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Identification of older adults with frailty in the Emergency Department using a frailty index: results from a multinational study

Audrey-Anne Brousseau[1,2], Elsa Dent[3], Ruth Hubbard[3], Don Melady[1,2], Marcel Émond[4,5,6], Éric Mercier[4,5,7], Andrew P. Costa[8], for the Multinational Emergency Department Study*

[1]Department of Family and Community Medicine, University of Toronto, Canada
[2]Schwartz-Reisman Emergency Medicine Institute, Mount Sinai Hospital, Toronto, Canada
[3]Centre for Research in Geriatric Medicine, The School of Medicine, The University of Queensland, Brisbane, Australia
[4]Axe Sante des Populations et Pratiques Optimales en Sante, Centre de recherche du CHU de Quebec, Canada
[5]Universite Laval, Quebec, Canada
[6]Centre d'excellence sur le Vieillissement de Quebec, Canada
[7]Department of Epidemiology and Preventive Medicine, Monash University, Australia
[8]Department of Clinical Epidemiology and Biostatistics and Department of Medicine, McMaster University, Hamilton, Canada

*Leonard C. Gray, John P. Hirdes, Aparajit B. Dey, Palmi V. Jonsson, Prabha Lakhan, Gunnar Ljunggren, Katrin Singler, Fredrik Sjostrand, Walter Swoboda, Nathalie I.H. Wellens
*Address correspondence to: Audrey-Anne Brousseau. Tel: 819-346-1110. Email: brousseau.audreyanne@gmail.com

Abstract

Objective: frailty is a central concept in geriatric medicine, yet its utility in the Emergency Department (ED) is not well understood nor well utilised. Our objectives were to develop an ED frailty index (FI-ED), using the Rockwood cumulative deficits model and to evaluate its association with adverse outcomes.
Method: this was a large multinational prospective cohort study using data from the interRAI Multinational Emergency Department Study. The FI-ED was developed from the Canadian cohort and validated in the multinational cohort. All patients aged ≥75 years presenting to an ED were included. The FI-ED was created using 24 variables included in the interRAI ED-Contact Assessment tool.
Results: there were 2,153 participants in the Canadian cohort and 1,750 in the multinational cohort. The distribution of the FI-ED was similar to previous frailty indices. The mean FI-ED was 0.26 (Canadian cohort) and 0.32 (multinational cohort) and the 99th percentile was 0.71 and 0.81, respectively. In the Canadian cohort, a 0.1 unit increase in the FI-ED was significantly associated with admission (odds ratio (OR) = 1.43 [95% CI: 1.34−1.52]); death at 28 days (OR = 1.55 [1.38–1.73]); prolonged hospital stay (OR = 1.37 [1.22–1.54]); discharge to long-term care (OR = 1.30 [1.16−1.47]); and need for Comprehensive Geriatric Assessment (OR = 1.51 [1.41–1.60]). The multinational cohort showed similar associations.
Conclusion: the FI-ED conformed to characteristics previously reported. A FI, developed and validated from a brief geriatric assessment tool could be used to identify ED patients at higher risk of adverse events.

Keywords: *frail older adults, frailty index, Emergency Department, geriatric emergency medicine, geriatric assessment, older people*

Introduction

The Emergency Department (ED) is a nexus for health care systems around the world: an intersection for community care, primary care, in-patient care, long-term care and rehabilitation care attended by the most vulnerable populations such as older adults. Populations are aging. Accordingly, ED attendance by older adults presenting to ED with complex needs and who are at high risk of adverse events is rising [1]. Frailty, although rarely discussed in emergency medicine,

is a core concept in geriatric medicine—a key factor in understanding older people and planning their care. It is defined as a syndrome, of multidimensional etiology, characterised by decreased physiologic reserve and resilience that increases a patient's vulnerability to stressors [2, 3]. Although the theoretical definition is clear, the clinical and operational application is challenging [4–7]. Screening tools for specific outcomes are well studied in the ED but valid measurement of frailty in the ED is lacking [8, 9]. It is hypothesised that measuring frailty in the ED could have a substantial impact on the clinical management of patients [10, 11]. Frailty may serve as the ideal clinical feature for this purpose and represent a crucial 'vital sign' for older adults [12]. To our knowledge, no research has investigated strategies to allow ED clinicians to identify frailty by something more than gestalt.

