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The SHARE Frailty Instrument for primary care predicts mortality similarly to a frailty index based on comprehensive geriatric assessment

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Abstract

Aim—frailty is an emerging concept in primary care, which potentially can provide healthcare commissioners with a clinical focus for targeting resources at an ageing population. However, primary care practitioners need valid instruments that are easy to use. With that purpose in mind, we created a Frailty Instrument (FIt) for primary care based on the *Survey of Health, Ageing and Retirement in Europe* (SHARE). The aim of the present study was to compare the mortality prediction of the 5-item SHARE-FIt with that of a 40-item Frailty Index (FIx) based on comprehensive geriatric assessment (CGA).

Methods—the subjects were 15,578 women and 12,783 men from the first wave of SHARE. A correspondence analysis was used to assess the degree of agreement between phenotypic classifications. The ability of the continuous frailty measures (FIt score and FIx) to predict mortality (mean follow-up of 2.4 years) was compared using receiver operating characteristic (ROC) plots and areas under the curve (AUCs).

Results—in both sexes, there was significant correspondence between phenotypic categories. The two continuous measures performed *equally well* as mortality predictors (women: AUC-FIx = 0.79, 95% CI: 0.75 – 0.82, $P < 0.001$; AUC-FIt = 0.77, 95% CI: 0.73 – 0.81, $P < 0.001$. Men: AUC-FIx = 0.77, 95% CI: 0.74 – 0.79, $P < 0.001$; AUC-FIt = 0.76, 95% CI: 0.74 – 0.79, $P < 0.001$). Their equivalent performance was confirmed by statistical comparisons of the AUCs.

Conclusions—SHARE-FIt is simpler and more usable, and predicts mortality similarly to a more complex FIx index based on CGA.

Keywords

Frail Elderly; Severity of Illness Index; Longitudinal Study; Mortality; Validation studies

Introduction

Frailty in older adults is a key clinical concept characterized by dysregulation of multiple biological systems, accumulation of deficits, vulnerability to stressors and increased risk of adverse outcomes such as falls, disability, hospitalization, institutionalization and death [1–3]. Although there is no international consensus on the definition of frailty [4,5], two popular operationalizations are the *phenotypic* and one defined by *accumulation of deficits* [6].

Disclosure
The author has no conflict of interest.

According to the phenotypic approach, frailty is defined as a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed, and low physical activity [7,8]. Surrogates for individual criteria are possible [9–12]. The phenotypic approach defines two additional states: pre-frail (i.e. one or two criteria present) and non-frail (i.e. none of the criteria present) [8]. An advantage of this approach is that it requires the measurement of only five variables, which makes the frailty assessment relatively quick.

Another way to operationalize frailty is by counting in an individual the number of deficits that he/she has accumulated from a given list (of usually 40 or more potential deficits) [13]. The number of counted deficits divided by the number of deficits considered results in a score called *frailty index* (FIx), which ranges from 0 (i.e. none of the deficits present) to 1 (i.e. all deficits present). The FIx approach is usually based on *comprehensive geriatric assessment* (CGA) [14]. Therefore, compared to the phenotypic approach, the FIx approach is more time consuming.

Frailty is an emerging concept in primary care [15], which potentially can provide healthcare commissioners with a clinical focus for targeting resources at an ageing population [16,17]. However, in order to fulfil that purpose, family physicians and community practitioners need valid instruments for frailty that are *easy to use* [18]. With that purpose in mind, we created and validated a Frailty Instrument (FIt) for primary care based on the *Survey of Health, Ageing and Retirement in Europe* (SHARE) [19]. This FIt is based on a modified phenotypic approach and includes two web-based frailty calculators (one for each gender) that are freely accessible on *BMC Geriatrics* (http://www.biomedcentral.com/1471-2318/10/57/additional). Their use is intended for community-dwelling adults aged 50 and over. Translated versions of the calculators can be accessed on https://sites.google.com/a/tcd.ie/share-frailty-instrument-calculators/. We have validated the SHARE FIt against incident disability [20] and mortality [21].

