review. *Maturitas*, 69(3), 208-219. doi:10.1016/j.maturitas.2011.04.008
- den Uyl, D., Nurmohamed, M. T., van Tuyl, L. H., Raterman, H. G., & Lems, W. F. (2011). (Sub)clinical cardiovascular disease is associated with increased bone loss and fracture risk; a systematic review of the association between cardiovascular disease and osteoporosis. *Arthritis Research & Therapy*, 13(1), R5. doi:10.1186/ar3224
- Dennis, H., & Thomas, K. (2007). Ageism in the workplace. *Generations*, 31(1):84-89
- Department of Economic and Social Affairs, Population Division. (2017). *World population prospects: The 2017 revision, key findings and advance*. United Nations, New York.
- Depp, C. A., & Jeste, D. V. (2006). Definitions and predictors of successful aging: A comprehensive review of larger quantitative studies. *American Journal of Geriatric Psychiatry*, 14(1), 6-20. doi:10.1097/01.JGP.0000192501.03069.bc
- Devroey, D., & Van Casteren, V. (2011). Signs for early diagnosis of heart failure in primary health care. *Vasc Health Risk Manag*, 7, 591-596. doi:10.2147/vhrm.S24476
- Dias, R., Santos, R. L., Sousa, M. F. B. d., Nogueira, M. M. L., Torres, B., Belfort, T., & Dourado, M. C. N. (2015). Resilience of caregivers of people with dementia: A systematic review of biological and psychosocial determinants. *Trends in Psychiatry and Psychotherapy*, 37, 12-19.
- Dickerson, A. E. (2013). Driving assessment tools used by driver rehabilitation specialists: Survey of use and implications for practice. *The American Journal of Occupational Therapy*, 67(5), 564-573. doi:10.5014/ajot.2013.007823
- Diz-Lois Martínez, F., Fernández Alvarez, O., & Pérez Vázquez, C. (2012). El paciente polimedicado. *Galicia Clínica*, 73, 37-41. doi:10.22546/17/311
- Dodds, R., Denison, H. J., Ntani, G., Cooper, R., Cooper, C., Sayer, A. A., & Baird, J. (2012). Birth weight and muscle strength: A systematic review and meta-analysis. *The Journal of Nutrition, Health and Aging*, 16(7), 609-615. doi:10.1007/s12603-012-0053-9
- Dodds, R. M., Syddall, H. E., Cooper, R., Benzeval, M., Deary, I. J., Dennison, E. M., ... Sayer, A. A. (2014). Grip strength across the life course: Normative data from twelve British studies. *PLOS ONE*, 9(12), e113637. doi:10.1371/journal.pone.0113637
- Dodson, J. A., Truong, T. T., Towle, V. R., Kerins, G., & Chaudhry, S. I. (2013). Cognitive impairment in older adults with heart failure: Prevalence, documentation, and impact on outcomes. *The American Journal of Medicine*, 126(2), 120-126. doi:10.1016/j.amjmed.2012.05.029
- Doherty, A. M., & Gaughran, F. (2014). The interface of physical and mental health. *Social Psychiatry Psychiatric Epidemiology*, 49(5), 673-682. doi:10.1007/s00127-014-0847-7
- Dolberg, P., Sigurðardóttir, S. H., & Trummer, U. (2018). Ageism and older immigrants. In L. Ayalon & C. Tesch-Römer (Eds.), *Contemporary perspectives on ageism* (pp. 177-191). Cham: Springer International Publishing.
- Donkor, A., McDonagh, T., & Hardman, S. (2017). *National heart failure audit*. London: Healthcare Quality Improvement Partnership.
- Dumanovsky, T., Augustin, R., Rogers, M., Lettang, K., Meier, D. E., & Morrison, R. S. (2016). The growth of palliative care in U.S. hospitals: A status report. *Journal of Palliative Medicine*, 19(1), 8-15. doi:10.1089/jpm.2015.0351
- Eby, D. W., Molnar, L. J., & Kartje, P. S. (2008). *Maintaining safe mobility in an aging society* (1st edition). Boca Raton: Taylor&Francis Group.
- ECDC/EMEA Joint Working Group. (2009). *The bacterial challenge: Time to react*. Retrieved from [https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/0909\\_TER\\_The\\_Bacterial\\_Challenge\\_Time\\_to\\_React.pdf](https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/0909_TER_The_Bacterial_Challenge_Time_to_React.pdf)
- EEAC. (2018a). *European economic area council, 20/11/2018*. EU Council press. Retrieved from <https://www.pubaffairsbruxelles.eu/European-economic-area-council-20-11-2018-eu-council-press/>
- EEAC. (2018b). *European Economic Area Council, 23/05/2018*. Main results. Retrieved from <https://www.consilium.europa.eu/en/meetings/international-ministerial-meetings/2018/05/23/>
- Elia, M., Parsons, E. L., Cawood, A. L., Smith, T. R., & Stratton, R. J. (2018). Cost-effectiveness of oral nutritional supplements in older malnourished care home residents. *Clinical Nutrition*, 37(2), 651-658. doi:10.1016/j.clnu.2017.02.008
- Elliott, A., Hull, L., & Conroy, S. P. (2017). Frailty identification in the emergency department—a systematic review focussing on feasibility. *Age and Ageing*, 46(3), 509-513. doi:10.1093/ageing/afx019
- Epizooties, O. I. d. (2015). Report of the meeting of the OIE ad hoc group on prioritisation of diseases for which vaccines could reduce antimicrobial use in animals. Retrieved from [http://www.oie.int/fileadmin/SST/adhocreports/Diseases%20for%20which%20Vaccines%20could%20reduce%20Antimicrobial%20Use/AN/AHG\\_AMUR\\_Vaccines\\_Apr2015.pdf](http://www.oie.int/fileadmin/SST/adhocreports/Diseases%20for%20which%20Vaccines%20could%20reduce%20Antimicrobial%20Use/AN/AHG_AMUR_Vaccines_Apr2015.pdf)
- Espay, A. J., Bonato, P., Nahab, F. B., Maetzler, W., Dean, J. M., Klucken, J., ... Technology, o. b. o. t. M. D. S. T. F. o. (2016). Technology in parkinson's disease: Challenges and opportunities. *Movement Disorders*, 31(9), 1272-1282. doi:10.1002/mds.26642

- Espeland, M. A., Crimmins, E. M., Grossardt, B. R., Crandall, J. P., Gelfond, J. A., Harris, T. B., ... Barzilai, N. (2017). Clinical trials targeting aging and age-related multimorbidity. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 72(3), 355-361. doi:10.1093/gerona/glw220
- Estebarsari, F., Dastoorpoor, M., Mostafaei, D., Khanjani, N., Khalifehkandi, Z. R., Froushani, A. R., ... Taghdisi, M. H. (2018). Design and implementation of an empowerment model to prevent elder abuse: A randomized controlled trial. *Clinical Interventions in Aging*, 13, 669-679. doi:10.2147/cia.S158097
- Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.-I., Corella, D., Arós, F., ... Martínez-González, M. A. (2018). Primary prevention of cardiovascular disease with a mediterranean diet supplemented with extra-virgin olive oil or nuts. *The New England Journal of Medicine*, 378(25), e34. doi:10.1056/NEJMoa1800389
- Etezadi, S., & Pushkar, D. (2013). Why are wise people happier? An explanatory model of wisdom and emotional well-being in older adults. *Journal of Happiness Studies*, 14(3), 929-950. doi:10.1007/s10902-012-9362-2
- Eurobarometer. (2012). Active ageing. Retrieved from [http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs\\_378\\_sum\\_en.pdf](http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_378_sum_en.pdf)
- Eurocarers. (2019). About us – Eurocarers Guiding Principles. Retrieved from <https://eurocarers.org/about/>
- European Association for Directors and Providers of Long-Term Care Services for the Elderly (E.D.E.). (2016). Daphne eustacea project. Retrieved from <http://www.ede-eu.org/en/articles/daphne-eustacea-project>
- European Centre for Disease Prevention and Control. (2013). Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals 2011-2012. Retrieved from <https://ecdc.europa.eu/en/publications-data/point-prevalence-survey-healthcare-associated-infections-and-antimicrobial-use-0>
- European Centre for Disease Prevention and Control. (2014). Point prevalence survey of healthcare-associated infections and antimicrobial use in European long-term care facilities. April–May 2013. Retrieved from <https://ecdc.europa.eu/en/publications-data/point-prevalence-survey-healthcare-associated-infections-and-antimicrobial-use-0>
- European Centre for Disease Prevention and Control. (2019). European Surveillance of Antimicrobial Consumption Network (ESAC-Net). Retrieved from <https://ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/esac-net>
- European Commission. (2007). Health strategy. Retrieved from [https://ec.europa.eu/health/policies/background/review/strategy\\_en](https://ec.europa.eu/health/policies/background/review/strategy_en)
- European Commission. (2008). Green paper on the European workforce for health. Retrieved from [https://ec.europa.eu/health/ph\\_systems/docs/workforce\\_gp\\_en.pdf](https://ec.europa.eu/health/ph_systems/docs/workforce_gp_en.pdf)
- European Commission. (2010). K4care - knowledge-based home-care eServices for an ageing Europe. Retrieved from <https://ec.europa.eu/digital-single-market/en/news/k4care-knowledge-based-home-care-eservices-ageing-Europe>
- European Commission. (2011). Directive 2011/24/EU of the European parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare. Retrieved from <https://eur-lex.europa.eu/eli/dir/2011/24/oj>
- European Commission. (2016). Patients' rights in the European Union: Mapping exercise. Retrieved from [https://ec.europa.eu/health/sites/health/.../2018\\_mapping\\_patientsrights\\_frep\\_en.pdf](https://ec.europa.eu/health/sites/health/.../2018_mapping_patientsrights_frep_en.pdf)
- European Commission. (2017). European pillar of social rights. Retrieved from [https://ec.europa.eu/commission/priorities/deeper-and-fairer-economic-and-monetary-union/European-pillar-social-rights\\_en](https://ec.europa.eu/commission/priorities/deeper-and-fairer-economic-and-monetary-union/European-pillar-social-rights_en)
- European Commission. (2018a). The 2018 ageing report. Economic & budgetary projections for the 28 EU member states (2016-2070). Luxembourg: European Commission.
- European Commission. (2018b). Commission work programme 2019: Delivering on promises and preparing for the future [Press release]. Retrieved from [http://europa.eu/rapid/press-release\\_IP-18-6147\\_en.pdf](http://europa.eu/rapid/press-release_IP-18-6147_en.pdf)
- European Commission. (2018c). European economic forecast. Autumn 2018. Retrieved from [https://ec.europa.eu/info/publications/economy-finance/European-economic-forecast-autumn-2018\\_en](https://ec.europa.eu/info/publications/economy-finance/European-economic-forecast-autumn-2018_en)
- European Commission. (2018d). European economic forecast. Autumn 2018. Institutional paper 089. Retrieved from [https://ec.europa.eu/info/publications/economy-finance/European-economic-forecast-autumn-2018\\_en](https://ec.europa.eu/info/publications/economy-finance/European-economic-forecast-autumn-2018_en)
- European Commission. (2019). Transformation of health and care in the digital single market. Retrieved from <https://ec.europa.eu/digital-single-market/en/European-policy-ehealth>
- European Commission. (2019a). Digital single market: Bringing down barriers to unlock online opportunities. Retrieved from [https://ec.europa.eu/commission/priorities/digital-single-market\\_en](https://ec.europa.eu/commission/priorities/digital-single-market_en)
- European Commission. (2019b). EU Health Policy Platform. Retrieved from <https://webgate.ec.europa.eu/hpfp/>
- European Commission & European Committee of the Regions. (2011). How to promote active ageing in Europe. EU support to local and regional actors. Retrieved from <https://publications.europa.eu/en/publication-detail/-/publication/6d80a85f-43d5-4462-b5bf-8dd8aafffb5>
- European Energy Agency. (2018a). Air quality in Europe - 2018 report. Retrieved from <https://www.eea.europa.eu/publications/air-quality-in-Europe-2018>
- European Energy Agency. (2018b). National climate change vulnerability and risk assessments in Europe, 2018. Retrieved from <https://www.eea.europa.eu/publications/national-climate-change-vulnerability-2018>
- European Innovation Partnership on Active and Healthy Ageing. (2012). Action plan on 'innovation for age-friendly buildings, cities & environments'. Retrieved from [https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/d4\\_action\\_plan.pdf](https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/d4_action_plan.pdf)

- European Innovation Partnership on Active and Healthy Ageing. (2019). Retrieved from [https://ec.europa.eu/eip/ageing/home\\_en](https://ec.europa.eu/eip/ageing/home_en)
- European Lung White Book. (2019). Chronic obstructive pulmonary disease. Retrieved from <https://www.erswhitebook.org/chapters/chronic-obstructive-pulmonary-disease/>
- European Medicines Agency. (2015). New strategy to fight antimicrobial resistance. News article from 17/11/2015. Retrieved from <https://www.ema.europa.eu/en/news/new-strategy-fight-antimicrobial-resistance>
- European Physical and Rehabilitation Medicine Bodies Alliance. (2018). White book on Physical and Rehabilitation Medicine (PRM) in Europe. Chapter 1. Definitions and concepts of prm. *European Journal of Physical and Rehabilitation Medicine*, 54(2), 156-165. doi:10.23736/s1973-9087.18.05144-4
- Eurostat. (2015). Women in the EU gave birth to their first child at almost 29 years of age on average [Press release]. Retrieved from <https://ec.europa.eu/eurostat/documents/2995521/6829228/3-13052015-CP-EN.pdf/7e9007fb-3ca9-445f-96eb-fd75d6792965>
- Eurostat. (2018a). Healthy life years and life expectancy at birth, by sex. Retrieved from: <https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00150>
- Eurostat. (2018b). Life expectancy at birth by sex. Retrieved from: [https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=sdg\\_03\\_10](https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=sdg_03_10)
- Eurostat. (2018c). Life expectancy by age, sex and educational attainment level. Retrieved from: [https://ec.europa.eu/eurostat/web/products-datasets/-/demo\\_mlexpecedu](https://ec.europa.eu/eurostat/web/products-datasets/-/demo_mlexpecedu)
- Eurostat. (2018d). Purchasing power adjusted gdp per capita. Retrieved from: [https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=sdg\\_10\\_10](https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=sdg_10_10)
- Eurostat. (2018e). Statistics explained: Healthcare personnel statistics - nursing and caring professionals. Retrieved from [https://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare\\_personnel\\_statistics\\_-\\_nursing\\_and\\_caring\\_professionals](https://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare_personnel_statistics_-_nursing_and_caring_professionals)
- Eurostat. (2018f). Statistics explained: Healthcare personnel statistics - physicians. Retrieved from [https://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare\\_personnel\\_statistics\\_-\\_physicians](https://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare_personnel_statistics_-_physicians)
- Eurostat. (2018g). Very elderly population aged 85 years and over living in an institutional household, by nuts level 2 region, 2011 (% share of very elderly population) piteu17. In: Eurostat Statistics Explained.
- Eurostat. (2018). Being young in Europe today - demographic trends. Retrieved from [https://ec.europa.eu/eurostat/statistics-explained/index.php/Being\\_young\\_in\\_Europe\\_today\\_-\\_demographic\\_trends](https://ec.europa.eu/eurostat/statistics-explained/index.php/Being_young_in_Europe_today_-_demographic_trends)
- Eurostat. (2019a). Statistics explained: Total fertility rate 1960-2017. Retrieved from [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Total\\_fertility\\_rate\\_1960%E2%80%932017\\_\(live\\_births\\_per\\_woman\).png](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Total_fertility_rate_1960%E2%80%932017_(live_births_per_woman).png)
- Eurostat. (2019b). Baseline projections: Demographic balances and indicators. Retrieved from <https://data.europa.eu/euodp/en/data/dataset/cgQfsU6YkvrjAlHYKMHp3w>
- Ewan, V. C., Witham, M. D., Kiernan, M., & Simpson, A. J. (2017). Hospital-acquired pneumonia surveillance-an unmet need. *The Lancet Respiratory Medicine*, 5(10), 771-772. doi:10.1016/s2213-2600(17)30296-5
- Excoffier, S., Herzig, L., N'Goran, A. A., Déruaz-Luyet, A., & Haller, D. M. (2018). Prevalence of multimorbidity in general practice: A cross-sectional study within the swiss sentinel surveillance system (sentinella). *BMJ Open*, 8(3), e019616. doi:10.1136/bmjopen-2017-019616
- Falcon, L. J., & Harris-Love, M. O. (2017). Sarcopenia and the new icd-10-cm code: Screening, staging, and diagnosis considerations. *Federal Practitioner*, 34(7), 24-32.
- Farr, M., Banks, J., Edwards, H. B., Northstone, K., Bernard, E., Salisbury, C., & Horwood, J. (2018). Implementing online consultations in primary care: A mixed-method evaluation extending normalisation process theory through service co-production. *BMJ Open*, 8(3), e019966. doi:10.1136/bmjopen-2017-019966
- Farre, T. B., Formiga, F., Ferrer, A., Plana-Ripoll, O., Almeda, J., & Pujol, R. (2014). Risk of being undernourished in a cohort of community-dwelling 85-year-olds: The Octabaix study. *Geriatrics & Gerontology International*, 14(3), 702-709. doi:10.1111/ggi.12142
- Fazio, S., Pace, D., Flinner, J., & Kallmyer, B. (2018). The fundamentals of person-centered care for individuals with dementia. *Gerontologist*, 58, 10-19. doi:10.1093/geront/gnx122
- Feast, A. R., White, N., Lord, K., Kupeli, N., Vickerstaff, V., & Sampson, E. L. (2018). Pain and delirium in people with dementia in the acute general hospital setting. *Age and Ageing*, 47(6), 841-846. doi:10.1093/ageing/afy112
- Ferlay, J., Colombet, M., Soerjomataram, I., Dyba, T., Randi, G., Bettio, M., ... Bray, F. (2018). Cancer incidence and mortality patterns in Europe: Estimates for 40 countries and 25 major cancers in 2018. *European Journal of Cancer*, 103, 356-387. doi:10.1016/j.ejca.2018.07.005
- Ferlay, J., Steliarova-Foucher, E., Lortet-Tieulent, J., Rosso, S., Coebergh, J. W. W., Comber, H., ... Bray, F. (2013). Cancer incidence and mortality patterns in Europe: Estimates for 40 countries in 2012. *European Journal of Cancer*, 49(6), 1374-1403. doi:10.1016/j.ejca.2012.12.027
- Fernandez-Friera, L., Penalvo, J. L., Fernandez-Ortiz, A., Ibanez, B., Lopez-Melgar, B., Laclaustra, M., ... Fuster, V. (2015). Prevalence, vascular distribution, and multiterritorial extent of subclinical atherosclerosis in a middle-aged cohort: The PESA (Progression of Early Subclinical Atherosclerosis) study. *Circulation*, 131(24), 2104-2113. doi:10.1161/circulationaha.114.014310

- Ferrari, A. J., Charlson, F. J., Norman, R. E., Patten, S. B., Freedman, G., Murray, C. J., ... Whiteford, H. A. (2013). Burden of depressive disorders by country, sex, age, and year: Findings from the global burden of disease study 2010. *PLOS Medicine*, 10(11), e1001547. doi:10.1371/journal.pmed.1001547
- Ferrari Bravo, M., Gallo, F., Marchello, C., Boicelli, R., Lupi, S., Atzei, M., ... Gabutti, G. (2018). Assessment of malnutrition in community-dwelling elderly people: Cooperation among general practitioners and public health. *Iranian Journal of Public Health*, 47(5), 633-640.
- Ferreira, E., Pina, E., Sousa-Uva, M., & Sousa-Uva, A. (2017). Risk factors for health care-associated infections: From better knowledge to better prevention. *American Journal of Infection Control*, 45(10), e103-e107. doi:10.1016/j.ajic.2017.03.036
- Ferreira, I. M., Brooks, D., White, J., & Goldstein, R. (2012a). Nutritional supplementation for stable chronic obstructive pulmonary disease. *The Cochrane Database of Systematic Reviews (CDSR)*, 12, Cd000998. doi:10.1002/14651858.CD000998.pub3
- Ferreira, M. L., Sherrington, C., Smith, K., Carswell, P., Bell, R., Bell, M., ... Vardon, P. (2012b). Physical activity improves strength, balance and endurance in adults aged 40-65 years: A systematic review. *Journal of Physiotherapy*, 58(3), 145-156. doi:10.1016/S1836-9553(12)70105-4
- Ferrer, R. L., & Palmer, R. (2004). Variations in health status within and between socioeconomic strata. *Journal of Epidemiology and Community Health*, 58(5), 381-387.
- Ferrucci, L., Cooper, R., Shardell, M., Simonsick, E. M., Schrack, J. A., & Kuh, D. (2016). Age-related change in mobility: Perspectives from life course epidemiology and geroscience. *The Journals of Gerontology*, 71(9), 1184-1194. doi:10.1093/gerona/glw043
- Fielding, R. A., Guralnik, J. M., King, A. C., Pahor, M., McDermott, M. M., Tudor-Locke, C., ... Rejeski, W. J. (2017). Dose of physical activity, physical functioning and disability risk in mobility-limited older adults: Results from the life study randomized trial. *PLOS ONE*, 12(8), e0182155. doi:10.1371/journal.pone.0182155
- Fitzmaurice, C., Dicker, D., Pain, A., Hamavid, H., Moradi-Lakeh, M., MacIntyre, M. F., ... Naghavi, M. (2015). The global burden of cancer 2013. *JAMA Oncology*, 1(4), 505-527. doi:10.1001/jamaoncol.2015.0735
- Flaxman, S. R., Bourne, R. R. A., Resnikoff, S., Ackland, P., Braithwaite, T., Cicinelli, M. V., ... Taylor, H. R. (2017). Global causes of blindness and distance vision impairment 1990-2020: A systematic review and meta-analysis. *The Lancet Global Health*, 5(12), e1221-e1234. doi:10.1016/s2214-109x(17)30393-5
- Fleming, J., & Brayne, C. (2008). Inability to get up after falling, subsequent time on floor, and summoning help: Prospective cohort study in people over 90. *The BMJ*, 337, a2227. doi:10.1136/bmj.a2227
- Fleming, T. P., Watkins, A. J., Velazquez, M. A., Mathers, J. C., Prentice, A. M., Stephenson, J., ... Godfrey, K. M. (2018). Origins of lifetime health around the time of conception: Causes and consequences. *Lancet*, 391(10132), 1842-1852. doi:10.1016/s0140-6736(18)30312-x
- Fletcher, M., Jha, A., Dunlop, W., Heron, L., Wolfram, V., Van der Molen, T., & Price, D. (2015). Patient reported burden of asthma on resource use and productivity across 11 countries in Europe. *Advances in Therapy*, 32(4), 370-380. doi:10.1007/s12325-015-0204-6
- Flodgren, G., Rachas, A., Farmer, A. J., Inzitari, M., & Shepperd, S. (2015). Interactive telemedicine: Effects on professional practice and health care outcomes. *The Cochrane Database of Systematic Reviews (CDSR)*(9), Cd002098. doi:10.1002/14651858.CD002098.pub2
- Flores, M., Glusman, G., Brogaard, K., Price, N. D., & Hood, L. (2013). P4 medicine: How systems medicine will transform the healthcare sector and society. *Personalized Medicine*, 10(6), 565-576. doi:10.2217/pme.13.57
- Fogel, R. W., & Costa, D. L. (1997). A theory of technophysio evolution, with some implications for forecasting population, health care costs, and pension costs. *Demography*, 34(1), 49-66.
- Fokkema, T., & Nedelcu, M. (2017). Ageing as a migrant: Vulnerabilities, agency and policy implications. *Journal of Ethnic and Migration Studies*, 43(2), 164-181. doi:10.1080/1369183X.2016.1238903
- Fontana, L. (2017). The science of nutritional modulation of aging. *Ageing Research Reviews*, 39, 1-2. doi:10.1016/j.arr.2017.08.002
- Forman, D. E., Arena, R., Boxer, R., Dolansky, M. A., Eng, J. J., Fleg, J. L., ... Shen, W. K. (2017). Prioritizing functional capacity as a principal end point for therapies oriented to older adults with cardiovascular disease: A scientific statement for healthcare professionals from the American Heart Association. *Circulation*, 135(16), e894-e918. doi:10.1161/cir.0000000000000483
- Forman, D. E., Maurer, M. S., Boyd, C., Brindis, R., Salive, M. E., Horne, F. M., ... Rich, M. W. (2018). Multimorbidity in older adults with cardiovascular disease. *Journal of the American College of Cardiology*, 71(19), 2149-2161. doi:10.1016/j.jacc.2018.03.022
- Foundation, T. I. H. (2014). *Design and dignity style book: Transforming end-of-life care in hospitals one room at a time*. Ireland: The Irish Hospice Foundation.
- Fraser, S. A., Li, K. Z., Berryman, N., Desjardins-Crepeau, L., Lussier, M., Vadaga, K., ... Bherer, L. (2016). Does combined physical and cognitive training improve dual-task balance and gait outcomes in sedentary older adults? *Frontiers in Human Neuroscience*, 10, 688. doi:10.3389/fnhum.2016.00688
- Frasquilho, D., Matos, M. G., Salonna, F., Guerreiro, D., Storti, C. C., Gaspar, T., & Caldas-de-Almeida, J. M. (2016). Mental health outcomes in times of economic recession: A systematic literature review. *BMC Public Health*, 16:115, 1-40. doi:10.1186/s12889-016-2720-y
- Freijer, K., Tan, S. S., Koopmanschap, M. A., Meijers, J. M., Halfens, R. J., & Nuijten, M. J. (2013). The economic costs of disease related malnutrition. *Clinical Nutrition*, 32(1), 136-141. doi:10.1016/j.clnu.2012.06.009
- Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., ... McBurnie, M. A. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology: Series A*, 56(3), M146-156.

