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Towards tailored elderly care

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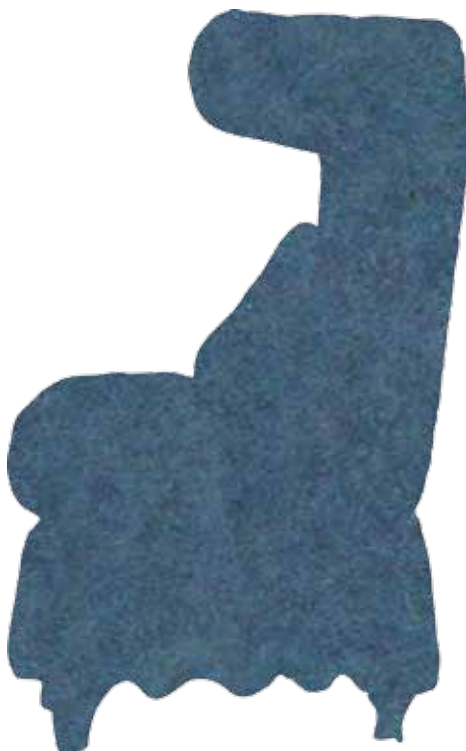
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Construct validity of the Groningen Frailty Indicator established in a large sample of home-dwelling elderly persons: evidence of stability across age and gender

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Submitted



ABSTRACT

Background The primary objective of the present study was to evaluate the validity of the Groningen Frailty Indicator (GFI) in a sample of Dutch elderly persons participating in LifeLines, a large population-based cohort study. Additional aims were to assess differences between frail and non-frail elderly and examine which individual characteristics were associated with frailty.

Methods By December 2012 almost 6,000 elderly persons were enrolled in LifeLines and complied with the inclusion criteria of the present study. Mann-Whitney U or Kruskal-Wallis tests were used to assess the variability of GFI-scores among elderly subgroups that differed in demographic characteristics, morbidity, obesity, and healthcare utilization. Within subgroups Kruskal-Wallis tests were also used to examine differences in GFI-scores across age groups. Multivariate logistic regression analyses were performed to assess associations between individual characteristics and frailty.

Results The GFI discriminated between subgroups: statistically significantly higher GFI-median scores (interquartile range) were found in e.g. males (1 [0-2]), the oldest old (2 [1-3]), in elderly who were single (1 [0-2]), with lower socio economic status (1 [0-3]), with increasing co-morbidity (2 [1-3]), who were obese (2 [1-3]), and used more healthcare (2 [1-4]). Overall age had an independent and statistically significant association with GFI scores. Compared with the non-frail, frail elderly persons experienced statistically significantly more chronic stress and more social/psychological related problems. In the multivariate logistic regression model, psychological morbidity had the strongest association with frailty.

Conclusion The present study supports the construct validity of the GFI and provides an insight in the characteristics of (non)frail community-dwelling elderly persons participating in LifeLines.

3.1 INTRODUCTION

Life expectancy is increasing worldwide, but not all life years gained are free of disease or loss of functioning¹. Ageing contributes considerably to the burden of chronic diseases and healthcare demands and expenses are increasing exponentially². Moreover, due to the increasing governmental pressures to control costs and to eliminate inefficiency, healthcare professionals are trying to identify elderly persons at risk for poor outcomes to allocate geriatric care more efficiently³. Age or diagnosed morbidity alone are not preferred selection criteria because of considerable inter-individual variation^{4,5}.

For this reason the concept of frailty has been introduced in primary and geriatric care as an indicator of risk of poor outcomes (e.g. mortality, institutionalization, hospitalization, and functional decline)⁶⁻⁹. Some researchers have defined the concept rather narrow with only a physical domain; this deficit model consists of an accumulation of impairments and conditions to create a Frailty Index^{10,11}. Another approach has been to define frailty based on a phenotype which marked an underlying physiologic state of multisystem and energy dysregulation^{10,11}. Still others have advocated an integrative and comprehensive approach including biological, cognitive, psychological, and social domains, which interact across an individual's lifespan¹². Due to these differences in perspectives the percentages of frailty in community-dwelling elderly persons appear to range between 4-59%¹³.

The Groningen Frailty Indicator (GFI) is an instrument that measures frailty from a multidimensional perspective. The self-assessment version of this instrument has been shown to have good psychometric properties and is widely used in community-dwelling elderly persons¹⁴⁻¹⁹. Previous studies indicated that the GFI discriminated between elderly subgroups as higher GFI-scores were observed in e.g. the oldest old, those who were institutionalized, who had physical morbidity and those who had a lower monthly income^{14,15}. Both studies reported frailty scores of several elderly subgroups although some of these had relatively small sample sizes. Furthermore, the reported subgroups were categorized according to differences on demographic characteristics and prevalence of diseases only. This appears suboptimal as other individual characteristics like psychological morbidity, presence of obesity, and healthcare utilization may also be related to higher GFI-scores.

Several studies have reported a GFI-total score in specific elderly populations^{14,15,19,20}. This total-score can be used to compare frailty scores between (study) populations. Moreover, by assessing frailty with the GFI on multiple time points the dynamic state of frailty can be captured. In daily practice the dichotomized GFI-score is frequently used to segment elderly persons into non-frail and frail subgroups, and subsequently provide

different care trajectories^{17,18,21}. Though we have previously shown that the commonly used cut-off satisfactorily differentiates between non-frail and frail elderly persons¹⁴, an extensive comparison between these subgroups on a battery of measures, morbidity and healthcare utilization, is currently lacking.

Thus the primary aim of the present study was to extensively evaluate the construct validity of the GFI in a homogeneous elderly population. Additionally, we present frailty scores for subgroups that differ in demographic characteristics, presence of physical or psychological morbidities, obesity, and previous healthcare utilization. Due to the large sample size of the present study these frailty scores could also be stratified for gender and age-groups. The secondary aim was to report whether frail and non-frail elderly persons differed statistically on measures such as stress and psychosocial problems. Finally, we examined which individual characteristics are associated with frailty. Hence, besides the evaluation of the construct validity of the GFI, the present study yields an oversight of the characteristics of community-dwelling elderly persons. The provided GFI-scores for subgroups and the overviews of specific characteristics of those non-frail and frail elderly persons may prove beneficial for policy makers, healthcare professionals and researchers to provide input for the development of tailored care interventions.

3.2 METHODS

3.2.1 LifeLines cohort study

LifeLines is a unique three generation multi-disciplinary prospective population based cohort study examining the health and health-related behaviors of 167,729 participants living in the North East region of The Netherlands^{22,23}. Baseline data of all participants were collected in the period 2006-2013. In brief, the study employs a broad range of investigative procedures to assess the biomedical, socio-demographic, behavioral, physical and psychological factors which contribute to the health status of the general population, with special focus on multi-morbidity and complex interactions between environmental, phenotypic and genetic characteristics²². Persons aged between 25 and 50 years old were invited to participate in LifeLines by their general practitioner. Subsequently their family members, if present, were invited to participate as well (parents, partner, children, parents in law) resulting in a three-generation study²². As a result of this enrolment scheme, the older generation was enrolled from 2008 onward.

The study was approved by the Ethics Committee of University Medical Center Groningen and written informed consent was obtained from all participants before participation (file number: M07.052740).

3.2.2 Elderly participants

For the present study baseline data were provided from elderly respondents aged 65 years or older who were enrolled in the LifeLines cohort study between July 2008 and December 2012. All elderly LifeLines participants completed a questionnaire including socio-demographic items. During the first study visit, cognitive function was assessed with the valid and reliable Minimal Mental State Examination²⁴. For ethical and practical considerations only elderly persons with a score of 26 or higher, i.e. no or minimal cognitive impairment, were included in the LifeLines cohort study²⁵. After inclusion, psychological morbidity was assessed with the Mini International Neuropsychiatric Interview²⁶. This structured interview is a valid and reliable method to assess psychological morbidity²⁶. Next, the subjects' height, weight, and waist circumference were measured.

3.2.3 Baseline measures

The included participants completed a second questionnaire comprising items on physical morbidity, monthly income, and healthcare utilization in the previous year. Furthermore, the participants completed a battery of reliable and valid measures:

Frailty was assessed with the self-assessment version of the GFI, of which the full version of items and scoring method was reported by the authors¹⁴. This instrument comprises 15 items and measures functions and resources in four domains: physical, cognitive, social, and psychological²⁷. Scores range from 0 to 15, higher scores indicating more frailty. Geriatric experts agreed that a score of four or higher represents moderate to severe frailty⁵.

The social domain of the INTERMED for the Elderly Self Assessment was assessed to measure case complexity in the social context (e.g. restrictions in social integration, social dysfunction, and social vulnerability)²⁸. For the five items a four point rating scale is used, ranging from 0 (no vulnerability to 3 (severe vulnerability). The items are summed to calculate a total score (range 0-15; higher scores indicate more case complexity).

Other instruments included were the Positive And Negative Affect Schedule (PANAS) consisting of 10 items measuring positive feelings (e.g. joy or pleasure) and 10 items measuring negative feelings (e.g. anxiety or sadness) during the last month^{29,30}. A five point rating scale is used for each item, ranging from 1 (not at all to very slightly) to 5 (extremely). Positive and negative affect scores were computed by summing items from each subscale. A higher score on the positive affect scale indicates a positive affect about feelings on being enthusiastic, active, and alert. A higher score on the negative affect scale indicates feelings of aversive mood states and general distress.