The English *NHS Evidence Adoption Centre* has rated SHARE-FIt as a potentially useful and highly usable tool for the individual assessment of frailty [22]. Furthermore, a recent systematic review of frailty screening tools in primary care identified SHARE-FIt as a promising measure in the primary care setting [23]. However, in the latter publication it was pointed out that there is no comparison of the tool with a reference geriatric assessment [23]. In that regard, we recently operationalized a FIx on SHARE based on 40 potential deficits [24], including the five defining SHARE-FIt. We found that SHARE-FIx was a powerful predictor of mortality [24], but we did not know the extent to which the addition of a considerably higher number of measurements would improve the mortality prediction *vis-à-vis* the more user-friendly SHARE-FIt. In order to answer that question, the aim of the present study was to compare the performance of these two tools to classify the SHARE sample and predict mortality.

Materials and methods

Subjects

15,578 women and 12,783 men from the first wave of the *Survey of Health, Aging and Retirement in Europe* (http://www.share-project.org/), including representative samples of 12 European countries: Austria (n = 1,620), Germany (n = 2,746), Sweden (n = 2,852), Netherlands (n = 2,777), Spain (n = 2,212), Italy (n = 2,304), France (n = 2,784), Denmark (n = 1,637), Greece (n = 2,581), Switzerland (n = 956), Belgium (n = 3,663) and Israel (n = 2,229). All subjects had information for both FIt and FIx.

Creation of SHARE-FIt

As detailed in our main study [19], SHARE-FIt was created via estimation of a discrete factor (DFactor) model based on five adapted phenotypic frailty items [12] (i.e. grip strength and four self-reported items: fatigue, loss of appetite and/or eating less than usual, difficulties climbing stairs and/or walking 100 metres, and low level of physical activity), using the LatentGOLD® statistical package. A DFactor with three ordered levels or latent classes (*non-frail*, *pre-frail* and *frail*) was obtained for each sex. When data is entered into the web-based calculator (http://www.biomedcentral.com/1471-2318/10/57/additional), the tool provides a continuous *frailty score* (i.e. the 'predicted discrete factor score', whose formulae are given in the paper) and enables classification into phenotypic *frailty categories*: non-frail, pre-frail and frail [19].

Creation of SHARE-FIx

Based on the first wave of SHARE, a 40-item FIx was created as per standard procedure [13]. Each of the 40 deficit variables was scored such that 0 = deficit absent and 1 = deficit present. The scores were added and divided by the total number of deficits evaluated (i.e. 40), to produce a FI between 0.0 (i.e. no deficits present) and 1.0 (i.e. all deficits present). Table 1 shows the FIx deficit variables and cut-off points. Primarily, the FIx is a continuous variable, but it can be graded to be equivalent to the phenotypic definition: non-frail (FIx < 0.08), pre-frail (0.08 ≤ FIx < 0.25) and frail (FIx ≥ 0.25) [25].

SHARE-FIt and SHARE-FIx: common variables

As Table 1 shows, the phenotypic variables that were used to construct SHARE-FIt [19] were included as deficits in SHARE-FIx [24]. Thus, SHARE-FIx is based on the SHARE-FIt measurements plus 34 additional measurements.

Mortality prediction

Wave 2 established whether wave 1 participants had died, were still alive, or had been lost to follow-up. For those who had died, the exact time to death since the initial interview was not collected. Wave 1 data were collected between 2004–2006 and wave 2 between 2006–2007. The mean individual follow up period between Wave 1 and Wave 2 was 2.4 years.

Statistical analyses

Unless otherwise indicated, statistics were computed with SPSS 16.0, separately for each sex. The level of significance was established at 0.01 throughout.