- Fuchsberger, C., Flannick, J., Teslovich, T. M., Mahajan, A., Agarwala, V., Gaulton, K. J., ... McCarthy, M. I. (2016). The genetic architecture of type 2 diabetes. *Nature*, 536(7614), 41-47. doi:10.1038/nature18642
- Furuya-Kanamori, L., Wangdi, K., Yakob, L., McKenzie, S. J., Doi, S. A. R., Clark, J., ... Clements, A. C. A. (2017). 25-Hydroxyvitamin D concentrations and *Clostridium difficile* infection: A meta-analysis. *Journal of Parenteral and Enteral Nutrition*, 41(5), 890-895. doi:10.1177/0148607115623457
- Fusco, M., Buja, A., Furlan, P., Casale, P., Marcolongo, A., Baldovin, T., ... Baldo, V. (2014). Older adults in emergency department: Management by clinical severity at triage. *Annali di Igiene*, 26(5), 409-417. doi:10.7416/ai.2014.2000
- Fuster, V. (2015). Stratified approach to health: Integration of science and education at the right time for each individual. *Journal of the American College of Cardiology*, 66(14), 1627-1629. doi:10.1016/j.jacc.2015.08.039
- Gabel, L., Macdonald, H. M., Nettlefold, L. A., & McKay, H. A. (2018). Sex-, ethnic-, and age-specific centile curves for PQCT- and HR-PQCT-derived measures of bone structure and strength in adolescents and young adults. *Journal of Bone and Mineral Research*, 33(6), 987-1000. doi:10.1002/jbmr.3399
- Gadkaree, S. K., Sun, D. Q., Li, C., Lin, F. R., Ferrucci, L., Simonsick, E. M., & Agrawal, Y. (2016). Does sensory function decline independently or concomitantly with age? Data from the Baltimore longitudinal study of aging. *Journal of Aging Research*, 2016, 1865038-1865038. doi:10.1155/2016/1865038
- Gadoud, A., Kane, E., Macleod, U., Ansell, P., Oliver, S., & Johnson, M. (2014). Palliative care among heart failure patients in primary care: A comparison to cancer patients using English family practice data. *PLOS ONE*, 9(11), e113188. doi:10.1371/journal.pone.0113188
- Gallieni, M., & Cancarini, G. (2014). Drugs in the elderly with chronic kidney disease: Beware of potentially inappropriate medications. *Nephrology Dialysis Transplantation*, 30(3), 342-344. doi:10.1093/ndt/gfu191
- Galobardes, B., Lynch, J. W., & Smith, G. D. (2008). Is the association between childhood socioeconomic circumstances and cause-specific mortality established? Update of a systematic review. *Journal of Epidemiology and Community Health*, 62(5), 387-390. doi:10.1136/jech.2007.065508
- Galobardes, B., Smith, G. D., & Lynch, J. W. (2006). Systematic review of the influence of childhood socioeconomic circumstances on risk for cardiovascular disease in adulthood. *Annals of Epidemiology*, 16(2), 91-104. doi:10.1016/j.annepidem.2005.06.053
- Garin, N., Koyanagi, A., Chatterji, S., Tyrovolas, S., Olaya, B., Leonardi, M., ... Haro, J. M. (2016). Global multimorbidity patterns: A cross-sectional, population-based, multi-country study. *The Journals of Gerontology: Series A*, 71(2), 205-214. doi:10.1093/gerona/glv128
- Gates, G. A., Beiser, A., Rees, T. S., D'Agostino, R. B., & Wolf, P. A. (2002). Central auditory dysfunction may precede the onset of clinical dementia in people with probable Alzheimer's disease. *Journal of the American Geriatrics Society*, 50(3), 482-488.
- Gates, G. A., & Mills, J. H. (2005). Presbycusis. *Lancet*, 366(9491), 1111-1120. doi:10.1016/s0140-6736(05)67423-5
- Gaugler, J. E., Kane, R. L., & Newcomer, R. (2007). Resilience and transitions from dementia caregiving. *The Journals of Gerontology: Series B, Psychological sciences and social sciences*, 62(1), P38-44.
- Gavazzi, G., & Krause, K. H. (2002). Ageing and infection. *Lancet Infectious Diseases*, 2(11), 659-666.
- Gavrin, J. R. (2007). Ethical considerations at the end of life in the intensive care unit. *Critical Care Medicine*, 35 (Suppl. 2), 85-94. doi:10.1097/01.Ccm.0000252909.52316.27
- GBD 2015 Mortality and Causes of Death Collaborators. (2016). Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: A systematic analysis for the global burden of disease study 2015. *Lancet*, 388(10053), 1459-1544. doi:10.1016/s0140-6736(16)31012-1
- GBD 2015 Obesity Collaborators, Afshin, A., Forouzanfar, M. H., Reitsma, M. B., Sur, P., Estep, K., ... Murray, C. J. L. (2017). Health effects of overweight and obesity in 195 countries over 25 years. *New England Journal of Medicine*, 377(1), 13-27. doi:10.1056/NEJMoa1614362
- Genet, N., Boerma, W., Kroneman, M., Hutchinson, A., & Saltman, R. (Eds.). (2012). Home care across Europe. Current structure and future challenges: World Health Organization: European Observatory on Health Systems and Policies.
- Gewirtz-Meydan, A., & Ayalon, L. (2017). Physicians' response to sexual dysfunction presented by a younger vs. an older adult. *Journal of Aging and Health*, 32(12), 1476-1483. doi:10.1002/gps.4638
- Ghosh, A. K., Francis, D. P., Chaturvedi, N., Kuh, D., Mayet, J., Hughes, A. D., & Hardy, R. J. (2014). Cardiovascular risk factors from early life predict future adult cardiac structural and functional abnormalities: A systematic review of the published literature. *Journal of Cardiology and Therapeutics*, 2(2), 78-87. doi:10.12970/2311-052X.2014.02.02.4
- Giannoulis, D., Calori, G. M., & Giannoulis, P. V. (2016). Thirty-day mortality after hip fractures: Has anything changed? *European Journal of Orthopaedic Surgery & Traumatology*, 26(4), 365-370. doi:10.1007/s00590-016-1744-4
- Giarratano, A., Green, S. E., & Nicolau, D. P. (2018). Review of antimicrobial use and considerations in the elderly population. *Clinical Interventions in Aging*, 13, 657-667. doi:10.2147/cia.S133640
- Gill, T. M., Gahbauer, E. A., Han, L., & Allore, H. G. (2010). Trajectories of disability in the last year of life. *The New England Journal of Medicine*, 362(13), 1173-1180. doi:10.1056/NEJMoa0909087
- Gilman, S. E., Kawachi, I., Fitzmaurice, G. M., & Buka, S. L. (2002). Socioeconomic status in childhood and the lifetime risk of major depression. *International Journal of Epidemiology*, 31(2), 359-367.
- Gilmartin, D., & O'Mahony, D. (2012). Polypharmacy and potentially inappropriate prescribing in hospitalised older Irish adults. *Age and Ageing*, 41, 78-78.

- Giustini, A., Varela, E., Franceschini, M., Votava, J., Zampolini, M., Bertheau, M., & Christodoulou, N. (2014). UEMS-position paper. New technologies designed to improve functioning: The role of the physical and rehabilitation medicine physician. *European Journal of Physical and Rehabilitation Medicine*, 50(5), 579-583.
- Gjestsens, M. T., Brønnick, K., & Testad, I. (2018). Characteristics and predictors for hospitalizations of home-dwelling older persons receiving community care: A cohort study from Norway. *BMC Geriatrics*, 18:203, 1-9. doi:10.1186/s12877-018-0887-z
- Glenner, G. G., & Wong, C. W. (1984). Alzheimer's disease: Initial report of the purification and characterization of a novel cerebrovascular amyloid protein. *Biochemical and Biophysical Research Communications*, 120(3), 885-890.
- Global Agenda Council on Ageing. (2016). Technological innovations for health and wealth for an ageing global population. Retrieved from [http://www3.weforum.org/docs/WEF\\_Global\\_Population\\_Ageing\\_Technological\\_Innovations\\_Health\\_Wealth\\_070916.pdf](http://www3.weforum.org/docs/WEF_Global_Population_Ageing_Technological_Innovations_Health_Wealth_070916.pdf)
- Glueck, J., & Bluck, S. (2018). The development of wisdom: New cross-sectional and longitudinal evidence. *Innovation in Aging*, 2 (Suppl. 1), 552-553. doi:10.1093/geroni/igy023.2041
- Gonzales, E., Matz-Costa, C., & Morrow-Howell, N. (2015). Increasing opportunities for the productive engagement of older adults: A response to population aging. *The Gerontologist*, 55(2), 252-261. doi:10.1093/geront/gnu176
- Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., & Hill, K. (2015). Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices. Retrieved from <https://www.nhtsa.gov/traffic-tech?title=Countermeasures%20That%20Work%2C%208th%20Edition>
- Goodwin, R. D., Chuang, S., Simuro, N., Davies, M., & Pine, D. S. (2006). Association between lung function and mental health problems among adults in the United States: Findings from the first national health and nutrition examination survey. *American Journal of Epidemiology*, 165(4), 383-388. doi:10.1093/aje/kwk026
- Gooneratne, N. S., & Vitiello, M. V. (2014). Sleep in older adults: Normative changes, sleep disorders, and treatment options. *Clinics in Geriatric Medicine*, 30(3), 591-627. doi:10.1016/j.cger.2014.04.007
- Gordon, C. M., Zemel, B. S., Wren, T. A., Leonard, M. B., Bachrach, L. K., Rauch, F., ... Winer, K. K. (2017). The determinants of peak bone mass. *The Journal of Pediatrics*, 180, 261-269. doi:10.1016/j.jpeds.2016.09.056
- Government of Ireland. (2018a). Age-friendly communities. In Government of Ireland (Ed.), *Project Ireland 2014 - national planning framework* (pp. 86-88). Ireland: Government of Ireland.
- Government of Ireland. (2018b). *Project Ireland 2040 - national planning framework*. Retrieved from <http://npl.ie/wp-content/uploads/Project-Ireland-2040-NPF.pdf>
- Govindaraju, T., Sahle, B. W., McCaffrey, T. A., McNeil, J. J., & Owen, A. J. (2018). Dietary patterns and quality of life in older adults: A systematic review. *Nutrients*, 10(8), 971. doi:10.3390/nu10080971
- Gow, A. J., Avlund, K., & Mortensen, E. L. (2014). Occupational characteristics and cognitive aging in the Glostrup 1914 cohort. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 69(2), 228-236. doi:10.1093/geronb/gbs115
- Gow, A. J., & Mortensen, E. L. (2016). Social resources and cognitive ageing across 30 years: The Glostrup 1914 cohort. *Age and Ageing*, 45(4), 480-486. doi:10.1093/ageing/afw070
- Gow, A. J., Pattie, A., & Deary, I. J. (2017). Lifecourse activity participation from early, mid, and later adulthood as determinants of cognitive aging: The Lothian birth cohort 1921. *The Journals of Gerontology, Series B, Psychological sciences and social sciences*, 72(1), 25-37. doi:10.1093/geronb/gbw124
- Grabowski, D. C. (2006). The cost-effectiveness of noninstitutional long-term care services: Review and synthesis of the most recent evidence. *Medical Care Research and Review*, 63(1), 3-28. doi:10.1177/1077558705283120
- Gray, B., Sarnak, D. O., & Burgers, J. (2015). Home care by self-governing nursing teams: The Netherlands' buurtzorg model. *The Commonwealth Fund*.
- Grey T., Xidous D., Kennedy S., Mahon S., Mannion V., de Freine P., ... D., O. N. (2018). Dementia friendly hospitals from a universal design approach. *Design guidelines 2018*. Retrieved from <http://dementia.ie/images/uploads/site-images/UD-DFH-Guidelines-2018-Full-doc-lw-res-compressed-A1.pdf>
- Grigorovich, A., Fang, M. L., Sixsmith, J., & Kontos, P. (2018). Defining and evaluating transdisciplinary research: Implications for aging and technology. *Disability and Rehabilitation: Assistive Technology*, 1-11. doi:10.1080/17483107.2018.1496361
- Grundy, E., & Henretta, J. C. (2006). Between elderly parents and adult children: A new look at the intergenerational care provided by the 'sandwich generation'. *Ageing and Society*, 26(5), 707-722. doi:10.1017/S0144686X06004934
- Gruneir, A., Silver, M. J., & Rochon, P. A. (2011). Emergency department use by older adults: A literature review on trends, appropriateness, and consequences of unmet health care needs. *Medical Care Research and Review*, 68(2), 131-155. doi:10.1177/1077558710379422
- Guggenheim, J. A., & Williams, C. (2016). Childhood febrile illness and the risk of myopia in UK Biobank participants. *Eye*, 30(4), 608-614. doi:10.1038/eye.2016.7
- Guirguis-Blake, J. M., Michael, Y. L., Perdue, L. A., Coppola, E. L., Beil, T. L., & Thompson, J. H. (2018). Interventions to prevent falls in community-dwelling older adults: A systematic review for the US Preventive Services Task Force. Retrieved from <https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/falls-prevention-in-older-adults-interventions1?ds=1&s=prevent%20falls>
- Gunderson, J. A., & Carr, D. C. (2016). The third age of life: Leveraging the mutual benefits of intergenerational engagement. *Public Policy & Aging Report*, 26(3), 83-87. doi:10.1093/ppar/prw013

- Curven, M., & Schniter, E. (2010). An evolutionary perspective can help unify disparate accounts of grandparental investment. *Behavioral and Brain Sciences*, 33(1), 25-26. doi:10.1017/S0140525X09991634
- Guthrie, B., Makubate, B., Hernandez-Santiago, V., & Dreischulte, T. (2015). The rising tide of polypharmacy and drug-drug interactions: Population database analysis 1995-2010. *BMC Medicine*, 13:74, 1-10. doi:10.1186/s12916-015-0322-7
- GWAS Catalog. 2017. Retrieved from <https://www.ebi.ac.uk/gwas/>
- Hadbavna, A., & O'Neill, D. (2013). Ageism in interventional stroke studies. *Journal of the American Geriatrics Society*, 61(11), 2054-2055.
- Hamer, M., Kivimaki, M., Lahiri, A., Yerramasu, A., Deanfield, J. E., Marmot, M. G., & Steptoe, A. (2010). Walking speed and subclinical atherosclerosis in healthy older adults: The Whitehall II study. *Heart*, 96(5), 380-384. doi:10.1136/hrt.2009.183350
- Hamm, J., Money, A. G., Atwal, A., & Paraskevopoulos, I. (2016). Fall prevention intervention technologies: A conceptual framework and survey of the state of the art. *Journal of Biomedical Informatics*, 59, 319-345. doi:10.1016/j.jbi.2015.12.013
- Han, J. W., Jeong, H., Park, J. Y., Kim, T. H., Lee, D. Y., Lee, D. W., ... Kim, K. W. (2014). Effects of social supports on burden in caregivers of people with dementia. *International Psychogeriatrics*, 26(10), 1639-1648. doi:10.1017/s1041610214001331
- Hancock, H. C., Close, H., Fuat, A., Murphy, J. J., Hungin, A. P., & Mason, J. M. (2014). Barriers to accurate diagnosis and effective management of heart failure have not changed in the past 10 years: A qualitative study and national survey. *BMJ Open*, 4(3), e003866. doi:10.1136/bmjopen-2013-003866
- Handforth, C., Clegg, A., Young, C., Simpkins, S., Seymour, M. T., Selby, P. J., & Young, J. (2015). The prevalence and outcomes of frailty in older cancer patients: A systematic review. *Annals of Oncology*, 26(6), 1091-1101. doi:10.1093/annonc/mdu540
- Hanson, M. A., Cooper, C., Aihie Sayer, A., Eendebak, R. J., Clough, G. F., & Beard, J. R. (2016). Developmental aspects of a life course approach to healthy ageing. *The Journal of Physiology*, 594(8), 2147-2160. doi:10.1113/jp270579
- Hanson, M. A., & Gluckman, P. D. (2014). Early developmental conditioning of later health and disease: Physiology or pathophysiology? *Physiological Reviews*, 94(4), 1027-1076. doi:10.1152/physrev.00029.2013
- Hardy, J., & Selkoe, D. J. (2002). The amyloid hypothesis of Alzheimer's disease: Progress and problems on the road to therapeutics. *Science*, 297(5580), 353-356. doi:10.1126/science.1072994
- Hardy, R., Cooper, R., Aihie Sayer, A., Ben-Shlomo, Y., Cooper, C., Deary, I. J., ... Kuh, D. (2013). Body mass index, muscle strength and physical performance in older adults from eight cohort studies: The HALCYON programme. *PLOS ONE*, 8(2), e56483. doi:10.1371/journal.pone.0056483
- Hardy, R., Lawlor, D. A., & Kuh, D. (2015). A life course approach to cardiovascular aging. *Future Cardiology*, 11(1), 101-113. doi:10.2217/fca.14.67
- Harmell, A. L., Chattillion, E. A., Roepke, S. K., & Mausbach, B. T. (2011). A review of the psychobiology of dementia caregiving: A focus on resilience factors. *Current Psychiatry Reports*, 13(3), 219-224. doi:10.1007/s11920-011-0187-1
- Harun, A., Semenov, Y. R., & Agrawal, Y. (2015). Vestibular function and activities of daily living: Analysis of the 1999 to 2004 National Health and Nutrition Examination Surveys. *Gerontology and Geriatric Medicine*, 1, 2333721415607124. doi:10.1177/2333721415607124
- Hawkins, J. E. (1973). Comparative otopathology: Aging, noise, and ototoxic drugs. *Advances in Oto-Rhino-Laryngology*, 20, 125-141.
- Hawley-Hague, H., Boulton, E., Hall, A., Pfeiffer, K., & Todd, C. (2014). Older adults' perceptions of technologies aimed at falls prevention, detection or monitoring: A systematic review. *International Journal of Medical Informatics*, 83(6), 416-426. doi:10.1016/j.ijmedinf.2014.03.002
- Heesterbeek, T. J., van der Aa, H. P. A., van Rens, G., Twisk, J. W. R., & van Nispen, R. M. A. (2017). The incidence and predictors of depressive and anxiety symptoms in older adults with vision impairment: A longitudinal prospective cohort study. *Ophthalmic and Physiological Optics*, 37(4), 385-398. doi:10.1111/opo.12388
- Heilbronn, L. K., de Jonge, L., Frisard, M. I., DeLany, J. P., Larson-Meyer, D. E., Rood, J., ... Ravussin, E. (2006). Effect of 6-month calorie restriction on biomarkers of longevity, metabolic adaptation, and oxidative stress in overweight individuals: A randomized controlled trial. *JAMA*, 295(13), 1539-1548. doi:10.1001/jama.295.13.1539
- Henderson, C., Knapp, M., Fernández, J.-L., Beecham, J., Hirani, S. P., Cartwright, M., ... Newman, S. P. (2013). Cost effectiveness of telehealth for patients with long term conditions (whole systems demonstrator telehealth questionnaire study): Nested economic evaluation in a pragmatic, cluster randomised controlled trial. 346, f1035. doi:10.1136/bmj.f1035
- Hernlund, E., Svedbom, A., Ivergård, M., Compston, J., Cooper, C., Stenmark, J., ... Kanis, J. A. (2013). Osteoporosis in the European union: Medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Archives of osteoporosis*, 8(1-2), 136-136. doi:10.1007/s11657-013-0136-1
- Herr, M., Grondin, H., Sanchez, S., Armaingaud, D., Blochet, C., Vial, A., ... Ankri, J. (2017). Polypharmacy and potentially inappropriate medications: A cross-sectional analysis among 451 nursing homes in France. *European Journal of Clinical Pharmacology*, 73(5), 601-608. doi:10.1007/s00228-016-2193-z
- Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest*, 9(1), 1-65. doi:10.1111/j.1539-6053.2009.01034.x
- Heumann, L., & Boldy, D. (Eds.). (1993). *Aging in place with dignity: International solutions relating to the low-income and frail elderly*. Westport, Connecticut: Praeger

- Hidalgo, M. C., & Hernández, B. (2001). Place attachment: Conceptual and empirical questions. *Journal of Environmental Psychology*, 21(3), 273-281. doi:10.1006/jevp.2001.0221
- Hiel, L., Beenackers, M. A., Renders, C. M., Robroek, S. J., Burdorf, A., & Croezen, S. (2015). Providing personal informal care to older European adults: Should we care about the caregivers' health? *Preventive Medicine*, 70, 64-68. doi:10.1016/j.ypmed.2014.10.028
- Higashi, R. T., Tillack, A. A., Steinman, M., Harper, M., & Johnston, C. B. (2012). Elder care as 'frustrating' and 'boring': Understanding the persistence of negative attitudes toward older patients among physicians-in-training. *Journal of Aging Studies*, 26(4), 476-483. doi:10.1016/j.jaging.2012.06.007
- Higgins, I., Van Der Riet, P., Slater, L., & Peek, C. (2007). The negative attitudes of nurses towards older patients in the acute hospital setting: A qualitative descriptive study. *Contemporary Nurse*, 26(2), 225-237. doi:10.5555/conu.2007.26.2.225
- Hignett, S. (2012). Can inclusive environmental design be achieved in acute hospitals? Paper presented at the 2nd International Conference on Human Factors and Ergonomics in Healthcare, San Francisco, CA.
- Hildreth, C. J., Burke, A. E., & Golub, R. M. (2011). Elder abuse. *JAMA*, 306(5), 568-568. doi:10.1001/jama.306.5.568
- Hill, J. O., Galloway, J. M., Goley, A., Marrero, D. G., Minners, R., Montgomery, B., ... Aroda, V. R. (2013). Scientific statement: Socioecological determinants of prediabetes and type 2 diabetes. *Diabetes Care*, 36(8), 2430-2439. doi:10.2337/dc13-1161
- Hill, N. R., Fatoba, S. T., Oke, J. L., Hirst, J. A., O'Callaghan, C. A., Lasserson, D. S., & Hobbs, F. D. R. (2016). Global prevalence of chronic kidney disease – a systematic review and meta-analysis. *PLOS ONE*, 11(7), e0158765. doi:10.1371/journal.pone.0158765
- Hines, S., Wilson, J., McCrow, J., Abbey, J., & Sacre, S. (2010). Oral liquid nutritional supplements for people with dementia in residential aged care facilities. *International Journal of Evidence-Based Healthcare*, 8(4), 248-251. doi:10.1111/j.1744-1609.2010.00186.x
- Hjorthol, R. J., Levin, L., & Siren, A. K. (2010). Mobility in different generations of older persons the development of daily travel in different cohorts in Denmark, Norway and Sweden. *Journal of Transport Geography*, 18(5), 624-633. doi:10.1016/j.jtrangeo.2010.03.011
- Honeth, L., Strom, P., Ploner, A., Bagger-Sjoberg, D., Rosenhall, U., & Nyren, O. (2015). Shooting history and presence of high-frequency hearing impairment in Swedish hunters: A cross-sectional internet-based observational study. *Noise & Health*, 17(78), 273-281. doi:10.4103/1463-1741.165043
- Hopewell, S., Adedire, O., Copsey, B. J., Boniface, G. J., Sherrington, C., Clemson, L., ... Lamb, S. E. (2018). Multifactorial and multiple component interventions for preventing falls in older people living in the community. *The Cochrane Database of Systematic Reviews (CDSR)*, 7, Cd012221. doi:10.1002/14651858.CD012221.pub2
- Horhota, M., Chasteen, A. L., & Crumley-Branyon, J. J. (2018). The many forms of ageism: Age differences in experience type, emotional impact, and coping strategies. *Innovation in Aging*, 2 (Suppl. 1), 614-615. doi:10.1093/geroni/igy023.2290
- Horner, B., & Boldy, D. P. (2008). The benefit and burden of 'ageing-in-place' in an aged care community. *Australian Health Review*, 32(2), 356-365. doi:10.1071/AH080356
- Horvath, S. (2013). DNA methylation age of human tissues and cell types. *Genome Biology*, 14(10), R115. doi:10.1186/gb-2013-14-10-r115
- Hough, E. S., Magnan, M. A., Templin, T., & Gadelrab, H. F. (2005). Social network structure and social support in HIV-positive inner city mothers. *Journal of the Association of Nurses in AIDS Care*, 16(4), 14-24. doi:10.1016/j.jana.2005.05.002
- Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., ... Buchbinder, R. (2012). A systematic review of the global prevalence of low back pain. *Arthritis Rheum*, 64(6), 2028-2037. doi:10.1002/art.34347
- Hsieh, L. C., Chow, C. J., Chang, W. C., Liu, T. H., & Chang, C. K. (2010). Effect of beta-hydroxy-beta-methylbutyrate on protein metabolism in bed-ridden elderly receiving tube feeding. *Asia Pacific Journal of Clinical Nutrition*, 19(2), 200-208.
- Huang, A. R., Larente, N., & Morais, J. A. (2011). Moving towards the age-friendly hospital: A paradigm shift for the hospital-based care of the elderly. *Canadian Geriatrics Journal*, 14(4), 100-103. doi:10.57700/cgj.v14i4.8
- Hughes, C., Tunney, M., & Bradley, M. C. (2013). Infection control strategies for preventing the transmission of Meticillin-Resistant *Staphylococcus aureus* (MRSA) in nursing homes for older people. *The Cochrane Database of Systematic Reviews (CDSR)*, (11). doi:10.1002/14651858.CD006354.pub4
- Huisingh-Scheetz, M., & Walston, J. (2017). How should older adults with cancer be evaluated for frailty? *Journal of Geriatric Oncology*, 8(1), 8-15. doi:10.1016/j.jgo.2016.06.003
- Hulsegge, G., Spijkerman, A. M. W., van der Schouw, Y. T., Bakker, S. J. L., Gansevoort, R. T., Smit, H. A., & Verschuren, W. M. M. (2017). Trajectories of metabolic risk factors and biochemical markers prior to the onset of type 2 diabetes: The population-based longitudinal doetinchem study. *Nutrition & Diabetes*, 7(5), e270. doi:10.1038/nutd.2017.23
- Huxley, R., Neil, A., & Collins, R. (2002). Unravelling the fetal origins hypothesis: Is there really an inverse association between birthweight and subsequent blood pressure? *Lancet*, 360(9334), 659-665. doi:10.1016/s0140-6736(02)09834-3
- Huxley, R., Owen, C. G., Whincup, P. H., Cook, D. G., Colman, S., & Collins, R. (2004). Birth weight and subsequent cholesterol levels: Exploration of the 'fetal origins' hypothesis. *JAMA*, 292(22), 2755-2764. doi:10.1001/jama.292.22.2755
- Huxley, R., Owen, C. G., Whincup, P. H., Cook, D. G., Rich-Edwards, J., Smith, G. D., & Collins, R. (2007). Is birth weight a risk factor for ischemic heart disease in later life? *The American Journal of Clinical Nutrition*, 85(5), 1244-1250. doi:10.1093/ajcn/85.5.1244
- Ibrahim, I., Dominguez-Valentin, M., Segal, B., Zeitouni, A., & da Silva, S. D. (2018). Mitochondrial mutations associated with hearing and balance disorders. *Mutation Research*, 810, 39-44. doi:10.1016/j.mrfmmm.2018.03.003

