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ORIGINAL RESEARCH

THE VALIDITY OF THE SUNFRAIL TOOL: A CROSS-SECTIONAL STUDY AMONG DUTCH COMMUNITY-DWELLING OLDER PEOPLE

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Abstract: *Background:* Early detection of frail older people is important. Timely intervention may allow health care professionals to prevent or delay the occurrence of adverse outcomes such as disability, increases in health care utilization, and premature death. *Objectives:* We assessed the construct and criterion validity of the SUNFRAIL tool, a questionnaire for measuring frailty among older people. *Design, Setting and Participants:* This cross-sectional study was carried out in a sample of Dutch citizens. A total of 195 community-dwelling persons aged 71 years and older completed the questionnaire. *Measurements:* Construct validity was examined by determining the correlation between the SUNFRAIL tool and the Tilburg Frailty Indicator (TFI). Criterion validity for the SUNFRAIL tool was determined by establishing the correlations with chronic diseases and adverse outcomes of frailty (disability, falls, indicators of health care utilization). Disability was measured using the Groningen Activity Restriction Scale. Participants also answered questions regarding falls and health care utilization. *Results:* The construct validity of this tool was good and showed significant correlations with the TFI. The correlation between SUNFRAIL total and TFI total was 0.624. The criterion validity of the SUNFRAIL tool was good for chronic diseases and good-to-excellent for adverse outcomes disability, receiving nursing care, and falls. The area under the curve for these outcomes was 0.840 (95% CI 0.781–0.899), 0.782 (95% CI 0.696–0.868), and 0.769 (95% CI 0.686–0.859), respectively. *Conclusions:* The results of our study suggest that the SUNFRAIL tool is a valid instrument for assessing frailty in community-dwelling older people. It is an attractive instrument for use in practice because it takes little time for health care professionals and older people to complete the questionnaire, and it expresses the integral functioning of human beings.

Key words: frailty, SUNFRAIL tool, validity, disability, health care utilization.

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Introduction

Frailty is a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, social) caused by the influence of a range of variables and which increases the risk of adverse outcomes (1). Well-known adverse outcomes of frailty include disability, an increase in health care utilization, falls, lower quality of life, and premature death (2-4). Early detection of frailty among older people is important. Timely intervention may allow health care professionals to prevent or delay the occurrence of the adverse outcomes of frailty.

Currently, health care professionals have several instruments at their disposal to fulfill this relevant task such as the Phenotype of Frailty (2) and the Frail scale (5), which are more focused on addressing the physical domain, and the Tilburg Frailty Indicator (TFI), which is more focused on investigating the multidimensional (biological, psychological, social) nature of frailty (6). However, many frailty instruments, such as the Phenotype of Frailty (2), are time-consuming and very poorly used in the daily practice, especially in primary care settings (7).

In the context of the SUNFRAIL project to improve the identification, prevention, and management of frailty in European Union countries, the SUNFRAIL tool has recently been developed (8). The SUNFRAIL tool is a questionnaire that contains three domains of frailty (physical, neuropsychological, social) with a total of nine questions, selected from evidence-based tools already adopted in health services in the European Union and the United States of America. It can be completed by health care professionals (e.g., nurse, general practitioner, physiotherapist) and social workers. This tool reflects the multidimensional nature of frailty well and emphasizes the integral assessment of human functioning. The advantage of the SUNFRAIL tool is that it includes only nine items covering the physical, neuropsychological and social domains of frailty. Currently, there is no instrument available that can be used to determine frailty on such a broad, multidimensional basis with so few questions.

The aim of this cross-sectional study was to establish

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the validity of the SUNFRAIL tool. First, we examined the construct validity by determining the correlation between the SUNFRAIL tool and the Tilburg Frailty Indicator (TFI), a questionnaire with good psychometric properties (3, 6). Second, we examined the criterion validity of the SUNFRAIL tool by establishing the correlations with chronic diseases and adverse outcomes of frailty (disability, falls, indicators of health care utilization). Finally, we identified the most appropriate cut-off point for frailty assessed by the SUNFRAIL tool.

Methods

Study sample and data collection

In September 2017 a questionnaire was sent to 241 community-dwelling older people aged 71 years and older living in an area of small villages close to Amsterdam; these older people who belonged to a general practice situated in this area had participated in a study one year earlier (9). The response rate was 80.9%, with 195 older people completing the questionnaire.