The correlation between the two continuous frailty measures, the FIt score and the FIx, was assessed with the Spearman's rank correlation coefficient (the normality of the variables was previously checked with the one-sample Kolmogorov-Smirnov test, and they were found non-normally distributed in both sexes). *Correspondence analysis* (with symmetrical normalization) was used to assess the degree of agreement between the two phenotypic classifications (FIt and FIx categories); correspondence analysis examines the relationship between two categorical variables graphically in a multidimensional space, and produces plots based on the scores. Categories that are similar to each other appear close to each other in the plots. In this way, it is easy to see which categories of a variable are similar to each other or which categories of the two variables are related.

To compare the performance of the phenotypic classifications (i.e. FIt and FIx categories) to predict mortality, Chi-square cross-tabulations were used, with the Phi statistic as measure of association (data were non-parametric). To compare the ability of the two continuous frailty measures (i.e. FIt score and FIx) to predict mortality, we used *receiver operating*

characteristic (ROC) plots. The pairwise comparison of the ROC curves was undertaken using the MedCalc® 12.3 statistical package (by selecting the 'comparison of ROC curves' procedure; the DeLong comparison method was selected).

Results

15,578 women and 12,783 men from the first wave of SHARE had information for both FIt and FIx. Two hundred and sixty-seven women and 361 men had died at follow-up.

Correlation between FIt-frailty score and FIx

In women, the bivariate correlation between the FIt-frailty score and the FIx was strong and highly significant (two-tailed Spearman's rank correlation coefficient: 0.70, $P < 0.001$). The same applied to men (two-tailed Spearman's rank correlation coefficient: 0.59, $P < 0.001$).

FIt and FIx categories: correspondence analysis

In women, there was a significant correspondence between FIt and FIx categories (inertia = 0.55, Chi-square = 8517.51, df = 4, $P < 0.001$). Table 2 shows the correspondence table and Figure 1 shows the correspondence biplot.

In men, there also was a significant correspondence between FIt and FIx categories (inertia = 0.48, Chi-square 6164.49, df = 4, $P < 0.001$). Table 2 shows the correspondence table and Figure 1 shows the correspondence biplot.

FIt and FIx categories: prospective mortality rates

Table 3 shows the prospective mortality information (mean follow-up: 2.4 years) for FIt and FIx categories, by gender. In women, the association between FIt categories and mortality was statistically significant (Chi-square = 281.05, df = 2, $P < 0.001$; Phi = 0.164, $P < 0.001$); and the association between FIx categories and mortality was also significant (Chi-square = 520.80, df = 2, $P < 0.001$; Phi = 0.214, $P < 0.001$).

In men, the association between FIt categories and mortality was statistically significant (Chi-square = 402.37, df = 2, $P < 0.001$; Phi = 0.216, $P < 0.001$); and the association between FIx categories and mortality was also significant (Chi-square = 520.34, df = 2, $P < 0.001$; Phi = 0.238, $P < 0.001$).

Mortality prediction by FIt score and FIx: ROC analyses

In women, the FIx had an area under the curve (AUC) of 0.79 (95% confidence interval, CI: 0.75 – 0.82; standard error, SE = 0.02; $P < 0.001$). The FIt score had an AUC of 0.77 (95% CI: 0.73 – 0.81; SE = 0.02; $P < 0.001$). Figure 2 shows the ROC curves. The pairwise comparison of the ROC curves showed the following results: Z statistic = 1.18, $P = 0.238$ (the non-significant P value indicates that the AUCs were not significantly different).

In men, the FIx had an AUC of 0.77 (95% CI: 0.74 – 0.79; SE = 0.01; $P < 0.001$), and the FIt score had an AUC of 0.76 (95% CI: 0.74 – 0.79; SE = 0.01; $P < 0.001$). Figure 2 shows the ROC curves. The pairwise comparison of the ROC curves showed the following results: Z statistic = 0.22, $P = 0.826$ (the AUCs were not significantly different).

Discussion

The present study compared the ability of SHARE-FIt [19] and SHARE-FIx [24] to predict mortality over a mean follow-up of 2.4 years in a large European population-based sample. Whilst the use of SHARE-FIx is unlikely to be feasible in a primary care context given the

high number of measurements required, SHARE-FIt only requires five simple measurements to be entered in an open-access online calculator.