- Ilgjin, D., Ozalevli, S., Kilinc, O., Sevinc, C., Cimrin, A. H., & Ucan, E. S. (2011). Gait speed as a functional capacity indicator in patients with chronic obstructive pulmonary disease. *Annals of Thoracic Medicine*, 6(3), 141-146. doi:10.4103/1817-1737.82448
- Imison, C., Thompson, J., & Poteliakhoff, E. (2012). Older people and emergency bed use: Exploring variation. Retrieved from <https://www.kingsfund.org.uk/publications/older-people-and-emergency-bed-use>
- Imoberdorf, R., Meier, R., Krebs, P., Hangartner, P. J., Hess, B., Staubli, M., ... Ballmer, P. E. (2010). Prevalence of undernutrition on admission to swiss hospitals. *Clinical Nutrition*, 29(1), 38-41. doi:10.1016/j.clnu.2009.06.005
- Ingersoll-Dayton, B., Morgan, D., & Antonucci, T. (1997). The effects of positive and negative social exchanges on aging adults. *The Journals of Gerontology: Series B*, 52(4), S190-199.
- Inouye, S. K., Studenski, S., Tinetti, M. E., & Kuchel, G. A. (2007). Geriatric syndromes: Clinical, research, and policy implications of a core geriatric concept. *Journal of the American Geriatrics Society*, 55(5), 780-791. doi:10.1111/j.1532-5415.2007.01156.x
- Institute of Mechanical Engineers. (2018). Healthy homes: Accommodating an ageing population. Retrieved from [http://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-healthy-homes-report.pdf?sfvrsn=2&utm\\_source=The%20King%27s%20Fund%20one](http://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-healthy-homes-report.pdf?sfvrsn=2&utm_source=The%20King%27s%20Fund%20one)
- International Diabetes Federation. (2017). IDF diabetes atlas - 8th edition. Brussels, Belgium: International Diabetes Federation.
- International Osteoporosis Foundation. (2018). Broken bones, broken lives: A roadmap to solve the fragility fracture crisis in Europe. Retrieved from <https://www.iofbonehealth.org/broken-bones-broken-lives>
- International Trade Union Confederation. (2016) "Investing in the Care Economy: A gender analysis of employment stimulus in seven OECD countries." Retrieved from <https://www.ituc-csi.org/investing-in-the-care-economy>
- Isaacs, B. (1992). *The challenge of geriatric medicine*. Oxford: Oxford University Press.
- Istepanian, R. S. H., & Al-Anzi, T. (2018). M-health 2.0: New perspectives on mobile health, machine learning and big data analytics. *Methods*, 151, 34-40. doi:10.1016/j.jymeth.2018.05.015
- Istepanian, R. S. H., & Woodward, B. (2016). *M-health: Fundamentals and applications*. Hoboken, New Jersey: Wiley-IEEE Press.
- Jack, C. R., Jr., Knopman, D. S., Jagust, W. J., Petersen, R. C., Weiner, M. W., Aisen, P. S., ... Trojanowski, J. Q. (2013). Tracking pathophysiological processes in Alzheimer's disease: An updated hypothetical model of dynamic biomarkers. *The Lancet Neurology*, 12(2), 207-216. doi:10.1016/s1474-4422(12)70291-0
- Jackson, C. A., Jones, M., Tooth, L., Mishra, G. D., Byles, J., & Dobson, A. (2015). Multimorbidity patterns are differentially associated with functional ability and decline in a longitudinal cohort of older women. *Age and Ageing*, 44(5), 810-816. doi:10.1093/ageing/afv095
- James, S. L., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbassi, N., ... Murray, C. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: A systematic analysis for the global burden of disease study 2017. *Lancet*, 392(10159), 1789-1858. doi:10.1016/s0140-6736(18)32279-7
- Janssen, F., Kunst, A., & Mackenbach, J. (2007). Variations in the pace of old-age mortality decline in seven European countries, 1950-1999: The role of smoking and other factors earlier in life (variations du rythme de baisse de la mortalité aux âges élevés dans sept pays européens, de 1950 à 1999: Rôle du tabac et des facteurs antérieurs dans la vie. *European Journal of Population*, 23(2), 171-188.
- Janssens, J. P., Pache, J. C., & Nicod, L. P. (1999). Physiological changes in respiratory function associated with ageing. *The European Respiratory Journal*, 13(1), 197-205. doi:10.1034/j.1399-3003.1999.13a36.x
- Jaye, C., Tordoff, J., Butler, M., Hale, B., McKechnie, R., Robertson, L., & Simpson, J. (2016). Quality in residential care: Exploring residents', family members', managers' and staff perspectives. *Quality in Ageing and Older Adults*, 17(4), 253-262. doi:10.1108/QAOA-03-2016-0015
- Jensø, M., & Haugen, T. (2004). Usability of hospital buildings: Is patient focus leading to usability in hospital buildings? Paper presented at the Hong Kong International Symposium, Facility Management and Asset Maintenance, The Human Element in Facilities Management, Hong Kong.
- Jeon, O. H., Kim, C., Laberge, R. M., Demaria, M., Rathod, S., Vasserot, A. P., ... Elisseeff, J. H. (2017). Local clearance of senescent cells attenuates the development of post-traumatic osteoarthritis and creates a pro-regenerative environment. *Nature Medicine*, 23(6), 775-781. doi:10.1038/nm.4324
- Jha, S., Wang, Z., Laucis, N., & Bhattacharyya, T. (2015). Trends in media reports, oral bisphosphonate prescriptions, and hip fractures 1996-2012: An ecological analysis. *Journal of Bone and Mineral Research*, 30(12), 2179-2187. doi:10.1002/jbmr.2565
- John, A., Patel, U., Rusted, J., Richards, M., & Gaysina, D. (2019). Affective problems and decline in cognitive state in older adults: A systematic review and meta-analysis. *Psychological Medicine*, 49(3), 353-365. doi:10.1017/s0033291718001137
- Johnson, S. C., Rabinovitch, P. S., & Kaeblerlein, M. (2013). MTOR is a key modulator of ageing and age-related disease. *Nature*, 493(7432), 338-345. doi:10.1038/nature11861
- Joint Action to support the eHealth Network. (2017). EU state of play of telemedicine services and uptake recommendations. Retrieved from <http://jasehn.eu/>
- Jones, R., Hardy, R., Sattar, N., Deanfield, J. E., Hughes, A., Kuh, D., ... Thomas, C. (2015). Novel coronary heart disease risk factors at 60-64 years and life course socioeconomic position: The 1946 British birth cohort. *Atherosclerosis*, 238(1), 70-76. doi:10.1016/j.atherosclerosis.2014.11.011
- Jourdain, P., & Juilliere, Y. (2011). Therapeutic education in patients with chronic heart failure: Proposal for a multiprofessional structured programme, by a French task force under the auspices of the French society of cardiology. *Archives of Cardiovascular Diseases*, 104(3), 189-201.

- June, A., & Andreoletti, C. (2018). Participation in intergenerational service-learning benefits older adults: A brief report. *Gerontology & Geriatrics Education*, 1-6. doi:10.1080/02701960.2018.1457529
- Juthani-Mehta, M., & Quagliarello, V. J. (2010). Infectious diseases in the nursing home setting: Challenges and opportunities for clinical investigation. *Clinical Infectious Diseases*, 51(8), 931-936. doi:10.1086/656411
- Kaffashian, S., Dugravot, A., Brunner, E. J., Sabia, S., Ankri, J., Kivimäki, M., & Singh-Manoux, A. (2013a). Midlife stroke risk and cognitive decline: A 10-year follow-up of the Whitehall II cohort study. *Alzheimer's & Dementia*, 9(5), 572-579. doi:10.1016/j.jalz.2012.07.001
- Kaffashian, S., Dugravot, A., Elbaz, A., Shipley, M. J., Sabia, S., Kivimaki, M., & Singh-Manoux, A. (2013b). Predicting cognitive decline: A dementia risk score vs. the Framingham vascular risk scores. *Neurology*, 80(14), 1300-1306. doi:10.1212/WNL.0b013e31828ab370
- Kaffashian, S., Dugravot, A., Nabi, H., Batty, G. D., Brunner, E., Kivimaki, M., & Singh-Manoux, A. (2011). Predictive utility of the Framingham general cardiovascular disease risk profile for cognitive function: Evidence from the Whitehall II study. *European Heart Journal*, 32(18), 2326-2332. doi:10.1093/eurheartj/ehr133
- Kaiser, M. J., Bauer, J. M., Ramsch, C., Uter, W., Guigoz, Y., Cederholm, T., ... Sieber, C. C. (2010). Frequency of malnutrition in older adults: A multinational perspective using the mini nutritional assessment. *Journal of the American Geriatrics Society*, 58(9), 1734-1738. doi:10.1111/j.1532-5415.2010.03016.x
- Kane, R. L., Butler, M., Fink, H. A., Brasure, M., Davila, H., Desai, P., ... Barclay, T. (2017). Interventions to prevent age-related cognitive decline, mild cognitive impairment, and clinical Alzheimer's-type dementia (Vol. Comparative Effectiveness Reviews, No. 188). Rockville (MD): Agency for Healthcare Research and Quality (US).
- Kanis, J. A., Borgstrom, F., Compston, J., Dreinhofer, K., Nolte, E., Jonsson, L., ... Stenmark, J. (2013). Scope: A scorecard for osteoporosis in Europe. *Archives of Osteoporosis*, 8, 144. doi:10.1007/s11657-013-0144-1
- Kannel, W. B., McGee, D., & Gordon, T. (1976). A general cardiovascular risk profile: The Framingham study. *The American Journal of Cardiology*, 38(1), 46-51. doi:10.1161/CIRCULATIONAHA.107.699579
- Kannus, P., Palvanen, M., Niemi, S., & Parkkari, J. (2007). Alarming rise in the number and incidence of fall-induced cervical spine injuries among older adults. *The Journals of Gerontology. Series A, Biological sciences and medical sciences*, 62(2), 180-183.
- Kaplanis, J., Gordon, A., Shor, T., Weissbrod, O., Geiger, D., Wahl, M., ... Erlich, Y. (2018). Quantitative analysis of population-scale family trees with millions of relatives. *Science*, 360(6385), 171-175. doi:10.1126/science.aam9309
- Kaschowitz, J., & Brandt, M. (2017). Health effects of informal caregiving across Europe: A longitudinal approach. *Social Science & Medicine*, 173, 72-80. doi:10.1016/j.socscimed.2016.11.036
- Kazemi, D. M., Borsari, B., Levine, M. J., Li, S., Lamberson, K. A., & Matta, L. A. (2017). A systematic review of the mHealth interventions to prevent alcohol and substance abuse. *Journal of Health Communication*, 22(5), 413-432. doi:10.1080/10810730.2017.1303556
- Kelan, E. K. (2014). From biological clocks to unspeakable inequalities: The intersectional positioning of young professionals. *British Journal of Management*, 25(4), 790-804. doi:10.1111/1467-8551.12062
- Keller, H., Beck, A. M., & Namasivayam, A. (2015). Improving food and fluid intake for older adults living in long-term care: A research agenda. *Journal of the American Medical Directors Association*, 16(2), 93-100. doi:10.1016/j.jamda.2014.10.017
- Kempen, G. I., Ranchor, A. V., Ambergen, T., & Zijlstra, G. A. (2014). The mediating role of disability and social support in the association between low vision and depressive symptoms in older adults. *Quality of Life Research*, 23(3), 1039-1043. doi:10.1007/s11136-013-0536-0
- Kenfield, S. A., & Stampfer, M. J. (2013). Healthy behaviours yield major benefits in ageing. *The BMJ*, 347, f5156. doi:10.1136/bmj.f5156
- Kennedy, C. C., Ioannidis, G., Thabane, L., Adachi, J. D., Marr, S., Giangregorio, L. M., ... Papaioannou, A. (2015). Successful knowledge translation intervention in long-term care: Final results from the vitamin D and osteoporosis study (vidos) pilot cluster randomized controlled trial. *Trials*, 16, 214. doi:10.1186/s13063-015-0720-3
- Kenny, R. A., Brignole, M., Dan, G. A., Deharo, J. C., van Dijk, J. G., Doherty, C., ... Wieling, W. (2015). Syncope unit: Rationale and requirement – the European Heart Rhythm Association position statement endorsed by the Heart Rhythm Society. *Europace*, 17(9), 1325-1340. doi:10.1093/europace/euv115
- Kenyon, C. J. (2010). The genetics of ageing. *Nature*, 464(7288), 504-512. doi:10.1038/nature08980
- Kessler, R. C., Mickelson, K. D., & Williams, D. R. (1999). The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *Journal of Health and Social Behavior*, 40(3), 208-230.
- Khanuja, K., Joki, J., Bachmann, G., & Cuccurullo, S. (2018). Gait and balance in the aging population: Fall prevention using innovation and technology. *Maturitas*, 110, 51-56. doi:10.1016/j.maturitas.2018.01.021
- Kher, D. R. (2016). Mobile and e-Healthcare: Recent trends and future directions. *Journal of Health and Medical Economics*, 2. doi:10.21767/2471-9927.100010
- Khosravi, P., & Ghapanchi, A. H. (2016). Investigating the effectiveness of technologies applied to assist seniors: A systematic literature review. *International Journal of Medical Informatics*, 85(1), 17-26. doi:10.1016/j.ijmedinf.2015.05.014
- Kiesswetter, E., Pohlhausen, S., Uhlig, K., Diekmann, R., Lesser, S., Uter, W., ... Volkert, D. (2014). Prognostic differences of the mini nutritional assessment short form and long form in relation to 1-year functional decline and mortality in community-dwelling older adults receiving home care. *Journal of the American Geriatrics Society*, 62(3), 512-517. doi:10.1111/jgs.12683

- Kim, D. H., Kim, C. A., Placide, S., Lipsitz, L. A., & Marcantonio, E. R. (2016). Preoperative frailty assessment and outcomes at 6 months or later in older adults undergoing cardiac surgical procedures: A systematic review. *Annals of Internal Medicine*, 165(9), 650-660. doi:10.7326/m16-0652
- Kim, Y., Wijndaele, K., Lee, D. C., Sharp, S. J., Wareham, N., & Brage, S. (2017). Independent and joint associations of grip strength and adiposity with all-cause and cardiovascular disease mortality in 403,199 adults: The UK biobank study. *The American Journal of Clinical Nutrition*, 106(3), 773-782. doi:10.3945/ajcn.117.156851
- King, A. C. (2001). Interventions to promote physical activity by older adults. *The Journals of Gerontology: Series A*, 56 Spec No 2, 36-46. doi:10.1093/gerona/56.suppl\_2.36
- Kirkwood, T. B., & Austad, S. N. (2000). Why do we age? *Nature*, 408(6809), 233-238. doi:10.1038/35041682
- Kite, M. E., & Wagner, L. S. (2002). Attitudes toward older adults. In T. D. Nelson (Ed.), *Ageism: Stereotyping and prejudice against older persons* (pp. 129-161). Cambridge (MA), London: MIT Press.
- Klaassens, M., & Meijering, L. (2015). Experiences of home and institution in a secured nursing home ward in the Netherlands: A participatory intervention study. *Journal of Aging Studies*, 34, 92-102. doi:10.1016/j.jaging.2015.05.002
- Klein, R., Klein, B. E., Moss, S. E., Davis, M. D., & DeMets, D. L. (1984). The Wisconsin epidemiologic study of diabetic retinopathy. II. Prevalence and risk of diabetic retinopathy when age at diagnosis is less than 30 years. *Archives of Ophthalmology*, 102(4), 520-526.
- Knapp, M., McDaid, D., & Parsonage, M. (2011). *Mental health promotion and mental illness prevention: The economic case*. London, UK: Department of Health.
- Kneebone, I. I., & Martin, P. R. (2003). Coping and caregivers of people with dementia. *British Journal of Health Psychology*, 8(Pt 1), 1-17. doi:10.1348/135910703762879174
- Koenen, K., Rudenstine, S., Susser, E., & Galea, S. (2013). *A life course approach to mental disorders*. Oxford: Oxford University Press.
- Kogan, A. C., Wilber, K., & Mosqueda, L. (2016). Person-centered care for older adults with chronic conditions and functional impairment: A systematic literature review. *Journal of the American Geriatrics Society*, 64(1), 1-7. doi:10.1111/jgs.13873
- Kolt, G. S., Schofield, G. M., Kerse, N., Garrett, N., Ashton, T., & Patel, A. (2012). Healthy steps trial: Pedometer-based advice and physical activity for low-active older adults. *Annals of Family Medicine*, 10(3), 206-212. doi:10.1370/afm.1345
- Koper, D., Kamenski, G., Flamm, M., Bohmdorfer, B., & Sonnichsen, A. (2013). Frequency of medication errors in primary care patients with polypharmacy. *Family Practice*, 30(3), 313-319. doi:10.1093/fampra/cms070
- Koren, C. (2011). Continuity and discontinuity: The case of second couplehood in old age. *The Gerontologist*, 51(5), 687-698. doi:10.1093/geront/gnr018
- Korner-Bitensky, N., Menon, A., von Zweck, C., & Van Benthem, K. (2010). A national survey of older driver refresher programs: Practice readiness for a rapidly growing need. *Physical & Occupational Therapy in Geriatrics*, 28. doi:10.3109/02703181.2010.491935
- Koucký, J., Bartušek, A., & Kovařovic, J. (2010). Who gets a degree? Access to tertiary education in Europe 1950-2009. Retrieved from <http://www.strediskovzdelavacipolitiky.info/download/Whogetsadegree.pdf>
- KPMG. (2015). The added value of buurtzorg relative to other providers of home care: A quantitative analysis of home care in the Netherlands in 2013 [in Dutch]. Retrieved from <http://www.invoorzorg.nl/literatuur-Rapport-De-toegevoegde-waarde-van-Buurtzorg-tov-van-andere-aanbieders-van-thuiszorg.html>
- Kreitzer, M. J., Monsen, K. A., Nandram, S., & de Blok, J. (2015). Buurtzorg Nederland: A global model of social innovation, change, and whole-systems healing. *Global Advances in Health and Medicine*, 4(1), 40-44. doi:10.7453/gahmj.2014.030
- Krekula, C., Nikander, P., & Wilińska, M. (2018). Multiple marginalizations based on age: Gendered ageism and beyond. In L. Ayalon & C. Tesch-Römer (Eds.), *Contemporary perspectives on ageism* (pp. 33-50). Cham: Springer International Publishing.
- Kripalani, S., Theobald, C. N., Anctil, B., & Vasilevskis, E. E. (2014). Reducing hospital readmission rates: Current strategies and future directions. *Annual Review of Medicine*, 65, 471-485. doi:10.1146/annurev-med-022613-090415
- Kruizenga, H., van Keeken, S., Weijts, P., Bastiaanse, L., Beijer, S., Huisman-de Waal, G., ... Thijs, A. (2016). Undernutrition screening survey in 564,063 patients: Patients with a positive undernutrition screening score stay in hospital 1.4 d longer. *The American Journal of Clinical Nutrition*, 103(4), 1026-1032. doi:10.3945/ajcn.115.126615
- Kuh, D. (2019). A life course approach to healthy ageing. In J.-P. Michel (Ed.), *Prevention of chronic diseases and age-related disability* (pp. 1-9). Cham: Springer International Publishing.
- Kuh, D., & Ben-Shlomo, Y. (2016). Chapter 5 - early life origins of adult health and aging. In L. K. George & K. F. Ferraro (Eds.), *Handbook of aging and the social sciences* (8th edition) (pp. 101-122). San Diego: Academic Press.
- Kuh, D., & Ben Shlomo, Y. (Eds.). (2004). *A life course approach to chronic disease epidemiology* (2 ed.). Oxford University Press.
- Kuh, D., Cooper, R., Hardy, R., Guralnik, J., & Richards, M. (2009). Lifetime cognitive performance is associated with midlife physical performance in a prospective national birth cohort study. *Psychosomatic Medicine*, 71(1), 38-48. doi:10.1097/PSY.0b013e31818a1620
- Kuh, D., Cooper, R., Hardy, R., Richards, M., & Ben Shlomo, Y. (Eds.). (2014a). *A life course approach to healthy aging*. Oxford: Oxford University Press.
- Kuh, D., Karunanathan, S., Bergman, H., & Cooper, R. (2014b). A life-course approach to healthy ageing: Maintaining physical capability. *The Proceedings of the Nutrition Society*, 73(2), 237-248. doi:10.1017/S0029665113003923

