Development and validation of fall risk screening tools for use in residential aged care facilities

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ABSTRACT

Objective: To develop screening tools for predicting falls in nursing home and intermediate-care hostel residents who can and cannot stand unaided.

Design and setting: Prospective cohort study in residential aged care facilities in northern Sydney, New South Wales, June 1999 – June 2003.

Participants: 2005 people aged 65–104 years (mean ± SD, 85.7 ± 7.1 years).

Main outcome measures: Demographic, health, and physical function assessment measures; number of falls over a 6-month period; validity of the screening models.

Results: Ability to stand unaided was identified as a significant event modifier for falls. In people who could stand unaided, having either poor balance or two of three other risk factors (previous falls, nursing home residence, and urinary incontinence) increased the risk of falling in the next 6 months threefold (sensitivity, 73%; specificity, 55%). In people who could not stand unaided, having any one of three risk factors (previous falls, hostel residence, and using nine or more medications) increased the risk of falling twofold (sensitivity, 87%; specificity, 29%).

Conclusions: These two screening models are useful for identifying older people living in residential aged care facilities who are at increased risk of falls. The screens are easy to administer and contain items that are routinely collected in residential aged care facilities in Australia.

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Falls are a significant burden on the health care system, with a substantial proportion of the associated health care costs occurring in residential aged care facilities (RACFs).[1] RACF residents have an elevated risk of falls due to high numbers of comorbidities; however, reduced physical activity,[2] safer environments and increased supervision may actually reduce fall risk in this setting.[3]

Identifying people at risk of falls in RACFs is complex, and risk assessment tools developed for community and acute hospital settings cannot be translated to RACFs.[4] Previous studies have shown that falls occur more frequently in mobile[5,6] and physically active nursing home residents.[7] As part of the Fracture Risk Epidemiology in the Elderly (FREE) study,[3,8] we reported a non-linear association between standing balance and falls, with low fall rates in those with the worst balance as well as those with the best balance. The FREE study also found that many fall risk factors in those who could stand were either not evident or were actually protective in those who could not stand, further indicating that fall risk identification in RACF residents is not straightforward. None of the currently available screening tools for RACFs can be considered definitive for predicting residents at risk of falls, as they have not been adequately validated in large populations.

The aim of this study was to use the FREE study database to develop and validate screening tools that take into account the complexities relating to fall risk in frail older people living in RACFs. Such validated screening tools would help maximise efficiency and cost-effectiveness of interventions in RACFs, where resources are often limited.

METHODS

Participants

The study sample comprised 2005 people who took part in the FREE study between June 1999 and June 2003.[3,8] Participants were recruited from randomly selected RACFs (898 participants from 80 nursing homes and 1107 participants from 50 intermediate-care hostels) in northern Sydney, New South Wales. The participation rate of eligible residents (ie, those not exclusively confined to bed) was 44.8% for nursing home residents and 55.2% for hostel residents. Participants were aged 65–104 years (mean ± SD, 85.7 ± 7.1 years), and 1532 (76.4%) were women. About half of the population (1033; 51.5%) had experienced at least one fall during the previous year.

The Northern Sydney Area Health Service Ethics Committee approved the study, and informed consent was obtained from the participants or from a person legally able to give consent on their behalf.

Baseline risk factor assessments

Medical conditions, medication use, and cognitive and psychological status

Resident assessment by a research nurse, self-report, care provider interviews, and medical records were used to determine the presence of medical conditions. Medication use, urinary incontinence, falls history, and use of assistive devices were documented from residents' medical records. Cognitive status was assessed with the Mini-Mental State Examination.[9]

Balance and physical function

Standing balance was assessed using a static balance test.[10] Participants were classified into five grades: 1 = unable to stand on the floor for any period without support from another person or a walking aid; 2 = unable to maintain balance on the floor for 30 s; 3 = able to maintain balance on the floor for 30 s but unable to maintain balance on a medium-density foam rubber mat (70 cm × 60 cm × 15 cm thick) for any period of time; 4 = able to maintain balance on the floor but unable to maintain balance on the foam rubber mat for 30 s; and 5 = able to maintain balance when standing on the floor and the foam mat for 30 s each. Twelve residents did not complete the static balance test and were excluded from the analysis.