There are two broadly accepted methods to measure frailty: the Fried phenotype approach and the Rockwood cumulative deficit approach. Both frailty models have been used with success to predict increased risk of hospitalisation, prolonged hospital stay, long-term care institutionalisation and death [6, 13–15]. The Fried phenotype model requires tests and information that are not readily available in an emergency setting, and it defines frailty in ordinal terms.

Rockwood developed a cumulative deficit index, based on the accumulated burden of deficits, to measure frailty [2] using 92 variables based on a Comprehensive Geriatric Assessment (CGA), done by a geriatrician. It would be complex and time-consuming to operationalise in the ED. More recent studies demonstrated that 30 variables are sufficient to generate the same association with adverse outcomes [13]. None have been validated for widespread use in the ED.

Our objective was to develop and validate an ED-specific frailty index (FI-ED), defined by the Rockwood cumulative deficits model, using items from an existing brief geriatric assessment tool in the ED.

Our secondary objective was to evaluate its association with the following outcomes: hospital admission, death, prolonged hospital stay, need for a CGA and long-term care disposition as previously described by other frailty indices.

Method

Study design and setting

We conducted a secondary analysis of two cohorts from a large multinational prospective cohort study, the interRAI Multinational Emergency Department study [16, 17]. The FI-ED was developed from the Canadian cohort and validated using the multinational cohort. Approvals were obtained from hospital and academic research ethics committees.

Selection of participants

Patients were recruited in nineteen EDs from seven countries (Australia, Belgium, Canada, Germany, Iceland, India, Sweden) in 2012. Fifteen sites were urban teaching hospitals, three were regional centres and one was a community centre. Patients aged 75 or older were eligible for inclusion. Patients in severe acute medical crisis defined as those to the highest triage level of acuity/severity; those expected to die within 24 h; and those who did not speak the native language were excluded. All countries recruited eligible patients from the time of ED registration without any additional pre-selection. Recruitment was done during weekdays, and on weekends in some sites [16, 17]. Details regarding participant recruitment, selection and consents have been reported previously [16, 17].

Method and measurements

Participants were recruited at ED registration and were assessed using the ED-Contact Assessment (ED-CA) shortly after registration. The ED-CA is a short (~15 min) geriatric assessment administered on supplementary software systems in real time to identify and examine individual patient problems across geriatric domains (see Supplementary data, Online Appendix 1, available in *Age and Ageing* online). The predictive validity of the ED-CA has been demonstrated [16] and the same assessment items have demonstrated excellent psychometric properties in acute hospital settings [18–20]. The clinical items in the ED-CA were extensively tested across a wide range of nations and languages [21]. The ED-CA is used as part of the extended nursing assessment either done by the nurse case manager or an allied health professional. It evaluates the patient's premorbid and present condition. Additional information collected included: socio-demographic including age, sex, and previous living situation, discharge disposition, previous ED use, hospital admission and a measure of triage acuity.

Development of FI-ED

A FI differs from a clinical decision rule and a diagnostic test. There is a well-defined methodology that guided the development of the FI-ED [22]. The deficits included met all these five criteria:

(1) must be associated with health status and not be a natural attribute of aging;
(2) prevalence must increase with age;
(3) must not saturate too early in age;
(4) must collectively cover a range of body systems; and
(5) must be used similarly and serially on the same sample.

The ED-CA recorded 39 clinical variables and 24 were selected by two experts. A third party evaluated the selection and discrepancies were resolved by discussions. Most variables were coded as binary: either 1 (present) or 0 (absence). The FI-ED was established as a fraction, where the numerator was the number of deficits present for the individual patient and the denominator was 24, the number of deficits collected from the ED-CA. Because the FI is based on a cumulative deficit model, we did not review the predictive value of each individual item.

We could not compare our FI with other instruments as there is no gold standard for frailty assessment in the ED [6].

In keeping with the methodological guidelines, we validated the FI by evaluating its association with a broad range of geriatric outcomes [22]. Consistent with all frailty indices, the FI-ED was expressed as a continuous number between 0 and 1.