- Kuiper, J. S., Zuidersma, M., Oude Voshaar, R. C., Zuidema, S. U., van den Heuvel, E. R., Stolk, R. P., & Smidt, N. (2015). Social relationships and risk of dementia: A systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews*, 22, 39-57. doi:10.1016/j.arr.2015.04.006
- Kuiper, J. S., Zuidersma, M., Zuidema, S. U., Burgerhof, J. G., Stolk, R. P., Oude Voshaar, R. C., & Smidt, N. (2016). Social relationships and cognitive decline: A systematic review and meta-analysis of longitudinal cohort studies. *International Journal of Epidemiology*, 45(4), 1169-1206. doi:10.1093/ije/dywo89
- Kundu, P., Blacher, E., Elinav, E., & Pettersson, S. (2017). Our gut microbiome: The evolving inner self. *Cell*, 171(7), 1481-1493. doi:10.1016/j.cell.2017.11.024
- Kusumastuti, S., Derks, M. G., Tellier, S., Di Nucci, E., Lund, R., Mortensen, E. L., & Westendorp, R. G. (2016). Successful ageing: A study of the literature using citation network analysis. *Maturitas*, 93, 4-12. doi:10.1016/j.maturitas.2016.04.010
- Kvamme, J. M., Gronli, O., Florholmen, J., & Jacobsen, B. K. (2011). Risk of malnutrition is associated with mental health symptoms in community living elderly men and women: The Tromsø Study. *BMC Psychiatry*, 11, 112, 1-8. doi:10.1186/1471-244x-11-112
- Kyrdalen, I. L., Moen, K., Roysland, A. S., & Helbostad, J. L. (2014). The Otago exercise program performed as group training versus home training in fall-prone older people: A randomized controlled trial. *Physiotherapy Research International*, 19(2), 108-116. doi:10.1002/pri.1571
- Laird, E., O'Halloran, A. M., Carey, D., Healy, M., O'Connor, D., Moore, P., ... Kenny, R. A. (2018). The prevalence of vitamin D deficiency and the determinants of 25(OH)D concentration in older Irish adults: Data from the Irish Longitudinal Study on Ageing (TILDA). *The Journals of Gerontology: Series A*, 73(4), 519-525. doi:10.1093/gerona/glx168
- Langa, K. M. (2015). Is the risk of Alzheimer's disease and dementia declining? *Alzheimer's Research & Therapy*, 7(1), 34. doi:10.1186/s13195-015-0118-1
- Lange, P., Celli, B., Agustí, A., Boje Jensen, G., Divo, M., Faner, R., ... Vestbo, J. (2015). Lung-function trajectories leading to chronic obstructive pulmonary disease. *The New England Journal of Medicine*, 373(2), 111-122. doi:10.1056/NEJMoa1411532
- Lange, P., Colak, Y., Ingebrigtsen, T. S., Vestbo, J., & Marott, J. L. (2016). Long-term prognosis of asthma, chronic obstructive pulmonary disease, and asthma-chronic obstructive pulmonary disease overlap in the Copenhagen City Heart study: A prospective population-based analysis. *The Lancet Respiratory Medicine*, 4(6), 454-462. doi:10.1016/s2213-2600(16)00098-9
- Langford, J., & Koppel, S. (2011). Licence restrictions as an under-used strategy in managing older driver safety. *Accident Analysis & Prevention*, 43(1), 487-493. doi:10.1016/j.aap.2010.09.005
- Langford, J., Koppel, S., Andrea, D., & Fildes, B. (2006). Determining older driver crash responsibility from police and insurance data. *Traffic Injury Prevention*, 7(4), 343-351. doi:10.1080/15389580600840706
- Lapierre, N., Neubauer, N., Miguel-Cruz, A., Rios Rincon, A., Liu, L., & Rousseau, J. (2018). The state of knowledge on technologies and their use for fall detection: A scoping review. *International Journal of Medical Informatics*, 111, 58-71. doi:10.1016/j.ijmedinf.2017.12.015
- Lapierre, S., Erlangsen, A., Waern, M., De Leo, D., Oyama, H., Scocco, P., ... Quinnett, P. (2011). A systematic review of elderly suicide prevention programs. *Crisis*, 32(2), 88-98. doi:10.1027/0227-5910/a000076
- Larsen, S. M., Mortensen, R. F., Kristensen, H. K., & Hounsgaard, L. (2018). Older adults' perspectives on the process of becoming users of assistive technology: A qualitative systematic review and meta-synthesis. *Disability and Rehabilitation: Assistive Technology*, 1-12. doi:10.1080/17483107.2018.1463403
- Larson, E. B., Yaffe, K., & Langa, K. M. (2013). New insights into the dementia epidemic. *The New England Journal of Medicine*, 369(24), 2275-2277. doi:10.1056/NEJMp1311405
- Lawlor, D. A., & Hardy, R. (2014). Vascular and metabolic function across the life course. In R. C. Diana Kuh, Rebecca Hardy, Marcus Richards, and Yoav Ben-Shlomo (Ed.), *A life course approach to healthy ageing*. Oxford, UK: Oxford University Press.
- Laxminarayan, R., Duse, A., Wattal, C., Zaidi, A. K., Wertheim, H. F., Sumpradit, N., ... Cars, O. (2013). Antibiotic resistance—the need for global solutions. *The Lancet Infectious Diseases*, 13(12), 1057-1098. doi:10.1016/s1473-3099(13)70318-9
- LeBlanc, E. S., Zakher, B., Daeges, M., Pappas, M., & Chou, R. (2015). Screening for vitamin d deficiency: A systematic review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*, 162(2), 109-122. doi:10.7326/m14-1659
- Lechanteur, Y. T., van de Camp, P. L., Smailhodzic, D., van de Ven, J. P., Buitendijk, G. H., Klaver, C. C., ... Klevering, B. J. (2015). Association of smoking and CFH and ARMS2 risk variants with younger age at onset of neovascular age-related macular degeneration. *JAMA Ophthalmology*, 133(5), 533-541. doi:10.1001/jamaophthalmol.2015.18
- Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet*, 380(9838), 219-229. doi:10.1016/s0140-6736(12)61031-9
- Legler, J., Fletcher, T., Govarts, E., Porta, M., Blumberg, B., Heindel, J. J., & Trasande, L. (2015). Obesity, diabetes, and associated costs of exposure to endocrine-disrupting chemicals in the European Union. *The Journal of Clinical Endocrinology and Metabolism*, 100(4), 1278-1288. doi:10.1210/jc.2014-4326
- Legramante, J. M., Morciano, L., Lucaroni, F., Gilardi, F., Caredda, E., Pesaresi, A., ... Palombi, L. (2016). Frequent use of emergency departments by the elderly population when continuing care is not well established. *PLOS ONE*, 11(12), e0165939-e0165939. doi:10.1371/journal.pone.0165939
- Lems, W. F., & Raterman, H. G. (2017). Critical issues and current challenges in osteoporosis and fracture prevention. An overview of unmet needs. *Therapeutic Advances in Musculoskeletal Disease*, 9(12), 299-316. doi:10.1177/1759720x17732562

- Leppin, A. L., Gionfriddo, M. R., Kessler, M., Brito, J. P., Mair, F. S., Gallacher, K., ... Montori, V. M. (2014). Preventing 30-day hospital readmissions: A systematic review and meta-analysis of randomized trials. *JAMA Internal Medicine*, 174(7), 1095-1107. doi:10.1001/jamainternmed.2014.1608
- Lesthaeghe, R. (2014). The second demographic transition: A concise overview of its development. *Proceedings of the National Academy of Sciences of the United States of America*, 111(51), 18112-18115. doi:10.1073/pnas.1420441111
- Levin, A., Tonelli, M., Bonventre, J., Coresh, J., Donner, J. A., Fogo, A. B., ... Eckardt, K. U. (2017). Global kidney health 2017 and beyond: A roadmap for closing gaps in care, research, and policy. *Lancet*, 390(10105), 1888-1917. doi:10.1016/s0140-6736(17)30788-2
- Levy, B. (2009). Stereotype embodiment: A psychosocial approach to aging. *Current Directions in Psychological Science*, 18(6), 332-336.
- Levy, B. R. (2003). Mind matters: Cognitive and physical effects of aging self-stereotypes. *The Journals of Gerontology: Series B*, 58(4), P203-P211. doi:10.1093/geronb/58.4.P203
- Levy, B. R., Slade, M. D., Kunkel, S. R., & Kasl, S. V. (2002). Longevity increased by positive self-perceptions of aging. *Journal of Personality and Social Psychology*, 83(2), 261-270.
- Levy, B. R., Slade, M. D., Murphy, T. E., & Gill, T. M. (2012). Association between positive age stereotypes and recovery from disability in older persons. *JAMA*, 308(19), 1972-1973. doi:10.1001/jama.2012.14541
- Li, K. Z., Roudaia, E., Lussier, M., Bherer, L., Leroux, A., & McKinley, P. A. (2010). Benefits of cognitive dual-task training on balance performance in healthy older adults. *The Journals of Gerontology: Series A*, 65(12), 1344-1352. doi:10.1093/gerona/gdq151
- Lim, S. L., Ong, K. C., Chan, Y. H., Loke, W. C., Ferguson, M., & Daniels, L. (2012). Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. *Clinical Nutrition*, 31(3), 345-350. doi:10.1016/j.clnu.2011.11.001
- Lin, F. R., Yaffe, K., Xia, J., Xue, Q. L., Harris, T. B., Purchase-Helzner, E., ... Simonsick, E. M. (2013). Hearing loss and cognitive decline in older adults. *JAMA Internal Medicine*, 173(4), 293-299. doi:10.1001/jamainternmed.2013.1868
- Linde-Feucht, S., & Coulouris, N. (2012). Integrating primary care and public health: A strategic priority. *American Journal of Public Health*, 102(S3), S310-S311. doi:10.2105/AJPH.2012.300849
- Lindeman, D. (2010). Interview: Lessons from a leader in telehealth diffusion: A conversation with Adam Darkins of the Veterans Health Administration. *Ageing International*, 36(1), 146-154.
- Litwic, A., Edwards, M. H., Dennison, E. M., & Cooper, C. (2013). Epidemiology and burden of osteoarthritis. *British Medical Bulletin*, 105, 185-199. doi:10.1093/bmb/lds038
- Litwin, H., Stoeckel, K. J., & Roll, A. (2014). Relationship status and depressive symptoms among older co-resident caregivers. *Ageing & Mental Health*, 18(2), 225-231. doi:10.1080/13607863.2013.837148
- Liu-Ambrose, T., Donaldson, M. G., Ahamed, Y., Graf, P., Cook, W. L., Close, J., ... Khan, K. M. (2008). Otago home-based strength and balance retraining improves executive functioning in older fallers: A randomized controlled trial. *Journal of the American Geriatrics Society*, 56(10), 1821-1830. doi:10.1111/j.1532-5415.2008.01931.x
- Liu, L., Stroulia, E., Nikolaidis, I., Miguel-Cruz, A., & Rios Rincon, A. (2016). Smart homes and home health monitoring technologies for older adults: A systematic review. *International Journal of Medical Informatics*, 91, 44-59. doi:10.1016/j.ijmedinf.2016.04.007
- Liu, Y., Croft, J. B., Anderson, L. A., Wheaton, A. G., Presley-Cantrell, L. R., & Ford, E. S. (2014). The association of chronic obstructive pulmonary disease, disability, engagement in social activities, and mortality among US adults aged 70 years or older, 1994-2006. *International Journal of Chronic Obstructive Pulmonary Disease*, 9, 75-83. doi:10.2147/copd.S53676
- Liu, Y. E., Norman, I. J., & While, A. E. (2013). Nurses' attitudes towards older people: A systematic review. *International Journal of Nursing Studies*, 50(9), 1271-1282. doi:10.1016/j.ijnurstu.2012.11.021
- Livingston, G., Sommerlad, A., Orgeta, V., Costafreda, S. G., Huntley, J., Ames, D., ... Mukadam, N. (2017). Dementia prevention, intervention, and care. *Lancet*, 390(10113), 2673-2734. doi:10.1016/s0140-6736(17)31363-6
- Lloyd-Jones, D. M., Larson, M. G., Leip, E. P., Beiser, A., D'Agostino, R. B., Kannel, W. B., ... Levy, D. (2002). Lifetime risk for developing congestive heart failure: The Framingham Heart Study. *Circulation*, 106(24), 3068-3072. doi:10.1161/01.CIR.0000039105.49749.6F
- Lloyd-Sherlock, P., Ebrahim, S., McKee, M., & Prince, M. (2015). A premature mortality target for the SDG for health is ageist. *Lancet*, 385(9983), 2147-2148. doi:10.1016/S0140-6736(15)61016-9
- Loboprabhu, S., & Molinari, V. (2012). Severe loneliness in community-dwelling aging adults with mental illness. *Journal of Psychiatric Practice*, 18(1), 20-28. doi:10.1097/01.pra.0000410984.15852.59
- Locquet, M., Beaudart, C., Reginster, J.-Y., Petermans, J., & Bruyère, O. (2017). Comparison of the performance of five screening methods for sarcopenia. *Clinical epidemiology*, 10, 71-82. doi:10.2147/CLEP.S148638
- Lopez-Alcalde, J., Mateos-Mazon, M., Guevara, M., Conterno, L. O., Sola, I., Cabir Nunes, S., & Bonfill Cosp, X. (2015). Gloves, gowns and masks for reducing the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) in the hospital setting. *The Cochrane Database of Systematic Reviews (CDSR)*, (7). doi:10.1002/14651858.CD007087.pub2
- Lopez-Otin, C., Blasco, M. A., Partridge, L., Serrano, M., & Kroemer, G. (2013). The hallmarks of aging. *Cell*, 153(6), 1194-1217. doi:10.1016/j.cell.2013.05.039
- Lopez Doblas, J., & Diaz Conde, M. D. P. (2018). Widowhood, loneliness, and health in old age. *Revista Española de Geriatria y Gerontología*, 53(3), 128-133. doi:10.1016/j.regg.2017.09.005

- Lorenzo-Lopez, L., Maseda, A., de Labra, C., Regueiro-Folgueira, L., Rodriguez-Villamil, J. L., & Millan-Calenti, J. C. (2017). Nutritional determinants of frailty in older adults: A systematic review. *BMC Geriatrics*, 17:108, 1-13. doi:10.1186/s12877-017-0496-2
- Loughrey, D. G., Lavecchia, S., Brennan, S., Lawlor, B. A., & Kelly, M. E. (2017). The impact of the mediterranean diet on the cognitive functioning of healthy older adults: A systematic review and meta-analysis. *Advances in Nutrition*, 8(4), 571-586. doi:10.3945/an.117.015495
- Lu, W., Sacker, A., & Pikhart, H. (2018). Domains and measurements of healthy aging in epidemiological studies: A review. *The Gerontologist*, gny029. doi:10.1093/geront/gny029
- Luhmann, M., & Hawkey, L. C. (2016). Age differences in loneliness from late adolescence to oldest old age. *Developmental Psychology*, 52(6), 943-959. doi:10.1037/dev0000117
- Luo, Y., Hawkey, L. C., Waite, L. J., & Cacioppo, J. T. (2012). Loneliness, health, and mortality in old age: A national longitudinal study. *Social Science & Medicine*, 74(6), 907-914. doi:10.1016/j.socscimed.2011.11.028
- Lyon, D., Lancaster, G. A., Taylor, S., Dowrick, C., & Chellaswamy, H. (2007). Predicting the likelihood of emergency admission to hospital of older people: Development and validation of the Emergency Admission Risk Likelihood Index (EARLI). *Family Practice*, 24(2), 158-167. doi:10.1093/fampra/cml069
- Macarthur Foundation Research Network on an Aging Society. (2010). Policies and politics for an aging America. *Contexts*, 9(1), 22-27. doi:10.1525/ctx.2010.9.1.22
- Mackenbach, J. P. (2013). Political conditions and life expectancy in Europe, 1900-2008. *Social Science & Medicine*, 82, 134-146. doi:10.1016/j.socscimed.2012.12.022
- Mackenbach, J. P., Valverde, J. R., Artnik, B., Bopp, M., Bronnum-Hansen, H., Deboosere, P., ... Nusselder, W. J. (2018). Trends in health inequalities in 27 European countries. *Proceedings of the National Academy of Sciences of the United States of America*, 115(25), 6440-6445. doi:10.1073/pnas.1800028115
- Maclullich, A. M., Anand, A., Davis, D. H., Jackson, T., Barugh, A. J., Hall, R. J., ... Cunningham, C. (2013). New horizons in the pathogenesis, assessment and management of delirium. *Age and Ageing*, 42(6), 667-674. doi:10.1093/ageing/aft148
- Maher, R. L., Hanton, J., & Hajjar, E. R. (2014). Clinical consequences of polypharmacy in elderly. *Expert Opinion on Drug Safety*, 13(1), 57-65. doi:10.1517/14740338.2013.827660
- Mair, C. A., Quinones, A. R., & Pasha, M. A. (2016). Care preferences among middle-aged and older adults with chronic disease in Europe: Individual health care needs and national health care infrastructure. *The Gerontologist*, 56(4), 687-701. doi:10.1093/geront/gnu119
- Malmstrom, H., Walldius, G., Carlsson, S., Grill, V., Jungner, I., Gudbjornsdottir, S., ... Hammar, N. (2018). Elevations of metabolic risk factors 20 years or more before diagnosis of type 2 diabetes: Experience from the amoris study. *Diabetes, Obesity and Metabolism*, 20(6), 1419-1426. doi:10.1111/dom.13241
- Malva, J. O., & Bousquet, J. (2016). Operational definition of active and healthy ageing: Roadmap from concept to change of management. *Maturitas*, 84, 3-4. doi:10.1016/j.maturitas.2015.11.004
- Malvezzi, M., Carioli, G., Bertuccio, P., Negri, E., & La Vecchia, C. (2018). Relation between mortality trends of cardiovascular diseases and selected cancers in the European Union, in 1970-2017. Focus on cohort and period effects. *European Journal of Cancer*, 103, 341-355. doi:10.1016/j.ejca.2018.06.018
- Mamo, S. K., Reed, N. S., Nieman, C. L., Oh, E. S., & Lin, F. R. (2016). Personal sound amplifiers for adults with hearing loss. *The American Journal of Medicine*, 129(3), 245-250. doi:10.1016/j.amjmed.2015.09.014
- Manchester City Council. (2017). Manchester: A great place to grow older - strategy 2017-2021. Retrieved from [https://www.manchester.gov.uk/downloads/download/6786/manchester\\_a\\_great\\_place\\_to\\_grow\\_older](https://www.manchester.gov.uk/downloads/download/6786/manchester_a_great_place_to_grow_older)
- Manchester Institute for Collaborative Research on Ageing. (2018). Manchester Institute for Collaborative Research on Ageing. Retrieved from <https://www.manchester.ac.uk/>
- Manchester Institute for Collaborative Research on Ageing. Retrieved from <https://www.micra.manchester.ac.uk/about-us/aims/>
- Manias, E., & Hughes, C. (2015). Challenges of managing medications for older people at transition points of care. *Research in Social and Administrative Pharmacy*, 11(3), 442-447. doi:10.1016/j.sapharm.2014.10.001
- Mannick, J. B., Del Giudice, G., Lattanzi, M., Valiante, N. M., Praestgaard, J., Huang, B., ... Klickstein, L. B. (2014). mTOR inhibition improves immune function in the elderly. *Science Translational Medicine*, 6(268), 268ra179. doi:10.1126/scitranslmed.3009892
- Marcolino, M. S., Oliveira, J. A. Q., D'Agostino, M., Ribeiro, A. L., Alkmim, M. B. M., & Novillo-Ortiz, D. (2018). The impact of mHealth interventions: Systematic review of systematic reviews. *JMIR Mhealth Uhealth*, 6(1), e23. doi:10.2196/mhealth.8873
- Marquardt, G., Bueter, K., & Motzek, T. (2014). Impact of the design of the built environment on people with dementia: An evidence-based review. *Herd*, 8(1), 127-157. doi:10.1177/193758671400800111
- Marshall, E. G., Clarke, B., Peddle, S., & Jensen, J. (2015). Care by design: New model of coordinated on-site primary and acute care in long-term care facilities. *Canadian Family Physician*, 61(3), e129-e134.
- Martikainen, M. H., Ronnema, T., & Majamaa, K. (2013). Prevalence of mitochondrial diabetes in southwestern Finland: A molecular epidemiological study. *Acta Diabetologica*, 50(5), 737-741. doi:10.1007/s00592-012-0393-2
- Martin, G. P., Sperrin, M., Ludman, P. F., deBelder, M. A., Gunning, M., Townend, J., ... Mamas, M. A. (2018). Do frailty measures improve prediction of mortality and morbidity following transcatheter aortic valve implantation? An analysis of the UK TAVI registry. *BMJ Open*, 8(6), e022543. doi:10.1136/bmjopen-2018-022543

- Martincorena, I., & Campbell, P. J. (2015). Somatic mutation in cancer and normal cells. *Science*, 349(6255), 1483-1489. doi:10.1126/science.aab4082
- Martone, A. M., Bianchi, L., Abete, P., Bellelli, G., Bo, M., Cherubini, A., ... Landi, F. (2017). The incidence of sarcopenia among hospitalized older patients: Results from the Glisten study. *Journal of Cachexia, Sarcopenia and Muscle*, 8(6), 907-914. doi:10.1002/jcsm.12224
- Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences*, 9(10), 496-502. doi:10.1016/j.tics.2005.08.005
- Mathew, M. C., Ervin, A. M., Tao, J., & Davis, R. M. (2012). Antioxidant vitamin supplementation for preventing and slowing the progression of age-related cataract. *The Cochrane Database of Systematic Reviews (CDSR)*(6), Cd004567. doi:10.1002/14651858.CD004567.pub2
- Matthews, F. E., Arthur, A., Barnes, L. E., Bond, J., Jagger, C., Robinson, L., ... Ageing, C. (2013). A two-decade comparison of prevalence of dementia in individuals aged 65 years and older from three geographical areas of England: Results of the cognitive function and ageing study I and II. *Lancet*, 382(9902), 1405-1412. doi:10.1016/S0140-6736(13)61570-6
- Mattson, M. P., Longo, V. D., & Harvie, M. (2017). Impact of intermittent fasting on health and disease processes. *Ageing Research Reviews*, 39, 46-58. doi:10.1016/j.arr.2016.10.005
- Mausbach, B. T., Patterson, T. L., Rabinowitz, Y. G., Grant, I., & Schulz, R. (2007). Depression and distress predict time to cardiovascular disease in dementia caregivers. *Health Psychology*, 26(5), 539-544. doi:10.1037/0278-6133.26.5.539
- McCabe, J. J., & Kennelly, S. P. (2015). Acute care of older patients in the emergency department: Strategies to improve patient outcomes. *Open access emergency medicine: OAEM*, 7, 45-54. doi:10.2147/OAEM.S69974
- McCarroll, R., Eyles, H., & Ni Mhurchu, C. (2017). Effectiveness of mobile health (mhealth) interventions for promoting healthy eating in adults: A systematic review. *Preventive Medicine*, 105, 156-168. doi:10.1016/j.ypmed.2017.08.022
- McCracken, K., & Phillips, D. R. (2017). *Global health: An introduction to current and future trends* (2 ed.). London, UK and New York, USA: Routledge.
- McDaid, D., & Park, A. L. (2011). Investing in mental health and well-being: Findings from the DataPrev project. *Health promotion international*, 26 (Suppl. 1), i108-i139. doi:10.1093/heapro/dar059
- McManus, S., Bebbington, P., Jenkins, R., & Brugha, T. e. (2016). *Mental health and wellbeing in England: Adult psychiatric morbidity survey 2014*. Leeds: NHS Digital.
- Medina-Garin, D. R., Dia, A., Bedubourg, G., Deparis, X., Berger, F., & Michel, R. (2016). Acute acoustic trauma in the French armed forces during 2007-2014. *Noise & Health*, 18(85), 297-302. doi:10.4103/1463-1741.195802
- Meiners, S., Eickelberg, O., & Konigshoff, M. (2015). Hallmarks of the ageing lung. *The European Respiratory Journal*, 45(3), 807-827. doi:10.1183/09031936.00186914
- Melzer, D., Atkins, J. L., Delgado, J., Bowman, K., Pilling, L. C., Masoli, J. A. H., ... Ferrucci, L. (2018). Impact of low cardiovascular risk profiles on geriatric outcomes: Evidence from 421,000 participants in two cohorts. *The Journals of Gerontology: Series A*, 74(3), 350-357. doi:10.1093/gerona/gly083
- Mensah, G. A., Wei, G. S., Sorlie, P. D., Fine, L. J., Rosenberg, Y., Kaufmann, P. G., ... Gordon, D. (2017). Decline in cardiovascular mortality: Possible causes and implications. *Circulation research*, 120(2), 366-380. doi:10.1161/CIRCRESAHA.116.309115
- Meyer, A. M., Becker, I., Siri, G., Brinkkotter, P. T., Benzing, T., Pilotto, A., & Polidori, M. C. (2018). New associations of the multidimensional prognostic index. *Zeitschrift für Gerontologie und Geriatrie*, 1-8. doi:10.1007/s00391-018-01471-6
- Mezuk, B., Edwards, L., Lohman, M., Choi, M., & Lapane, K. (2012). Depression and frailty in later life: A synthetic review. *International Journal of Geriatric Psychiatry*, 27(9), 879-892. doi:10.1002/gps.2807
- Michel, J.-P., Beattie, L. B., Finbarr, M. C., & Walston, J., D. (2017). *Oxford textbook of geriatric medicine* (3rd edition). Oxford, UK: Oxford University Press.
- Michel, J. P. (Ed.) (2019). *Prevention of chronic diseases and age-related disability*. Cham: Springer International Publishing.
- Michel, J. P., & Sadana, R. (2017). 'Healthy aging' concepts and measures. *Journal of the American Medical Directors Association*, 18(6), 460-464. doi:10.1016/j.jamda.2017.03.008
- Mijnarends, D. M., Luiking, Y. C., Halfens, R. J. G., Evers, S. M. A. A., Lenaerts, E. L. A., Verlaan, S., ... Meijers, J. M. M. (2018). Muscle, health and costs: A glance at their relationship. *The Journal of Nutrition, Health and Aging*, 22(7), 766-773. doi:10.1007/s12603-018-1058-9
- Milte, C. M., & McNaughton, S. A. (2016). Dietary patterns and successful ageing: A systematic review. *European Journal of Nutrition*, 55(2), 423-450. doi:10.1007/s00394-015-1123-7
- Mistry, H. (2012). Systematic review of studies of the cost-effectiveness of telemedicine and telecare. *Changes in the economic evidence over twenty years. Journal of Telemedicine and Telecare*, 18(1), 1-6. doi:10.1258/jtt.2011.110505
- Mody, L., Krein, S. L., Saint, S., Min, L. C., Montoya, A., Lansing, B., ... Bradley, S. F. (2015). A targeted infection prevention intervention in nursing home residents with indwelling devices: A randomized clinical trial. *JAMA Internal Medicine*, 175(5), 714-723. doi:10.1001/jamainternmed.2015.132
- Money, A., Carder, M., Turner, S., Hussey, L., & Agius, R. (2011). *Surveillance for work-related audiological disease in the UK: 1998-2006* (Vol. 61).
- Monsen, K. A., & de Blok, J. (2013). Buurtzorg: Nurse-led community care. *Creative Nursing*, 19(3), 122-127.