Overall, in both women and men, there was a strong direct correlation between the FIt score and FIx. There was also a significant correspondence between the phenotypic categories. As Figure 1 shows, non-frail categories showed the highest degree of closeness; and pre-frail and frail categories were somewhat closer in women than in men. The frail definition by FIt was more 'restrictive' than the one by FIx, as supported by the fact that none of those classified as frail by FIt were classified as non-frail by FIx; however, 136 frail women and 125 frail men by FIx were non-frail by FIt (Table 2). This means that, in practice, FIt may be more specific (and perhaps less sensitive) than FIx for the phenotypic diagnosis of frailty. However, the phenotypic FIx cut-offs used in the present study [25] are of arbitrary nature, and alternative FIx cut-offs have been proposed [26] that could lead to difference correspondences with the FIt categories. In contrast, the FIt cut-offs are non-arbitrary and derive from discrete factor analysis [19].

The two continuous measures, the FIt score and the FIx, performed *equally well* as mortality predictors in the ROC analyses, as evidenced by the overlap of 95% CIs for the AUC, both in women and in men (Figure 2). This suggests that the measurement of 34 additional variables with FIx does not translate, in terms of mortality prediction, into any marginal benefit. The simpler combined measurement of *exhaustion*, *appetite*, two *functional difficulties*, *physical activity* and *handgrip strength* predicted mortality just as well as a 40-item FIx. Hence, it is possible that not all the variables defining the FIx have the same relative importance, as far as prospective mortality is concerned, and some of them could be redundant. On the other hand, results may indicate that the variables defining the frailty phenotype, which are based on biological theory (i.e. the cycle of frailty) [8], are in fact a good 'summary' of the multiple system dysregulation that occurs in frailty, at least as far as mortality prediction goes.

As in the present study, the focus of previous studies has been the comparison of the ability of different frailty tools to predict frailty-related outcomes and, in general, they have also found similar predictive properties. For example, in the *Conselice Study of Brain Aging*, a 43-item FIx and a 7-item Brain Aging Score were strongly correlated with each other and each was independently predictive of death in a multivariate model [27]. In the *Canadian Study of Health and Aging*, the comparison of a 47-item FIx, a Clinical Frailty Score and the Fried frailty phenotype showed that all frailty measures allowed quantification of individual vulnerability and predicted both cognitive changes and mortality [28]. A recent multi-centre study compared the prognostic accuracy for all-cause mortality of various frailty instruments and found that all the frailty indexes considered were significantly associated with one-month and one-year all-cause mortality [29]. Other studies comparing phenotypic-based frailty tools have also found that simpler tools predict outcomes as well as more complex ones [30], with the advantage that the former may be more usable in a clinical setting [22].

SHARE-FIt is easy to use, freely accessible online (http://www.biomedcentral.com/1471-2318/10/57/additional) and may contribute to quality in primary care by helping assess and monitor frailty in community dwelling people over the age of 50, and prioritize their access to resources. Importantly, anyone using the online SHARE-FIt calculators should be aware that he/she is comparing him/herself to the European reference population as a whole, and not to the population of a specific participating country. The construction of SHARE-FIt was based on population-representative samples of 12 European countries, but the prevalences of frailty in the various participating countries have been noted to differ significantly [12], perhaps owing to European socio-economic gradients or even cultural differences in the interpretation of the subjective (i.e. self-reported) items [19]. In our original

study [19], we argued that the construction of country-specific SHARE-FIt calculators was at risk of underpower; for the same reason, the comparison of FIx and FIt at individual country levels was not undertaken, due to the small numbers of mortality events.

In conclusion, the present study provided further validation of the SHARE Frailty Instrument by comparing it with a Frailty Index based on comprehensive geriatric assessment, and found that their mortality prediction is very similar. SHARE-FI may contribute to quality in primary care by offering a readily accessible, simple and reliable way to assess and monitor frailty in community-dwelling adults over the age of 50, prioritize their access to resources and serve as a tool for audit and research.