Participants' sit-to-stand ability was measured by assessing their ability to rise from a standard-height (0.43 m) chair with arm rests.[11] Participants were graded on a four-point scale: 1 = unable; 2 = able with the help of another person; 3 = able with the use of arm support; and 4 = able without the need for arm support.

1 Investigated risk factors for falls in people who could and could not stand unaided

Risk factor	Could stand unaided ($n = 1569$)		Could not stand unaided ($n = 377$)	
	Value*	Odds ratio (95% CI)	Value*	Odds ratio (95% CI)
Demographics				
Age (mean [SD] in years)	85.6 (6.9)	1.03 (1.01–1.04)†	85.6 (7.6)	1.02 (0.99–1.05)
Sex (no. [%] of women)	1195 (76.2%)	1.00 (0.79–1.27)	297 (78.8%)	0.76 (0.46–1.26)
Nursing home residence (no. [%] of residents)	505 (32.2%)	2.75 (2.21–3.41)†	349 (92.6%)	0.18 (0.07–0.42)†
Previous fall in the past year (no. [%] of residents)	773 (50.6%)	2.16 (1.75–2.66)†	231 (63.6%)	2.00 (1.26–3.18)†
Medical conditions				
Implicit Illness Severity Scale (median score [IQR])	3 (2–3)	2.21 (1.83–2.66)†	3 (3–3)	1.68 (0.93–3.01)
Standardised MMSE score (mean [SD])	21.5 (8.1)	0.94 (0.93–0.96)†	15.6 (10.3)	1.00 (0.98–1.02)
Parkinson disease (no. [%] of residents)	73 (4.7%)	1.70 (1.06–2.72)†	39 (10.9%)	0.83 (0.41–1.68)
Urinary incontinence (no. [%] of residents)	863 (56.0%)	1.75 (1.42–2.15)†	274 (75.9%)	1.05 (0.64–1.73)
Osteoarthritis of knee (no. [%] of residents)	532 (35.8%)	1.26 (1.01–1.56)†	118 (37.1%)	0.81 (0.51–1.29)
Use of aid during walking (no. [%] of residents)	985 (61.1%)	1.39 (1.12–1.71)†	0	na
Psychoactive medication (no. [%] of residents)	180 (12.5%)	0.86 (0.62–1.18)	59 (15.9%)	1.51 (0.86–2.64)
Number of medications used (median [IQR])	6 (4–9)	1.05 (1.02–1.08)†	7 (4–10)	1.06 (1.01–1.12)†
Physical measures				
Static balance (median grade [IQR])‡	4 (3–5)	0.58 (0.52–0.64)†	1 (1–1)	na
Sit-to-stand ability (median grade [IQR])‡	2 (1–2)	1.84 (1.52–2.23)†	3 (3–4)	0.54 (0.37–0.77)†

IQR = interquartile range. MMSE = Mini-Mental State Examination. na = not applicable. * Values are defined in parentheses in "Risk factor" column. Denominators for percentages vary due to missing data for some risk factors. † $P < 0.05$. ‡ See Methods for details of classification. ◆

Falls

All residents were followed up for a period of 6 months or until death, if sooner. Falls were ascertained from incident reports and medical records and were classified using the Kellogg definition.[12] Forty-seven residents died within 3 months without having a fall and were excluded from the analysis.

Statistical analysis

Ability to stand unaided was identified as a significant event modifier for falls. Accordingly, separate logistic regression models were used to calculate univariate odds ratios for the associations between demographic, health, and physical measures and falls in those who could (static balance grades 2–5) and could not (static balance grade 1) stand unaided. In subsequent multivariate regression models, the best set of independent and significant risk factors for falls were sought for the two groups. The predictive accuracy of combinations of the identified independent and significant risk factors were then examined using Mantel–Haenszel statistics. Finally, the sample was divided randomly into two groups and the validity of the models assessed with split-half analyses.

The data were analysed using SPSS for Windows (SPSS Inc, Chicago, Ill, USA).

RESULTS

Of the 1946 residents assessed, 813 (41.8%) fell once or more during the 6-month follow-up period. Of these, 410 fell twice or more, and 460 suffered at least one fall that resulted in an injury.[2]

Screening model for falls in residents who could stand unaided

Univariate analyses showed that the risk of experiencing at least one fall during the prospective period significantly increased with age, and was higher in nursing home residents and in those who had fallen in the past year. Factors associated with falls included poor static balance and sit-to-stand ability, greater illness severity, impaired cognitive status, Parkinson disease, urinary incontinence, knee osteoarthritis, use of a walking aid, and use of many medications (Box 1).