- Moralejo, D., El Dib, R., Prata, R. A., Barretti, P., & Correa, I. (2018). Improving adherence to standard precautions for the control of health care-associated infections: The Cochrane Database of Systematic Reviews (CDSR), 2. Cd010768. doi:10.1002/14651858.CD010768.pub2
- Moran, N., Glendinning, C., Wilberforce, M., Stevens, M., Netten, A. N. N., Jones, K., ... Jacobs, S. (2013). Older people's experiences of cash-for-care schemes: Evidence from the English individual budget pilot projects. *Ageing and Society*, 33(5), 826-851. doi:10.1017/S0144686X12000244
- Morin, L., Laroche, M. L., Texier, G., & Johnell, K. (2016). Prevalence of potentially inappropriate medication use in older adults living in nursing homes: A systematic review. *Journal of the American Medical Directors Association*, 17(9), 862.e861-869. doi:10.1016/j.jamda.2016.06.011
- Morley, J. E. (2012). Undernutrition in older adults. *Family Practice*, 29 (Suppl. 1), i89-i93. doi:10.1093/fampra/cm054
- Morris, G. P., Clark, I. A., & Vissel, B. (2014). Inconsistencies and controversies surrounding the amyloid hypothesis of Alzheimer's disease. *Acta Neuropathologica Communications*, 2, 135. doi:10.1186/s40478-014-0135-5
- Moskven, E., Bourassa-Moreau, E., Charest-Morin, R., Flexman, A., & Street, J. (2018). The impact of frailty and sarcopenia on postoperative outcomes in adult spine surgery: A systematic review of the literature. *The Spine Journal*, 18(12), 2354-2369. doi:10.1016/j.spinee.2018.07.008
- Most, J., Tosti, V., Redman, L. M., & Fontana, L. (2017). Calorie restriction in humans: An update. *Ageing Research Reviews*, 39, 36-45. doi:10.1016/j.arr.2016.08.005
- Moyet, J., Deschasse, G., Marquant, B., Mertl, P., & Bloch, F. (2018). Which is the optimal orthogeriatric care model to prevent mortality of elderly subjects post hip fractures? A systematic review and meta-analysis based on current clinical practice. *International Orthopaedics*, 43(6), 1449-1454. doi:10.1007/s00264-018-3928-5
- Mueller, C., Christ, M., Cowie, M., Cullen, L., Maisel, A. S., Masip, J., ... Mebazaa, A. (2017). European society of cardiology-acute cardiovascular care association position paper on acute heart failure: A call for interdisciplinary care. *European Heart Journal: Acute Cardiovascular Care*, 6(1), 81-86. doi:10.1177/2048872615593279
- Muir, T. (2016). The long-term care workforce in OECD countries. An overview of characteristics, trends and policy challenges. Retrieved from <https://www.ilpnetwork.org/wp-content/media/2016/10/Muir-ILPN-conference-06-Sep-LTC-workforce.pdf>
- Mukaetova-Ladinska, E. B. (2018). The therapeutic 'make-over' of dementias—an introduction. *Age and Ageing*, 47(3), 331-333. doi:10.1093/ageing/afy019
- Murayama, Y., Ohba, H., Yasunaga, M., Nonaka, K., Takeuchi, R., Nishi, M., ... Fujiwara, Y. (2015). The effect of intergenerational programs on the mental health of elderly adults. *Aging Ment Health*, 19(4), 306-314. doi:10.1080/13607863.2014.933309
- Nahhas, R. W., Choh, A. C., Lee, M., Chumlea, W. M., Duren, D. L., Siervogel, R. M., ... Czerwinski, S. A. (2010). Bayesian longitudinal plateau model of adult grip strength. *American Journal of Human Biology*, 22(5), 648-656. doi:10.1002/ajhb.21057
- Namasivayam, A. M., & Steele, C. M. (2015). Malnutrition and dysphagia in long-term care: A systematic review. *Journal of Nutrition in Gerontology and Geriatrics*, 34(1), 1-21. doi:10.1080/21551197.2014.1002656
- Narushima, M. (2008). More than nickels and dimes: The health benefits of a communitybased lifelong learning programme for older adults. *International Journal of Lifelong Education*, 27(6), 673-692. doi:10.1080/02601370802408332
- National Academies of Sciences, Engineering and Medicine, Health and Medicine Division, Board on Global Health, & Committee on Global Health and the Future of the United States. (2017). Promoting cardiovascular health and preventing cancer. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK458468/>
- National Academies of Sciences, Engineering and Medicine (2017). Preventing cognitive decline and dementia: A way forward. Washington, DC: The National Academies Press.
- National Audit Office. (2018). The adult social care workforce in England. Retrieved from <https://www.nao.org.uk/report/the-adult-social-care-workforce-in-England/>
- National Institute for Health and Care Excellence. (2015). Home care: Delivering personal care and practical support to older people living in their own homes. Retrieved from <https://www.nice.org.uk/guidance/ng21/evidence/full-guideline-pdf-489149252>
- Naylor, M. D., Broton, D., Campbell, R., Jacobsen, B. S., Mezey, M. D., Pauly, M. V., & Schwartz, J. S. (1999). Comprehensive discharge planning and home follow-up of hospitalized elders: A randomized clinical trial. *JAMA*, 281(7), 613-620.
- Nelson, P. T., Braak, H., & Markesbery, W. R. (2009). Neuropathology and cognitive impairment in Alzheimer disease: A complex but coherent relationship. *Journal of Neuropathology & Experimental Neurology*, 68(1), 1-14. doi:10.1097/NEN.0b013e3181919a48
- Neuburger, J., Currie, C., Wakeman, R., Tsang, C., Plant, F., De Stavola, B., ... van der Meulen, J. (2015). The impact of a national clinician-led audit initiative on care and mortality after hip fracture in England: An external evaluation using time trends in non-audit data. *Medical Care*, 53(8), 686-691. doi:10.1097/mlr.0000000000000383
- Newman, A. B., Sanders, J. L., Kizer, J. R., Boudreau, R. M., Odden, M. C., Zeki Al Hazzouri, A., & Arnold, A. M. (2016). Trajectories of function and biomarkers with age: The CHS All Stars Study. *International Journal of Epidemiology*, 45(4), 1135-1145. doi:10.1093/ije/dyw092
- New York Academy of Medicine. (2007) Age-friendly NYC. Retrieved from <https://nyam.org/age-friendly-nyc/about/>
- Nexø, M. A., Meng, A., & Borg, V. (2016). Can psychosocial work conditions protect against age-related cognitive decline? Results from a systematic review. *Occupational and Environmental Medicine*, 73(7), 487-496. doi:10.1136/oemed-2016-103550

- Ngandu, T., Lehtisalo, J., Solomon, A., Levalahti, E., Ahtiluoto, S., Antikainen, R., ... Kivipelto, M. (2015). A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (finger): A randomised controlled trial. *Lancet*, 385(9984), 2255-2263. doi:10.1016/s0140-6736(15)60461-5
- NHS Digital. (2009). Adult Psychiatric Morbidity in England - 2007. Results of a household survey. Retrieved from <https://digital.nhs.uk/data-and-information/publications/statistical/adult-psychiatric-morbidity-survey/adult-psychiatric-morbidity-in-england-2007-results-of-a-household-survey#summary>
- Niedzwiedz, C. L., Katikireddi, S. V., Pell, J. P., & Mitchell, R. (2012). Life course socio-economic position and quality of life in adulthood: A systematic review of life course models. *BMC Public Health*, 12:628, 1-11. doi:10.1186/1471-2458-12-628
- Nieuwenhuizen, W. F., Weenen, H., Rigby, P., & Hetherington, M. M. (2010). Older adults and patients in need of nutritional support: Review of current treatment options and factors influencing nutritional intake. *Clinical Nutrition*, 29(2), 160-169. doi:10.1016/j.clnu.2009.09.003
- Niezabitowska, E. D. (2018). *Research methods and techniques in architecture*. New York: Routledge.
- Noon, R. B., & Ayalon, L. (2018). Older adults in public open spaces: Age and gender segregation. *The Gerontologist*, 58(1), 149-158. doi:10.1093/geront/gnx047
- Norton, S., Matthews, F. E., Barnes, D. E., Yaffe, K., & Brayne, C. (2014). Potential for primary prevention of Alzheimer's disease: An analysis of population-based data. *Lancet Neurology*, 13(8), 788-794. doi:10.1016/s1474-4422(14)70136-x
- Nunez-Nunez, M., Navarro, M. D., Palomo, V., Rajendran, N. B., Del Toro, M. D., Voss, A., ... Rodriguez-Bano, J. (2018). The methodology of surveillance for antimicrobial resistance and healthcare-associated infections in Europe (suspire): A systematic review of publicly available information. *Clinical Microbiology and Infection*, 24(2), 105-109. doi:10.1016/j.cmi.2017.07.014
- O'Rourke, N., Kupferschmidt, A. L., Claxton, A., Smith, J. Z., Chappell, N., & Beattie, B. L. (2010). Psychological resilience predicts depressive symptoms among spouses of persons with Alzheimer disease over time. *Aging and Mental Health*, 14(8), 984-993. doi:10.1080/13607863.2010.501063
- O'Shea, E., Trawley, S., Manning, E., Barrett, A., Browne, V., & Timmons, S. (2017). Malnutrition in hospitalised older adults: A multicentre observational study of prevalence, associations and outcomes. *The Journal of Nutrition, Health and Aging*, 21(7), 830-836. doi:10.1007/s12603-016-0831-x
- O'Sullivan, D., O'Mahony, D., O'Connor, M. N., Gallagher, P., Gallagher, J., Cullinan, S., ... Byrne, S. (2016). Prevention of adverse drug reactions in hospitalised older patients using a software-supported structured pharmacist intervention: A cluster randomised controlled trial. *Drugs & Aging*, 33(1), 63-73. doi:10.1007/s40266-015-0329-y
- O'Mahony, D. (2017). Optimizing pharmacotherapy for older patients In Jean-Pierre Michel, B. Lynn Beattie, Finbarr C. Martin, & J. D. Walston (Eds.), *Oxford textbook of geriatric medicine* (3rd edition, pp. 183-188). Oxford: Oxford University Press.
- O'Mahony, D., Gallagher, P., Ryan, C., Byrne, S., Hamilton, H., Barry, P., ... Kennedy, J. (2010). Stopp & start criteria: A new approach to detecting potentially inappropriate prescribing in old age. *European Geriatric Medicine*, 1(1), 45-51. doi:10.1016/j.eurger.2010.01.007
- O'Neill, J. (2016). Tackling drug-resistant infections globally: Final report and recommendations. Retrieved from [https://amr-review.org/sites/default/files/160518\\_Final%20paper\\_with%20cover.pdf](https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf)
- O'Toole, P. W., & Jeffery, I. B. (2015). Gut microbiota and aging. *Science*, 350(6265), 1214-1215. doi:10.1126/science.aac8469
- Oakley, B., Nightingale, J., Moran, C. G., & Moppett, I. K. (2017). Does achieving the best practice tariff improve outcomes in hip fracture patients? An observational cohort study. *The BMJ*, 7(2), e014190. doi:10.1136/bmjopen-2016-014190
- OECD. (2005). Long-term care for older people. The OECD health project. Retrieved from <http://www.oecd.org/els/health-systems/long-term-care-for-older-people.htm>
- OECD. (2017a). *Health at a glance 2017*. Paris: OECD Publishing.
- OECD. (2017b). *Pensions at a glance 2017*.
- OECD/EU. (2016). 'Diabetes prevalence'. In: *Health at a glance : Europe 2016 : State of health in EU cycles*. Retrieved from <https://www.oecd.org/els/health-systems/Health-at-a-Glance-Europe-2016-CHARTSET.pdf>
- OECD/European Commission. (2013). *A good life in old age? Monitoring and improving quality in long-term care*. Retrieved from <https://www.oecd.org/els/health-systems/PolicyBrief-Good-Life-in-Old-Age.pdf>
- Oeppen, J., & Vaupel, J. W. (2002). Broken limits to life expectancy. *Science*, 296(5570), 1029-1031. doi:10.1126/science.1069675
- Officer, A., & de la Fuente-Núñez, V. (2018). A global campaign to combat ageism. *Bulletin of the World Health Organization*, 96(4), 295-296. doi:10.2471/BLT.17.202424
- Ogilvie, D., Craig, P., Griffin, S., Macintyre, S., & Wareham, N. J. (2009). A translational framework for public health research. *BMC Public Health*, 9:116, 1-10. doi:10.1186/1471-2458-9-116
- Oksuzyan, A., Juel, K., Vaupel, J. W., & Christensen, K. (2008). Men: Good health and high mortality. Sex differences in health and aging. *Aging Clinical and Experimental Research*, 20(2), 91-102.
- Okubo, Y., Schoene, D., & Lord, S. R. (2017). Step training improves reaction time, gait and balance and reduces falls in older people: A systematic review and meta-analysis. *British Journal of Sports Medicine*, 51(7), 586-593. doi:10.1136/bjsports-2015-095452
- Omran, A. R. (2005). The epidemiologic transition: A theory of the epidemiology of population change. 1971. *The Milbank Quarterly*, 83(4), 731-757. doi:10.1111/j.1468-0009.2005.00398.x

- Ong, A. D., Uchino, B. N., & Wethington, E. (2016). Loneliness and health in older adults: A mini-review and synthesis. *Gerontology*, 62(4), 443-449. doi:10.1159/000441651
- Oral, A., Rapidi, C. A., Votava, J., Roussos, N., Michail, X., Kujawa, J., ... Christodoulou, N. (2017). Evidence based position paper on Physical and Rehabilitation Medicine (PRM) professional practice for ageing people with disabilities. The European PRM position (UEMS PRM section). *European Journal of Physical and Rehabilitation Medicine*, 53(5), 802-811. doi:10.23736/s1973-908717.04864-x
- Ouchida, K. M., & Lachs, M. S. (2015). Not for doctors only: Ageism in healthcare. *Generations*, 39(3), 46-57.
- Oxley, H. (2009). Policies for healthy ageing: An overview. Retrieved from <https://www.oecd-ilibrary.org/docserver/226757488706.pdf?expires=1550588094&id=id&accname=guest&checksum=0952D6797F4E671877BA0E9262628356>
- Paccagnella, A., Marcon, M. L., Baruffi, C., Giometto, M., Mauri, A., Vigo, C., ... De Marco, M. C. (2016). Enteral nutrition at home and in nursing homes: An 11-year (2002-2012) epidemiological analysis. *Minerva Gastroenterol Dietol*, 62(1), 1-10.
- Paddon-Jones, D., Sheffield-Moore, M., Cree, M. G., Hewlings, S. J., Aarsland, A., Wolfe, R. R., & Ferrando, A. A. (2006). Atrophy and impaired muscle protein synthesis during prolonged inactivity and stress. *The Journal of Clinical Endocrinology and Metabolism*, 91(12), 4836-4841. doi:10.1210/jc.2006-0651
- Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. (2011). Summary of the updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *Journal of the American Geriatrics Society*, 59(1), 148-157. doi:10.1111/j.1532-5415.2010.03234.x
- Parry, S. W., & Kenny, R. A. (2005). Drop attacks in older adults: Systematic assessment has a high diagnostic yield. *Journal of the American Geriatrics Society*, 53(1), 74-78. doi:10.1111/j.1532-5415.2005.53013.x
- Parsons, E. L., Stratton, R. J., Cawood, A. L., Smith, T. R., & Elia, M. (2017). Oral nutritional supplements in a randomised trial are more effective than dietary advice at improving quality of life in malnourished care home residents. *Clinical Nutrition*, 36(1), 134-142. doi:10.1016/j.clnu.2016.01.002
- Partridge, L., Deelen, J., & Slagboom, P. E. (2018). Facing up to the global challenges of ageing. *Nature*, 561(7721), 45-56. doi:10.1038/s41586-018-0457-8
- Paterson, M., Kinnear, M., Bond, C., & McKinstry, B. (2017). A systematic review of electronic multi-compartment medication devices with reminder systems for improving adherence to self-administered medications. *International Journal of Pharmacy Practice*, 25(3), 185-194. doi:10.1111/ijpp.12242
- Patz, J. A., Frumkin, H., Holloway, T., Vimont, D. J., & Haines, A. (2014). Climate change: Challenges and opportunities for global health. *JAMA*, 312(15), 1565-1580. doi:10.1001/jama.2014.13186
- Pautex, S., Curiale, V., Pfisterer, M., Rexach, L., Ribbe, M., & Van Den Noortgate, N. (2010). A common definition of geriatric palliative medicine. *Journal of the American Geriatrics Society*, 58(4), 790-791. doi:10.1111/j.1532-5415.2010.02791.x
- Pavic, T., Ljubcic, N., Stojavljec, S., & Krznaric, Z. (2012). Nutritional screening model in tertiary medical unit in Croatia. *Annals of Nutrition and Metabolism*, 61(1), 65-69. doi:10.1159/000338967
- Pawelec, G. (2019). Immune signatures associated with mortality differ in elderly populations from different birth cohorts and countries even within northern Europe. *Mechanisms of Ageing and Development*, 177, 182-185. doi:10.1016/j.mad.2018.04.005
- Peake, M. D., Thompson, S., Lowe, D., & Pearson, M. G. (2003). Ageism in the management of lung cancer. *Age and Ageing*, 32(2), 171-177.
- Peek, S. T., Luijckx, K. G., Rijnaard, M. D., Nieboer, M. E., van der Voort, C. S., Aarts, S., ... Wouters, E. J. (2016). Older adults' reasons for using technology while aging in place. *Gerontology*, 62(2), 226-237. doi:10.1159/000430949
- Peeters, G., van Schoor, N. M., Cooper, R., Tooth, L., & Kenny, R. A. (2018). Should prevention of falls start earlier? Co-ordinated analyses of harmonised data on falls in middle-aged adults across four population-based cohort studies. *PLOS ONE*, 13(8), e0201989. doi:10.1371/journal.pone.0201989
- Peeters, G. M., Jones, M., Byles, J., & Dobson, A. J. (2015). Long-term consequences of noninjurious and injurious falls on well-being in older women. *The Journals of Gerontology: Series A*, 70(12), 1519-1525. doi:10.1093/gerona/glv102
- Penalvo, J. L., Santos-Beneit, G., Sotos-Prieto, M., Bodega, P., Oliva, B., Orrit, X., ... Fuster, V. (2015). The SI! Program for cardiovascular health promotion in early childhood: A cluster-randomized trial. *Journal of the American College of Cardiology*, 66(14), 1525-1534. doi:10.1016/j.jacc.2015.08.014
- Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, 18(2), 189-193.
- Peplau, L. A., & Perlman, D. (1982). *Loneliness: A sourcebook of current theory, research and therapy* New York: Wiley.
- Peres, K., Matharan, F., Daien, V., Nael, V., Edjolo, A., Bourdel-Marchasson, I. s., ... Carriere, I. (2017). Visual loss and subsequent activity limitations in the elderly: The French three-city cohort. *American Public Health Association (APHA)*, 107(4), 564-569. doi:10.2105/ajph.2016.303631
- Perez-Jover, V., Mira, J. J., Carratala-Munuera, C., Gil-Guillen, V. F., Basora, J., Lopez-Pineda, A., & Orozco-Beltran, D. (2018). Inappropriate use of medication by elderly, polymedicated, or multipathological patients with chronic diseases. *International Journal of Environmental Research and Public Health*, 15(2). doi:10.3390/ijerph15020310
- Petrovic, D., de Mestral, C., Bochud, M., Bartley, M., Kivimaki, M., Vineis, P., ... Stringhini, S. (2018). The contribution of health behaviors to socioeconomic inequalities in health: A systematic review. *Preventive Medicine*, 113, 15-31. doi:10.1016/j.ypmed.2018.05.003

- Pettersson, I., Hagberg, L., Fredriksson, C., & Hermansson, L. N. (2016). The effect of powered scooters on activity, participation and quality of life in elderly users. *Disability and Rehabilitation: Assistive Technology*, 11(7), 558-563. doi:10.3109/17483107.2015.1027301
- Phelan, A. (2008). Elder abuse, ageism, human rights and citizenship: Implications for nursing discourse. *Nursing Inquiry*, 15(4), 320-329. doi:10.1111/j.1440-1800.2008.00423.x
- Piercy, K. L., & Troiano, R. P. (2018). Physical activity guidelines for Americans from the US Department of Health and Human Services. *Circulation: Cardiovascular Quality and Outcomes*, 11(11), e005263. doi:10.1161/circoutcomes.118.005263
- Pilotto, A., Ferrucci, L., Franceschi, M., D'Ambrosio, L. P., Scarcelli, C., Cascavilla, L., ... Leandro, G. (2008). Development and validation of a multidimensional prognostic index for one-year mortality from comprehensive geriatric assessment in hospitalized older patients. *Rejuvenation Research*, 11(1), 151-161. doi:10.1089/rej.2007.0569
- Pilotto, A., Gallina, P., Copetti, M., Pilotto, A., Marcato, F., Mello, A. M., ... Panza, F. (2016a). Warfarin treatment and all-cause mortality in community-dwelling older adults with atrial fibrillation: A retrospective observational study. *Journal of the American Geriatrics Society*, 64(7), 1416-1424. doi:10.1111/jgs.14221
- Pilotto, A., Gallina, P., Panza, F., Copetti, M., Cella, A., Cruz-Jentoft, A., ... Marchionni, N. (2016b). Relation of statin use and mortality in community-dwelling frail older patients with coronary artery disease. *The American Journal of Cardiology*, 118(11), 1624-1630. doi:10.1016/j.amjcard.2016.08.042
- Pilotto, A., & Martin, F. C. e. (2018). *Comprehensive geriatric assessment*. Cham: Springer International Publishing.
- Pilotto, A., Panza, F., Copetti, M., Simonato, M., Sancarlo, D., Gallina, P., & Strandberg, T. (2015). Statin treatment and mortality in community-dwelling frail older patients with diabetes mellitus: A retrospective observational study. *PLOS ONE*, 10(6), e0130946. doi:10.1371/journal.pone.0130946
- Pilotto, A., Polidori, M. C., Veronese, N., Panza, F., Arboretti Giancristofaro, R., Pilotto, A., ... Multidimensional Prognostic Index (MPI)\_Age Project Investigators. (2018). Association of antedementia drugs and mortality in community-dwelling frail older patients with dementia: The role of mortality risk assessment. *Journal of the American Medical Directors Association*, 19(2), 162-168. doi:10.1016/j.jamda.2017.08.017
- Pinquart, M., & Sorensen, S. (2001). Influences on loneliness in older adults: A meta-analysis. *Basic and Applied Social Psychology*, 23(4), 245-266. doi:10.1207/S15324834BASP2304\_2
- Pinquart, M., & Sorensen, S. (2003). Differences between caregivers and noncaregivers in psychological health and physical health: A meta-analysis. *Psychology and Aging*, 18(2), 250-267.
- Planetree. (2017). The Planetree philosophy of care. Retrieved from <https://www.stamfordhealth.org/about/planetree/>
- Plevova, P., Paprskarova, M., Tvrda, P., Turska, P., Slavkovsky, R., & Mrazkova, E. (2017). STRC deletion is a frequent cause of slight to moderate congenital hearing impairment in the Czech Republic. *Otology & Neurotology*, 38(10), 393-400. doi:10.1097/mao.0000000000001571
- Polders, E., Brijs, T., Vlahogianni, E., Papadimitriou, E., Yannis, G., Leopold, F., ... Diamandouros, K. (2015). Eldersafe: Risks and countermeasures for road traffic of elderly in Europe. Retrieved from [https://ec.europa.eu/transport/road\\_safety/users/eldery-drivers\\_en](https://ec.europa.eu/transport/road_safety/users/eldery-drivers_en)
- Polisena, J., Tran, K., Cimon, K., Hutton, B., McGill, S., Palmer, K., & Scott, R. E. (2010). Home telehealth for chronic obstructive pulmonary disease: A systematic review and meta-analysis. *Journal of Telemedicine and Telecare*, 16(3), 120-127. doi:10.1258/jtt.2009.090812
- Ponikowski, P., Anker, S. D., AlHabib, K. F., Cowie, M. R., Force, T. L., Hu, S., ... Filippatos, G. (2014). Heart failure: Preventing disease and death worldwide. *ESC Heart Failure*, 1(1), 4-25. doi:10.1002/ehf2.12005
- Ponikowski, P., Voors, A. A., Anker, S. D., Bueno, H., Cleland, J. G. F., Coats, A. J. S., ... van der Meer, P. (2016). 2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure: The task force for the diagnosis and treatment of acute and chronic heart failure of the European society of cardiology (esc). Developed with the special contribution of the heart failure association (hfa) of the esc. *European Heart Journal*, 37(27), 2129-2200. doi:10.1093/eurheartj/ehw128
- Poorthuis, M., M Algra, A., Algra, A., Kappelle, L., & Klijn, C. (2016). Female- and male-specific risk factors for stroke a systematic review and meta-analysis (Vol. 74).
- Popham, C., & Orrell, M. (2012). What matters for people with dementia in care homes? *Aging and Mental Health*, 16(2), 181-188. doi:10.1080/13607863.2011.628972
- Potter, L., Zawadzki, M., P Eccleston, C., E Cook, J., Snipes, S., J Sliwinski, M., & M Smyth, J. (2018). The intersections of race, gender, age, and socioeconomic status: Implications for reporting discrimination and attributions to discrimination. *Stigma and Health*, Advance online publication. doi:10.1037/sah0000099
- Poulain, M., Herm, A., & Pes, G. (2013). The blue zones: Areas of exceptional longevity around the world. *Vienna Yearbook of Population Research*, 11, 87-108.
- Powell, J., Mackintosh, S., Bird, E., Ige, J., Garrett, H., & Roys, M. (2017). *The role of home adaptations in improving later life*. UK: Centre for Ageing Better
- Preston, L., Chambers, D., Campbell, F., Cantrell, A., Turner, J., & Goyder, E. (2018). What evidence is there for the identification and management of frail older people in the emergency department? A systematic mapping review. *Health Services and Delivery Research No. 6.16*. doi:10.3310/hsdr06160
- PricewaterhouseCoopers International. (2018). *European economic outlook 2018-2022*. Retrieved from <https://www.pwc.nl/nl/themas/Europe-monitor/documents/pwc-European-economic-outlook-2018.pdf>