Acknowledgments

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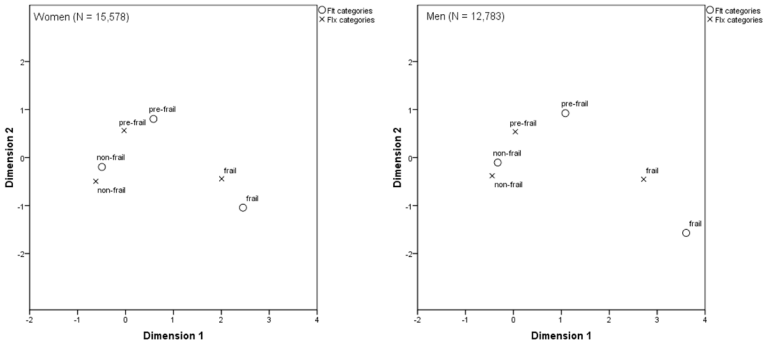

Figure 1.
Correspondence analysis between FIt and FIx categories.

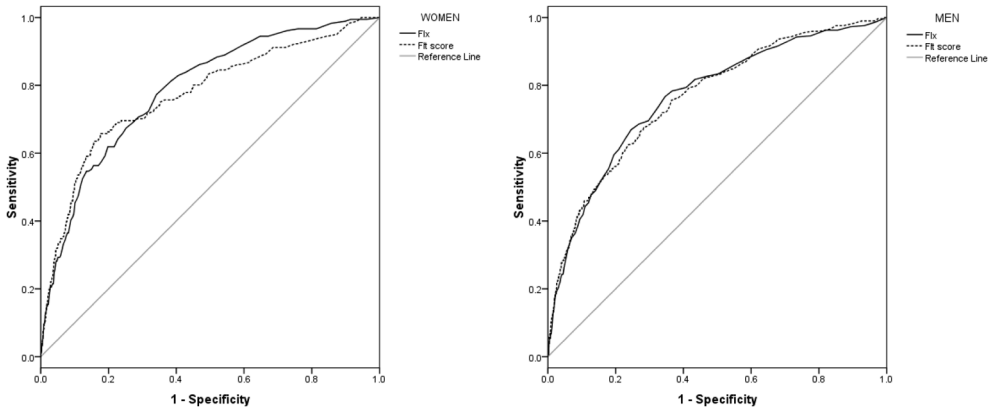

Figure 2.
Mortality prediction by FIt score and FIx: Receiver operating characteristic (ROC) curves, by gender.

Table 1

Health variables and cut-points for the SHARE Frailty Index (FIx). The phenotypic variables underlying the SHARE Frailty Instrument (FIt) are highlighted in bold.