Measures

Frailty: SUNFRAIL tool

The SUNFRAIL tool consists of nine items in three domains: physical (five), neuropsychological (one), and social (three; see the Appendix). For each item (reported problem or difficulty) one point can be scored. The maximum total score ranged from 0 to 9 and for the physical, neuropsychological, and social domains the maximum scores ranged from 0 to 5, 0 to 1, and 0 to 3, respectively. Higher scores indicate more frailty. The tool was translated into Dutch using the back translation method. The back translation was made by a different translator from the one who made the initial Dutch translation.

Frailty: Tilburg Frailty Indicator (TFI)

Part B of the TFI was used to assess frailty. The TFI contains 15 items: 8 items refer to physical frailty, 4 items refer to psychological frailty, and 3 items refer to social frailty. The maximum scores are 15, 8, 4, and 3, for total, physical, psychological, and social frailty, respectively. More information concerning the scoring of the TFI is available in previous studies (3, 6). The TFI is the most extensively examined in terms of psychometric properties among 38 frailty measurement instruments (10).

Disability in ADL and IADL: Groningen Activity Restriction Scale (GARS)

The GARS is a validated questionnaire to measure disability in activities of daily living (ADL) and instrumental activities of daily living (IADL) (11). This questionnaire consists of 18 items with four response categories. Eleven items refer to ADL and seven items refer to IADL. GARS scores range from 18 (no disability) to 72 (maximum disability); ADL and IADL scores range from 11 to 44, and from 7 to 28, respectively. The cut-off point of 29 was chosen for the disabled group (12).

Falls

Falls was determined by asking: "Have you fallen in the previous year?" with the response categories "yes" and "no."

Indicators of health care utilization

Five indicators of health care utilization were used: visit to a general practitioner, hospital admission, receiving personal care, receiving nursing care, and contact with health care professionals. We used the same question and answer categories as in a previous study (3).

Chronic diseases

Eleven chronic diseases were examined: diabetes mellitus, chronic obstructive pulmonary disease, cardiac disease, rheumatoid arthritis or osteoarthritis, skin diseases, cerebrovascular accidents, cancer, urinary incontinence, migraine, peripheral arterial disease, and hypertension. Multimorbidity was defined as the presence of two or more chronic diseases.

Socio-demographic characteristics

Socio-demographic characteristics assessed were age, gender, marital status, and education. See Table 1 for the answer categories.

Statistical analysis

Data were analyzed with IBM SPSS Statistics 22.0 (IBM, Armonk, NY, USA). We used descriptive analyses to describe the characteristics of our sample. Construct validity was determined by an examination of the correlations, expressed in Pearson correlation coefficients, between the SUNFRAIL tool total score and domain scores and the TFI total score and domain scores. It was expected that the SUNFRAIL domains would demonstrate the highest correlations with their corresponding domains of the TFI (convergent construct validity) and the lowest correlations with the other domains (divergent construct validity). Correlations were considered to be small, medium, or large with coefficients of .1, .3, or . 5, respectively (13).

The criterion validity (concurrent) was checked by examining the Pearson correlations between the SUNFRAIL tool total and its three domains and the total number of chronic diseases and adverse outcomes (disability, falls, indicators of health care utilization). We also checked the criterion validity (predictive) using linear regression analysis for continuous, and logistic regression analysis for dichotomous, adverse outcomes. These analyses consisted of two blocks. The effect of the background characteristics and diseases was estimated in the first block and the second block contained the SUNFRAIL tool; the latter enabled testing of the effect of the SUNFRAIL tool on adverse outcomes after controlling for all of the other variables

in the model.

Finally, the criterion validity for the SUNFRAIL tool was examined by conducting receiver operating characteristic (ROC) curve analyses. These analyses were applied to five adverse outcomes (disability, falls, hospitalization, receiving personal care, receiving nursing care). Sensitivity and specificity were estimated for each criterion at each cut-off point for the SUNFRAIL tool score, and the area under the curve (AUC) with 95% confidence interval was reported.

Ethical considerations

We did not obtain medical ethics approval as particular treatments or interventions were not offered or withheld from respondents as a consequence of participating in this study, the main criterion in medical ethical procedures in the Netherlands (14). Nevertheless, written informed consent for the collection and use of information was obtained from all participants.