Also the subscale Somatization (12 items) of the Symptom Checklist 90 (SCL-90) was included to evaluate distressing bodily symptoms (e.g. pain) that had occurred in the previous week³¹. A five point Likert-scale is used for each item, ranging from no problem (1) to severe problems (5). A higher score indicates more psychopathology (range 12-60)³¹.

The RAND-36-item Health Survey (RAND-36) is a generic health related quality of life questionnaire, which measures the following domains: physical functioning, social functioning, role limitations due to physical health problems, role limitations due to emotional problems, general mental health, vitality, bodily pain and general health perception^{32,33}. The total score range of all scales is 0 to 100, with higher scores indicating better health^{32,33}.

Stress was measured by the List of Threatening Experiences (LTE) and the Long-term Difficulties Inventory (LDI). The LTE consists of 12 items and assesses the occurrence of major life events (e.g. serious illness or death of close relative) in the previous year³⁴.

All answer categories were dichotomized and a score of 1 indicated that a stressful live event had occurred. The range of the LTE is 0-12³⁴. A higher score indicates more acute stress³⁴. The LDI consists of 12 items and assesses difficulties related to e.g. housing, social relationships and finances in the previous year³⁴. A three point Likert-scale is used for each item, ranging from 0 (not stressful) to 2 (very stressful). The range of the LDI is 0-24. A higher score indicates more chronic stress³⁴.

Social well-being was assessed with the following subscales of the Well-being (SPF-IL): affection, (i.e. feeling loved), behavioral confirmation (i.e. belonging and doing things right), and status (i.e. distinction in valued aspects: skills, education, wealth)^{35,36}. Each subscale comprises three items and the rating scale ranges from never (1) to always (4). A higher score indicates greater well-being^{35,36}.

3.2.4 Statistical analyses

Baseline characteristics were analyzed using descriptive statistics. Differences between participating and excluded elderly persons were evaluated with the Mann-Whitney U test and Pearson Chi-Square tests, where appropriate. To avoid potential bias and decreased statistical power, missing data on measures with Likert-scales were imputed with a relative mean substitution method if at least half of the items were completed³⁷. The missing values of the measures with a dichotomous scoring were imputed with a '0' if at least 75% of the items were completed^{14,15}. For all measures, the mean (standard deviation, [SD]) and median (interquartile range, [IQR]) were calculated.

The construct validity of the GFI was assessed in terms of known group validity³⁸. We hypothesized that higher GFI-scores would be observed in elderly people who were: female, older, single, living in assisted-living residences, with lower socio economic status, more diseases, obese, and who utilized more healthcare in the previous year^{14,15}. Differences on GFI-scores between elderly subgroups were assessed with Mann-Whitney U and Kruskal-Wallis tests, since the data were not normally distributed. Differences on GFI- scores between age-groups within elderly subgroups (i.e. with similar individual characteristics) were also examined with Kruskal-Wallis tests.

Mann-Whitney U tests were also calculated to compare measurement scores between the non-frail and frail populations. Since some measures are associated with the GFI, we hypothesized that compared with the non-frail older adults, frail elderly persons have higher scores on measures of case complexity, negative feelings, distressing bodily symptoms, and stress^{14,28}. Moreover, we hypothesized that frail elderly persons experience lower scores on measures of cognitive impairment, positive feelings, quality of life, and well-being^{14,19}. Additionally, Chi-square tests were calculated to compare subgroups on morbidity and healthcare utilization.

Finally, we used univariate and multivariate logistic regression analyses to assess the associations between frailty and demographic characteristics, morbidity, and obesity. These associations were expressed as odds ratios (OR) with 95% confidence intervals (95% CI). To prevent multicollinearity in the multivariate model, the data of Body Mass Index (BMI) and waist circumference were combined. Compared with income, education level had substantial less missing values and was therefore selected to reflect the socio-economic status. We entered the following interaction terms separately in the multivariate model: education*age, education*physical morbidity and education*psychological morbidity. The multivariate linear regression models were developed with a backward stepwise selection method. Potential variables were added to the multivariate model if their p-value was ≤ 0.15 in the univariate analyses, values for alpha greater than 0.05 are frequently used in multivariate modeling to limit the bias in the predictor coefficients³⁹. In the final multivariate logistic regression model, variables were included if their p-value was ≤ 0.05 .

All statistical analyses were performed with SPSS Statistics 22.0 (SPSS inc. Chicago, Illinois).

3.3 RESULTS

In total 12,706 elderly persons were included in the LifeLines cohort study²³. After the first data release the recruitment of the study was still ongoing, i.e., at the time of analysis the data of 7,414 elderly persons were validated and available for the present study. In total 1,702 persons were excluded due to cognitive dysfunction ($n=1,418$), and due to missing data on the MMSE ($n=119$) and the GFI ($n=165$, see Figure 1 Flowchart). Compared with the 1,702 elderly persons excluded from the present study, the included participants were more likely to be male ($p=0.01$), younger ($p\leq 0.001$), or to have a partner ($p\leq 0.001$), or obtained a higher level of education ($p\leq 0.001$).

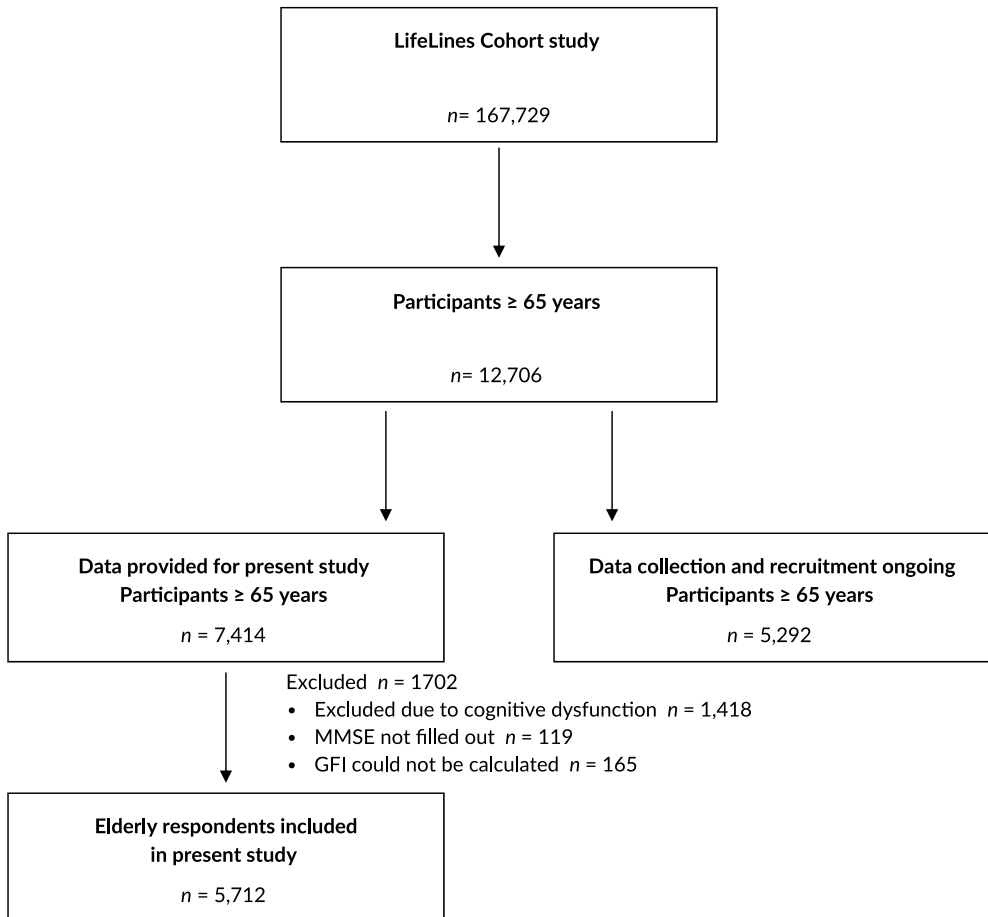


Figure 1 Flowchart

3.3.1 Baseline characteristics

Participants had a mean age of 70 (SD 4) years and 53% was female (Table 1). Twenty eight percent had two or more physical diseases ($n=1,601$). The diseases with the highest prevalence were: coronary heart disease (41%, $n=2,339$), arthritis (24%, $n=1,386$) and cataract (15%, $n=866$). Eight percent of the population ($n=431$) was diagnosed with at least one psychological morbidity, the highest prevalences were observed for agoraphobia without panic disorder (5%, $n=259$), generalized anxiety disorder (2%, $n=90$) or major depressive disorder (1%, $n=70$). Almost twenty percent ($n=1,104$) were obese (BMI ≥ 30 kg/m²) and only 14 persons were underweight (BMI < 18.5 kg/m²). The majority of the population (88%, $n=5,004$) had visited their general practitioner in the previous year.

In the total population the median GFI-score was 1 (IQR 0-2) and the corresponding prevalence of frailty was 9% ($n=528$). Although the GFI median score was the same for both males and females (1; IQR 0-2), the Mann-Whitney U test showed a significant difference between both genders ($p=0.047$). The prevalence of frailty was 9% ($n=272$) in females and 10% ($n=256$) in males.