Outcomes

Outcomes measured included: admission to hospital following the present ED visit; death at 28 days recorded from hospital data, death certificate or telephone follow-up; prolonged length of stay in-hospital if admitted following the ED visit (in days) defined as the country specific 90th percentile of length of stay; discharge to a long-term care facility (nursing home). Alternate level of care (ALC), a prolonged hospital admission beyond the acute care phase due to absence of suitable discharge destination, is widely used in Canada. Follow-up at 28 days was done by telephone or with the secondary use of electronic regional hospital and mortality records. Beyond objective outcomes, the perceived need for a CGA was recorded by the assessor (trained nurses or allied health professionals), based on their overall clinical judgement.

Analysis

Stratified analyses were used to investigate the prevalence of descriptive characteristics, frailty, and adverse outcomes by country. Univariate logistic regression was used to determine the observed relationship between the FI-ED and adverse outcome in both cohorts. The number of events included in each cohort provided more than adequate power to estimate associations between the FI-ED and adverse outcomes [23]. Confidence intervals were calculated at the 95% level (alpha = 0.05).

Ad hoc analysis sought to determine outcome specific cut-points for the FI-ED that optimised both sensitivity and specificity based on the Youden's J statistic. Because there are no widely accepted cut-points for a FI, we showed the highest 10% (90th percentile) and the highest 25% (75th percentile) of the FI-ED range in our population. Likelihood ratios (LR) were calculated for each outcomes and cut-point of the FI-ED. LR combine sensitivity and specificity to determine probability of the outcome with a high FI-ED (positive LR/ability to rule-in outcome) and lower FI-ED (negative LR/ability to rule-out outcome). All analyses were performed using SAS® Version 9.3 for Windows (SAS Institute, Inc., Cary, NC). We report our findings according to the STROBE statement [24].

Results

For the development of the FI-ED, we included 2,153 participants from the Canadian cohort. For the validation, we included 1,750 participants from the multinational cohort. As previously reported, follow-up was complete for 97% of participants [16]. Missing data was limited: 0.1–2% in most items; 14.2% in the informal helper status question. Mean age and gender distribution were similar in both groups (Table 1). Participants in the validation cohort seemed to have a greater burden of disease.

The list of the variables included in the FI-ED is shown in Online Appendix 1 (Supplementary data are available in *Age and Ageing* online). Among the Canadian cohort, the mean FI-ED was 0.26; with a 99th percentile of 0.71. Online Appendix 2 (Supplementary data are available in *Age and Ageing* online) shows the distribution of the FI-ED across all countries. For the multinational cohort, the mean FI-ED was 0.32; with a 99th percentile of 0.82. Across all countries the mean FI-ED ranged from 0.24 (Australia) to 0.59 (India). Similarly the 99th percentile ranged from 0.69 (Iceland) and 0.86 (India). It shows the normal distribution, a characteristic used to evaluate a FI performance (according to previous studies), of the FI-ED across all countries [2, 22, 25].

Admission rates varied widely across both cohorts. In the Canadian cohort 52% of patients were admitted; in the validation cohort, admission rates varied from 34% (Australia) to 91% (Germany) (Figure 1). Table 2 demonstrates the association between the FI-ED and the outcomes. The odds ratio (OR) represents the association with outcomes for each 0.1-increase of the FI-ED. A higher FI-ED showed a statistically significant association with admission in both cohorts. A sensitivity analysis was done to evaluate the association of the FI-ED with admission excluding the German cohort, which showed a significant association with an unadjusted OR of 1.12 (CI 95%: 1.04–1.20). Death at 28 days and prolonged hospital stay were significantly associated with increased FI-ED in both cohorts. Similarly, there was a statistically significant association with the FI-ED and a prolonged hospital stay. In the Canadian cohort the rate of disposition to long-term care was 9.9 and 17% of admitted patients were designated ALC. The FI-ED was associated with both outcomes. Although the rate of disposition to long-term care was similar in both cohorts (≈10%), it was negatively associated with the FI-ED in the validation cohort (OR = 0.84 [CI 95%: 0.75–0.85]). The FI-ED was strongly associated with the assessors' perceived need for a CGA.

