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Examining three frailty conceptualizations in their ability to predict negative outcomes for home-care clients

SIR—Although being recognized as an important issue for public health researchers [1] and for clinicians [2], the concept of frailty remains controversial [3]. Albeit some definitions of frailty have received considerable attention and support [4], there is still no broad consensus on the definition of frailty and how it should be measured [5–7]. One way to compare the utility of alternative operationalisations of frailty is to test their relative ability to predict negative outcomes. Prior studies have compared the predictive ability of various measures of frailty in community samples of older persons [8, 9]; fewer studies have compared frailty measures in older persons within a health-care setting.

Home health services are an increasingly important component of the health-care system [10]. We chose to compare three common conceptualisations of frailty in a large sample of older home-care clients in Ontario, Canada. Given that home-care services play a critical role in managing the transition between community and institutional living for older individuals [10], the ability to identify the most at-risk frail individuals in this population is important. A frailty measure that was strongly predictive of poor outcomes among home-care clients could be used to target individuals for preventive or supportive interventions.

Methods

For these analyses, we made use of a large database ($n = 23,952$) with comprehensive health information on home care clients (aged 65+) of eight Community Care Access Centres (CCACs) in Ontario, Canada. CCACs coordinate access to home-care services and long-term care placement in the province.

Data were collected using the RAI-HC (sometimes referred to as MDS-HC [11, 12]), an assessment that has been mandated in Ontario since 2002 for all home-care clients expected to use services for longer than 60 days. The RAI-HC is one of a family of assessment tools developed by the international inter-RAI consortium [13]. The data entry software that collected the assessment information has checks at input, which constrains item responses as non-missing, within appropriate ranges, and with logical checks.

Frailty measures

For our comparison, we were interested in three conceptually different approaches to the measurement of frailty that could be operationalised using RAI-HC data. The first measure of frailty included is the Changes in Health, End-Stage Disease and Signs and Symptoms (CHESS) scale. This measure utilises client assessment information in its calculation and is designed to identify individuals at risk of serious decline [13]. The CHESS scale was developed using statistical methods, based on items available in the interRAI instruments. Although not explicitly a frailty measure, it is described as a measure of health 'instability'—an analogous concept—and to be predictive of mortality. The scores ranging from 0 (meaning no instability) to 5 (for the highest level of instability) have been demonstrated to be a strong predictor of mortality ($P < 0.0001$) in continuing care patients [13]. The second measure examined is the Edmonton Frail Scale (EFS), a brief multidimensional clinical measure designed for geriatricians in both inpatient and outpatient settings [14]. With the maximum score of 17 representing the highest level of frailty, the EFS is constructed of items from the following domains: cognition, general health status, functional independence, social support, medication use, nutrition, mood, continence and functional performance. In post-operative older adults, high scores on the EFS has been shown to be associated with increased complications and a lower chance of being discharged home after surgery [15]. To

operationalise the EFS, items were selected from the RAI-HC that were comparable to the items found in the EFS. The complete list of corresponding items can be seen in Supplementary data available in *Age and Ageing* online.

The third frailty measure is a frailty index (FI) developed by Rockwood and Mitnitski [16] based on an 'accumulation of deficits' approach. The FI is based on the view that frailty is a non-specific multifactorial state that is better characterised by the quantity, rather than the quality, of health deficits that an individual accumulates during the life course [16]. The FI is calculated as the proportion of potential deficits that are present in a given individual and can be calculated in most ageing databases [17]. An FI was constructed in the RAI-HC data using procedures outlined in Searle *et al.* [17] (see Supplementary data available in *Age and Ageing* online).

Analyses

Outcomes were dichotomised into adverse outcomes (institutionalisation or death) or favourable outcomes (discontinuation of services) for all discharged from the home-care services. For each measure, clients with the lowest 60% of the scores comprised the low grouping (Least Frail Grouping), the middle 25% comprised the mid-range grouping (Medium Grouping) and the highest 15% of the scores were positioned into the high grouping (Most Frail Grouping). The Cox proportional hazards analyses were performed with each measure to determine how well each one predicted time to event (adverse outcome) for the home-care clients. Each model controlled for age and gender.

Statistical analyses were carried out using SAS version 9.1.3 [18].

Results

Sample characteristics are presented in Supplementary data available in *Age and Ageing* online. Within 1 year of the assessment, 19% of the home-care clients were institutionalised and 7% were deceased.

The FI and the EFS were moderately correlated with each other within the home-care data set ($r = 0.61$). The correlations between CHESS and the other measures were low (EFS, $r = 0.39$; FI, $r = 0.35$).