3.3.2 Construct validity

The median GFI-scores differed between elderly subgroups as hypothesized, except for gender. Higher GFI-scores were found in e.g. males, the oldest age group, those with a higher prevalence of physical/psychological morbidity, those who were obese and participants who used more healthcare in the previous year ($p \leq 0.05$, Table 1). Visual inspection demonstrated similar discriminatory abilities of the GFI among age-groups of the total, female and male population (Table 2a-c). However, some contrasting results were found in the oldest age group where higher GFI-scores were reported in those with higher levels of education. In general, GFI-scores increased statistically significantly with age, independent of individual characteristics, except for psychological morbidity, and home care. Obesity showed different results between females and males. For example, elderly females aged 75-79 years with presence or either absence of abdominal adiposity showed similar GFI-scores. Females aged 80 years and older with abdominal adiposity showed the lowest frailty scores, whereas males with the same characteristics showed the highest frailty scores.

As hypothesized, compared with the non-frail older adults, frail elderly persons scored worse on all measures (Table 3). In contrast with non-frail older adults, frail persons showed statistically significantly higher proportions of physical morbidity (82% vs. 64%, $p \leq 0.001$) and psychological morbidity (18% vs. 7%, $p \leq 0.001$). Consequently,

frail elderly persons received more home care, (10% vs. 2%, $p \leq 0.001$), had more visits to the general practitioner (93% vs. 87%, $p \leq 0.001$), emergency visits to the general practitioner (10% vs. 6%, $p=0.004$), and outpatient clinic visits (68% vs. 51%, $p \leq 0.001$).

Psychological morbidity had the strongest association with frailty in the multivariate model (adjusted OR 2.90; 95% CI 2.24-3.77, Table 4). Physical morbidity and an assisted-living situation showed also strong associations with frailty, adjusted ORs (95% CI) were respectively 2.26 (1.78-2.87) and, 2.65 (1.46-4.81). In the extended multivariate model none of the interaction terms were statistically significantly associated.

Table1 Characteristics and frailty scores (n=5,712)

	n (%)	GFI- score ¹ mean (SD) ²	GFI- score ¹ median (IQR) ³	Prevalence of frailty ¹ n (%)	Differences in GFI ¹ -median scores p-value
DEMOGRAPHIC CHARACTERISTICS					
Gender					
Female	3,045 (53)	1.4 (1.4)	1 (0-2)	272 (9)	0.05
Male	2,667 (47)	1.5 (1.4)	1 (0-2)	256 (10)	
Age					
65-69 years	3,324 (58)	1.4 (1.4)	1 (0-2)	276 (8)	≤0.001
70-74 years	1,586 (28)	1.5 (1.4)	1 (0-2)	145 (9)	
75-79 years	598 (10)	1.7 (1.5)	1 (1-3)	68 (11)	
≥80 years	204 (4)	2.0 (1.5)	2 (1-3)	39 (19)	
Marital status					
No partner	1,010 (18)	1.5 (1.5)	1 (0-2)	109 (11)	0.05
Partner/spouse	4,702 (82)	1.4 (1.4)	1 (0-2)	419 (9)	
Living situation					
Home-dwelling elderly	5,623 (98)	1.4 (1.4)	1 (0-2)	508 (9)	≤0.001
Assisted-living residences	64 (2)	2.3 (1.9)	2 (1-4)	17 (27)	
Unknown	25 (0)	1.6 (1.4)	1 (0.5-2)	3 (12)	
Education level					
None/Primary school	1,769 (32)	1.6 (1.5)	1 (0-2)	210 (12)	≤0.001
Secondary school	2,577 (45)	1.4 (1.4)	1 (0-2)	226 (9)	
Higher education	1,156 (20)	1.2 (1.3)	1 (0-2)	73 (6)	
Unknown	183 (3)	1.7 (1.5)	1 (1-2)	19 (10)	
Income per month in €					
≤ 1500	961 (17)	1.7 (1.6)	1 (0-3)	129 (13)	≤0.001
1501-2000	1,023 (18)	1.5 (1.5)	1 (0-2)	105 (10)	
2001-2500	946 (16)	1.4 (1.4)	1 (0-2)	80 (9)	
≥ 2500	1,673 (30)	1.2 (1.3)	1 (0-2)	105 (6)	
Unknown	1,109 (19)	1.5 (1.4)	1 (0-2)	109 (10)	
MORBIDITY					
Physical morbidity⁴					
No physical morbidity	1,980 (35)	1.0 (1.2)	1 (0-2)	95 (5)	≤0.001
1 physical morbidity	2,131 (37)	1.4 (1.3)	1 (0-2)	164 (8)	
≥2 physical morbidities	1,601 (28)	2.0 (1.6)	2 (1-3)	269 (17)	
Psychological morbidity⁵					
No psychological morbidity	5,281 (92)	1.4 (1.4)	1 (0-2)	434 (8)	≤0.001
≥ 1 psychological morbidity	431 (8)	2.3 (1.8)	2 (1-3)	94 (22)	

	n (%)	GFI- score ¹	GFI- score ¹	Prevalence	Differences in
		mean (SD) ²	median (IQR) ³	of frailty ¹	GFI ¹ -median scores
				n (%)	p-value
OBESITY					
General obesity (Body Mass Index)⁶					
< 25	1,735 (30)	1.3 (1.3)	1 (0-2)	108 (6)	≤0.001
25-29.9	2,869 (50)	1.4 (1.4)	1 (0-2)	273 (10)	
30-34.9	899 (16)	1.6 (1.5)	1 (1-2)	109 (12)	
≥ 35	205 (4)	2.1 (1.7)	2(1.3-2.8)	38 (19)	
Unknown	4 (0)	2 (0.8)	2 (1.3-2.8)	0 (0)	
Abdominal adiposity (waist circumference)					
♀ < 80 cm, ♂ < 0.94 cm	1,161 (20)	1.2 (1.3)	1 (0-2)	68 (6)	≤0.001
♀ 80-87.9 cm, ♂ 0.94-101.9 cm	1,635 (29)	1.4 (1.4)	1 (0-2)	126 (8)	
♀ ≥ 88 cm, ♂ ≥ 102 cm	2,913 (51)	1.6 (1.5)	1 (0-2)	334 (12)	
Unknown	3 (0)	2.0 (1.0)	NA		
HEALTHCARE UTILIZATION					
Home care					
No home care provided	5,531 (97)	1.4 (1.4)	1 (0-2)	473 (9)	≤0.001
Home care provided	181 (3)	2.6 (1.8)	2 (1-4)	55 (31)	
General practitioner					
No visit to general practitioner	708 (12)	1.1 (1.2)	1 (0-2)	39 (6)	≤0.001
≥ 1 visit to general practitioner	5,004 (88)	1.5 (1.4)	1 (0-2)	489 (10)	
Emergency visit general practitioner					
No emergency visit to general practitioner	5,330 (93)	1.4 (1.4)	1 (0-2)	477 (9)	≤0.001
≥ 1 emergency visit to general practitioner	382 (7)	1.8 (1.5)	1 (1-3)	51 (13)	
Outpatient clinic					
No visit to outpatient clinic	2,711 (47)	1.2 (1.3)	1 (0-2)	168 (6)	≤0.001
≥ 1 visit to outpatient clinic	3,001 (53)	1.7 (1.5)	1 (1-2)	360 (12)	

¹ Groningen Frailty Indicator (GFI), GFI- score 0-3: non-frail ; GFI-score 4-15: frail

² Standard deviation

³ Interquartile range

⁴ Physical morbidity was assessed with the presence of diseases with the highest burden - according to the Disability-Adjusted Life Years measurement of the Dutch National Public Health compass: coronary heart disease (i.e. angina pectoris, arrhythmia or myocardial infarction), cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, arthritis, lung cancer, visual restrictions (i.e. cataract), heart failure, colon cancer

⁵ Psychological morbidity: major depressive disorder, dysthymia, generalized anxiety disorder, social phobia, panic disorder, agoraphobia, panic disorder with agoraphobia

⁶ Body Mass Index in kg/m²

Table 2a Descriptive scores on the Groningen Frailty Indicator in the total elderly population for specific age groups (n=5,712)