The results are unadjusted for gender and age because they were not different when analysed.

The highest 10 and 25% scores on the FI-ED were associated with overall modest diagnostic performance across outcomes and cohorts (see Supplementary data, Online Appendix 3, available in *Age and Ageing* online). The perceived need for CGA as well as death at 28 days showed meaningful positive LR across cohorts. Cut-points optimised for both sensitivity and specificity varied from 0.22 (admission) to 0.48 (death) with a maximum sensitivity of 78% achieved for being discharged to higher level of care (specificity 50%) in the Canadian cohort.

Discussion

This is the first study to develop and validate a FI according to a broadly endorsed model from a multinational perspective. Our findings suggest that frailty is generalisable to many contexts, including the ED. A strength of the FI-ED

Table 1. Characteristics of study participants, derivation and validation cohorts

Variables	Derivation cohort (Canada) *n* = 2,153%	Validation cohort (multinational) *n* = 1,750% (range)
Mean age (y)	82.2	82.7
Sex (F)	60.7	56.9 (44.9–61.4)
Admitted from		
Community/home	95.2	89.7 (77.2–100.0)
Long-term care facility (nursing home)	0.0	7.8 (0.0–19.5)
Other settings	4.8	2.5 (0.0–5.0)
Death in Emergency Department	0.1	0.3 (0.0–5.1)
Discharge disposition		
Community/home	43.5	29.3 (6.2–61.1)
Long-term care facility (nursing home)	0.0	1.1 (0.0–2.4)
Admitted to acute care	53.6	67.9 (33.9–91.4)
Other settings	2.9	1.7 (0.0–7.1)
Lives alone	37.3	40.0 (3.1–59.7)
Caregiver distress[a]	19.0	24.2 (6.4–75.5)
Previous ED use (in the last 90 days)	41.4	26.3 (17.1–65.3)
Hospital stay in the last 3 months	25.6	29.9 (22.1−63.3)
CTAS level[b]		
1 (Highest acuity)	0.6	0.6 (0.0–1.6)
2	20.9	19.0 (7.8–29.3)
3	58.6	53.7 (46.5–78.3)
4	15.9	23.8 (7.1–40.5)
5	4.0	2.9 (0.5–4.8)
Conditions and symptoms		
Cognition impairment (premorbid[c])	15.9	20.5 (4.2–63.3)
Potential delirium[d]	5.4	5.5 (0.8–19.6)
Functional impairment on ADLs* (premorbid)	37.2	45.9 (24.4–68.4)
Acute functional decline[e]	11.6	20.1 (11.6–30.9)
Previous falls (last 90 days)	32.0	38.2 (31.8–44.2)
Depressive symptoms[f]	20.1	33.4 (22.6–51.2)
Dyspnea (premorbid)[g]	20.4	27.1 (13.9–45.9)
Daily and severe pain[h]	18.6	31.4 (22.5–45.1)
Weight loss	9.0	24.6 (18.0–74.2)

[a]Primary informal helper(s) expresses feelings of distress, anger or depression.
[b]Canadian Triage and Acuity Scale (CTAS): Belgium, Canada, Germany, Iceland, India. Australian Triage and Acuity Scale (ATAS): Australia. Medical Emergency Triage and Treatment System (METTS): Sweden.
[c]Premorbid: The 3-day period prior to the onset of the current acute illness or episode.
[d]Acute change in mental status from person's usual functioning (e.g. restlessness, lethargy, difficult to arouse, altered environmental perception).
[e]Acute decline from premorbid: at admission, new impairment relative to premorbid.
[f]When asked, patient reports feeling sad, depressed or hopeless in last 3 days.
[g]Dyspnea at rest, or present when performing normal day-to-day activities.
[h]Pain that is severe or excruciating in last 3 days.
*ADLs: activities of daily living (dressing, eating, grooming, toiletting, bathing, ambulating).

is that it represented frailty in a continuous, clinically relevant manner. This allows for clinical interpretation and judgement across a continuous spectrum. Sirois *et al.* [26] recognised the clinical utility of measuring frailty and functional decline but did not establish a practical way to operationalise it in the ED. We demonstrated that an easily administered 24-item assessment that captures important geriatric conditions, and available in an electronic medical record, can be used to generate the FI-ED [27].