For each of the frailty measures, the frailest clients had a higher proportion of individuals with psychotropic drug use, antidepressant drug use, recent weight loss, a dementia diagnosis, morbid obesity and unsteady gait. The frailest clients were more likely to be male and a significant difference between chronological age was only found between the FI groupings. These results can be found in Table 1.

When examining the time to adverse outcome, the Cox proportional hazards analyses indicated that each of the frailty measures significantly predicted time to adverse outcome. By comparing those in the frailest grouping of each measure with those in the least frail grouping, individuals had hazard ratios well over 1.00 (CHESS HR = 2.32;

Table 1. Group comparison of variables of interest at initial assessment

| | Frailty measures | | | | | |
| | EFS | | CHESS | | FI | |
	Least frail	Frailest	Least frail	Frailest	Least frail	Frailest
Average frailty score	1.92	7.00*	0.52	3.22*	0.18	0.42*
Average age	81.82	81.67	81.71	81.80	81.32	82.53*
Gender (% female)	71.3	65.3*	70.8	64.6*	71.5	66.0*
Antipsychotic drug use (%)	5.44	14.64*	7.47	9.29**	5.17	14.71*
Antidepressant drug use (%)	17.96	28.81*	20.88	23.17**	17.49	30.83*
Recent weight loss (%)	3.84	20.67*	2.05	32.75*	6.72	13.67*
Smokers (%)	7.13	6.67	7.20	8.03**	8.08	5.15*
Drinking problem (%)	0.98	1.73**	1.09	1.82**	1.30	1.14
Dementia (%)	13.66	35.66*	17.92	25.95*	11.27	40.02*
Unsteady gait (%)	50.92	73.94*	51.74	74.22*	45.39	85.10*
Average number of falls	0.42	0.60*	0.45	0.59*	0.49	0.84*
Morbid obesity (%)	2.60	2.85	2.25	3.75**	2.20	4.17*

*Significantly different from least frail group at <0.0001 level.
**Significantly different from least frail group at the 0.05 level.

EFS HR = 2.49; FI HR = 1.93). Being female was protective and increasing age was detrimental. The Cox proportional hazards model results are found in Table 2.

Discussion

In this large cohort of older home-care clients, we found that greater evidence of frailty as defined by each of the three measures was associated with greater risk of adverse outcomes. This result, additionally confirmed in logistic regression analyses, demonstrates the potential utility of a frailty concept for identifying vulnerable individuals within the home health-care sector. We believe that the results of this study provide additional evidence for the validity of all three approaches as measures of frailty. The CHESS was initially proposed as a measure of health instability that was predictive of mortality—in this study, its ability to predict negative outcomes was comparable to that of the EFS and FI that were

Table 2. Results of the regression analyses[a]

	EFS	CHESS	FI
Medium grouping			
Hazard ratio (95% CI)	1.71 (1.60–1.83)	1.69 (1.58–1.80)	1.34 (1.26–1.42)*
Frailest grouping			
Hazard ratio (95% CI)	2.49 (2.32–2.68)	2.32 (2.15–2.51)	1.93 (1.79–2.08)*

[a]Cox proportional hazards regression results: modelling time to adverse outcomes: comparing medium scoring and highest scoring groups with the low scoring group.
*In order to have an interpretable OR, the FI was converted to a continuous value by multiplying the index score by 100.

more explicitly intended as measures of frailty. There is potential for the EFS to be utilised as a brief clinical instrument that can be completed by non-specialists to measure frailty in older adults. Also, mathematical models, such as the FI, can utilise data collected during clinical assessments to provide a quantitative indicator of a client's level of frailty.

Despite these results, our modelling of adverse outcomes predicted by age, gender and frailty measures demonstrated that each frailty measure performed at approximately the same level with large amounts of unexplained variance remaining in each model. Additional conceptual and empirical work in home-care settings might improve the performance of these measures. All three of the frailty conceptualisations take a primarily biomedical approach and address characteristics pertaining directly to the individual. However, in order to remain in the community, older individuals also rely on aspects in their social (e.g. caregivers) and physical (e.g. quality of housing) environment [19]. Therefore, for home-care clients, adjusting the frailty measures to reflect more of a biopsychosocial or integrative [7] approach may improve their utility.

The maximum score achieved on the FI (0.66) corresponds with the previous work performed on limits of the FI. Rockwood and Mitnitski [20], in evaluating the limits to a FI, found that, for 33,069 individuals aged 65+, the maximum score that could be achieved was 0.65 ± 0.05. Our data reinforce their earlier findings that a limit may exist in the accumulation of deficits where higher levels of frailty are unsustainable.