	65-69 years (n=3,324)			70-74 years (n=1,586)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
Frailty (GFI) ¹ (n=5,712)	1.3 (1.4)	1 (0-2)	276/3,324 (8)	1.5 (1.4)	1 (0-2)	145/1,586 (9)
DEMOGRAPHIC CHARACTERISTICS						
Marital status						
No partner (n=1,010)	1.4 (1.5)	1 (0-2)	46/488 (9)	1.5(1.5)	1 (0-2)	33/291 (11)
Partner/spouse (n=4,702)	1.3 (1.4)	1 (0-2)	230/2,836 (8)	1.5 (1.4)	1 (0-2)	112/1,295 (9)
Living situation						
Independently (n=5,623)	1.3 (1.4)	1 (0-2)	271/3,294 (8)	1.5 (1.4)	1 (0-2)	141/1,561 (9)
Assisted living residences (n=64)	1.7 (1.6)	1.5 (0-2.5)	3/14 (21)	2.2 (2.1)	1.5 (1-3)	3/20 (15)
Unknown (n=25)	1.7 (1.5)	1 (1-2)	2/16 (13)	1.4 (1.7)	1 (0-3)	1/5 (20)
Education level						
Primary school (n=1,796)	1.5 (1.5)	1 (0-2)	106/1,009 (11)	1.7 (1.5)	1 (1-3)	65/487 (13)
Secondary school (n=2,577)	1.3 (1.4)	1 (0-2)	122/1,504 (8)	1.5 (1.4)	1 (0-2)	58/725 (8)
Higher education (n=1,156)	1.1 (1.2)	1 (0-2)	41/718 (6)	1.2 (1.2)	1 (0-2)	16/307 (5)
Unknown (n=183)	1.6 (1.3)	1 (1-2.5)	7/93 (8)	1.4 (1.3)	1 (0-2)	6/67 (9)
Income per month in €						
≤ 1500 (n=961)	1.6 (1.6)	1 (0-2)	60/480 (13)	1.7 (1.5)	1 (1-3)	37/263 (14)
1501-2000 (n=1,023)	1.4 (1.4)	1 (0-2)	49/571 (9)	1.6 (1.5)	1 (1-2)	32/296 (11)
2001-2500 (n=946)	1.3 (1.3)	1 (0-2)	48/569 (8)	1.4 (1.4)	1 (0-2)	21/268 (8)
≥ 2500 (n=1,673)	1.1 (1.2)	1 (0-2)	59/1,075 (6)	1.3 (1.3)	1 (0-2)	27/438 (10)
Unknown (n=1,109)	1.4 (1.4)	1 (0-2)	60/629 (10)	1.5 (1.4)	1 (0-2)	28/321 (9)
MORBIDITY						
Physical morbidity⁴						
No physical morbidity (n=1,980)	1.0 (1.2)	1 (0-1)	57/1,281 (4)	1.1 (1.2)	1 (0-2)	25/504 (5)
1 physical morbidity (n=2,131)	1.3 (1.4)	1 (0-2)	98/1,254 (8)	1.4 (1.3)	1 (0-2)	43/587 (7)
≥2 physical morbidities (n=1,601)	1.9 (1.6)	2 (1-3)	121/789 (15)	2.0 (1.5)	2 (1-3)	77/495 (16)
Psychological morbidity⁵						
No psychological morbidity (n=5,281)	1.3 (1.3)	1 (0-2)	222/3,071 (7)	1.4 (1.3)	1 (0-2)	117/1,457 (8)
≥ 1 psychological morbidity (n=431)	2.2 (1.7)	2 (1-3)	54/253 (21)	2.3 (1.8)	2 (1-3)	28/129 (22)

75-79 years (n=598)			80 years and older (n=204)			Differences in GFI ¹ -median scores between age groups	p-value
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)		
1.7 (1.5)	1 (1-3)	68/598 (11)	2.0 (1.5)	2 (1-3)	39/204 (19)		≤0.001
1.6 (1.4)	1 (1-3)	14/149 (9)	2.0 (1.5)	2 (1-3)	16/82 (20)		0.004
1.8 (1.5)	1 (1-3)	54/449 (12)	2.1 (1.6)	2 (1-3)	23/122 (19)		≤0.001
1.7 (1.5)	1 (1-3)	65/579 (11)	1.9 (1.5)	2 (1-3)	31/189 (16)		≤0.001
1.8 (1.6)	1 (0-3)	3/15 (20)	3.3 (1.9)	4 (1-5)	8/15 (53)		0.09
1.5 (1.0)	2 (0.5-2)	0/4 (0)	-	-	-		
1.8 (1.4)	2 (1-3)	27/230 (12)	1.9 (1.7)	1 (1-3)	12/70 (17)		≤0.001
1.6 (1.4)	1 (1-3)	27/257 (11)	2.1 (1.5)	2 (1-3)	19/91 (21)		≤0.001
1.5 (1.4)	1 (0-2)	8/93 (9)	2.2 (1.6)	2 (1-3)	8/38 (21)		≤0.001
2.7 (2.6)	2 (0.8-4.3)	6/18 (33)	1.6 (1.3)	1 (0.5-3)	0/5 (0)		≤0.001
1.8 (1.4)	1 (1-3)	22/162 (14)	1.8 (1.5)	1 (1-3)	10/56 (18)		0.08
1.9 (1.6)	2 (1-3)	15/117 (13)	2.2 (1.5)	2 (1-3)	9/39 (23)		≤0.001
1.6 (1.3)	1 (1-2)	6/83 (7)	2.0 (1.4)	2 (1-3)	5/26 (19)		0.002
1.6 (1.5)	1 (0-3)	12/117 (10)	1.9 (1.5)	2 (1-3)	7/43 (16)		≤0.001
1.7 (1.5)	1 (1-3)	13/119 (11)	2.2 (1.7)	2 (1-3)	8/40 (20)		0.01
1.3 (1.3)	1 (0-2)	9/153 (6)	1.6 (1.2)	1 (1-2)	4/42 (10)		≤0.001
1.6 (1.2)	1 (1-2)	14/220 (6)	1.7 (1.4)	1 (1-3)	9/70 (13)		0.02
2.2 (1.6)	2 (1-3)	45/225 (20)	2.5 (1.6)	2 (1-4)	26/92 (28)		≤0.001
1.7 (1.4)	1 (1-3)	58/556 (10)	2.0 (1.5)	2 (1-3)	37/197 (19)		≤0.001
2.4 (2.0)	2 (1-3.3)	10/42 (24)	2.9 (2.3)	2 (1-6)	2/7 (29)		0.86

Table 2a (continued)

	65-69 years (n=3,324)			70-74 years (n=1,586)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
OBESITY						
General obesity						
(Body Mass Index in kg/m²)						
< 25 (n=1,735)	1.2 (1.3)	1 (0-2)	61/1,016 (6)	1.2 (1.2)	1 (0-2)	21/473 (4)
25-29.9 (n=2,869)	1.3 (1.4)	1 (0-2)	133/1,624 (8)	1.5 (1.5)	1 (0-2)	90/832 (11)
30-34.9 (n=899)	1.5 (1.5)	1 (0-2)	62/553 (11)	1.6 (1.4)	1 (1-2)	23/230 (10)
≥ 35 (n=205)	2.0 (1.6)	2 (1-3)	20/129 (16)	2.2 (1.7)	2 (1-3)	11/50 (22)
Unknown (n=4)	2.5 (0.7)	NA	0/2 (0)	2.0 (NA)	NA	0/1 (0)
Abdominal adiposity						
(waist circumference in cm)						
♀ < 80, ♂ < 94 (n=1,161)	1.1 (1.3)	1 (0-2)	40/699 (6)	1.2 (1.2)	1 (0-2)	15/333 (5)
♀ 80-87.9, ♂ 94-101.9 (n=1,635)	1.3 (1.3)	1 (0-2)	70/958 (7)	1.3 (1.3)	1 (0-2)	27/440 (6)
♀ ≥ 88, ♂ ≥ 102 (n=2,913)	1.5 (1.5)	1 (0-2)	166/1,666 (10)	1.7 (1.5)	1 (1-2)	103/812 (13)
Unknown (n=3)	3 (NA)	NA	0/1 (0)	2.0 (NA)	NA	0/2 (0)
HEALTHCARE UTILIZATION						
Home care						
No home care provided (n=5,531)	1.3 (1.4)	1 (0-2)	264/3,279 (8)	1.4 (1.4)	1 (0-2)	130/1,528 (9)
Homecare provided (n=181)	2.5 (2.1)	2 (1-4)	12/45 (27)	2.4 (1.8)	2 (1-4)	15/58 (26)
General practitioner						
No visit to general practitioner (n=708)	1.1 (1.2)	1 (0-2)	25/464 (5)	1.0 (1.2)	1 (0-2)	6/167 (4)
≥ 1 visit to general practitioner (n=5,004)	1.4 (1.4)	1 (0-2)	251/2,860 (9)	1.5 (1.4)	1 (0-2)	139/1,419 (10)
Emergency visit general practitioner						
No emergency visit (n=5,330)	1.3 (1.4)	1 (0-2)	252/3,112 (8)	1.5 (1.4)	1 (0-2)	131/1,479 (9)
≥ 1 emergency visit (n=382)	1.8 (1.4)	1 (1-2)	24/212 (11)	1.6 (1.4)	1 (1-2)	14/1,07(13)
Outpatient clinic						
No visit to outpatient clinic (n=2,711)	1.1 (1.3)	1 (0-2)	102/1,694 (6)	1.2 (1.3)	1 (0-2)	41/702 (6)
≥ 1 visit to outpatient clinic (n=3,001)	1.5 (1.5)	1 (0-2)	174/1,630 (11)	1.7 (1.5)	1 (1-3)	104/884 (12)

¹ Groningen Frailty Indicator (GFI), GFI- score 0-3 : non-frail ; GFI-score 4-15: frail