We confirmed that the FI-ED had similar properties to more detailed frailty indices that were validated and are in use in other contexts [28, 29], and we established that the FI-ED was associated with a variety of patient-centred and system-centred outcomes.

Other studies have also explored the use of frailty measurement in the ED. Salvi *et al.* found that frailty was associated with poor survival rate, as well as a higher rate of hospital admission and ED revisit at 6 months using a Rockwood cumulative deficit model that was based on a CGA. We employed a cumulative deficits model given its ability to be derived from existing information and therefore maximising cost-utility. A recent systematic review and meta-analysis, by Carpenter *et al.* [8], showed that available geriatric screening tools do not adequately discriminate between low risk and high-risk patients, highlighting the need for a more refined and detailed, yet feasible, measure to prioritise vulnerability.

The FI-ED showed variability across countries, which likely reflects differences in underlying health care systems as well as each site's unique organisation within countries. The Indian cohort had the highest mean FI-ED, 0.59 compared to 0.32 in the entire multinational cohort [30]. We noted other differences in ED care in this study. In Germany, 91%

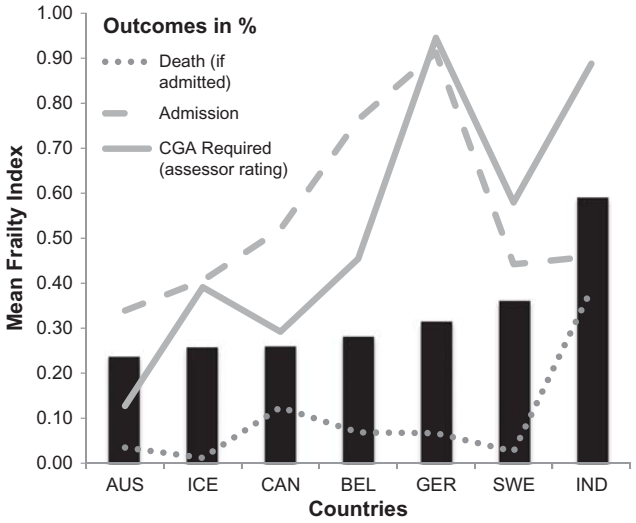

Figure 1. Distribution of the mean frailty index scores and outcomes across countries

Table 2. Association of the FI-ED with outcomes, derivation (Canada) and validation (multinational) cohorts

Outcomes	Derivation cohort (Canada) *n* = 2,153		Validation cohort (multinational) *n* = 1,750	
	%	Odds ratio[d] (CI 95%)	%	Odds ratio (CI 95%)
Admission	52.0	1.43 (1.34–1.52)	64.1	1.09 (1.02–1.15)
Death in Hospital	12.4	1.55 (1.38–1.73)	6.8	1.57 (1.39–1.79)
CGA[a] required	29.2	1.51 (1.41–1.60)	59.3	1.86 (1.71–2.03)
Discharge to higher level of care (LTC[b])	9.9	1.30 (1.16–1.47)	10	0.84 (0.75–0.85)
Alternate level of care[c]	17.0	1.41 (1.28–1.56)	–	–
Prolong stay in hospital	10.6	1.37 (1.22–1.54)	9.4	1.18 (1.06–1.31)

[a]CGA required: Comprehensive Geriatric Assessment needs perceived by assessors.
[b]LTC: long-term care.
[c]Alternate level of care: patients admitted but the acute medical issues are resolved and are waiting for a long-term care bed.
[d]The odds ratio represents the association with outcomes for each 0.1 increase of the FI-ED.

of older adults were admitted compared to 52% in Canada and 34% in Australia. We found a protective effect of frailty for long-term care disposition in the multinational validation cohort suggesting that the use of long-term care resources in acute care is not consistent across countries.

We analysed the possibility of defining outcome specific cut-points for the FI-ED that optimised sensitivity and specificity. We found that the overall predictive value for each outcome was modest for each cut-point across countries. Given low sensitivity at higher cut-points, the FI-ED may be best utilised for case findings (i.e. prioritise specificity) according to available geriatric resources rather than using optimised a priori diagnostic thresholds.