Results

Participant characteristics

The participants' characteristics are presented in Table 1. The sample consisted of 125 men (52.3%). The mean age of the participants was 77.4 years (SD = 5.1), with a range of 71 – 90 years. Of the participants, 72.7% were married or cohabiting, and secondary education was the highest level of education completed by 59.6% of the participants. Multimorbidity was present in 57.3% of the participants. Applying the TFI cut-off point of five, 37.2% were identified as frail and, according to the GARS, 20.0% of the participants were disabled. The mean score on the SUNFRAIL tool (total) was 1.7 (SD = 1.6).

Construct validity

The significant correlations between the SUNFRAIL domains were 0.317 between the physical and neuropsychological domains, and 0.356 between the neuropsychological and social domains (all $P < 0.001$). No significant correlation was found between the SUNFRAIL physical and social domains ($r = 0.117$, $P = 0.111$). Table 2 shows the correlations between the SUNFRAIL tool total and its domains (physical, neuropsychological, social) with the TFI total and its domains (physical, neuropsychological, social). All variables were significantly correlated to each other, with one exception: SUNFRAIL Physical was not correlated with TFI Social. The convergent validity of the biological, psychological, and social domains of the SUNFRAIL tool was good, as these domains were significantly correlated with the corresponding domains of the TFI, as expected. The divergent validity was also good, because these correlations were stronger than the correlations with the other TFI domains.

Table 1
Characteristics of the participants (N=195)*

Characteristic	n (%)
Socio-demographic characteristics	
Age, mean (SD), range	77.4 (5.1), 71–90
Sex, % of men	102 (52.3)
Marital status	
Married or cohabiting	141 (72.7)
Divorced	4 (2.1)
Not married	9 (4.6)
Widowed	40 (20.6)
Education	
None or primary	40 (20.7)
Secondary	115 (59.6)
Higher	38 (19.7)
Chronic diseases	
Number of chronic diseases, mean (SD), range	1.8 (1.4), 0–7
Multimorbidity (≥ 2 chronic diseases)	110 (57.3)
Diabetes mellitus	45 (23.4)
Chronic obstructive pulmonary disease	23 (12.0)
Cardiac disease	25 (13.0)
Rheumatoid arthritis or osteoarthritis	102 (53.1)
Skin diseases	12 (6.3)
Cerebrovascular accidents	2 (1.0)
Cancer	18 (9.4)
Urinary incontinence	32 (16.7)
Migraine	10 (5.2)
Peripheral arterial disease	20 (10.4)
Hypertension	61 (31.8)
Frailty (SUNFRAIL tool), mean (SD), range	
SUNFRAIL Total	1.7 (1.6), 0–7
SUNFRAIL Biological	1.2 (1.2), 0–4
SUNFRAIL Psychological	.27 (0.5), 0–1
SUNFRAIL Social	.21 (0.5), 0–3
Frailty (TFI), mean (SD), range	
TFI Total	3.6 (3.5), 0–14
TFI Physical	2.1 (2.2), 0–8
TFI Psychological	.84 (1.1), 0–4
TFI Social	.76 (0.9), 0–3
Disability, mean (SD), range	
GARS total	24.3 (9.6), 18–66
GARS, ADL	13.8 (4.7), 11–38
GARS, IADL	10.5 (5.3), 7 –28
Health care utilization	
Visits general practitioner, mean (SD)	2.8 (1.1)
0	14 (7.4)
1–2	67 (35.4)
3–4	67 (35.4)

Table 1 (continued)
Characteristics of the participants (N=195)*

Characteristic	n (%)
Health care utilization	
5–6	20 (10.6)
≥ 7	21 (11.1)
Contacts with health care professionals, mean (SD)	2.2 (1.5)
Medical specialist	107 (56.3)
Dentist	103 (54.5)
Home care	17 (9.0)
Physiotherapist	69 (36.7)
Occupational therapist	6 (3.2)
Speech therapist	1 (0.5)
Alternative healer	8 (4.3)
Dietician	10 (5.3)
Chiropodist	74 (39.4)
Psychologist/psychiatrist	9 (4.8)
Social worker	9 (4.8)
Hospitalization, % of Yes	28 (14.8)
Receiving personal care, % of Yes	7 (3.7)
Receiving nursing care, % of Yes	17 (9.2)
Falls, % of Yes	40 (20.7)

* The maximum of missing values was fifteen (<10%); therefore we did not include the category "unknown"; all percentages are based on the known values.