² Standard deviation

³ Interquartile range

75-79 years (n=598)			80 years and older (n=204)			Differences in GFI ¹ -median scores between age groups
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	
1.6 (1.4)	1 (1-2)	18/193 (9)	2.0 (1.4)	2 (1-3)	8/53 (15)	≤0.001
1.7 (1.5)	1 (1-3)	33/301 (11)	1.8 (1.5)	1 (1-3)	17/112 (15)	≤0.001
1.9 (1.3)	2 (1-3)	11/80 (14)	2.6 (1.9)	2 (1-4)	13/36(36)	≤0.001
2.4 (1.9)	3 (1-4)	6/23 (26)	3.3 (0.6)	NA	1/3 (33)	0.16
1.0 (NA)	NA	0/1 (0)	-	-	-	NA
1.5 (1.4)	1 (1-2)	9/97 (9)	1.9 (1.4)	2 (1-2)	4/32 (13)	≤0.001
1.8 (1.5)	2 (1-3)	19/180 (11)	1.9 (1.5)	2 (1-3)	10/57 (18)	≤0.001
1.8 (1.4)	1 (1-3)	40/320 (13)	2.1 (1.6)	2 (1-3)	25/115 (22)	≤0.001
1 (NA)	NA	0/1 (0)	-	-	-	NA
1.7 (1.4)	1 (0-2)	54/552 (10)	1.9 (1.4)	2 (1-3)	25/172 (15)	≤0.001
2.6 (1.7)	2.5 (1-4)	14/46 (30)	2.9 (1.9)	3 (1.3-4)	14/32 (44)	0.54
1.6 (1.5)	1 (0-2)	6/59 (10)	1.5 (1.3)	1 (0.8-2.3)	2/18 (11)	0.02
1.7 (1.4)	1 (1-3)	62/539 (12)	2.1 (1.6)	2 (1-3)	37/186 (20)	≤0.001
1.7 (1.4)	1 (0-2)	59/552 (11)	2.0 (1.5)	2 (1-3)	35/187 (19)	≤0.001
2.2 (1.6)	2 (1-3)	9/46 (20)	2.3 (1.8)	2 (1-3)	4/17 (24)	0.08
1.3 (1.3)	1 (0-2)	12/230 (5)	1.8 (1.5)	1 (1-3)	13/85 (15)	≤0.001
2.0 (1.5)	2 (1-3)	56/368 (15)	2.2 (1.5)	2 (1-3)	26/119 (22)	≤0.001

⁴ Physical morbidity was assessed with the presence of diseases with the highest burden - according to the Disability-Adjusted Life Years measurement of the Dutch National Public Health compass: coronary heart disease (i.e. angina pectoris, arrhythmia or myocardial infarction), cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, arthritis, lung cancer, visual restrictions (i.e. cataract), heart failure, colon cancer

⁵ Psychological morbidities includes the following: major depressive disorder, dysthymia, generalized anxiety disorder, social phobia, panic disorder, agoraphobia, panic disorder with agoraphobia

Table 2b Descriptive scores on the Groningen Frailty Indicator in the female elderly population for specific age groups (n=3,045)

	65-69 years (n=1,779)			70-74 years (n=855)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
Frailty (n=3,045)	1.3 (1.4)	1 (0-2)	133/1,779 (8)	1.5 (1.4)	1 (0-2)	85/855 (10)
DEMOGRAPHIC CHARACTERISTICS						
Marital status						
No partner (n=853)	1.4 (1.5)	1 (0-2)	37/408 (9)	1.5 (1.5)	1 (0-2)	30/253 (12)
Partner/spouse (n=2,191)	1.2 (1.4)	1 (0-2)	96/1,370 (7)	1.5 (1.4)	1 (0-2)	55/602 (9)
Living situation						
Independently (n=2,997)	1.3 (1.4)	1 (0-2)	129/1,764 (7)	1.5 (1.4)	1 (0-2)	83/842 (10)
Assisted living residences (n=41)	1.5 (1.8)	1 (0-2.3)	2/10 (20)	2.0 (1.6)	2 (1-3)	2/13 (15)
Unknown (n=7)	3.0 (2.1)	3 (1-5)	2/5 (40)	-	-	-
Education level						
Primary school (n=1,078)	1.4 (1.5)	1 (0-2)	51/594 (9)	1.7 (1.5)	1 (1-3)	40/300 (13)
Secondary school (n=1,458)	1.3 (1.4)	1 (0-2)	62/859 (7)	1.4 (1.4)	1 (0-2)	37/418 (9)
Higher education (n=391)	1.0 (1.2)	1 (0-1)	15/263 (6)	1.1 (1.0)	1 (0-2)	3/96 (14)
Unknown (n=118)	1.6 (1.4)	1 (1-2)	5/63 (8)	1.6 (1.3)	1 (1-2)	5/41 (12)
Income per month in €						
≤ 1500 (n=708)	1.6 (1.6)	1 (0-3)	45/366 (12)	1.6 (1.5)	1 (1-2)	25/195 (13)
1501-2000 (n=547)	1.3 (1.3)	1 (0-2)	18/295 (6)	1.6 (1.6)	1 (0-2)	21/169 (12)
2001-2500 (n=408)	1.3 (1.4)	1 (0-2)	18/255 (7)	1.4 (1.4)	1 (0-2)	10/123 (8)
≥ 2500 (n=661)	1.0 (1.1)	1 (0-1.5)	18/457 (4)	1.3 (1.3)	1 (0-2)	10/158 (6)
Unknown (n=721)	1.4 (1.4)	1 (0-2)	34/406 (8)	1.5 (1.4)	1 (1-2)	19/210 (9)
MORBIDITY						
Physical morbidity⁴						
No physical morbidity (n=929)	0.9 (1.1)	1 (0-1)	16/605 (3)	1.1 (1.2)	1 (0-2)	11/232 (5)
1 physical morbidity (n=1,141)	1.3 (1.3)	1 (0-2)	49/679 (7)	1.4 (1.4)	1 (0-2)	27/326 (8)
≥2 physical morbidities (n=975)	1.8 (1.6)	1 (1-3)	68/495 (14)	1.9 (1.5)	2 (1-3)	47/297 (16)
Psychological morbidity⁵						
No psychological morbidity (n=2,755)	1.2 (1.3)	1 (0-2)	99/1,607 (6)	1.4 (1.3)	1 (0-2)	65/772 (8)
≥ 1 psychological morbidity (n=290)	2.2 (1.7)	2 (1-3)	34/172 (20)	2.6 (1.8)	2 (1-3)	20/83 (24)

75-79 years (n=316)			80 years and older (n=95)			Differences in GFI ¹ -median scores between age groups	p-value
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)		
1.7 (1.4)	1 (1-3)	34/316 (11)	2.0 (1.6)	1 (1-3)	20/95 (21)		≤0.001
1.6 (1.5)	1 (0-2)	12/130 (9)	1.9 (1.5)	2 (1-3)	13/62 (21)		0.05
1.8 (1.4)	2 (1-3)	22/186 (12)	2.1 (1.6)	1 (1-3)	7/33 (21)		≤0.001
1.7 (1.4)	1 (1-3)	33/305 (11)	1.9 (1.6)	1 (1-3)	16/86 (19)		≤0.001
1.8 (1.6)	2 (0-3)	1/9 (11)	2.6 (1.7)	2 (1-4)	4/9 (44)		0.50
2 (0)2 (2- NA9)		0/2 (0)	-	-	-		
1.8 (1.4)	2 (1-3)	16/143 (11)	1.8 (1.)	1 (1-3)	6/41 (15)		≤0.001
1.6 (1.4)1 (0.3-2.8)		12/140 (9)	2.0 (1.6)	2 (1-3.5)	10/41 (24)		≤0.001
1.6 (1.7)1.5 (0-2.3)		3/22 (14)	2.6 (1.6)	2 (1.8-4)	4/10 (40)		0.002
2.1 (2.3)	2 (0-5)	3/11 (27)	1.7 (1.2)	1 (1-NA)	0/3 (0)		0.99
1.6 (1.4)	1 (1-2)	12/109 (11)	1.7 (1.3)	1 (1-3)	5/38 (13)		0.62
1.8 (1.4)	1 (1-3)	8/65 (12)	1.7 (1.5)	1.5 (0-3)	3/18 (17)		0.03
1.7 (1.6)	1 (1-2.8)	3/24 (13)	2.8 (1.2)	3 (1.8-4)	2/6 (33)		0.02
1.8 (1.6)	2 (0-3)	4/35 (11)	2.1 (1.4)	2 (1-4)	3/11 (27)		0.01
1.7 (1.3)	2 (1-3)	7/83 (8)	2.5 (2.1)	1.5 (1-5)	7/22 (32)		0.01
1.3 (1.2)	1 (0-2)	2/74 (3)	1.5 (1.3)1 (0.8-2.3)		2/18 (11)		0.02
1.4 (1.1)	1 (1-2)	3/104 (3)	1.6 (1.4)	1 (1-3)	4/32 (13)		0.15
2.1 (1.6)	2 (1-3)	29/138 (21)	2.4 (1.7)	2 (1-4)	14/45 (31)		0.02
1.6 (1.4)	1 (1-3)	27/285 (10)	1.9 (1.5)	1 (1-3)	19/91 (21)		≤0.001
2.1 (1.7)	1 (1-3)	7/31 (23)	2.8 (2.4)	2 (1-5.3)	1/4 (25)		0.24

Table 2b (continued)