Research by Markle-Reid *et al.* [21] has demonstrated that proactive care with home-care services resulted in better health outcomes (reduced depression, better mental health functioning, enhanced perception of social support) at no additional costs from a societal perspective. The ability to identify individuals who are currently receiving care within the community and at most risk of adverse outcomes would be extremely useful in targeting home-care clients for such interventions.

Key points

- Greater evidence of frailty as defined by each of the three measures was associated with a greater risk of adverse outcomes.
- For home-care clients, adjusting the frailty measures to reflect more of a biopsychosocial or integrative approach may improve their utility.
- The ability to identify individuals at most risk of adverse outcomes would be useful in targeting interventions towards unstable home-care clients.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

Conflicts of interest

None declared.

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Frailty measures, inflammatory biomarkers and post-operative complications in older surgical patients

SIR—The syndrome of frailty is a state of increased vulnerability towards stressors in older individuals, leading to an heightened risk of experiencing adverse health outcomes [1].

An operational definition is the one-dimensional physical 'frailty phenotype', which includes the presence of at least three of the following five criteria: unintentional weight loss, exhaustion, muscle weakness, slow walking speed and reduced physical activity [2].

A different tool to detect vulnerability in older patients is the Comprehensive Geriatric Assessment (CGA)—a multidimensional evaluation of health status including comorbidity, polypharmacy, physical functioning, nutritional and cognitive status, depression and social support. Based on a CGA, patients may be categorized into groups of fit, intermediate or frail [3]. CGA may uncover potentially remediable medical problems with implications for treatment, prognosis and rehabilitation [4–6]. We have previously shown that a CGA-based frailty measure predicts postoperative complications in older patients undergoing surgery for colorectal cancer [7].

An important aspect of the pathophysiology of frailty seems to be dysregulation of inflammatory pathways and of the coagulation system [1]. Thus, measuring circulating biomarkers might contribute to the clinical diagnosis of frailty. Higher serum levels of the acute-phase protein C-reactive protein (CRP), as well as the inflammatory cytokines interleukin-6 (IL-6) and tumour necrosis factor-α (TNF-α), have been associated with reduced physical function and

different frailty measures [8–13]. Increased levels of plasma D-dimer, a marker of ongoing coagulation and fibrinolysis, have also been linked to these outcomes [8, 11].

The purpose of this study was to compare levels of inflammatory biomarkers (CRP, IL-6, TNF-α), and D-dimer in elderly colorectal cancer patients classified according to a modified version of the physical frailty phenotype and according to a CGA. We further wanted to investigate the predictive value of the individual biomarkers for the development of post-operative complications [7].

Materials and methods

This was a substudy of a prospective study designed to explore whether CGA frailty predicted post-operative complications in elderly patients with colorectal cancer [7]. The Regional Committee for Medical and Health Research Ethics in Eastern Norway approved the study. Patients provided a written informed consent.

Eligible participants were inpatients from three public hospitals in Norway (Ullevål, Aker and Akershus University Hospitals), 70 years and older, undergoing elective resections of tumours in colon or rectum.

A physician trained in geriatrics performed a pre-operative CGA, and blood samples were collected within 14 days before surgery. For details on assessment tools, frailty classifications and the analyses of blood samples, see Supplementary data available in *Age and Ageing* online.

Information on post-operative complications was retrospectively collected from hospital records, along with information from staff, patients and caregivers. Complications were classified as minor (grade I), potentially life-threatening with (grade II) or without (grade III) sequelae or fatal (grade IV) based on the grading system developed by Clavien *et al.* [14]. Details on this are given in Supplementary data available in *Age and Ageing* online. The outcome variables were defined as 'severe' ($\geq$grade II) versus 'no/mild' complications ($\leq$grade I) and 'any' complication versus 'no' complications.

Non-parametric statistics were applied due to skewed distribution of biomarkers. The D-dimer analyses had a lower detection level of 0.04 mg/l and measurements below threshold were given this value.

To examine differences in the levels of the various biomarkers within each frailty measure, the Kruskal–Wallis test was used. When overall significant differences ($P < 0.05$) were found, we performed Mann–Whitney U tests between group pairs, adjusting the statistical level of significance to 2.5% using the Bonferroni correction.

We grouped levels of individual biomarkers into quartiles or tertiles and examined their association with post-operative complications by chi-square tests. Trend analyses were performed to identify cut-off points. CRP-levels were dichotomized into values below the 25th percentile versus higher levels and IL-6 into values below the 66.66th percentile versus higher levels. The dichotomized variables were subsequently included in crude and adjusted logistic