Criterion (concurrent) validity

Table 2 also presents the Pearson correlations between the SUNFRAIL tool and chronic diseases and adverse outcomes of frailty. The SUNFRAIL total and all three domains were significantly associated with chronic diseases. The analyses also showed that SUNFRAIL total, physical, and neuropsychological were correlated with disability total, disability ADL, IADL, falls, and three indicators of health care utilization (visits to a general practitioner, receiving nursing, contact with health care professionals).

Criterion (predictive) validity

The linear regression analyses demonstrated that the SUNFRAIL total score significantly improved the prediction of total disability, ADL disability, IADL disability, visits to a general practitioner, and contact with health care professionals, after controlling for all of the other variables in the model. The explained variance ranged from 2.1% (contact with health care professionals) to 9.1% (disability IADL; Table 3).

The logistic regression analyses revealed that the SUNFRAIL total score predicted falls, after controlling for background characteristics and diseases. The SUNFRAIL total score did not predict hospitalization, receiving personal care, and receiving nursing care (Table 4).

The criterion (predictive) validity of the SUNFRAIL tool with respect to the GARS total was excellent (AUC > 0.8), as evidenced by an AUC of 0.840. The AUCs for both receiving nursing care and falls were good (AUC > 0.7), 0.782 and 0.769, respectively. The criterion (predictive) validity was mediocre for receiving personal care and hospitalization (see Table 5). A cut-off point of 2 or 3 gave the best results for sensitivity and specificity; the optimal cut-off point depends on the adverse outcome (see Table 5).

Discussion

The present study shows that the SUNFRAIL tool is a valid instrument for assessing frailty in community-dwelling older people, as expressed by good construct validity and predominantly good criterion validity. An issue concerning the construct validity warrants some discussion. Our study demonstrated that all correlations between the SUNFRAIL social score and the TFI total and its domains were less strong than the correlations between the other domains. In addition, the SUNFRAIL social score was not significantly correlated with the SUNFRAIL physical score. These findings are not supported by a study on the psychometric properties of the TFI, which showed higher correlation coefficients between social frailty and physical measures compared with psychological frailty (e.g., grip strength test, timed up & go test) and a significant correlation between social frailty and physical frailty ($r = 0.19$, $P < 0.001$) (6). An explanation for this finding is the difference in operationalization between the two frailty measures: only one of the three items in the SUNFRAIL tool and the TFI refers to the same problem (loneliness). We recommend further research into the construct validity of the SUNFRAIL tool through examination of the correlations between the SUNFRAIL domains and other multidimensional measures of frailty such as the Frailty Index (15), the Edmonton Scale (16), and the EASY-Care Two-Step Older persons Screening (EASY-Care TOS) (17). Moreover, the construct validity could be established by determining the correlations between the SUNFRAIL domains and the unidimensional measures of components of frailty as performance-based tests (e.g., the Timed Up & Go test) (18) and validated questionnaires (e.g., Center for Epidemiologic Studies Depression Scale [CES-D]) (19).

The SUNFRAIL tool correlated as expected with chronic diseases. This finding is not surprising. Many previous studies have shown that frailty is related to individual chronic diseases, such as anemia and diabetes mellitus (20) and multimorbidity (21). The criterion (concurrent) validity of the SUNFRAIL tool was also demonstrated, in particular, by the—for the most part—strong correlations between the SUNFRAIL total score and its biological domain with disability total, ADL, and IADL (0.462 to 0.541) (13). Just like frailty, disability is an important health outcome for older people; it is also associated with outcomes such as lower quality of life and mortality (22, 23), and also places a high burden on health care professionals as well as health care systems (24).