- Prince, M., Comas-Herrera, A., Knapp, M., Guerchet, M., & Karagiannidou, M. (2016). World Alzheimer report 2016: Improving healthcare for people living with dementia: Coverage, quality and costs now and in the future. Retrieved from <https://www.alz.co.uk/research/WorldAlzheimerReport2016.pdf>
- Prince, M. J., Beekman, A. T., Deeg, D. J., Fuhrer, R., Kivela, S. L., Lawlor, B. A., ... Copeland, J. R. (1999). Depression symptoms in late life assessed using the EURO-D scale. Effect of age, gender and marital status in 14 European centres. *British Journal of Psychiatry*, 174, 339-345.
- Prince, M. J., Harwood, R. H., Blizard, R. A., Thomas, A., & Mann, A. H. (1997a). Impairment, disability and handicap as risk factors for depression in old age. The Gospel Oak Project V. *Psychological Medicine*, 27(2), 311-321.
- Prince, M. J., Harwood, R. H., Blizard, R. A., Thomas, A., & Mann, A. H. (1997b). Social support deficits, loneliness and life events as risk factors for depression in old age. The Gospel Oak Project VI. *Psychological Medicine*, 27(2), 323-332.
- Pronk, M., Deeg, D., Smits, C., van Tilburg, T., J Kuik, D., M Festen, J., & Kramer, S. (2011). Prospective effects of hearing status on loneliness and depression in older persons: Identification of subgroups. *International Journal of Audiology*, 50(12), 887-896. doi:10.3109/14992027.2011.599871
- Prsic, E. H., & Teno, J. M. (2017). Oxford textbook of geriatric medicine. In: *Why, when, and where do older people die?* Oxford: Oxford University Press.
- Qiu, C., von Strauss, E., Bäckman, L., Winblad, B., & Fratiglioni, L. (2013). Twenty-year changes in dementia occurrence suggest decreasing incidence in central Stockholm, Sweden. *Neurology*, 80(20), 1888-1894. doi:10.1212/WNL.0b013e318292a2f9
- Qiu, W. Q., Dean, M., Liu, T., George, L., Gann, M., Cohen, J., & Bruce, M. L. (2010). Physical and mental health of homebound older adults: An overlooked population. *Journal of the American Geriatrics Society*, 58(12), 2423-2428. doi:10.1111/j.1532-5415.2010.03161.x
- Rachel Gordon, H. (2007). Allies within and without how adolescent activists conceptualize ageism and navigate adult power in youth social movements. *Journal of Contemporary Ethnography*, 36(6), 631-668. doi:10.1177/0891241606293608
- Radović-Marković, M. (2013). An aging workforce: Employment opportunities and obstacles. *Cadmus: Promoting Leadership in Thought that Leads to Action*, 1(6), 152-155.
- Rae, M. J., Butler, R. N., Campisi, J., de Grey, A. D. N. J., Finch, C. E., Gough, M., ... Logan, B. J. (2010). The demographic and biomedical case for late-life interventions in aging. *Science translational medicine*, 2(40), 40cm21-40cm21. doi:10.1126/scitranslmed.3000822
- Rahi, J. S., Cumberland, P. M., & Peckham, C. S. (2011). Myopia over the lifecourse: Prevalence and early life influences in the 1958 British birth cohort. *Ophthalmology*, 118(5), 797-804. doi:10.1016/j.ophtha.2010.09.025
- Rantz, M. J., Marek, K. D., Aud, M., Tyrer, H. W., Skubic, M., Demiris, G., & Hussam, A. (2005). A technology and nursing collaboration to help older adults age in place. *Nursing Outlook*, 53(1), 40-45. doi:10.1016/j.outlook.2004.05.004
- Rasekaba, T., Lee, A. L., Naughton, M. T., Williams, T. J., & Holland, A. E. (2009). The six-minute walk test: A useful metric for the cardiopulmonary patient. *Journal of Internal Medicine*, 39(8), 495-501. doi:10.1111/j.1445-5994.2008.01880.x
- Ray, J., Popli, G., & Fell, G. (2018). Association of cognition and age-related hearing impairment in the English longitudinal study of ageing. *JAMA Otolaryngology-Head & Neck Surgery*, 144(10), 876-882. doi:10.1001/jamaoto.2018.1656
- Rebok, G. W., Ball, K., Guey, L. T., Jones, R. N., Kim, H. Y., King, J. W., ... Willis, S. L. (2014). Ten-year effects of the advanced cognitive training for independent and vital elderly cognitive training trial on cognition and everyday functioning in older adults. *Journal of the American Geriatrics Society*, 62(1), 16-24. doi:10.1111/jgs.12607
- Reijnierse, E. M., de van der Schueren, M. A. E., Trappenburg, M. C., Doves, M., Meskers, C. G. M., & Maier, A. B. (2017). Lack of knowledge and availability of diagnostic equipment could hinder the diagnosis of sarcopenia and its management. *PLOS ONE*, 12(10), e0185837. doi:10.1371/journal.pone.0185837
- Reunes, S., Rombaut, V., Vogelaers, D., Brusselaers, N., Lizy, C., Cankurtaran, M., ... Blot, S. (2011). Risk factors and mortality for nosocomial bloodstream infections in elderly patients. *European Journal of Internal Medicine*, 22(5), e39-44. doi:10.1016/j.ejim.2011.02.004
- Riek, L. D. (2017). Healthcare robotics. *Communications of the ACM*, 60(11), 68-78. doi:10.1145/3127874
- Rijnaard, M. D., van Hoof, J., Janssen, B. M., Verbeek, H., Pocornie, W., Eijkelenboom, A., ... Wouters, E. J. (2016). The factors influencing the sense of home in nursing homes: A systematic review from the perspective of residents. *Journal of Aging Research*, 2016, 6143645. doi:10.1155/2016/6143645
- Risnes, K. R., Vatten, L. J., Baker, J. L., Jameson, K., Sovio, U., Kajantie, E., ... Bracken, M. B. (2011). Birthweight and mortality in adulthood: A systematic review and meta-analysis. *International Journal of Epidemiology*, 40(3), 647-661. doi:10.1093/ije/dyq267
- Rizzo, M., Anderson, S. W., Dawson, J., & Nawrot, M. (2000). Vision and cognition in Alzheimer's disease. *Neuropsychologia*, 38(8), 1157-1169. doi:10.1016/S0028-3932(00)00023-3
- Roberts, J. S., McLaughlin, S. J., & Connell, C. M. (2014). Public beliefs and knowledge about risk and protective factors for Alzheimer's disease. *Alzheimer's & Dementia*, 10 (Suppl. 5), S381-S389. doi:10.1016/j.jalz.2013.07.001
- Robertson, R., Gregory, S., & Jabbal, J. (2014). The social care and health systems of nine countries. Retrieved from <https://www.kingsfund.org.uk/sites/default/files/media/commission-background-paper-social-care-health-system-other-countries.pdf>
- Robidoux, A., Redmond, C. K., Wickerham, D. L., Tan-Chiu, E., Atkins, J., Costantino, J. P., ... Breast, o. N. S. A. (1998). Tamoxifen for prevention of breast cancer: Report of the National Surgical Adjuvant Breast and Bowel Project P-1 Study. *JNCI: Journal of the National Cancer Institute*, 90(18), 1371-1388. doi:10.1093/jnci/90.18.1371

- Robine, J. M., Michel, J. P., & Herrmann, F. R. (2007). Who will care for the oldest people in our ageing society? *The BMJ*, 334(7593), 570-571. doi:10.1136/bmj.39129.397373.BE
- Robinson, S. M., Jameson, K. A., Syddall, H. E., Dennison, E. M., Cooper, C., & Aihie Sayer, A. (2013). Clustering of lifestyle risk factors and poor physical function in older adults: The hertfordshire cohort study. *Journal of the American Geriatrics Society*, 61(10), 1684-1691. doi:10.1111/jgs.12457
- Rochon, P. A., & Gurwitz, J. H. (2017). The prescribing cascade revisited. *Lancet*, 389(10081), 1778-1780. doi:10.1016/s0140-6736(17)31188-1
- Rohwedder, S., & Willis, R. J. (2010). Mental retirement. *Journal of Economic Perspectives - American Economic Association*, 24(1), 119-138. doi:10.1257/jep.24.1.119
- Rondanelli, M., Opizzi, A., Antonello, N., Boschi, F., Iadarola, P., Pasini, E., ... Dioguardi, F. S. (2011). Effect of essential amino acid supplementation on quality of life, amino acid profile and strength in institutionalized elderly patients. *Clinical Nutrition*, 30(5), 571-577. doi:10.1016/j.clnu.2011.04.005
- Rosel, N. (2003). Aging in place: Knowing where you are. *The International Journal of Aging and Human Development*, 57(1), 77-90. doi:10.2190/AMUD-8XVX-gFPK-MR8G
- Rosenhall, U., & Rubin, W. (1975). Degenerative changes in the human vestibular sensory epithelia. *Acta Oto-Laryngologica*, 79(1-2), 67-80.
- Roth, D. L., Mittelman, M. S., Clay, O. J., Madan, A., & Haley, W. E. (2005). Changes in social support as mediators of the impact of a psychosocial intervention for spouse caregivers of persons with Alzheimer's disease. *Psychology and Aging*, 20(4), 634-644. doi:10.1037/0882-7974.20.4.634
- Roth, T. N., Hanebuth, D., & Probst, R. (2011). Prevalence of age-related hearing loss in Europe: A review. *European Archives of Oto-Rhino-Laryngology*, 268(8), 1101-1107. doi:10.1007/s00405-011-1597-8
- Rowe, J. W., & Kahn, R. L. (1987). Human aging: Usual and successful. *Science*, 237(4811), 143-149. doi:10.1126/science.3299702
- Royal College of Physicians. (2018). Outpatients: The future. Adding value through sustainability. Retrieved from <https://www.rcplondon.ac.uk/projects/outputs/outpatients-future-adding-value-through-sustainability>
- Royce, T. J., Hendrix, L. H., Stokes, W. A., Allen, I. M., & Chen, R. C. (2014). Cancer screening rates in individuals with different life expectancies. *JAMA Internal Medicine*, 174(10), 1558-1565. doi:10.1001/jamainternmed.2014.3895
- Rubenstein, L. Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Ageing*, 35 (Suppl. 2), ii37-ii41. doi:10.1093/ageing/afl084
- Rubin, J., Taylor, J., Krapels, J., Sutherland, A., Felician, M., Liu, J. L., ... Rohr, C. (2016). Are better health outcomes related to social expenditure? A cross-national empirical analysis of social expenditure and population health measures. Santa Monica, CA: RAND.
- Runhaar, J., & Zhang, Y. (2018). Can we prevent OA? Epidemiology and public health insights and implications. *Rheumatology*, 57 (Suppl. 4), iv3-iv9. doi:10.1093/rheumatology/key014
- Russ, S. A., Tremblay, K., Halfon, N., & Davis, A. (2018). A life course approach to hearing health. In N. Halfon, C. B. Forrest, R. M. Lerner, & E. M. Faustman (Eds.), *Handbook of life course health development* (pp. 349-373). Cham: Springer International Publishing.
- Russell, D. W., Cutrona, C. E., McRae, C., & Gomez, M. (2012). Is loneliness the same as being alone? *The Journal of Psychology*, 146(1-2), 7-22. doi:10.1080/00223980.2011.589414
- Rutter, M. (2012). Achievements and challenges in the biology of environmental effects. *Proceedings of the National Academy of Sciences of the United States of America*, 109 (Suppl. 2), 17149-17153. doi:10.1073/pnas.1121258109
- Rutter, M., Kim-Cohen, J., & Maughan, B. (2006). Continuities and discontinuities in psychopathology between childhood and adult life. *47(34)*, 276-295. doi:10.1111/j.1469-7610.2006.01614.x
- Sabia, S., Elbaz, A., Britton, A., Bell, S., Dugravot, A., Shipley, M., ... Singh-Manoux, A. (2014). Alcohol consumption and cognitive decline in early old age. *Neurology*, 82(4), 332-339. doi:10.1212/WNL.000000000000063
- Sabia, S., Elbaz, A., Dugravot, A., Head, J., Shipley, M., Hagger-Johnson, G., ... Singh-Manoux, A. (2012). Impact of smoking on cognitive decline in early old age: The Whitehall II cohort study. *Archives Of General Psychiatry*, 69(6), 627-635. doi:10.1001/archgenpsychiatry.2011.2016
- Sadamori, S., Hayashi, S., Fujihara, I., Abekura, H., Hamada, T., & Akagawa, Y. (2012). Nutritional status and oral status of the elderly with dementia: A 2-year study. *Gerodontology*, 29(2), e756-760. doi:10.1111/j.1741-2358.2011.00555.x
- Sadana, R., & Michel, J.-P. (2019). Healthy ageing: What is it and how to describe it? In: *Prevention of chronic diseases and age-related disability* (pp. 11-24). Cham: Springer International Publishing.
- Salisbury, C., O'Cathain, A., Thomas, C., Edwards, L., Montgomery, A. A., Hollinghurst, S., ... Segar, J. (2017). An evidence-based approach to the use of telehealth in long-term health conditions: Development of an intervention and evaluation through pragmatic randomised controlled trials in patients with depression or raised cardiovascular risk. *Programme Grants for Applied Research*, 5(1). doi:10.3310/pgfar05010
- Salzman, B. (2010). Gait and balance disorders in older adults. *American Family Physician*, 82(1), 61-68.
- Samaras, N., Chevalley, T., Samaras, D., & Gold, G. (2010). Older patients in the emergency department: A review. *Annals of Emergency Medicine*, 56(3), 261-269. doi:10.1016/j.annemergmed.2010.04.015

- Samieri, C., Perier, M.-C., Gaye, B., Proust-Lima, C., Helmer, C., Dartigues, J.-F., ... Empana, J.-P. (2018). Association of cardiovascular health level in older age with cognitive decline and incident dementia. *JAMA*, 320(7), 657-664. doi:10.1001/jama.2018.11499
- Samoliński, B., Fronczak, A., Kuna, P., Akdis, C. A., Anto, J. M., Bialoszewski, A. Z., ... Council on the European, U. (2012). Prevention and control of childhood asthma and allergy in the EU from the public health point of view: Polish presidency of the European Union. *Allergy*, 67(6), 726-731. doi:10.1111/j.1398-9995.2012.02822.x
- Santini, Z. I., Fiori, K. L., Feeney, J., Tyrovolas, S., Haro, J. M., & Koyanagi, A. (2016). Social relationships, loneliness, and mental health among older men and women in Ireland: A prospective community-based study. *Journal of Affective Disorders*, 204, 59-69. doi:10.1016/j.jad.2016.06.032
- Sara, J. D., Prasad, M., Eleid, M. F., Zhang, M., Widmer, R. J., & Lerman, A. (2018). Association between work-related stress and coronary heart disease: A review of prospective studies through the job strain, effort-reward balance, and organizational justice models. *Journal of the American Heart Association*, 7(9), e008073. doi:10.1161/jaha.117.008073
- Sayer, A. A., Robinson, S. M., Patel, H. P., Shavlakadze, T., Cooper, C., & Grounds, M. D. (2013). New horizons in the pathogenesis, diagnosis and management of sarcopenia. *Age and Ageing*, 42(2), 145-150. doi:10.1093/ageing/afs191
- Sayer, A. A., Syddall, H., Martin, H., Patel, H., Baylis, D., & Cooper, C. (2008). The developmental origins of sarcopenia. *The Journal of Nutrition, Health and Aging*, 12(7), 427-432.
- SBU. (2013). Urinary incontinence in the elderly. Retrieved from <https://www.sbu.se/en/publications/sbu-assesses/urinary-incontinence-in-the-elderly/>
- SBU. (2014). Chronic ulcers in the elderly – prevention and treatment. Retrieved from <https://www.sbu.se/en/publications/sbu-assesses/chronic-ulcers-in-the-elderly--prevention-and-treatment/>
- SBU. (2015). Depression treatment for the elderly. Retrieved from <https://www.sbu.se/en/publications/sbu-assesses/depression-treatment-for-the-elderly/>
- SBU. (2017). Treatment options of arm fractures in the elderly a systematic review and assessment of the medical, economic, social and ethical aspects. Retrieved from [https://www.ncbi.nlm.nih.gov/books/NBK476414/pdf/Bookshelf\\_NBK476414.pdf](https://www.ncbi.nlm.nih.gov/books/NBK476414/pdf/Bookshelf_NBK476414.pdf)
- Schink, T., Kreutz, G., Busch, V., Pigeot, I., & Ahrens, W. (2014). Incidence and relative risk of hearing disorders in professional musicians. *Occupational and Environmental Medicine*, 71(7), 472-476. doi:10.1136/oemed-2014-102172
- Schmid, D., & Leitzmann, M. F. (2014). Association between physical activity and mortality among breast cancer and colorectal cancer survivors: A systematic review and meta-analysis. *Annals of Oncology*, 25(7), 1293-1311. doi:10.1093/annonc/mdl012
- Schniter, E. (2009). Why Old Age: Non-material contributions and patterns of aging among older adult Tsimane'. *SSRN Electronic Journal*, 607. doi:10.2139/ssrn.2122014
- Schoenborn, N. L., Bowman, T. L., 2nd, Cayea, D., Pollack, C. E., Feeser, S., & Boyd, C. (2016). Primary care practitioners' views on incorporating long-term prognosis in the care of older adults. *JAMA Internal Medicine*, 176(5), 671-678. doi:10.1001/jamainternmed.2016.0670
- Schoene, D., Valenzuela, T., Toson, B., Delbaere, K., Severino, C., Garcia, J., ... Lord, S. R. (2015). Interactive cognitive-motor step training improves cognitive risk factors of falling in older adults - a randomized controlled trial. *PLOS ONE*, 10(12), e0145161. doi:10.1371/journal.pone.0145161
- Schonberg, M. A., Breslau, E. S., Hamel, M. B., Bellizzi, K. M., & McCarthy, E. P. (2015). Colon cancer screening in U.S. adults aged 65 and older according to life expectancy and age. *Journal of the American Geriatrics Society*, 63(4), 750-756. doi:10.1111/jgs.13335
- Schroyen, S., Adam, S., Marquet, M., Jerusalem, G., Thiel, S., Giraudet, A. L., & Missotten, P. (2018). Communication of healthcare professionals: Is there ageism? *European Journal of Cancer Care*, 27(1). doi:10.1111/ecc.12780
- Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., ... Stubbs, B. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry*, 175(7), 631-648. doi:10.1176/appi.ajp.2018.17111194
- Schuknecht, H. F. (1974). *Pathology of the ear*. Cambridge: Harvard University Press.
- Schulz, R., & Martire, L. M. (2004). Family caregiving of persons with dementia: Prevalence, health effects, and support strategies. *The American Journal of Geriatric Psychiatry*, 12(3), 240-249.
- Schulz, R., O'Brien, A. T., Bookwala, J., & Fleissner, K. (1995). Psychiatric and physical morbidity effects of dementia caregiving: Prevalence, correlates, and causes. *The Gerontologist*, 35(6), 771-791.
- Schweiger, J. U., Schweiger, U., Hüppe, M., Kahl, K. G., Greggersen, W., & Fassbinder, E. (2016). Bone density and depressive disorder: A meta-analysis. *Brain and Behavior*, 6(8), e00489-e00489. doi:10.1002/brb3.489
- Segel-Karpas, D., Ayalon, L., & Lachman, M. E. (2018). Loneliness and depressive symptoms: The moderating role of the transition into retirement. *Aging and Mental Health*, 22(1), 135-140. doi:10.1080/13607863.2016.1226770
- Segelman, M., Cai, X., van Reenen, C., & Temkin-Greener, H. (2017). Transitioning from community-based to institutional long-term care: Comparing 1915(c) waiver and pace enrollees. *The Gerontologist*, 57(2), 300-308. doi:10.1093/geront/gnv106
- Seltzer, M. M., & Li, L. W. (2000). The dynamics of caregiving: Transitions during a three-year prospective study. *The Gerontologist*, 40(2), 165-178. doi:10.1093/geront/40.2.165