This study collected data amongst the most representative multinational cohorts available and was consistent with previously studies. However, the cohorts were convenience samples and do not necessarily reflect the entire population of older adults. Some country cohorts were unable to recruit all consecutive participants and most were unable to recruit patients outside of weekdays. Nonetheless, the study was designed to ensure no other systematic bias in selection. There are no guidelines that endorse patient-centred adverse outcome post-discharge among older ED patients. In the absence of guidelines, we used outcomes commonly reported in the literature. The FI-ED focussed primarily on functional characteristics. It could have been improved by the inclusion of diagnostic information. However, in the ED, diagnoses are often provisional, and reliable diagnostic information could not be collected across countries. Despite the absence of diagnostic information, a validated FI was possible, suggesting that geriatric syndromes are a reflection of underlying conditions and are powerful in isolation.

The FI-ED was developed from a short, electronic ED geriatric assessment identifying the most vulnerable older adults in the ED provides an opportunity to consider frailty in diagnostic reasoning, intervention and disposition planning. It may also allow EDs to systematically adapt care in order to prevent adverse events such as deconditioning, and to support post-discharge care providers in providing timely and effective follow-up care.

Conclusion

In summary, we used a cumulative deficit model of frailty to develop a feasible ED-specific FI. We demonstrated the validity of the FI-ED using a cohort from seven countries. In an era of increasing ED presentations by older adults and as EDs implement models of care to improve their assessment and management, the FI-ED may provide a tool to better target resources and tailor care.

Key points

- This is the first study to develop a frailty index according to a broadly endorsed model from a multinational perspective.
- Frailty may serve as the ideal clinical feature for prognosis in the Emergency Department and represent a crucial 'vital sign' for older adult.
- The Frailty Index is easily measured in real-time in the Emergency Department (ED), using the ED-Contact Assessment, an InterRAI tool.

Supplementary Data

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

Conflict of interest

None.