Stepwise logistic regression analysis identified four significant independent risk factors for falls: nursing home residence, impaired balance, a history of falls in the past year, and urinary incontinence (Box 2). In a second step, impaired balance was dichotomised based on examination of a receiver operating characteristic (ROC) curve as the inability to stand on a foam mat (static balance grades 2–3). The model significantly predicted falls ($\chi^2 = 159.5$, df = 4, $P < 0.001$) and accounted for 14% of the variance in faller status, with 80% of the non-fallers successfully predicted, 44% of the fallers successfully predicted, and 65% overall faller status successfully predicted.

Additional analyses examining the predictive accuracy of all combinations of independent and significant risk factors showed that the risk of experiencing a fall was 3.55 times greater when the person had poor balance, and 2.73 times greater for any two other risk factors. According to this model, the proportion of people at risk of a fall was 57%, with a sensitivity of 73% and a specificity of 55%.

Screening model for falls in residents who could not stand unaided

Fewer risk factors were evident for the residents who could not stand unaided (Box 1). In this group, residents with a history of falls and those who were taking more medications had an increased risk of falls. Nursing home residence, increased care levels and reduced ability to rise from a chair were associated with fewer falls.

The logistic regression analysis identified three significant independent risk factors for

falls: hostel residence, a history of falls in the past year, and use of many medications (Box 3). In a second step, the number of medications was dichotomised based on an ROC curve inspection, with the cut-off point at nine or more medications. The model significantly predicted falls ($\chi^2 = 31.43$, df = 3, $P < 0.001$) and accounted for 11% of the variance in faller status, with 97% of the non-fallers successfully predicted, 16% of the fallers successfully predicted, and 67% overall faller status successfully predicted.

Additional analyses examining the predictive accuracy of each combination of independent and significant risk factors showed that the risk of experiencing a fall was 2.09 times greater when the person scored positive on any one of these risk factors. According to the model, the proportion of people at risk was 77%, with a sensitivity of 87% and a specificity of 29%.

2 Fall risk models for people who could stand unaided

Variable	Regression coefficient	*P*	Odds ratio (95% CI)
Regression model*			
Nursing home residence	0.650	< 0.001	1.92 (1.49–2.46)
Poor balance†	0.645	< 0.001	1.91 (1.49–2.43)
Previous fall in past year	0.577	< 0.001	1.78 (1.43–2.22)
Incontinent	0.304	0.008	1.36 (1.08–1.70)
Constant	–1.238	< 0.001	0.29
Combination models‡			
Number of risk factors			
0			1.00
1 (any but balance)		0.018	1.56 (1.08–2.24)
1 (only balance)		< 0.001	3.55 (1.87–6.75)
2 (any but balance)		< 0.001	2.73 (1.87–3.98)
2 (balance + any 1)		< 0.001	3.83 (2.43–6.03)
3 (balance + any 2)		< 0.001	5.00 (3.34–7.48)
3 (any but balance)		< 0.001	12.36 (6.09–25.07)
4 (all)		< 0.001	7.85 (5.05–12.21)

* Using multivariate logistic regression analyses. † Static balance grades 2–3. ‡ Using Mantel–Haenszel analyses. ◆

Validation of the screening models

The split-half validation of the regression model for residents who could stand unaided revealed that the sensitivity and specificity were 74% and 56%, respectively, in the exploratory analyses, and 73% and 54% in the confirmatory analyses. For the people who could not stand unaided, the sensitivity and specificity were 86% and 30%, respectively, in the exploratory analyses, and 90% and 29% in the confirmatory analyses.

DISCUSSION

Two fall risk screening models emerged from this study: one for people who could stand unaided and one for people who could not. The stronger model was achieved in people who could stand unaided. Having poor balance or a positive score for two of three other risk factors (previous falls, nursing home residence, and urinary incontinence) produced a threefold increased risk of falling in the next 6 months. These factors have consistently been identified as important risk factors for falls.[3,8,13-17]

The model in people who could not stand unaided was less robust. Having had a previous fall, using nine or more medications, or residing in a hostel were associated with a twofold increased risk of falling during the follow-up period. Thus, "standard" physical risk factors do not appear to be present in this subpopulation, in accordance with previous findings.[3,6,15] Measures such as providing high-level care, using alarm devices, and regular medication review may be particularly beneficial for this group.