Table 2
Correlations between SUNFRAIL tool total score and its domains with TFI, chronic diseases, GARS, falls, and indicators of health care utilization

	SUNFRAIL Total		SUNFRAIL Physical		SUNFRAIL Neuropsychological		SUNFRAIL Social	
	r	P-value	r	P-value	r	P-value	r	P-value
TFI Total	0.624	<0.001	0.561	<0.001	0.429	<0.001	0.251	<0.001
TFI Physical	0.625	<0.001	0.632	<0.001	0.349	<0.001	0.160	0.031
TFI Psychological	0.499	<0.001	0.390	<0.001	0.453	<0.001	0.228	0.002
TFI Social	0.248	<0.001	0.123	0.094	0.233	0.001	0.305	<0.001
Chronic diseases	0.495	<0.001	0.509	<0.001	0.218	0.003	0.183	0.012
GARS total	0.516	<0.001	0.540	<0.001	0.264	<0.001	0.119	0.113
GARS ADL	0.462	<0.001	0.491	<0.001	0.227	0.002	0.092	0.217
GARS IADL	0.517	<0.001	0.541	<0.001	0.270	<0.001	0.119	0.110
Falls	0.430	<0.001	0.482	<0.001	0.186	0.010	0.038	0.600
Visits GP	0.388	<0.001	0.397	<0.001	0.221	0.002	0.108	0.142
Hospitalization	0.194	0.009	0.249	<0.001	0.074	0.314	-0.048	0.518
Receiving personal care	0.099	0.185	0.136	0.065	0.006	0.938	-0.025	0.734
Receiving nursing	0.253	<0.001	0.279	<0.001	0.226	0.002	-0.021	0.780
Contacts with HCP	0.307	<0.001	0.314	<0.001	0.210	0.004	0.059	0.422

TFI = Tilburg Frailty Indicator; GARS = Groningen Activity Restriction Scale; ADL = Activities of Daily Living; IADL = Instrumental Activities of Daily Living; GP = general practitioner; HCP = health care professionals

Table 3
Effect of background characteristics and SUNFRAIL tool on adverse outcomes: Results of linear regression analysis

	Disability Total			Disability ADL			Disability IADL			Visits GP			Contacts with HCP		
	B	SE	P-value	B	SE	P-value	B	SE	P-value	B	SE	P-value	B	SE	P-value
Sex (women)	-2.443	1.317	0.065	-0.657	0.668	0.327	-1.558	0.705	0.029	0.312	0.153	0.042	0.129	0.229	0.574
Age	0.396	0.129	0.003	0.177	0.065	0.007	0.232	0.069	0.001	0.012	0.015	0.414	0.016	0.022	0.478
Marital status	0.391	1.504	0.795	-0.178	0.762	0.816	0.508	0.805	0.529	0.124	0.173	0.473	0.180	0.259	0.488
Education	-1.148	1.050	0.276	-0.219	0.528	0.680	-0.792	0.557	0.156	0.034	0.119	0.777	0.045	0.179	0.803
Disease(s)	1.161	0.517	0.026	-0.642	0.262	0.015	0.518	0.278	0.064	0.273	0.060	<0.001	0.260	0.089	0.004
R^2	0.235		<0.001	0.198		<0.001	0.236		<0.001	0.241		<0.001	0.117		<0.001
SUNFRAIL Total	2.072	0.474	<0.001	0.855	0.238	<0.001	1.187	0.254	<0.001	0.129	0.054	0.019	0.164	0.082	0.047
R^2	0.083		<0.001	0.060		<0.001	0.091		<0.001	0.025		0.019	0.021		0.047
R^2 Total	0.318		<0.001	0.258		<0.001	0.326		<0.001	0.266		<0.001	0.138		<0.00

ADL = Activities of Daily Living; IADL = Instrumental Activities of Daily Living; GP = general practitioner; HCP = health care professionals

The findings of the regression analyses provided evidence for the criterion (predictive) validity of the SUNFRAIL tool for disability, visits to a general practitioner, contacts with health care professionals, and falls, after controlling for background characteristics and diseases. Due to the cross-sectional design of the current study, a longitudinal study concerning the predictive value of the individual domains of the SUNFRAIL tool is recommended. For intervening on frailty it is important for health care professionals to know the predictive value of the three domains for the different adverse outcomes in older people. In this study quality of life should also be measured, because this concept is very important for elderly and lower quality of life is frequently present in frail older people (25).