	65-69 years (n=1,779)			70-74 years (n=855)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
OBESITY						
General obesity						
(Body Mass Index in kg/m²)						
<25 (n=985)	1.2 (1.3)	1 (0-2)	38/598 (6)	1.2 (1.2)	1 (0-2)	11/263 (4)
25-<30 (n=1,363)	1.2 (1.3)	1 (0-2)	45/766 (6)	1.5 (1.5)	1 (0-2)	47/399 (12)
30-<35 (n=533)	1.5 (1.5)	1 (0-2)	35/317 (11)	1.7 (1.4)	1 (1-3)	18/151 (12)
≥ 35 (n=161)	1.9 (1.7)	2 (1-3)	15/97 (16)	2.1 (1.8)	2 (1-3)	9/41 (22)
Unknown (n=3)	3 (NA)	NA	0/1 (0)	2 (NA)	NA	0/1 (0)
Abdominal adiposity						
(waist circumference in cm)						
<80 (n=410)	1.2 (1.2)	1 (0-2)	14/264 (5)	1.0 (1.0)	1(0-1)	1/108 (1)
80-<88 (n=706)	1.3 (1.3)	1 (0-2)	20/430 (5)	1.3 (1.3)	1 (0-2)	12/178 (7)
≥ 88 (n=1,926)	1.4 (1.5)	1 (0-2)	99/1084 (9)	1.6 (1.5)	1 (1-2)	72/568 (13)
Unknown (n=3)	3 (NA)	NA	0/1 (0)	2(NA)	NA	0/1 (0)
HEALTHCARE UTILIZATION						
Home care						
No home care provided (n=2,892)	1.3 (1.4)	1 (0-2)	122/1,738 (7)	1.4 (1.4)	1 (0-2)	70/803 (9)
Home care provided (n=153)	2.5 (2.1)	2 (1-4)	11/41 (27)	2.5 (1.9)	2 (1-4)	15/52 (29)
Primary care						
No visit to primary care clinic (n=356)	0.9 (1.1)	1 (0-2)	6/232 (3)	1.1 (1.3)	1 (0-2)	4/83 (5)
≥ 1 visit to primary care clinic (n=2,689)	1.3 (1.4)	1 (0-2)	127/1,547 (8)	1.5 (1.4)	1 (0-2)	81/772 (11)
Primary care emergency visit						
No emergency visit (n=2,816)	1.3 (1.4)	1 (0-2)	119/1,644 (7)	1.5 (1.4)	1 (0-2)	78/791 (10)
≥ 1 emergency visit (n=229)	1.7 (1.4)	1 (0-2)	14/135 (10)	1.5 (1.3)	1 (0-2)	7/64 (11)
Outpatient clinic						
No visit to outpatient clinic (n=1,481)	1.1 (1.3)	1 (0-2)	48/914 (5)	1.3 (1.4)	1 (0-2)	30/378 (8)
≥ 1 visit to outpatient clinic (n=1,564)	1.5 (1.5)	1 (0-2)	85/865 (10)	1.7 (1.4)	1 (1-2)	55/477 (12)

¹ Groningen Frailty Indicator (GFI), GFI- score 0-3 : non-frail ; GFI-score 4-15: frail

² Standard deviation

³ Interquartile range

75-79 years (n=316)			80 years and older (n=95)			Differences in GFI ¹ -median scores between age groups
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	p-value
1.5 (1.3)	1 (1-2)	8/101 (8)	1.8 (1.5)	2 (1-2)	5/23 (22)	0.01
1.7 (1.4)	1 (1-3)	16/147 (11)	1.7 (1.4)	1 (1-3)	7/51 (14)	≤0.001
1.8 (1.3)	1.5 (1-3)	4/46 (9)	2.7 (1.9)	3 (1-4)	8/19 (42)	0.01
2.4 (2.0)	3 (0.5-4)	6/21 (29)	3.0 (0)	NA	0/2 (0)	0.36
1 (NA)	NA	0/1 (0)	-	-	-	
1.8 (1.7)	1 (0.5-3)	4/29 (14)	2.0 (1.5)	1 (1-3)	2/9 (22)	0.02
1.5 (1.1)	1 (1-2)	3/82 (4)	2.1 (1.7)	1.5 (1-3.8)	4/16 (25)	0.02
1.8 (1.5)	1 (1-3)	27/204 (13)	1.9 (1.6)	1.5 (1-3)	14/70 (20)	≤0.001
1 (NA)	NA	0/1 (0)	-	-	-	
1.6 (1.3)	1 (1-2)	22/275 (8)	1.8 (1.5)	1 (1-3)	13/76 (17)	0.001
2.6 (1.8)	2 (1-4)	12/41 (29)	2.8 (1.6)	3 (2-4)	7/19 (37)	0.80
1.6 (1.5)	1 (0-3)	2/33 (6)	2.0 (1.7)	2 (0.3-3.8)	2/8 (25)	0.02
1.7 (1.4)	1 (1-3)	32/283 (11)	2.0 (1.6)	1 (1-3)	18/87 (21)	≤0.001
1.7 (1.4)	1 (1-3)	30/295 (10)	2.0 (1.5)	1.5 (1-3)	18/86 (21)	≤0.001
2.1 (1.5)	2 (1-3)	4/21 (19)	2.2 (2.3)	1 (0.5-4.5)	2/9 (22)	0.47
1.4 (1.2)	1 (0-2)	6/144 (4)	1.6 (1.4)	1 (1-3)	5/45 (11)	0.02
1.9 (1.5)	2 (1-3)	28/172 (16)	2.3 (1.7)	2 (1-4)	15/50 (30)	≤0.001

⁴ Physical morbidity was assessed with the presence of diseases with the highest burden - according to the Disability-Adjusted Life Years measurement of the Dutch National Public Health compass: coronary heart disease (i.e. angina pectoris, arrhythmia or myocardial infarction), cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, arthritis, lung cancer, visual restrictions (i.e. cataract), heart failure, colon cancer

⁵ Psychological morbidities includes the following: major depressive disorder, dysthymia, generalized anxiety disorder, social phobia, panic disorder, agoraphobia, panic disorder with agoraphobia

Table 2c Descriptive scores on the Groningen Frailty Indicator in the male elderly population for specific age groups (n=2,667)

	65-69 years (n=1,545)			70-74 years (n=731)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
Frailty (n=2,667)	1.4 (1.4)	1 (0-2)	143/1,545 (9)	1.5 (1.3)	1 (0-2)	60/731 (8)
DEMOGRAPHIC CHARACTERISTICS						
Marital status						
No partner (n=157)	1.4 (1.5)	1(0-2)	9/80 (11)	1.5 (1.4)	1 (0-3)	3/38 (8)
Partner/spouse (n=2,510)	1.4 (1.4)	1 (0-2)	134/1,465 (9)	1.5 (1.4)	1 (0-2)	57/693 (8)
Living situation						
Independently (n=2,626)	1.4 (1.4)	1 (0-2)	142/1,530 (9)	1.4 (1.4)	1 (0-2)	58/719 (8)
Assisted living residences (n=23)	2.3 (1.3)	2 (1.3-3.5)	1/4 (25)	2.6 (2.9)	1 (1-3)	1/7 (14)
Unknown (n=18)	1.1 (0.7)	1 (1-2)	0/11 (0)	1.4 (1.7)	1 (0-3)	1/5 (20)
Education level						
< Primary school (n=718)	1.6 (1.5)	1 (0-2)	55/415 (13)	1.7 (1.5)	1 (1-3)	25/187 (13)
Secondary school (n=1,119)	1.4 (1.4)	1 (0-2)	60/645 (9)	1.5 (1.4)	1 (0-2)	21/307 (7)
Higher education (n=765)	1.2 (1.2)	1 (-0-2)	26/455 (6)	1.2 (1.3)	1 (0-2)	13/211 (6)
Unknown (n=65)	1.7 (1.2)	1 (1-3)	2/30 (7)	1.2 (1.1)	1 (0-2)	1/26 (4)
Income per month in €						
≤ 1500 (n=253)	1.6 (1.5)	1 (0.8-2)	15/114 (13)	2.1 (1.7)	2 (1-3)	12/68 (19)
1501-2000 (n=476)	1.5 (1.5)	1 (0-2)	31/276 (11)	1.6 (1.4)	1 (1-2)	11/127(9)
2001-2500 (n=538)	1.3 (1.3)	1 (0-2)	30/314 (10)	1.4 (1.4)	1 (0-2)	11/145 (8)
≥ 2500 (n=1,012)	1.2 (1.3)	1 (0-2)	41/618 (7)	1.3 (1.3)	1 (0-2)	17/280 (6)
Unknown (n=388)	1.6 (1.5)	1 (0-2)	26/223 (12)	1.4 (1.3)	1 (0-2)	9/111 (8)
MORBIDITY						
Physical morbidity⁴						
No physical morbidity (n=929)	1.1(1.3)	1 (0-2)	41/676 (6)	1.1 (1.2)	1 (0-2)	14/272 (5)
1 physical morbidity (n=1,141)	1.4 (1.4)	1 (0-2)	49/575 (9)	1.4 (1.2)	1 (0-2)	16/261 (6)
≥2 physical morbidities (n=975)	2.0 (1.5)	2 (1-3)	53/294 (18)	2.1 (1.5)	2 (1-3)	30/198 (15)
Psychological morbidity⁵						
No psychological morbidity (n=2,526)	1.3 (1.4)	1 (0-2)	123/1,464 (8)	1.4 (1.4)	1 (0-2)	52/685 (8)
≥ 1 psychological morbidity (n=141)	2.3 (1.6)	2 (1-3)	20/81 (25)	1.9 (1.7)	2 (1-3)	8/46 (17)