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References

1. Pines JM, Mullins PM, Cooper JK, Feng LB, Roth KE. National trends in emergency department use, care patterns, and quality of care of older adults in the United States. J Am Geriatr Soc 2013; 61: 12–7. PubMed PMID: 23311549.
2. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I *et al*. A global clinical measure of fitness and frailty in elderly people. Can Med Assoc J 2005; 173: 489–95. PubMed PMID: 16129869. Pubmed Central PMCID: 1188185.
3. Todd OM, Clegg AP. Moving upstream in the frailty trajectory. Age Ageing 2016; 45: 438–9. PubMed PMID: 27146302.
4. Rockwood K. What would make a definition of frailty successful? Age Ageing 2005; 34: 432–4. PubMed PMID: 16107450.
5. Karunananthan S, Wolfson C, Bergman H, Beland F, Hogan DB. A multidisciplinary systematic literature review on frailty: overview of the methodology used by the Canadian Initiative on Frailty and Aging. BMC Med Res Methodol 2009; 9: 68. PubMed PMID: 19821972. Pubmed Central PMCID: 2765448.
6. Dent E, Kowal P, Hoogendijk EO. Frailty measurement in research and clinical practice: a review. Eur J Intern Med 2016; 31: 3–10. PubMed PMID: 27039014.
7. Rodriguez-Manas L, Feart C, Mann G, Vina J, Chatterji S, Chodzko-Zajko W *et al*. Searching for an operational definition of frailty: a Delphi method based consensus statement: the frailty operative definition-consensus conference project. J Gerontol A Biol Sci Med Sci 2013; 68: 62–7. PubMed PMID: 22511289. Pubmed Central PMCID: 3598366.
8. Carpenter CR, Shelton E, Fowler S, Suffoletto B, Platts-Mills TF, Rothman RE *et al*. Risk factors and screening instruments to predict adverse outcomes for undifferentiated older emergency department patients: a systematic review and meta-analysis. Acad Emerg Med 2015; 22: 1–21. PubMed PMID: 25565487.
9. Elliott A, Phelps K, Regen E, Conroy SP. Identifying frailty in the Emergency Department-feasibility study. Age Ageing 2017; 46: 840–5. PubMed PMID: 28541400.
10. Provencher V, Sirois MJ, Emond M, Perry JJ, Daoust R, Lee JS *et al*. Frail older adults with minor fractures show lower health-related quality of life (SF-12) scores up to six months following emergency department discharge. Health Qual Life Outcomes 2016; 14: 40. PubMed PMID: 26956158. Pubmed Central PMCID: 4782387.
11. Dwyer R, Stoelwinder J, Gabbe B, Lowthian J. Unplanned transfer to Emergency Departments for frail elderly residents of aged care facilities: a review of patient and organizational factors. J Am Med Dir Assoc 2015; 16: 551–62. PubMed PMID: 25933726.
12. Forman DE, Alexander KP. Frailty: a vital sign for older adults with cardiovascular disease. Can J Cardiol 2016; 32: 1082–7. PubMed PMID: 27476987.
13. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013; 381: 752–62. PubMed PMID: 23395245. Pubmed Central PMCID: 4098658.
14. Ritt M, Schwarz C, Kronawitter V, Delinic A, Bollheimer LC, Gassmann KG *et al*. Analysis of Rockwood *et al*.'s Clinical Frailty Scale and Fried *et Al*.'s Frailty Phenotype as predictors of mortality and other clinical outcomes in older patients who were admitted to a geriatric ward. J Nutr Health Aging 2015; 19: 1043–8. PubMed PMID: 26624218.
15. Chang SF, Lin PL. Frail phenotype and mortality prediction: a systematic review and meta-analysis of prospective cohort studies. Int J Nurs Stud 2015; 52: 1362–74. PubMed PMID: 25986959.
16. Costa AP, Hirdes JP, Heckman GA, Dey AB, Jonsson PV, Lakhan P *et al*. Geriatric syndromes predict postdischarge outcomes among older emergency department patients: findings from the interRAI Multinational Emergency Department Study. Acad Emerg Med 2014; 21: 422–33. PubMed PMID: 24730405.
17. Gray LC, Peel NM, Costa AP, Burkett E, Dey AB, Jonsson PV *et al*. Profiles of older patients in the emergency department: findings from the interRAI Multinational Emergency Department Study. Ann Emerg Med 2013; 62: 467–74. PubMed PMID: 23809229.
18. Gray LC, Bernabei R, Berg K, Finne-Soveri H, Fries BE, Hirdes JP *et al*. Standardizing assessment of elderly people in acute care: the interRAI Acute Care instrument. J Am Geriatr Soc 2008; 56: 536–41. PubMed PMID: 18179498.
19. Wellens NI, Deschodt M, Boonen S, Flamaing J, Gray L, Moons P *et al*. Validity of the interRAI Acute Care based on test content: a multi-center study. Aging Clin Exp Res 2011; 23: 476–86. PubMed PMID: 22526080.
20. Hirdes JP, Ljunggren G, Morris JN, Frijters DH, Finne Soveri H, Gray L *et al*. Reliability of the interRAI suite of assessment instruments: a 12-country study of an integrated health information system. BMC Health Serv Res 2008; 8: 277. PubMed PMID: 19115991. Pubmed Central PMCID: 2631461.
21. Wellens NI, Flamaing J, Moons P, Deschodt M, Boonen S, Milisen K. Translation and adaption of the interRAI Suite to local requirements in Belgian hospitals. BMC Geriatr 2012; 12: 53. PubMed PMID: 22958520. Pubmed Central PMCID: 3492186.
22. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. BMC Geriatr 2008; 8: 24. PubMed PMID: 18826625. Pubmed Central PMCID: 2573877.
23. Vittinghoff E, McCulloch CE. Relaxing the rule of ten events per variable in logistic and Cox regression. Am J Epidemiol 2007; 165: 710–8. PubMed PMID: 17182981.
24. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP *et al*. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008; 61: 344–9. PubMed PMID: 18313558.
25. Hubbard RE, Peel NM, Samanta M, Gray LC, Fries BE, Mitnitski A *et al*. Derivation of a frailty index from the interRAI acute care instrument. BMC Geriatr 2015; 15: 27. PubMed PMID: 25887105. Pubmed Central PMCID: 4373301.
26. Sirois MJ, Griffith L, Perry J, Daoust R, Veillette N, Lee J *et al*. Measuring frailty can help Emergency Departments identify independent seniors at risk of functional decline after minor injuries. J Gerontol A Biol Sci Med Sci 2015; 72: 68–74. PubMed PMID: 26400735.
27. Murdoch TB, Detsky AS. The inevitable application of big data to health care. J Am Med Assoc 2013; 309: 1351–2. PubMed PMID: 23549579.
28. Hoogendijk EO, van der Horst HE, Deeg DJ, Frijters DH, Prins BA, Jansen AP *et al*. The identification of frail older adults in primary care: comparing the accuracy of five simple instruments. Age Ageing 2013; 42: 262–5. PubMed PMID: 23108163. Epub 2012/10/31.eng.