SHARE code	Variable	Cut-point	Reference
ph049d3	Difficulties: bathing or showering	Yes = 1, No = 0	
ph049d1	Difficulties: dressing, including shoes and socks	Yes = 1, No = 0	
ph048d3	Difficulties: getting up from chair	Yes = 1, No = 0	
ph049d2	Difficulties: walking across a room	Yes = 1, No = 0	
ph049d4	Difficulties: eating, cutting up food	Yes = 1, No = 0	
ph048d7	Difficulties: reaching or extending arms above shoulder	Yes = 1, No = 0	
ph049d6	Difficulties: using the toilet, including getting up or down	Yes = 1, No = 0	
ph048d5	**Difficulties: climbing one flight of stairs**	Yes = 1, No = 0	
ph048d9	Difficulties: lifting or carrying weights over 5 kilos	Yes = 1, No = 0	
ph049d9	Difficulties: shopping for groceries	Yes = 1, No = 0	
ph049d12	Difficulties: doing work around the house or garden	Yes = 1, No = 0	
ph049d8	Difficulties: preparing a hot meal	Yes = 1, No = 0	
ph049d11	Difficulties: taking medications	Yes = 1, No = 0	
ph049d13	Difficulties: managing money	Yes = 1, No = 0	
ph048d1	**Difficulties: walking 100 metres**	Yes = 1, No = 0	
ph049d5	Difficulties: getting in or out of bed	Yes = 1, No = 0	
Phactiv	**Moderate or vigorous physical activity: hardly ever, or never**	Yes = 1, No = 0	
mh011_, mh012_	**Diminution in the desire for food and/or eating less than usual**	Yes = 1, No = 0	
Spheu	Self-perceived health	Very bad = 1, Bad = 0.75, Fair = 0.5, Good = 0.25, Very good = 0	(13)
ph004_	Long-term illness	Yes = 1, No = 0	
mh013_	**Fatigue**	Yes = 1, No = 0	
mh002_	Sad or depressed	Yes = 1, No = 0	
mh016_	Lack of enjoyment	Yes = 1, No = 0	
mh003_	Hopelessness	Yes = 1, No = 0	
ph006d2	Doctor told you had: high blood pressure or hypertension	Yes = 1, No = 0	
ph006d1	Doctor told you had: heart attack	Yes = 1, No = 0	
ph006d4	Doctor told you had: stroke	Yes = 1, No = 0	
ph006d10	Doctor told you had: cancer	Yes = 1, No = 0	
ph006d5	Doctor told you had: diabetes or high blood sugar	Yes = 1, No = 0	
ph006d8	Doctor told you had: arthritis	Yes = 1, No = 0	
ph006d6	Doctor told you had: chronic lung disease	Yes = 1, No = 0	
ph006d9	Doctor told you had: osteoporosis	Yes = 1, No = 0	
ph006d14	Doctor told you had: hip fracture or femoral fracture	Yes = 1, No = 0	

SHARE code	Variable	Cut-point	Reference
Orienti	Impaired orientation to date, month, year and day of week (i.e. less than good)	Yes = 1, No = 0	
Bmi	Body mass index (Kg/m^2) deficit	<18.5 or ≥30 = 1 25 to <30 = 0.5 18.5 to <25 = 0	(13)
ph010d3	Bothered by: breathlessness	Yes = 1, No = 0	
ph010d7	Bothered by: falling down	Yes = 1, No = 0	
ph010d8	Bothered by: fear of falling down	Yes = 1, No = 0	
ph010d9	Bothered by: dizziness, faints or blackouts	Yes = 1, No = 0	
Maxgrip	**Grip strength (Kg) deficit**	Men: • For BMI ≤ 24, GS ≤ 29 • For BMI > 24 and ≤ 28, GS ≤ 30 • For BMI > 28, GS ≤ 32 Women: • For BMI ≤ 23, GS ≤ 17 • For BMI > 23 and ≤ 26, GS ≤ 17.3 • For BMI > 26 and ≤ 29, GS ≤ 18 • For BMI > 29, GS ≤ 21	(13)

Table 2

Correspondence between FIt and FIx categories.

FIt categories	FIx categories			
	non-frail	pre-frail	frail	Active Margin
Women				
non-frail	5935	4349	136	10420
pre-frail	391	2669	965	4025
frail	0	179	954	1133
Active Margin	6326	7197	2055	15578
Men				
non-frail	6271	4121	125	10517
pre-frail	157	1212	502	1871
frail	0	49	346	395
Active Margin	6428	5382	973	12783

Table 3

FIt and FIx: prospective mortality rates.

	Women				Men			
	FIt		FIx		FIt		FIx	
	N total	N dead (%)	N total	N dead (%)	N total	N dead (%)	N total	N dead (%)
Continuous measure	15578	181 (1.7)	15578	181 (1.7)	12783	296 (3.4)	12783	296 (3.4)
Non-frail	10420	51 (0.7)	6326	15 (0.4)	10517	142 (2.0)	6428	51 (1.1)
Pre-frail	4025	67 (2.6)	7197	74 (1.5)	1871	102 (8.8)	5382	152 (4.2)
Frail	1133	63 (9.2)	2055	92 (7.0)	395	52 (22.6)	973	93 (16.0)