We chose 2 and 3 as the cut-off points for the SUNFRAIL tool. In our opinion, this choice depends on the adverse outcomes assessed. For predicting disability, the cut-off point 2 seems the most appropriate, but for receiving nursing care, a cut-off point of 3 seems better. Using the cut-off points 2

Table 4
Effect of background characteristics and SUNFRAIL tool on adverse outcomes: Results of logistic regression analysis

	Falls			Hospitalization			Receiving personal care			Receiving nursing care		
	B	SE	P-value	B	SE	P-value	B	SE	P-value	B	SE	P-value
Sex (women)	0.198	0.462	0.668	-0.443	0.482	0.358	-0.307	0.912	0.736	-0.098	0.651	0.880
Age	0.079	0.043	0.065	-0.011	0.047	0.817	0.155	0.083	0.062	0.090	0.058	0.121
Marital status	-0.253	0.495	0.609	0.572	0.594	0.335	-0.498	0.927	0.592	-0.412	0.694	0.553
Education	0.500	0.358	0.162	-0.097	0.402	0.810	-0.635	0.761	0.404	-0.456	0.537	0.396
Disease(s)	0.100	0.166	0.548	0.386	0.174	0.026	0.376	0.328	0.252	0.186	0.227	0.412
χ^2 (5)	16.929		0.005	11.056		0.050	11.203		0.048	12.280		0.031
SUNFRAIL Total	0.641	0.158	<0.001	0.145	0.156	0.353	0.045	0.330	0.890	0.395	0.205	0.054
χ^2 (1)	18.778		<0.001	0.845		0.358	0.019		0.891	3.635		0.057
χ^2 (6)	35.706		<0.001	11.902		0.064	11.221		0.082	15.915		0.014

Table 5
Predictive validity of the SUNFRAIL tool for disability, falls, and indicators of health care utilization

Screening cut-off point	Outcome	Sensitivity	Specificity	AUC (95% CI)
≥ 2	Disability	0.971	0.647	0.840 (0.781–0.899)
≥ 3		0.647	0.813	
≥ 2	Falls	0.763	0.601	0.769 (0.686–0.859)
≥ 3		0.553	0.797	
≥ 2	Hospitalization	0.741	0.574	0.673 (0.571–0.776)
≥ 3		0.444	0.761	
≥ 2	Receiving personal care	0.714	0.537	0.693 (0.553–0.833)
≥ 3		0.714	0.743	
≥ 2	Receiving nursing care	0.875	0.577	0.782 (0.696–0.868)
≥ 3		0.750	0.785	

AUC = area under the curve; CI = confidence interval

and 3, 47.3% and 28.4% of the participants were identified as frail. The first figure is comparable with the prevalence of frailty assessed with the Groningen Frailty Indicator (GFI), 46.3% (26), and the TFI (40.2%) in Dutch community-dwelling older people with a similar mean age (77.2 years) (27). The advantage of using the cut-off point 3 is that the efforts of health care professionals to overcome frailty can be deployed for a smaller group that probably is in greater need of those efforts. So we suggest to use 3 as the cut-off point for the SUNFRAIL tool.

The present study does have some limitations that should be considered. First, there is an overlap between items on the SUNFRAIL tool and adverse outcomes. The item "falls" in the physical domain was also assessed as an adverse outcome in our study. The related questions were almost the same. There was also an overlap, albeit smaller, between the SUNFRAIL items "medications" and "GP" and chronic disease and visits to a general practitioner, respectively. This will undoubtedly have led to higher correlations. Second, the SUNFRAIL tool was developed as an instrument that has to be completed by a health care professional. In our study, the questionnaire was filled out by older people themselves. Third, we conducted a cross-sectional study with the consequence that strict cause-effect interpretations of the associations between frailty, chronic diseases, and adverse outcomes are not possible. Finally, it should be noted that only 20% of the sample was considered disabled according to the GARS.

In conclusion, this study shows that the SUNFRAIL tool is a valid instrument for assessing frailty among community-dwelling older people. The construct validity of this tool was good, as demonstrated by significant correlations with the TFI. In addition, the criterion validity of the SUNFRAIL tool was good for chronic diseases and good-to-excellent for adverse outcomes disability, falls, and receiving nursing care. The SUNFRAIL tool is an attractive instrument for use in practice because it takes little time for professionals and older people to complete the questionnaire compared to other similar instruments and expresses the integral functioning of human

beings.

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