29. Theou O, Brothers TD, Mitnitski A, Rockwood K. Operationalization of frailty using eight commonly used scales and comparison of their ability to predict all-cause mortality. J Am Geriatr Soc 2013; 61: 1537–51. PubMed PMID: 24028357. Epub 2013/09/14. eng.
30. Biritwum RB, Minicuci N, Yawson AE, Theou O, Mensah GP, Naidoo N *et al.* Prevalence of and factors associated with frailty and disability in older adults from China, Ghana, India, Mexico, Russia and South Africa. Maturitas 2016; 91: 8–18. PubMed PMID: 27451316.

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Alcohol consumption in midlife and old age and risk of frailty

Alcohol paradox in a 30-year follow-up study

Arto Y. Strandberg[1], Teemu Trygg[1], Kaisu H. Pitkälä[2], Timo E. Strandberg[1,3]*

[1]University of Helsinki and Helsinki University Central Hospital, Helsinki, Finland
[2]Department of General Practice and Helsinki University Central Hospital, University of Helsinki, Unit of Primary Health Care, Helsinki, Finland
[3]University of Oulu, Center for Life Course Health Research, Oulu, Finland

*Address correspondence to: T. E. Strandberg, University of Helsinki, PO Box 340, FIN-00029 HUS, Finland. Tel/Fax: +358 40 672 4533. E-mail: timo.strandberg@oulu.fi

Abstract

Background: alcohol consumption has many harmful health effects, but also benefits of moderate consumption on frailty have been reported. We examined this relationship longitudinally from midlife to old age.
Methods: data of reported alcohol consumption in midlife (year 1974) and in old age (years 2000 and 2003) were available of a socioeconomically homogenous sample of 2360 men (born 1919–34, the Helsinki Businessmen Study). Alcohol consumption was divided into zero (N = 131 at baseline), light (1–98 g/week, N = 920), moderate (99–196, N = 593), and high consumption (>196, n = 716). Incidence of phenotypic frailty and prefrailty was assessed in 2000 and 2003. Alcohol consumption (reference 1–98 g/week, adjusted for age, body mass index and smoking) was related to frailty both longitudinally (from 1974 to 2000, and from 2000 to 2003) and cross-sectionally in 2000 and 2003.
Results: during a 30-year follow-up, high consumption clearly decreased whereas lighter consumption remained stable. High consumption in midlife predicted both frailty (odds ratio = 1.61, 95% confidence interval = 1.01–2.56) and prefrailty (1.42; 1.06–1.92) in 2000, association with zero and moderate consumption was insignificant. Cross-sectionally in 2000, both zero (2.08; 1.17–3.68) and high consumption (1.83; 1.07–3.13) were associated with frailty, while in 2003 only zero consumption showed this association (2.47; 1.25–4.88).
Conclusion: the relationship between alcohol and frailty is a paradox during the life course. High, not zero, consumption in midlife predicts old age frailty, while zero consumption in old age is associated with frailty, probably reflecting reverse causality.

Keywords: *frailty, alcohol, healthy ageing, life course, older people*

Introduction

Frailty is caused by the gradual accumulation of diverse molecular and cellular damage which eventually results in vulnerability and disease [1, 2]. Oxidative stress, telomere shortening, and mutations of mitochondria and nuclear DNA may be defects at the cellular level. Alcohol is known