75-79 years (n=282)			80 years and older (n=109)			Differences in GFI ¹ -median scores between age groups	p-value
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)		
1.8 (1.5)	1 (1-3)	34/282 (12)	2.1 (1.5)	2 (1-3)	19/109 (17)		≤0.001
2.0 (1.2)	2 (1-3)	2/19 (11)	2.1 (1.5)	2 (1-2.8)	3/20 (15)		0.07
1.8 (1.5)	1 (1-3)	32/263 (12)	2.1 (1.5)	2 (1-3)	16/89 (18)		≤0.001
1.8 (1.5)	1 (1-3)	32/274 (12)	1.9 (1.4)	2 (1-3)	15/103 (15)		≤0.001
1.8 (1.7)	1 (0.8-4)	2/6 (33)	4.3 (2.0)	5 (2-6)	4/6 (67)		0.11
1.0 (1.4)	1 (0-NA) ⁶	0/2(0)	-	-	-		
1.9 (1.4)	2 (1-3)	11/87 (13)	2.1 (1.8)	2(1-3)	6/29 (21)		0.04
1.8 (1.5)	2 (1-3)	15/117 (13)	2.1 (1.4)	2 (1-3)	9/50 (18)		≤0.001
1.4 (1.3)	1(1-2)	5/71(7)	2.0 (1.5)	2 (1-3)	4/28 (14)		0.01
3.6 (3.1)	3 (1-4)	3/7 (43)	1.5 (2.1)	1.5 (0-NA)	0/2 (0)		0.99
2.1 (1.4)	2 (1-3)	10/53 (19)	2.2 (1.9)	2 (1-4)	5/18 (28)		0.05
2.0 (1.8)	2 (1-3)	7/52 (14)	2.6 (1.4)	2 (1.5-4)	6/21 (29)		≤0.001
1.6 (1.1)	2 (1-2)	3/59 (5)	1.8 (1.4)	1 (1-3)	3/20 (15)		0.07
1.6 (1.4)	1 (1-2)	8/82 (10)	1.9 (1.6)	2 (1-3)	4/32 (13)		0.01
1.8 (1.8)	1 (1-3)	6/36 (17)	1.9 (1.2)	2 (1-2)	1/18 (6)		0.21
1.3 (1.4)	1 (0-2)	7/79 (9)	1.6 (1.2)	1.5(1-2)	2/24 (8)		0.04
1.7 (1.3)	1 (1-2)	11/116 (10)	1.7 (1.5)	1 (1-2.3)	5/238 (15)		0.02
2.3 (1.6)	2 (1-3)	16/87 (18)	2.6 (1.6)	2 (1-4)	12/47 (26)		0.09
1.7 (1.4)	1 (1-3)	31/271 (11)	2.0 (1.5)	2 (1-3)	18/106 (17)		≤0.001
3.2 (2.7)	2 (2-5)	3/11 (27)	3.0 (2.6)	2 (1-NA)	1/3 (33)		0.30

Table 2c (continued)

	65-69 years (n=1,545)			70-74 years (n=731)		
	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)
OBESITY						
General obesity						
(Body Mass Index in kg/m²)						
< 25 (n=750)	1.1 (1.2)	1 (0-2)	23/419 (5)	1.3 (1.2)	1 (0-2)	10/210 (5)
25-<30 (n=1,506)	1.4 (1.4)	1 (0-2)	88/858 (10)	1.5 (1.4)	1 (0-2)	43/433 (10)
30-<35 (n=366)	1.6 (1.5)	1 (1-2)	27/236 (11)	1.6 (1.5)	1 (1-2)	5/79 (6)
≥35 (n=44)	2.1 (1.4)	2 (1-3)	5/32 (16)	2.7 (1.7)	3 (1.5-4)	2/9 (22)
Abdominal adiposity						
(waist circumference in cm)						
<94 (n=751)	1.1 (1.3)	1(0-2)	26/435 (6)	1.2 (1.3)	1 (0-2)	14/225 (6)
94-<102 (n=929)	1.3 (1.4)	1 (0-2)	50/528 (10)	1.3 (1.3)	1 (0-2)	15/262(6)
≥ 102 (n=987)	1.6 (1.5)	1 (0-2)	67/582 (12)	1.8 (1.5)	1 (1-3)	31/244 (13)
HEALTHCARE UTILIZATION						
Home care						
No home care provided (n=2,639)	1.4 (1.4)	1 (0-2)	142/1,541 (9)	1.5 (1.4)	1 (0-2)	60/725 (8)
Home care provided (n=28)	2.0 (2.2)	1.5(0.3-4.3)	1 /4 (25)	2 (0.9)	2 (1-3)	0/6 (0)
Primary care						
No visit to primary care clinic (n=352)	1.2 (1.3)	1 (0-2)	19/232 (8)	0.9 (1.1)	1 (0-1)	2/84 (2)
≥ 1 visit to primary care clinic (n=2,315)	1.4 (1.4)	1 (0-2)	124/1,313 (9)	1.5 (1.4)	1 (0-2)	58/647 (9)
Primary care emergency visit						
No emergency visit (n=2,514)	1.4 (1.4)	1 (0-2)	133/468 (9)	1.4 (1.4)	1 (0-2)	53/688 (8)
≥ 1 emergency visit (n=153)	1.8 (1.4)	1 (1-2.5)	10/77 (13)	1.7 (1.5)	1 (1-3)	7/43 (16)
Outpatient clinic						
No visit to outpatient clinic (n=1,230)	1.2 (1.3)	1 (0-2)	54/780 (7)	1.1 (1.1)	1 (0-2)	11/324 (3)
≥ 1 visit to outpatient clinic (n=1,437)	1.6 (1.4)	1 (1-2)	89/756 (21)	1.8 (1.5)	1 (1-3)	49/407 (12)

¹ Groningen Frailty Indicator (GFI), GFI- score 0-3 : non-frail ; GFI-score 4-15: frail

² Standard deviation

³ Interquartile range

75-79 years (n=282)			80 years and older (n=109)			Differences in GFI ¹ -median scores between age groups	p-value
GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)	GFI ¹ Mean (SD) ²	GFI ¹ Median (IQR) ³	Prevalence of frailty ¹ n (%)		
1.6 (1.4)	1 (1-2)	10/92 (11)	2.1 (1.3)	2 (1-3)	3/30 (10)	≤0.001	
1.8 (1.6)	1 (1-3)	17/154 (11)	1.9 (1.5)	1 (1-3)	10/61 (16)	≤0.001	
2.1 (1.3)	2 (1-3)	7/34 (21)	2.5 (1.8)	2 (1-3)	5/17 (29)	0.03	
2.5 (0.7)	NA	0/2 (0)	4.0 (NA)	NA	1/1 (100)	NA	
1.4 (1.3)	1 (0-2)	5/68 (7)	1.8 (1.4)	2 (1-2)	2/23 (9)	0.01	
2.1 (1.7)	2 (1-3)	16/98 (16)	1.8 (1.4)	2 (1-3)	6/41(15)	≤0.001	
1.7 (1.3)	1 (1-3)	13/116 (11)	2.4 (1.6)	2 (1-3.5)	11/45 (24)	0.002	
1.8 (1.5)	1 (1-3)	60/277(8)	1.9 (1.4)	2 (1-3)	12/96 (13)	≤0.001	
2.8 (1.3)	3 (1.5-4)	2/5 (40)	3.1 (2.2)	4 (1-5)	7/13 (54)	0.63	
1.5 (1.5)	1 (0.8-2)	4/26 (15)	1.1 (0.7)	1 (0.8-2)	0/10 (0)	0.09	
1.8 (1.5)	2 (1-3)	30/256 (12)	2.2 (1.5)	2 (1-3)	19/99 (19)	≤0.001	
1.7 (1.5)	1 (1-2.5)	29/257 (11)	2.0 (1.5)	2 (1-3)	17/101 (17)	≤0.001	
2.3 (1.6)	2 (1-3)	5/25 (20)	2.4 (1.2)	2 (1.3-3.8)	2/8 (25)	0.19	
1.2 (1.3)	1 (0-2)	6/86 (7)	2.1 (1.6)	2 (1-3)	8/40 (20)	≤0.001	
2.0 (1.5)	2 (1-3)	28/196 (14)	2.1 (1.5)	2 (1-3)	11/69 (16)	≤0.001	

⁴ Physical morbidity was assessed with the presence of diseases with the highest burden - according to the Disability-Adjusted Life Years measurement of the Dutch National Public Health compass: coronary heart disease (i.e. angina pectoris, arrhythmia or myocardial infarction), cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, arthritis, lung cancer, visual restrictions (i.e. cataract), heart failure, colon cancer

⁵ Psychological morbidities includes the following: major depressive disorder, dysthymia, generalized anxiety disorder, social phobia, panic disorder, agoraphobia, panic disorder with agoraphobia

⁶ Not applicable

Table 3 Mean and median scores on measures of frailty, case complexity, cognition, feelings and emotions, psychological problems, quality of life, stress, and wellbeing for the total population, non-frail population and frail population