- Selwyn, A., Hajat, C., Harris, M., & Yach, D. (2015). Time to reset the prevention agenda: Age-specific interventions for the second half of life. Retrieved from [https://www.vitalitygroup.com/wp-content/uploads/2017/01/Time-to-Reset-the-Prevention-Agenda\\_FINAL.pdf](https://www.vitalitygroup.com/wp-content/uploads/2017/01/Time-to-Reset-the-Prevention-Agenda_FINAL.pdf)
- Sentouh, C., Popieul, P. J., Debernard, S., & Boverie, S. (2014). Human-machine interaction in automated vehicles: The abv project. Paper presented at the 19th World Congress of the International Federation of Automatic Control (IFAC), Cape Town, South Africa. <http://folk.ntnu.no/skoge/prost/proceedings/ifac2014/media/files/1721.pdf>
- Seo, J. Y., & Chao, Y. Y. (2018). Effects of exercise interventions on depressive symptoms among community-dwelling older adults in the United States: A systematic review. *Journal of Gerontological Nursing, 44*(3), 31-38. doi:10.3928/00989134-20171024-01
- Shah, T. M., Weinborn, M., Verdile, G., Sohrabi, H. R., & Martins, R. N. (2017). Enhancing cognitive functioning in healthy older adults: A systematic review of the clinical significance of commercially available computerized cognitive training in preventing cognitive decline. *Neuropsychology Review, 27*(1), 62-80. doi:10.1007/s11065-016-9338-9
- Share, P., & Pender, J. (2018). Preparing for a robot future? Social professions, social robotics and the challenges ahead. *Irish Journal of Applied Social Studie, 18*(1). doi:10.21427/D7472M
- Shaw, S. C., Dennison, E. M., & Cooper, C. (2017). Epidemiology of sarcopenia: Determinants throughout the lifecourse. *Calcified Tissue International, 101*(3), 229-247. doi:10.1007/s00223-017-0277-0
- Shaw, W. S., Patterson, T. L., Ziegler, M. G., Dimsdale, J. E., Semple, S. J., & Grant, I. (1999). Accelerated risk of hypertensive blood pressure recordings among Alzheimer caregivers. *Journal of Psychosomatic Research, 46*(3), 215-227. doi:[https://doi.org/10.1016/S0022-3999\(98\)00084-1](https://doi.org/10.1016/S0022-3999(98)00084-1)
- Sheldon, R. S., Morillo, C. A., Krahn, A. D., O'Neill, B., Thiruganasambandamoorthy, V., Parkash, R., ... Leather, R. (2011). Standardized approaches to the investigation of syncope: Canadian cardiovascular society position paper. *Canadian Journal of Cardiology, 27*(2), 246-253. doi:10.1016/j.cjca.2010.11.002
- Shimada, H., Makizako, H., Tsutsumimoto, K., Hotta, R., Nakakubo, S., & Doi, T. (2016). Driving and incidence of functional limitation in older people: A prospective population-based study. *Gerontology, 62*(6), 636-643. doi:10.1159/000448036
- Shippee, T. P. (2009). 'But I am not moving': Residents' perspectives on transitions within a continuing care retirement community. *The Gerontologist, 49*(3), 418-427. doi:10.1093/geront/gnp030
- Silva, E., Neves, M., & Silva, D. (2014). Nurses' perceptions of advance directives. *Atención Primaria, 46*, 145-149. doi:10.1016/S0212-6567(14)70082-4
- Silverwood, R. J., Pierce, M., Hardy, R., Thomas, C., Ferro, C., Savage, C., ... Nitsch, D. (2013a). Early-life overweight trajectory and ckd in the 1946 British birth cohort study. *American Journal of Kidney Diseases, 62*(2), 276-284. doi:10.1053/j.ajkd.2013.03.032
- Silverwood, R. J., Pierce, M., Thomas, C., Hardy, R., Ferro, C., Sattar, N., ... Nitsch, D. (2013b). Association between younger age when first overweight and increased risk for ckd. *Journal of the American Society of Nephrology, 24*(5), 813-821. doi:10.1681/ASN.2012070675
- Simeoni, U., & Barker, D. J. (2009). Offspring of diabetic pregnancy: Long-term outcomes. *Seminars in Fetal and Neonatal Medicine, 14*(2), 119-124. doi:10.1016/j.siny.2009.01.002
- Singh-Manoux, A., Czernichow, S., Elbaz, A., Dugravot, A., Sabia, S., Hagger-Johnson, G., ... Kivimaki, M. (2012). Obesity phenotypes in midlife and cognition in early old age: The Whitehall II cohort study. *Neurology, 79*(8), 755-762. doi:10.1212/WNL.0b013e3182661f63
- Singh-Manoux, A., Dugravot, A., Brunner, E., Kumari, M., Shipley, M., Elbaz, A., & Kivimaki, M. (2014). Interleukin-6 and C-reactive protein as predictors of cognitive decline in late midlife. *Neurology, 83*(6), 486-493. doi:10.1212/wnl.0000000000000665
- Siren, A., & Haustein, S. (2014). Driving cessation anno 2010: Which older drivers give up their license and why? Evidence from Denmark. *Journal of Applied Gerontology, 35*(1), 18-38. doi:10.1177/0733464814521690
- Sixsmith, J., Sixsmith, A., Fänge, A. M., Naumann, D., Kucsera, C., Tomsone, S., ... Woolrych, R. (2014). Healthy ageing and home: The perspectives of very old people in five European countries. *Social Science & Medicine, 106*, 1-9. doi:10.1016/j.socscimed.2014.01.006
- Skills Panorama. (2018). Health & social care. Retrieved from <https://skillspanorama.cedefop.europa.eu/en/sectors/health-social-care>
- Skytthe, A., Pedersen, N. L., Kaprio, J., Stazi, M. A., Hjelmborg, J. V., Iachine, I., ... Christensen, K. (2003). Longevity studies in GenomEUtwin. *Twin Research and Human Genetics, 6*(5), 448-454. doi:10.1375/136905203770326457
- Slovensky, D. J., & Malvey, D. M. (2017). Introduction to focused issue on mHealth infrastructure: Issues and solutions that challenge optimal deployment of mHealth products and services. *The Journal of mHealth, 3*, 52-52. doi:10.21037/mhealth.2017.12.03
- Smith, T. G., Castro, K. M., Troeschel, A. N., Arora, N. K., Lipscomb, J., Jones, S. M., ... Clauser, S. B. (2016). The rationale for patient-reported outcomes surveillance in cancer and a reproducible method for achieving it. *Cancer, 122*(3), 344-351. doi:10.1002/cncr.29767
- Sorknaes, A. D., Bech, M., Madsen, H., Titlestad, I. L., Hounsgaard, L., Hansen-Nord, M., ... Ostergaard, B. (2013). The effect of real-time teleconsultations between hospital-based nurses and patients with severe COPD discharged after an exacerbation. *Journal of Telemedicine and Telecare, 19*(8), 466-474. doi:10.1177/1357633x13512067
- Sourdet, S., Lafont, C., Rolland, Y., Nourhashemi, F., Andrieu, S., & Vellas, B. (2015). Preventable iatrogenic disability in elderly patients during hospitalization. *Journal of the American Medical Directors Association, 16*(8), 674-681. doi:10.1016/j.jamda.2015.03.011

- Sperling, R. A., Aisen, P. S., Beckett, L. A., Bennett, D. A., Craft, S., Fagan, A. M., ... Phelps, C. H. (2011). Toward defining the preclinical stages of Alzheimer's disease: Recommendations from the national institute on aging-Alzheimer's association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia*, 7(3), 280-292. doi:10.1016/j.jalz.2011.03.003
- Spinewine, A., Fialova, D., & Byrne, S. (2012). The role of the pharmacist in optimizing pharmacotherapy in older people. *Drugs & Aging*, 29(6), 495-510. doi:10.2165/11631720-000000000-00000
- Stafford, M., Cooper, R., Cadar, D., Carr, E., Murray, E., Richards, M., ... Kuh, D. (2017). Physical and cognitive capability in mid-adulthood as determinants of retirement and extended working life in a British cohort study. *Scandinavian Journal of Work, Environment & Health*, 43(1), 15-23. doi:10.5271/sjweh.3589
- Stange, I., Bartram, M., Liao, Y., Poeschl, K., Kolpatzik, S., Uter, W., ... Volkert, D. (2013). Effects of a low-volume, nutrient- and energy-dense oral nutritional supplement on nutritional and functional status: A randomized, controlled trial in nursing home residents. *Journal of the American Medical Directors Association*, 14(8), 628.e1-628.e8. doi:10.1016/j.jamda.2013.05.011
- Stein, G. Y., Kremer, A., Shochat, T., Bental, T., Korenfeld, R., Abramson, E., ... Fuchs, S. (2012). The diversity of heart failure in a hospitalized population: The role of age. *Journal of Cardiac Failure*, 18(8), 645-653. doi:10.1016/j.cardfail.2012.05.007
- Steinhubl, S. R., Muse, E. D., & Topol, E. J. (2013). Can mobile health technologies transform health care? *JAMA*, 310(22), 2395-2396. doi:10.1001/jama.2013.281078
- Stel, V. S., Smit, J. H., Pluijm, S. M., & Lips, P. (2004). Consequences of falling in older men and women and risk factors for health service use and functional decline. *Age and Ageing*, 33(1), 58-65.
- Steliarova-Foucher, E., O'Callaghan, M., Ferlay, J., Masuyer, E., Rosso, S., Forman, D., ... Comber, H. (2015). The European cancer observatory: A new data resource. *European Journal of Cancer*, 51(9), 1131-1143. doi:10.1016/j.ejca.2014.01.027
- Stéphan, S., Fajnkuchen, F., Addou-Regnard, M., Grenet, T., Nghiem-Buffet, S., Chaine, G., & Giocanti-Auregan, A. (2014). Sévérité de l'œdème maculaire diabétique (OMD) en Seine-Saint-Denis chez des patients traités par anti-VEGF. *Journal Français d'Ophthalmologie*, 37(9), 717-721. doi:10.1016/j.jfo.2014.08.002
- Stevens, E., Emmett, E., Wang, Y., McKeivitt, C., & Wolfe, C. (2017). The burden of stroke in Europe - the challenges for policy makers. Retrieved from [http://www.strokeEurope.eu/downloads/The\\_Burden\\_of\\_Stroke\\_in\\_Europe\\_-\\_Challenges\\_for\\_policy\\_makers.pdf](http://www.strokeEurope.eu/downloads/The_Burden_of_Stroke_in_Europe_-_Challenges_for_policy_makers.pdf)
- Stones, D., & Gullifer, J. (2016). 'At home it's just so much easier to be yourself': Older adults' perceptions of ageing in place. *Ageing and Society*, 36(3), 449-481. doi:10.1017/S0144686X14001214
- Storeng, S. H., Sund, E. R., & Krokstad, S. (2018). Factors associated with basic and instrumental activities of daily living in elderly participants of a population-based survey: The nord-trondelag health study, Norway. *BMJ Open*, 8(3), e018942. doi:10.1136/bmjopen-2017-018942
- Stringhini, S., Carmeli, C., Jokela, M., Avendaño, M., McCrory, C., d'Errico, A., ... Kivimäki, M. (2018). Socioeconomic status, non-communicable disease risk factors, and walking speed in older adults: Multi-cohort population based study. *BMJ*, 360, k1046. doi:10.1136/bmj.k1046
- Stringhini, S., Carmeli, C., Jokela, M., Avendano, M., Muennig, P., Guida, F., ... Kivimäki, M. (2017). Socioeconomic status and the 25 x 25 risk factors as determinants of premature mortality: A multicohort study and meta-analysis of 1.7 million men and women. *Lancet*, 389(10075), 1229-1237. doi:10.1016/s0140-6736(16)32380-7
- Strupp, M., & Brandt, T. (2013). Peripheral vestibular disorders. *Current Opinion in Neurology*, 26(1), 81-89. doi:10.1097/WCO.0b013e32835c5fd4
- Stypińska, J., & Nikander, P. (2018). Ageism and age discrimination in the labour market: A macrostructural perspective. In L. Ayalon & C. Tesch-Römer (Eds.), *Contemporary perspectives on ageism* (pp. 91-108). Cham: Springer International Publishing.
- Subbe, C. P., Goulden, N., Mawdsley, K., & Smith, R. (2017). Anticipating care needs of patients after discharge from hospital: Frail and elderly patients without physiological abnormality on day of admission are more likely to require social services input. *European Journal of Internal Medicine*, 45, 74-77. doi:10.1016/j.ejim.2017.09.029
- Suitor, J. J., & Pillemer, K. (1996). Sources of support and interpersonal stress in the networks of married caregiving daughters: findings from a 2-year longitudinal study. *The Journals of Gerontology: Series B*, 51B(6), S297-S306. doi:10.1093/geronb/51B.6.S297
- Sund, T., Iwarsson, S., Anttila, H., & Brandt, A. (2015). Effectiveness of powered mobility devices in enabling community mobility-related participation: A prospective study among people with mobility restrictions. *PM&R*, 7(8), 859-870. doi:10.1016/j.pmrj.2015.02.001
- Sundstrom, G., Fransson, E., Malmberg, B., & Davey, A. (2009). Loneliness among older Europeans. *European Journal of Ageing*, 6(4), 267. doi:10.1007/s10433-009-0134-8
- Swedish National Institute of Public Health. (2006). Healthy ageing: a challenge for Europe. Retrieved from [https://ec.europa.eu/eip/ageing/file/347/download\\_en?token=ILPtPvNr](https://ec.europa.eu/eip/ageing/file/347/download_en?token=ILPtPvNr)
- Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Bogard, J. R., ... Dietz, W. H. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *The Lancet*, 393(10173), 791-846. doi:10.1016/S0140-6736(18)32822-8
- Syddall, H., Evandrou, M., Cooper, C., & Sayer, A. A. (2009). Social inequalities in grip strength, physical function, and falls among community dwelling older men and women: Findings from the herfordshire cohort study. *Journal of Aging and Health*, 21(6), 913-939. doi:10.1177/0898264309340793
- Tabassum, F., Mohan, J., & Smith, P. (2016). Association of volunteering with mental well-being: A lifecourse analysis of a national population-based longitudinal study in the UK. *BMJ*, 6(8), e011327. doi:10.1136/bmjopen-2016-011327

- Tabbarah, M., Crimmins, E. M., & Seeman, T. E. (2002). The relationship between cognitive and physical performance: MacArthur studies of successful aging. *The Journals of Gerontology: Series A*, 57(4), M228-235.
- Tang, T. C., Hwang, A. C., Liu, L. K., Lee, W. J., Chen, L. Y., Wu, Y. H., ... Chen, L. K. (2018). FNIH-defined sarcopenia predicts adverse outcomes among community-dwelling older people in Taiwan: Results from I-Lan longitudinal aging study. *The Journals of Gerontology: Series A*, 73(6), 828-834. doi:10.1093/gerona/glx148
- Teater, B., & Chonody, J. M. (2017). Stereotypes and attitudes toward older people among children transitioning from middle childhood into adolescence: Time matters. *Gerontology and Geriatrics Education*, 38(2), 204-218. doi:10.1080/02701960.2015.1079708
- Teh, R. O., Menzies, O. H., Connolly, M. J., Doughty, R. N., Wilkinson, T. J., Pillai, A., ... Kerse, N. (2018). Patterns of multi-morbidity and prediction of hospitalisation and all-cause mortality in advanced age. *Age and Ageing*, 47(2), 261-268. doi:10.1093/ageing/afx184
- Terry, D. F., Wilcox, M. A., McCormick, M. A., Pennington, J. Y., Schoenhofen, E. A., Andersen, S. L., & Perls, T. T. (2004). Lower all-cause, cardiovascular, and cancer mortality in centenarians' offspring. *Journal of The American Geriatrics Society*, 52(12), 2074-2076. doi:10.1111/j.1532-5415.2004.52561.x
- The Academy of Medical Sciences UK. (2018). Multimorbidity: A priority for global health research. Retrieved from <https://acmedsci.ac.uk/policy/policy-projects/multimorbidity>
- The Cancer Atlas. (2019). In Europe, the cancer burden for men and women varies widely by country. Retrieved from <http://canceratlas.cancer.org/the-burden/cancer-in-Europe/>
- The Emerging Risk Factors Collaboration. (2012). Adult height and the risk of cause-specific death and vascular morbidity in 1 million people: Individual participant meta-analysis. *International Journal of Epidemiology*, 41(5), 1419-1433. doi:10.1093/ije/dys086
- Thematic Network on Smart Healthy Age-Friendly Environments. (2018). Smart healthy age-friendly environments: Joint statement. Retrieved from <https://ec.europa.eu/digital-single-market/en/news/smart-healthy-age-friendly-environments-network-launches-joint-statement-policy-making>
- Thomas, S., Mackintosh, S., & Halbert, J. (2010). Does the 'Otago exercise programme' reduce mortality and falls in older adults?: A systematic review and meta-analysis. *Age and Ageing*, 39(6), 681-687. doi:10.1093/ageing/afq102
- Timonen, V., Convery, J., & Cahill, S. (2006). Care revolutions in the making? A comparison of cash-for-care programmes in four European countries. *Ageing and Society*, 26(3), 455-474. doi:10.1017/S0144686X0600479X
- Tinetti, M. E., Inouye, S. K., Gill, T. M., & Doucette, J. T. (1995). Shared risk factors for falls, incontinence, and functional dependence. Unifying the approach to geriatric syndromes. *JAMA*, 273(17), 1348-1353. doi:10.1001/jama.1995.03520410042024
- Tinetti, M. E., Liu, W. L., & Claus, E. B. (1993). Predictors and prognosis of inability to get up after falls among elderly persons. *JAMA*, 269(1), 65-70. doi:10.1001/jama.1993.03500010075035
- Tirosh, A., Shai, I., Afek, A., Dubnov-Raz, G., Ayalon, N., Gordon, B., ... Rudich, A. (2011). Adolescent BMI trajectory and risk of diabetes versus coronary disease. *New England Journal of Medicine*, 364(14), 1315-1325. doi:10.1056/NEJMoa1006992
- Toledo, E., Salas-Salvado, J., Donat-Vargas, C., Buil-Cosiales, P., Estruch, R., Ros, E., ... Martinez-Gonzalez, M. A. (2015). Mediterranean diet and invasive breast cancer risk among women at high cardiovascular risk in the predimed trial: A randomized clinical trial. *JAMA Internal Medicine*, 175(11), 1752-1760. doi:10.1001/jamainternmed.2015.4838
- Tolkacheva, N., Van Groenou, M. B., De Boer, A., & Van Tilburg, T. (2011). The impact of informal care-giving networks on adult children's care-giver burden. *Ageing and Society*, 31(1), 34-51. doi:10.1017/S0144686X10000711
- Tommelein, E., Mehuys, E., Petrovic, M., Somers, A., Colin, P., & Boussery, K. (2015). Potentially inappropriate prescribing in community-dwelling older people across Europe: A systematic literature review. *European Journal of Clinical Pharmacology*, 71(12), 1415-1427. doi:10.1007/s00228-015-1954-4
- Topol, E. J., Harvey, H., Manero, E., McCarthy, M., McKendry, R., Roberts, T., ... Woolard, J. (2019). The Topol review: Preparing the healthcare workforce to deliver the digital future. Retrieved from <https://topolhee.nhs.uk/wp-content/uploads/HEE-Topol-Review-2019.pdf>
- Toptas, M., Yalcin, M., Akkoc, I., Demir, E., Metin, C., Savas, Y., ... Can, M. M. (2018). The relation between sarcopenia and mortality in patients at intensive care unit. *BioMed Research International*, 2018, 5263208. doi:10.1155/2018/5263208
- Torras, C. (2016). Service robots for citizens of the future. *European Review*, 24(1), 17-30. doi:10.1017/S1062798715000393
- Torras, C. (2018). *The vestigial heart. A novel of the robot age*. Cambridge, MA: The MIT Press.
- Torre, L. A., Bray, F., Siegel, R. L., Ferlay, J., Lortet-Tieulent, J., & Jemal, A. (2015). Global cancer statistics, 2012. *CA - A Cancer Journal for Clinicians*, 65(2), 87-108. doi:10.3322/caac.21262
- Toth, G., Szabo, D., Sandor, G. L., Szalai, I., Lukacs, R., Pek, A., ... Nemeth, J. (2017). Diabetes and diabetic retinopathy in people aged 50 years and older in Hungary. *British Journal of Ophthalmology*, 101(7), 965-969. doi:10.1136/bjophthalmol-2016-309016
- Trahan, L. M., Spiers, J. A., & Cummings, G. G. (2016). Decisions to transfer nursing home residents to emergency departments: A scoping review of contributing factors and staff perspectives. *Journal of the American Medical Directors Association*, 17(11), 994-1005. doi:10.1016/j.jamda.2016.05.012
- Tran Ba Huy, P. (2011). Troubles de l'équilibre du sujet âgé. *Revue du praticien*, 6(61), 819-837.
- Troisi, R., Hatch, E. E., Titus, L., Strohsnitter, W., Gail, M. H., Huo, D., ... Palmer, J. R. (2017). Prenatal diethylstilbestrol exposure and cancer risk in women. *Environmental and Molecular Mutagenesis*, 60(5). doi:10.1002/em.22155

- Truong, J. L., Doherty, C., & Suh, N. (2018). The effect of socioeconomic factors on outcomes of distal radius fractures: A systematic review. *HAND*, 13(5), 509-515. doi:10.1177/1558944717735945
- Tse, G., Gong, M., Nunez, J., Sanchis, J., Li, G., Ali-Hasan-Al-Saegh, S., ... Woo, J. (2017). Frailty and mortality outcomes after percutaneous coronary intervention: A systematic review and meta-analysis. *Journal of the American Medical Directors Association*, 18(12), 1097.e1091-1097.e1010. doi:10.1016/j.jamda.2017.09.002
- Tuligenga, R. H., Dugravot, A., Tabak, A. G., Elbaz, A., Brunner, E. J., Kivimaki, M., & Singh-Manoux, A. (2014). Midlife type 2 diabetes and poor glycaemic control as risk factors for cognitive decline in early old age: A post-hoc analysis of the Whitehall II cohort study. *Lancet Diabetes Endocrinol*, 2(3), 228-235. doi:10.1016/s2213-8587(13)70192-x
- Tuppin, P., Cuerq, A., de Peretti, C., Fagot-Campagna, A., Danchin, N., Juilliere, Y., ... Paccaud, F. (2013). First hospitalization for heart failure in France in 2009: Patient characteristics and 30-day follow-up. *Archives of Cardiovascular Diseases*, 106(11), 570-585. doi:10.1016/j.acvd.2013.08.002
- Turkeshi, E., Vaes, B., Andreeva, E., Mathei, C., Adriaensen, W., Van Pottelbergh, G., & Degryse, J. M. (2015). Short-term prognostic value of forced expiratory volume in 1 second divided by height cubed in a prospective cohort of people 80 years and older. *BMC Geriatrics*, 15, 1-10. doi:10.1186/s12877-015-0013-4
- Tzouvaras, D. (2015). RAMCIP project: Robot research to help people with mild cognitive impairment. Retrieved from <https://ec.europa.eu/programmes/horizon2020/en/news/ramcip-project-robot-research-help-people-mild-cognitive-impairment>
- Ulrich, R. S., Zimring, C., Joseph, A., Quan, X., & Choudhary, R. (2004). The role of the physical environment in the hospital of the 21st century: A once-in-a-lifetime opportunity. Retrieved from <https://www.healthdesign.org/chd/knowledge-repository/role-physical-environment-hospital-21st-century-once-lifetime-opportunity-o>
- Ungar, A., Mannarino, G., van der Velde, N., Baan, J., Thibodeau, M. P., Masson, J. B., ... Schoenenberger, A. W. (2018). Comprehensive geriatric assessment in patients undergoing transcatheter aortic valve implantation - results from the CGA-TAVI multicentre registry. *BMC Cardiovascular Disorders*, 18, 1-16. doi:10.1186/s12872-017-0740-x
- United Nations. (2001). Replacement migration: Is it a solution to declining and ageing populations? Retrieved from <https://www.un.org/en/development/desa/population/publications/ageing/replacement-migration.asp>
- United Nations. (2002). Political declaration and Madrid international plan of action on ageing. Paper presented at the Second World Assembly on Ageing, Madrid. Retrieved from [http://www.un.org/en/events/pastevents/pdfs/Madrid\\_plan.pdf](http://www.un.org/en/events/pastevents/pdfs/Madrid_plan.pdf)
- United Nations. (2017). World population prospects: The 2017 revision. Retrieved from <https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html>
- United Nations. (2019). The sustainable development goals. Retrieved from <https://sustainabledevelopment.un.org/?menu=1300>
- US Department of Health and Human Services. (2017) Million Hearts. Retrieved from <https://millionhearts.hhs.gov/>
- Valenzuela, M. J., & Sachdev, P. (2006). Brain reserve and dementia: A systematic review. *Psychological Medicine*, 36(4), 441-454. doi:10.1017/s0033291705006264
- Vallin, J., & Meslé, F. (2004). Convergences and divergences in mortality: A new approach of health transition. *Demographic Research*, S2, 11-44. doi:10.4054/DemRes.2004.S2.2
- Valtorta, N. K., Kanaan, M., Gilbody, S., Ronzi, S., & Hanratty, B. (2016). Loneliness and social isolation as risk factors for coronary heart disease and stroke: Systematic review and meta-analysis of longitudinal observational studies. *Heart*, 102(13), 1009-1016. doi:10.1136/heartjnl-2015-308790
- van Bokhorst-de van der Schueren, M. A. E., Guaitoli, P. R., Jansma, E. P., & de Vet, H. C. W. (2014). A systematic review of malnutrition screening tools for the nursing home setting. *Journal of the American Medical Directors Association*, 15(3), 171-184. doi:10.1016/j.jamda.2013.10.006
- Van Cleven, A., Boyen, F., Paepe, D., Chantziaras, I., Sarrazin, S., Haesebrouck, F., & Dewulf, J. (2018). Presence of resistance against 'highest priority critically important antimicrobials' in *Escherichia coli* isolated from dogs and cats. *Vlaams Diergeneeskunding Tijdschrift*, 87(1), 22-29.
- Van De Kaa, D. J. (1987). Europe's second demographic transition. *Population bulletin*, 42(1), 1-59.
- van den Berg, N., Beekman, M., Smith, K. R., Janssens, A., & Slagboom, P. E. (2017). Historical demography and longevity genetics: Back to the future. *Ageing Research Reviews*, 38, 28-39. doi:10.1016/j.arr.2017.06.005
- van den Berg, N., & Lindeboom, M. (2014). Aging: Conditions early in life and health and mortality at advanced ages. In T. Culyer (Ed.), *Encyclopedia of health economics*. North Holland, Amsterdam: Elsevier.
- van den Berg, N., Rodriguez-Gironde, M., van Dijk, I. K., Mourits, R. J., Mandemakers, K., Janssens, A. A. P. O., ... Slagboom, P. E. (2019). Longevity defined as top 10% survivors and beyond is transmitted as a quantitative genetic trait. *Nature Communications*, 10(1), 35. doi:10.1038/s41467-018-07925-0
- van den Heuvel, W. J. A., & Olaroiu, M. (2017). How important are health care expenditures for life expectancy? A comparative, European analysis. *Journal of the American Medical Directors Association*, 18(3), 276.e279-276.e212. doi:10.1016/j.jamda.2016.11.027
- van der Steen, J. T., Galway, K., Carter, G., & Brazil, K. (2016). Initiating advance care planning on end-of-life issues in dementia: Ambiguity among UK and Dutch physicians. *Archives of Gerontology and Geriatrics*, 65, 225-230. doi:10.1016/j.archger.2016.04.005
- van der Worp, H. B., & van Gijn, J. (2007). Acute ischemic stroke. 357(6), 572-579. doi:10.1056/NEJMcp072057