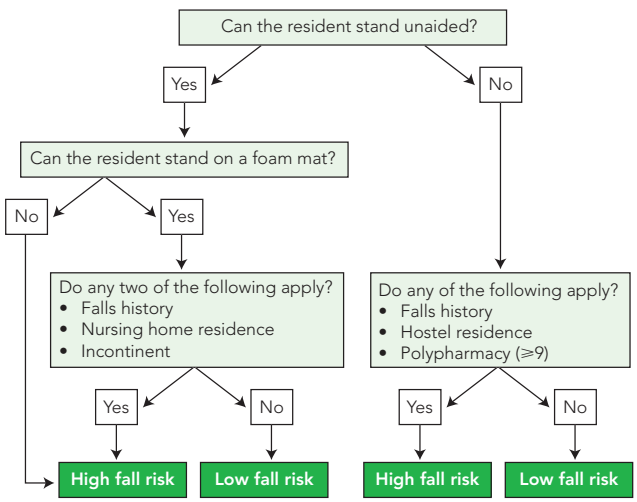
Several fall risk screening tools for residential care have previously been published.[6,18] However, their small to moderate sample sizes (ranging between 78 and 472 participants), as well as the frequent use of univariate approaches, have been insufficient to produce validated tools with acceptable sensitivity–specificity ratios. One study undertaken in Germany used multivariate modelling, similar to our approach, to construct an algorithm for predicting falls in nursing homes.[6] It found that falls history,

3 Fall risk models for people who could not stand unaided

Variable	Regression coefficient	*P*	Odds ratio (95% CI)
Regression model*			
Hostel residence	1.740	< 0.001	5.70 (2.31–14.08)
Previous fall in past year	0.608	0.012	1.84 (1.14–2.96)
Using ⩾ 9 medications	0.637	0.007	1.89 (1.19–3.01)
Constant	–1.285	< 0.001	0.28
Combination models†			
Number of risk factors			
0			1.00
1 (any)		0.026	2.09 (1.13–3.85)
2 (any)		< 0.001	4.29 (2.17–8.47)
3 (all)		0.001	22.94 (2.59–203.61)

* Using multivariate logistic regression analyses. † Using Mantel–Haenszel analyses. ◆

4 Algorithm summarising classification of aged care facility residents as high or low fall risk



vision impairment and incontinence were fall risk factors in residents able to transfer independently from bed to a standing position, compared with risk factors of falls history and restraint use in residents unable to transfer independently. Our study builds on this work by including hostel as well as nursing home residents and by including a simple balance assessment, which assists in identifying the more mobile people at risk of future falls. Our sample size was also sufficiently large to allow investigation of multiple measures and split-half validation. The resultant screening models are quick and easy to administer and require only one inexpensive and readily available piece of equipment (a 15 cm thick, medium-density foam rubber mat).

A simple algorithm, shown in Box 4, demonstrates how the screening models could be used in RACFs. By using them this way, only 56% of people who can stand unaided would need to be targeted to identify 75% of all fallers. Similarly, 77% of people who cannot stand unaided would need to be targeted to identify 87% of fallers. While these models assist in identifying most residents at risk of falls, we acknowledge that significant proportions of fallers would not be identified. Therefore, a multifaceted approach to fall prevention should be considered as part of routine care for all older people in RACFs.[1] These care plans should include evidence-based strategies such as education of staff[19-21] and residents,[19] environmental modifications,[19-21] regular medication reviews,[20,21] and exercise to improve strength, balance, gait, safe transfers and walking aid use.[19,20,22] Our screening model augments this care, not only by identifying residents most at risk, but also by providing information on risk factors to guide tailored intervention strategies.

As yet, no randomised controlled trials have been undertaken for fall prevention in RACFs in Australia, and disparate findings regarding the effectiveness of interventions have been published in other countries.[19-23] This discordance likely reflects differences in what constitutes an RACF, staffing and casemix within RACFs, and study design and quality of interventions. The screening tools developed in this study have some clinical utility in terms of identifying at-risk fallers, but further work is required to tease out whether screening tools offer clinical efficacy and cost-effectiveness. In the absence of a consensus approach to routine assessment and intervention in RACFs, the suggested screening models offer these facilities the option of applying a validated tool to identify residents at high risk of falling.

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COMPETING INTERESTS

None identified.

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