	Total population n=5,712		Non-Frail population ¹ n=5,184	
	Mean (SD) ²	Median (IQR) ³	Mean (SD) ²	Median (IQR) ³
MEASURES				
Frailty (GFI) ¹	1.4 (1.4)	1 (0-2)	1.1 (1.0)	1 (0-2)
Case Complexity (IM-E-SA)⁴				
Social dysfunction	0.3 (0.8)	0 (0-0)	0.3 (0.7)	0 (0-0)
Feelings and emotions (PANAS)⁵				
Positive feelings	35 (4)	35 (32-37)	35 (4)	35 (32-38)
Negative feelings	20 (5)	20 (17-24)	20 (5)	20 (17-23)
Distressing bodily symptoms (SCL-90)⁶				
Somatization	16 (4)	15 (13-18)	16 (4)	15 (13-17)
Quality of life (RAND-36)⁷				
Physical functioning	83 (19)	90 (75-95)	84 (17)	90 (78-95)
Social function	89 (16)	100 (88-100)	91 (15)	100 (88-100)
Role limitations physical	85 (31)	100 (100-100)	87 (29)	100 (100-100)
Role limitations emotional	93 (23)	100 (100-100)	94 (20)	100 (100-100)
Mental health	82 (13)	84 (76-92)	83 (12)	84 (76-92)
Vitality	73 (16)	75 (65-85)	74 (15)	75 (65-85)
Bodily pain	84 (19)	90 (67-100)	85 (18)	90 (67-100)
General health	67 (12)	70 (60-75)	68 (12)	70 (60-75)
Stress				
Acute stress (LTE) ⁸	1.0 (1.1)	1 (0-2)	1.0 (1.1)	1 (0-2)
Chronic stress (LDI) ⁹	0.9 (1.2)	0 (0-1)	0.8 (1.2)	0 (0-1)
Well-being (SPF-IL)¹⁰				
Affection	9.3 (1.7)	9 (8-11)	9.5 (1.6)	9 (8-11)
Behavioral confirmation	9.2 (1.7)	9 (8-10)	9.4 (1.5)	9 (9-10)
Status	6.1 (1.7)	6 (5-7)	6.1 (1.7)	6 (5-7)

¹ Groningen Frailty Indicator (GFI), GFI- score 0-3: non-frail, GFI-score 4-15: frail

² Standard deviation

³ Interquartile range

⁴ INTERMED for the Elderly Self Assessment

⁵ Positive And Negative Affect Schedule

⁶ Symptom Checklist 90 subscale Somatization

⁷ RAND-36-item Health Survey

⁸ List of Threatening Experiences

⁹ Long-term Difficulties Inventory

¹⁰ Social Production Function Instrument for the Level of Well-being

	Frail population ¹ n=528		Difference in median scores between non-frail and frail elderly persons
	Mean (SD) ²	Median (IQR) ³	p-value
	4.6 (0.9)	4 (4-5)	≤ 0.001
	0.9 (1.2)	0 (0-1)	≤ 0.001
	32 (5)	33 (29-35)	≤ 0.001
	23 (6)	23 (19-26)	≤ 0.001
	20 (6)	18 (15-23)	≤ 0.001
	69 (24)	70 (55-90)	≤ 0.001
	77 (22)	75 (63-100)	≤ 0.001
	63 (41)	75 (25-100)	≤ 0.001
	79 (36)	100 (67-100)	≤ 0.001
	72 (17)	76 (60-84)	≤ 0.001
	59 (19)	60 (45-75)	≤ 0.001
	72 (24)	69 (57-100)	≤ 0.001
	59 (13)	60 (50-70)	≤ 0.001
	1.2 (1.2)	1 (0-2)	0.003
	1.7 (1.8)	1 (0-2)	≤ 0.001
	7.5 (1.9)	7 (6-9)	≤ 0.001
	7.3 (1.9)	7 (6-8)	≤ 0.001
	5.5 (1.6)	6 (4-6)	≤ 0.001

Table 4 Univariate and multivariate logistic regression models to assess associations between frailty and demographic characteristics, morbidity, and biometric measures

	Univariate model		Multivariate model ¹	
	OR (95% CI) ²	p-value	OR (95% CI)	p-value
DEMOGRAPHIC CHARACTERISTICS				
Gender ³	1.08 (0.91-1.30)	0.39	-	-
Age	1.05 (1.03-1.07)	≤ 0.001	1.04 (1.02-1.06)	≤ 0.001
Marital status ⁴	0.81 (0.65-1.01)	0.06	-	-
Living situation ⁵	3.64 (2.08-6.39)	≤ 0.001	2.65 (1.46- 4.81)	≤ 0.001
Education level ⁶	0.66 (0.55-0.79)	≤ 0.001	0.74 (0.61-0.89)	0.002
MORBIDITY				
Physical morbidity ⁷	2.60 (2.07-3.28)	≤ 0.001	2.26 (1.78-2.87)	≤ 0.001
Psychological morbidity ⁸	3.12 (2.43-4.00)	≤ 0.001	2.90 (2.24-3.77)	≤ 0.001
BIOMETRIC MEASURES				
Obesity ⁹	1.76 (1.46-2.12)	≤ 0.001	1.46 (1.20-1.77)	≤ 0.001

¹ If the variable had a p-value ≤0.15 in the univariate analysis, it was considered in the final multivariable model (if p-value was 0.05)

² OR: Odds Ratio, 95%CI: 95% Confidence Interval

³ Gender: 0 is female; 1 is male

⁴ Marital status: 0 is no partner/spouse; 1 is partner/spouse

⁵ Living situation: 0 is living independently; 1 is living in assisted living-residences

⁶ Education level: 0 is primary school or lower; 1 is secondary school or higher

⁷ Physical Morbidity: 0 is no physical morbidity; 1 is the presence of at least one of the following diseases: coronary heart disease (i.e. angina pectoris, arrhythmia or myocardial infarction), cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, arthritis, lung cancer, visual restrictions (i.e. cataract), heart failure, colon cancer.

⁸ Psychological morbidity: 0 is no psychological morbidity; 1 is the presence of at least one of the following diseases: major depressive disorder, dysthymia, generalized anxiety disorder, social phobia, panic disorder, agoraphobia, panic disorder with agoraphobia

⁹ Obesity: 0 is Body mass index (kg/m²) is < 30 and waist circumference < 88 cm (females), < 102 cm (males); 1 is Body mass index (kg/m²) is ≥ 30 or waist circumference is ≥ 88 cm (females) or ≥ 102 cm males

3.4 DISCUSSION

This study supports the construct validity of the GFI in community-dwelling elderly persons who participated in LifeLines. The GFI demonstrated discriminatory validity between elderly subgroups, which is consistent with results of two psychometric studies^{14,15}. The frailty scores stratified for age and gender showed some opposite results in subgroups that differed between general obesity and abdominal obesity. However, combining both obesity measures in one, it showed a strong association with frailty. This intriguing result is consistent with the results of a systematic review which showed that obesity in later life contributed to (physical) frailty⁴⁰. On the one hand excessive adiposity contributes to frailty by reducing the ability of elderly persons to perform physical activities and increasing metabolic instability⁴⁰. On the other hand, severe underweight is also associated with frailty due to the loss of muscles strength and mass⁴⁰. The latter could, however, not be assessed due to the low number of underweight persons in the study.

Compared with the non-frail, frail elderly persons experienced more chronic stress and more social/psychological related problems. This is congruent with a study that published an association between allostatic load and frailty⁴¹.

The presented extensive overview of frailty scores for specific subgroups may be beneficial for intervention development. For example, interventions based on self management abilities with a focus on either physical or psychosocial activities may strengthen an individual's spirit or establish some weight loss, which consequently may result in a decrease in GFI-scores⁴². Frail elderly persons should be identified as early as possible since frailty is potentially reversible when adequate care interventions are provided^{43,44}. The present study showed that almost all elderly persons visited their general practitioner annually. Therefore, the primary care clinic may be the evident healthcare setting to screen for frailty in elderly populations, preferably using a web-based questionnaire or a smartphone-app.

The present study has potential limitations. The presented frailty scores are consistently lower than the scores reported in previous studies that included a broad sample of Dutch community -dwelling elderly^{14,15,19,20}. This can be explained by the lower mean age in our study, compared with the age in the other studies (range 73-81 years). Moreover, in contrast with those studies, in this study elderly persons with cognitive impairment were excluded. Apparently, a vigorous subgroup of the elderly population was included in the present study, which was also reflected by the higher levels of quality of life and lower levels of chronic stress compared with other community-dwelling elderly populations^{33,34}. Furthermore, the age group of 80 years and older was relatively small and therefore

the results for this age group should be interpreted with caution. As there are no data available on non-responders in LifeLines, it is unknown to which extent selection bias may have occurred. It is possible that elderly persons with an interest in their own health status and with fewer disabilities were more able and willing to participate in the cohort-study.

The extensive assessment of construct validity of the GFI in the population of LifeLines was a major strength of the study due to the enormous data collection of demographic characteristics, morbidity, obesity and measures. We recommend repeating some of the baseline measures in the follow-up period of LifeLines, to examine the process of ageing extensively for all age-groups, especially those in the oldest age old group. Furthermore, with these follow-up data we recommend the evaluation of the predictive validity of the GFI. Finally, we recommend other researchers to develop tailored interventions to enhance strength and reduce vulnerability in home-dwelling elderly persons, which will be beneficial for the elderly persons to maintain their lives as autonomously as possible according to their own choices and wishes.

3.4.1 Conclusion

the present study supported the construct validity of the GFI and provided an extensive overview of characteristics of frail community-dwelling elderly persons participating in LifeLines.

3.4.2 Acknowledgements

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