- van Hoof, J., Verbeek, H., Janssen, B. M., Eijkelenboom, A., Molony, S. L., Felix, E., ... Wouters, E. J. (2016). A three perspective study of the sense of home of nursing home residents: The views of residents, care professionals and relatives. *BMC Geriatrics*, 16:169, 1-15. doi:10.1186/s12877-016-0344-9
- Van Lancker, A., Verhaeghe, S., Van Hecke, A., Vanderwee, K., Goossens, J., & Beeckman, D. (2012). The association between malnutrition and oral health status in elderly in long-term care facilities: A systematic review. *International Journal of Nursing Studies*, 49(12), 1568-1581. doi:10.1016/j.ijnurstu.2012.04.001
- van Willigenburg, H., de Keizer, P. L. J., & de Bruin, R. W. F. (2018). Cellular senescence as a therapeutic target to improve renal transplantation outcome. *Pharmacological Research*, 130, 322-330. doi:10.1016/j.phrs.2018.02.015
- Vaportzis, E., & Gow, A. J. (2018). People's beliefs and expectations about how cognitive skills change with age: Evidence from a U.K.-wide aging survey. *The American Journal of Geriatric Psychiatry*, 26(7), 797-805. doi:10.1016/j.jagp.2018.03.016
- Vaughan, L., Corbin, A. L., & Goveas, J. S. (2015). Depression and frailty in later life: A systematic review. *Clinical Interventions in Aging*, 10, 1947-1958. doi:10.2147/cia.S69632
- Vellas, B., Fielding, R. A., Bens, C., Bernabei, R., Cawthon, P. M., Cederholm, T., ... Cesari, M. (2018). Implications of ICD-10 for sarcopenia clinical practice and clinical trials: Report by the international conference on frailty and sarcopenia research task force. *The Journal of Frailty & Aging*, 7(1), 2-9. doi:10.14283/jfa.2017.30
- Verbakel, E. (2014). Informal caregiving and well-being in Europe: What can ease the negative consequences for caregivers? *Journal of European Social Policy*, 24(5), 424-441. doi:10.1177/0958928714543902
- Verbakel, E., Kempen, G. I. J. M., & Metzelthin, S. F. (2016). Caregiving to older adults: Determinants of informal caregivers' subjective well-being and formal and informal support as alleviating conditions. *The Journals of Gerontology: Series B*, 73(6), 1099-1111. doi:10.1093/geronb/gbw047
- Verhaak, P. F., Dekker, J. H., de Waal, M. W., van Marwijk, H. W., & Comijs, H. C. (2014). Depression, disability and somatic diseases among elderly. *Journal of Affective Disorders*, 167, 187-191. doi:10.1016/j.jad.2014.05.057
- Vermeiren, S., Vella-Azzopardi, R., Beckwee, D., Habbig, A. K., Scafoglieri, A., Jansen, B., & Bautmans, I. (2016). Frailty and the prediction of negative health outcomes: A meta-analysis. *Journal of the American Medical Directors Association*, 17(12), 1163.e1161-1163.e1117. doi:10.1016/j.jamda.2016.09.010
- Vervloet, M., Linn, A. J., van Weert, J. C., de Bakker, D. H., Bouvy, M. L., & van Dijk, L. (2012). The effectiveness of interventions using electronic reminders to improve adherence to chronic medication: A systematic review of the literature. *Journal of the American Medical Informatics Association*, 19(5), 696-704. doi:10.1136/amiainl-2011-000748
- Vestbo, J., Hurd, S. S., Agusti, A. G., Jones, P. W., Vogelmeier, C., Anzueto, A., ... Rodriguez-Roisin, R. (2013). Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: Gold executive summary. *American Journal of Respiratory and Critical Care Medicine*, 187(4), 347-365. doi:10.1164/rccm.201204-0596PP
- Vestbo, J., & Lange, P. (2016). Natural history of COPD: Focusing on change in FEV<sub>1</sub>. *Respirology*, 21(1), 34-43. doi:10.1111/resp.12589
- Vetrano, D. L., Rizzuto, D., Calderón-Larrañaga, A., Onder, G., Welmer, A.-K., Bernabei, R., ... Fratiglioni, L. (2018). Trajectories of functional decline in older adults with neuropsychiatric and cardiovascular multimorbidity: A Swedish cohort study. *PLOS Medicine*, 15(3), e1002503. doi:10.1371/journal.pmed.1002503
- Villemagne, V. L., Burnham, S., Bourgeat, P., Brown, B., Ellis, K. A., Salvado, O., ... Masters, C. L. (2013). Amyloid beta deposition, neurodegeneration, and cognitive decline in sporadic Alzheimer's disease: A prospective cohort study. *Lancet Neurology*, 12(4), 357-367. doi:10.1016/s1474-4422(13)70044-9
- Violan, C., Foguet-Boreu, Q., Flores-Mateo, G., Salisbury, C., Blom, J., Freitag, M., ... Valderas, J. M. (2014). Prevalence, determinants and patterns of multimorbidity in primary care: A systematic review of observational studies. *PLOS ONE*, 9(7), e102149. doi:10.1371/journal.pone.0102149
- Vital Wave Consulting (2009). mHealth for development report. The opportunity of mobile technology for healthcare in the developing world. Retrieved from [http://www.globalproblems-globalsolutions-files.org/unf\\_website/assets/publications/technology/mhealth/mHealth\\_for\\_Development\\_full.pdf](http://www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/technology/mhealth/mHealth_for_Development_full.pdf)
- Vitman, A., Iecovich, E., & Alfasi, N. (2014). Ageism and social integration of older adults in their neighborhoods in Israel. *The Gerontologist*, 54(2), 177-189. doi:10.1093/geront/gnt008
- Vozzi, D., Morgan, A., Vuckovic, D., D'Eustacchio, A., Abdulhadi, K., Rubinato, E., ... Girotto, G. (2014). Hereditary hearing loss: A 96 gene targeted sequencing protocol reveals novel alleles in a series of Italian and Qatari patients. *Gene*, 542(2), 209-216. doi:10.1016/j.gene.2014.03.033
- Vyshka, G., & Kruja, J. (2011). Inapplicability of advance directives in a paternalistic setting: The case of a post-communist health system. *BMC Medical Ethics*, 12:12, 1-6. doi:10.1186/1472-6939-12-12
- Wagner, M., & Brandt, M. (2018). Long-term care provision and the well-being of spousal caregivers: An analysis of 138 European regions. *The Journals of Gerontology: Series B*, 73(4), e24-e34. doi:10.1093/geronb/gbx133
- Walker, A. (2019). *The future of ageing in Europe: Making an asset of longevity*. UK: Palgrave Macmillan.
- Walker, V., Perret-Guillaume, C., Kesse-Guyot, E., Agrinier, N., Hercberg, S., Galan, P., ... Rotonda, C. (2016). Effect of multimorbidity on health-related quality of life in adults aged 55 years or older: Results from the su.Vi.Max 2 cohort. *PLOS ONE*, 11(12), e0169282. doi:10.1371/journal.pone.0169282
- Walkner, T. J., Weare, A. M., & Tully, M. (2018). 'You get old. You get invisible': Social isolation and the challenge of communicating with aging women. *Journal of Women & Aging*, 30(5), 399-416. doi:10.1080/08952841.2017.1304785

- Wall, H. K., Ritchey, M. D., Gillespie, C., Omura, J. D., Jamal, A., & George, M. G. (2018). Vital signs: Prevalence of key cardiovascular disease risk factors for million hearts 2022 - United States, 2011-2016. *Morbidity and Mortality Weekly Report*, 67(35), 983-991. doi:10.15585/mmwr.mm6735a4
- Walters, S., Khan, T., Ong, T., & Sahota, O. (2017). Fracture liaison services: Improving outcomes for patients with osteoporosis. *Clinical Interventions in Aging*, 12, 117-127. doi:10.2147/CIAS85551
- Wang, S. G., Lee, U. J., Goh, E. K., & Chon, K. M. (2004). Factors associated with postoperative delirium after major head and neck surgery. *Annals of Otolaryngology, Rhinology, and Laryngology*, 113(1), 48-51. doi:10.1177/000348940411300111
- Wang, Y., Xue, H., Huang, Y., Huang, L., & Zhang, D. (2017). A systematic review of application and effectiveness of mHealth interventions for obesity and diabetes treatment and self-management. *Advances in Nutrition*, 8(3), 449-462. doi:10.3945/an.116.014100
- Wang, Y. P., & Andrade, L. H. (2013). Epidemiology of alcohol and drug use in the elderly. *Current Opinion in Psychiatry*, 26(4), 343-348. doi:10.1097/YCO.0b013e328360eafd
- Weening-Dijksterhuis, E., de Greef, M. H., Scherder, E. J., Slaets, J. P., & van der Schans, C. P. (2011). Frail institutionalized older persons: A comprehensive review on physical exercise, physical fitness, activities of daily living, and quality-of-life. *American Journal of Physical Medicine & Rehabilitation*, 90(2), 156-168. doi:10.1097/PHM.0b013e3181f703ef
- Weiss, H. A., Potischman, N. A., Brinton, L. A., Brogan, D., Coates, R. J., Gammon, M. D., ... Schoenberg, J. B. (1997). Prenatal and perinatal risk factors for breast cancer in young women. *Epidemiology*, 8(2), 181-187.
- Westendorp, R. G., van Heemst, D., Rozing, M. P., Frolich, M., Mooijaart, S. P., Blauw, G. J., ... Slagboom, P. E. (2009). Nonagenarian siblings and their offspring display lower risk of mortality and morbidity than sporadic nonagenarians: The Leiden Longevity Study. *Journal of The American Geriatrics Society*, 57(9), 1634-1637. doi:10.1111/j.1532-5415.2009.02381.x
- Whalley, L. J., Dick, F. D., & McNeill, G. (2006). A life-course approach to the aetiology of late-onset dementias. *Lancet Neurology*, 5(1), 87-96. doi:10.1016/s1474-4422(05)70286-6
- Whincup, P. H., Kaye, S. J., Owen, C. G., Huxley, R., Cook, D. G., Anazawa, S., ... Yarbrough, D. E. (2008). Birth weight and risk of type 2 diabetes: A systematic review. *JAMA*, 300(24), 2886-2897. doi:10.1001/jama.2008.886
- Whiteford, H. A., Degenhardt, L., Rehm, J., Baxter, A. J., Ferrari, A. J., Erskine, H. E., ... Vos, T. (2013). Global burden of disease attributable to mental and substance use disorders: Findings from the global burden of disease study 2010. *Lancet*, 382(9904), 1575-1586. doi:10.1016/s0140-6736(13)61611-6
- WHO. (2002). Active ageing: A policy framework. Retrieved from [https://www.who.int/ageing/publications/active\\_ageing/en/](https://www.who.int/ageing/publications/active_ageing/en/)
- WHO. (2006a). Who global network for age-friendly cities and communities. Retrieved from [https://www.who.int/ageing/projects/age\\_friendly\\_cities\\_network/en/](https://www.who.int/ageing/projects/age_friendly_cities_network/en/)
- WHO. (2006b). Working together for health: The world health report 2006. Retrieved from [https://www.who.int/whr/2006/whr06\\_en.pdf](https://www.who.int/whr/2006/whr06_en.pdf)
- WHO. (2007a). Global age-friendly cities: A guide. Retrieved from [https://www.who.int/ageing/publications/Global\\_age\\_friendly\\_cities\\_Guide\\_English.pdf](https://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf)
- WHO. (2007b). Global surveillance, prevention and control of chronic respiratory diseases. A comprehensive approach. Retrieved from <https://www.who.int/gard/publications/GARD%20Book%202007.pdf>
- WHO. (2008). Age-friendly primary health care centres toolkit. Switzerland: World Health Organisation.
- WHO. (2011a). mHealth: New horizons for health through mobile technologies: Second global survey on eHealth. Retrieved from [https://www.who.int/goe/publications/goe\\_mhealth\\_web.pdf](https://www.who.int/goe/publications/goe_mhealth_web.pdf)
- WHO. (2011b). Palliative care for older people: Better practices. Retrieved from [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0017/143153/e95052.pdf](http://www.euro.who.int/__data/assets/pdf_file/0017/143153/e95052.pdf)
- WHO. (2011c). World report on disability 2011. Retrieved from [https://www.who.int/disabilities/world\\_report/2011/report.pdf](https://www.who.int/disabilities/world_report/2011/report.pdf)
- WHO. (2012). Leading causes of death in Europe: Fact sheet. Copenhagen: WHO Regional Office for Europe.
- WHO. (2013). Health and the environment in the world European region: Creating resilient communities and supportive environments. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.
- WHO. (2014). Identification of risks from exposure to endocrine-disrupting chemicals at the country level. Retrieved from [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0008/245744/Identification-of-risks-from-exposure-to-ENDOCRINE-DISRUPTING-CHEMICALS-at-the-country-level.pdf](http://www.euro.who.int/__data/assets/pdf_file/0008/245744/Identification-of-risks-from-exposure-to-ENDOCRINE-DISRUPTING-CHEMICALS-at-the-country-level.pdf)
- WHO. (2015a). The European mental health action plan 2013-2020. Retrieved from [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0020/280604/WHO-Europe-Mental-Health-Acion-Plan-2013-2020.pdf](http://www.euro.who.int/__data/assets/pdf_file/0020/280604/WHO-Europe-Mental-Health-Acion-Plan-2013-2020.pdf)
- WHO. (2015b). World report on ageing and health (978 92 4 069481 1). Retrieved from <https://www.who.int/ageing/events/world-report-2015-launch/en/>
- WHO. (2015c). Global Action Plan on Antimicrobial Resistance. Retrieved from [http://www.wpro.who.int/entity/drug\\_resistance/resources/globalAction\\_plan\\_eng.pdf](http://www.wpro.who.int/entity/drug_resistance/resources/globalAction_plan_eng.pdf)
- WHO. (2016a). Global diffusion of ehealth: Making universal health coverage achievable - report of the third global survey on ehealth. Retrieved from [https://www.who.int/goe/publications/global\\_diffusion/en/](https://www.who.int/goe/publications/global_diffusion/en/)
- WHO. (2016b). Global strategy and action plan on ageing and health (2016- 2020). A framework for coordinated global action by the World Health Organization, member states, and partners across the sustainable development goals. Retrieved from <https://www.who.int/ageing/GSAP-Summary-EN.pdf>

- WHO. (2016c). Global strategy on human resources for health: Workforce 2030. Retrieved from [https://www.who.int/hrh/resources/pub\\_globstrathrh-2030/en/](https://www.who.int/hrh/resources/pub_globstrathrh-2030/en/)
- WHO. (2016d). Preventing depression in the WHO European region. Retrieved from [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0003/325947/New-Preventing-depression.pdf?ua=1](http://www.euro.who.int/__data/assets/pdf_file/0003/325947/New-Preventing-depression.pdf?ua=1)
- WHO. (2017a). Rehabilitation 2030: A call for action. Executive boardroom, WHO headquarters, geneva, switzerland 6-7 february 2017. Retrieved from <http://www.who.int/disabilities/care/rehab-2030/en/>
- WHO. (2017b). WHO guidelines on integrated care for older people (ICOPE). Retrieved from <https://www.who.int/ageing/publications/guidelines-icope/en/>
- WHO. (2018a). Elder abuse. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/elder-abuse>
- WHO. (2018b). Mapping and analysis of capacity building initiatives on human resources for health leadership, 23. Retrieved from <https://www.who.int/hrh/resources/health-observer23/en/>
- WHO. (2019). Tobacco Free Initiative (TFI). Retrieved from <https://www.who.int/tobacco/en/>
- WHO. (2019a) Infection prevention and control - the burden of health care-associated infection worldwide. Retrieved from [https://www.who.int/infection-prevention/publications/burden\\_hcai/en/](https://www.who.int/infection-prevention/publications/burden_hcai/en/)
- Wiles, J. L., Leibing, A., Guberman, N., Reeve, J., & Allen, R. E. (2012). The meaning of 'aging in place' to older people. *The Gerontologist*, 52(3), 357-366. doi:10.1093/geront/gnr098
- Wilkins, E., El-Sadi, F., Shah, R., Townsend, N., Nichols, M., Kelly, P., & Wright, F. L. (2018). Epidemiology report: Trends in sex-specific cerebrovascular disease mortality in Europe based on who mortality data. doi:10.1093/eurheartj/ehy378
- Wilkins, E., Wilson, L., Wickramasinghe, K., Bhatnagar, P., Leal, J., Luengo-Fernandez, R., ... Townsend, N. (2017). European cardiovascular disease statistics 2017. Retrieved from <https://www.bhf.org.uk/informationsupport/publications/statistics/european-cardiovascular-disease-statistics-2017>
- Wilkins, J. T., Ning, H., Berry, J., Zhao, L., Dyer, A. R., & Lloyd-Jones, D. M. (2012). Lifetime risk and years lived free of total cardiovascular disease. *JAMA*, 308(17), 1795-1801. doi:10.1001/jama.2012.14312
- Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., ... Murray, C. J. L. (2019). Food in the anthropocene: The EAT - Lancet Commission on healthy diets from sustainable food systems. *Lancet*, 393(10170), 447-492. doi:10.1016/S0140-6736(18)31788-4
- Williams, K. M., Bertelsen, G., Cumberland, P., Wolfram, C., Verhoeven, V. J., Anastasopoulos, E., ... Hammond, C. J. (2015). Increasing prevalence of myopia in Europe and the impact of education. *Ophthalmology*, 122(7), 1489-1497. doi:10.1016/j.ophtha.2015.03.018
- Williams, K. M., Krapohl, E., Yonova-Doing, E., Hysi, P. G., Plomin, R., & Hammond, C. J. (2018). Early life factors for myopia in the British twins early development study. *British Journal of Ophthalmology*. doi:10.1136/bjophthalmol-2018-312439
- Wills, A. K., Black, S., Cooper, R., Coppack, R. J., Hardy, R., Martin, K. R., ... Kuh, D. (2012). Life course body mass index and risk of knee osteoarthritis at the age of 53 years: Evidence from the 1946 British birth cohort study. *Annals of the Rheumatic Diseases*, 71(5), 655-660. doi:10.1136/ard.2011.154021
- Wilson, G. (2000). *Understanding old age: Critical and global perspectives*. London: SAGE Publications Ltd.
- Winblad, B., Amouyel, P., Andrieu, S., Ballard, C., Brayne, C., Brodaty, H., ... Zetterberg, H. (2016). Defeating Alzheimer's disease and other dementias: A priority for European science and society. *Lancet Neurology*, 15(5), 455-532. doi:10.1016/S1474-4422(16)00062-4
- Windham, B. G., Harrison, K. L., Lirette, S. T., Lutsey, P. L., Pompeii, L. A., Gabriel, K. P., ... Mosley, T. H., Jr. (2017). Relationship between midlife cardiovascular health and late-life physical performance: The ARIC study. *Journal of the American Geriatrics Society*, 65(5), 1012-1018. doi:10.1111/jgs.14732
- Windle, G., & Bennett, K. M. (2012). Caring relationships: How to promote resilience in challenging times. In M. Ungar (Ed.), *The social ecology of resilience. A handbook of theory and practice* (pp. 219-232). New York, Dordrecht, Heidelberg, London: Springer.
- Windsor, T. D., Anstey, K. J., Butterworth, P., Luszcz, M. A., & Andrews, G. R. (2007). The role of perceived control in explaining depressive symptoms associated with driving cessation in a longitudinal study. *The Gerontologist*, 47(2), 215-223.
- Wirth, K., Klenk, J., Brefka, S., Dallmeier, D., Faehling, K., Roque, I. F. M., ... Stubbs, B. (2017). Biomarkers associated with sedentary behaviour in older adults: A systematic review. *Ageing Research Reviews*, 35, 87-111. doi:10.1016/j.arr.2016.12.002
- Wood, A. M., Kaptoge, S., Butterworth, A. S., Willeit, P., Warnakula, S., Bolton, T., ... Danesh, J. (2018). Risk thresholds for alcohol consumption: Combined analysis of individual-participant data for 599 912 current drinkers in 83 prospective studies. *Lancet*, 391(10129), 1513-1523. doi:10.1016/S0140-6736(18)30134-X
- Wootton, R. (2012). Twenty years of telemedicine in chronic disease management – an evidence synthesis. *Journal of Telemedicine and Telecare*, 18(4), 211-220. doi:10.1258/jtt.2012.120219
- Writing Group for the European Working Group on Sarcopenia in Older People 2, the Extended Group for EWGSOP2, Cruz-Jentoft, A. J., Sayer, A. A., Schneider, S. M., Sieber, C. C., ... Rolland, Y. (2018). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing*, 48(1), 16-31. doi:10.1093/ageing/afy169
- Wu, S., Powers, S., Zhu, W., & Hannun, Y. A. (2016). Substantial contribution of extrinsic risk factors to cancer development. *Nature*, 529(7584), 43-47. doi:10.1038/nature16166
- Wurm, S., & Benyamini, Y. (2014). Optimism buffers the detrimental effect of negative self-perceptions of ageing on physical and mental health. *Psychology & Health*, 29(7), 832-848. doi:10.1080/08870446.2014.891737

- Wyman, M. F., Shiovitz-Ezra, S., & Bengel, J. (2018). Ageism in the health care system: Providers, patients, and systems. In L. Ayalon & C. Tesch-Römer (Eds.), *Contemporary perspectives on ageism* (pp. 193-212). Cham: Springer International Publishing.
- Yang, K., & Victor, C. (2011). Age and loneliness in 25 European nations. *Ageing and Society*, 31(8), 1368-1388. doi:10.1017/S0144686X1000139X
- Yechezkel, R., & Ayalon, L. (2013). Social workers' attitudes towards intimate partner abuse in younger vs. older women. *Journal of Family Violence*, 28(4), 381-391. doi:10.1007/s10896-013-9506-0
- Yee, J. L., & Schulz, R. (2000). Gender differences in psychiatric morbidity among family caregivers: A review and analysis. *The Gerontologist*, 40(2), 147-164.
- Yon, Y., Mikton, C. R., Gassoumis, Z. D., & Wilber, K. H. (2017). Elder abuse prevalence in community settings: A systematic review and meta-analysis. *The Lancet Global Health*, 5(2), e147-e156. doi:10.1016/s2214-109x(17)30006-2
- Young, Y., Kalamaras, J., Kelly, L., Hornick, D., & Yucel, R. (2015). Is aging in place delaying nursing home admission? *Journal of the American Medical Directors Association*, 16(10), 900.e901-906. doi:10.1016/j.jamda.2015.07.017
- Yücel, G. F. (2013). Street furniture and amenities: Designing the user-oriented urban landscape. In M. Özyavuz (Ed.), *Advances in landscape architecture* (pp. 623-644). London, UK: Intech Open. doi:10.5772/55770
- Yusif, S., Soar, J., & Hafeez-Baig, A. (2016). Older people, assistive technologies, and the barriers to adoption: A systematic review. *International Journal of Medical Informatics*, 94, 112-116. doi:10.1016/j.ijmedinf.2016.07.004
- Zafar, S. Y. (2016). Financial toxicity of cancer care: It's time to intervene. *Journal of the National Cancer Institute*, 108(5). doi:10.1093/jnci/djv370
- Zaidi, A., Katrin, G., Hofmarcher-Holzhacker, M., Lelkes, O., Marin, B., Rodrigues, R., ... Zolyomi, E. (2013). Active ageing index 2012. Concept, methodology, and final results. Retrieved from <http://wikiprogress.org/articles/initiatives/active-ageing-index-2012-concept-methodology-and-final-results/>
- Zalacain, R., Torres, A., Celis, R., Blanquer, J., Aspa, J., Esteban, L., ... Borderias, L. (2003). Community-acquired pneumonia in the elderly: Spanish multicentre study. *European Respiratory Society*, 21(2), 294-302. doi:10.1183/09031936.03.00064102
- Zanaboni, P., & Wootton, R. (2012). Adoption of telemedicine: From pilot stage to routine delivery. *BMC Medical Informatics and Decision Making*, 12:1, 1-9. doi:10.1186/1472-6947-12-1
- Zhang, F. (2018). Intergenerational play between young people and old family members: Patterns, benefits, and challenges. Paper presented at the Human Aspects of IT for the Aged Population. Acceptance, Communication and Participation. Cham: Springer International Publishing.
- Zhang, X., Zhang, W., Wang, C., Tao, W., Dou, Q., & Yang, Y. (2018). Sarcopenia as a predictor of hospitalization among older people: A systematic review and meta-analysis. *BMC Geriatrics*, 18:188, 1-9. doi:10.1186/s12877-018-0878-0
- Zhavoronkov, A., Mamoshina, P., Vanhaelen, Q., Scheiby-Knudsen, M., Moskalev, A., & Aliper, A. (2019). Artificial intelligence for aging and longevity research: Recent advances and perspectives. *Ageing Research Reviews*, 49, 49-66. doi:10.1016/j.arr.2018.11.003
- Zlokovic, B. V. (2011). Neurovascular pathways to neurodegeneration in Alzheimer's disease and other disorders. *Nature Reviews Neuroscience*, 12(12), 723-738. doi:10.1038/nrn3114





SAPEA is part of the European Commission's Scientific Advice Mechanism, which provides independent, interdisciplinary, and evidence-based scientific advice on policy issues to the European Commission.

This Evidence Review Report will inform the GCSA's Scientific Opinion on the topic.



[www.sapea.info](http://www.sapea.info)  
@SAPEAnews