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Development and evaluation of evidence based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case-control and cohort studies

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Abstract

Objectives: To identify clinical characteristics of elderly inpatients that predict their chance of falling (phase 1) and to use these characteristics to derive a risk assessment tool and to evaluate its power in predicting falls (phases 2 and 3).
Design: Phase 1: a prospective case-control study. Phases 2 and 3: prospective evaluations of the derived risk assessment tool in predicting falls in two cohorts.
Setting: Elderly care units of St Thomas's Hospital (phase 1 and 2) and Kent and Canterbury Hospital (phase 3).
Subjects: Elderly hospital inpatients (aged ≥65 years): 116 cases and 116 controls in phase 1, 217 patients in phase 2, and 331 in phase 3.
Main outcome measures: 21 separate clinical characteristics were assessed in phase 1, including the abbreviated mental test score, modified Barthel index, a transfer and mobility score obtained by combining the transfer and mobility sections of the Barthel index, and several nursing judgments.
Results: In phase 1 five factors were independently associated with a higher risk of falls: fall as a presenting complaint (odds ratio 4.64 (95% confidence interval 2.59 to 8.33); a transfer and mobility score of 3 or 4 (2.10 (1.22 to 3.61)); and primary nurses' judgment that a patient was agitated (20.9 (9.62 to 45.62)), needed frequent toileting (2.48 (1.08 to 5.70)), and was visually impaired (3.56 (1.26 to 10.05)). A risk assessment score (range 0-5) was derived by scoring one point for each of these five factors. In phases 2 and 3 a risk assessment score >2 was used to define high risk: the sensitivity and specificity of the score to predict falls during the following week was 93% and 88% respectively in phase 2 and 92% and 68% respectively in phase 3.
Conclusion: This simple risk assessment tool predicted with clinically useful sensitivity and specificity a high percentage of falls among elderly hospital inpatients.

Introduction

Falls are common among elderly hospital inpatients.[1 2] For the patient, consequences may include fracture,[3 4] fear of falling,[5] anxiety and depression,[6] and loss of confidence,[7] all of which lead to greater disability. Falls by inpatients are associated with increased duration of stay in hospital and a greater chance of unplanned readmission or of discharge to residential or nursing home care.[8]

Successful rehabilitation to minimise long term disability of elderly people requires that staff aim to reduce patients' dependency and to increase their autonomy during recovery from acute illness when it is associated with disability. The occurrence of some falls is an unwelcome but probably inevitable consequence of encouraging patients to regain mobility early after acute illness. None the less, there may be simple measures that could reduce the incidence of falls[2 9] without the need for physical restraints, sedation, excessive supervision, or other measures that undermine a patient's dignity and independence.

A strategy which has proved successful in the prevention of pressure sores[10] is to select patients at high risk and target prevention strategies. Various clinical characteristics (over 400 in total on systematic review[11]) have been shown to be associated with an increased incidence of falls occurring at home or outdoors. Examples include use of particular drugs, muscle weakness, unstable gait, postural hypotension, and

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poor visual acuity.[12-14] Some of these characteristics may not be evident early in an inpatient episode or may require specialised equipment or diagnostic skills. They are therefore unsuitable for use in a routine clinical assessment applicable to large numbers of hospital inpatients. Moreover, most factors predictive of falls among elderly people in the community may not apply to hospital inpatients, where recovery from acute illness that is associated with changing mobility is more common.

Studies to identify risk factors for elderly inpatients falling have shown that a few readily assessable risk factors may predict a large proportion of these falls.[2 15-17] Since the occurrence of falls depends on patient characteristics (case mix) and institutional characteristics such as clinical and nursing practice,[2 3] risk factors may be specific to particular hospital units. Most of the presently available information is from the United States and often from nursing homes whose populations are more clinically stable. There is little evidence from British acute hospital wards for elderly patients.

We report a three phase investigation. In phase 1 we conducted a case-control study to discover which risk factors were significantly associated with falls occurring in the Elderly Care Unit at St Thomas's Hospital. The study was performed with the aim of identifying risk factors for falls that could be readily identified by ward nurses as part of the routine nursing assessment. Potential risk factors that might require equipment, measurement, or detailed medical examination of the patient were therefore not considered. In phases 2 and 3 we investigated the operational characteristics of a risk assessment tool, derived from the results of phase 1, to identify fallers in local and remote validation cohorts.

Subjects and methods

Settings

Phases 1 and 2 were conducted at St Thomas's Hospital in London, an inner city, 700 bed, teaching hospital. The Elderly Care Unit has 96 beds on four wards, admitting patients with a minimum age of 65 years on the basis of need. One of the four wards is dedicated to stroke rehabilitation, and the others admit acutely ill and usually disabled patients with a mean age of 79.5 years and a mean length of stay of 13 days. There were 1800 admissions in 1995.

Phase 3 was conducted at the Kent and Canterbury Hospital, a 500 bed district general hospital with two acute and four rehabilitation wards for elderly patients. The service has an age related admission policy (over 75 years). On the acute wards the patients' mean age is 83 years, their mean length of stay is seven days, and there were 3000 admissions in 1995. On the four wards in the separate rehabilitation unit patients' mean age is 83 years and their mean length of stay is 14 days.

Phase 1: case-control study

From the adverse events recorded in ward incident books, we identified all falls occurring on the four elderly care wards at St Thomas's Hospital over a three month period. A fall was defined as "an incident in which a patient suddenly and involuntarily came to rest upon the ground or surface lower than their original station." Each fall was regarded as a new incident, and thus patients who fell several times were the subject of several data sets. For each fall, a control patient was selected who was a patient in the next bed and who had not yet fallen during his or her admission. Fallers and control patients were not matched for age or sex since these variables were among the risk factors being investigated. If control patients subsequently fell, new data were collected to reflect their status on this occasion as fallers Thus, one patient could contribute two or more sets of data.

Characteristics (putative risk factors) listed for patients who fall and controls (phase 1)

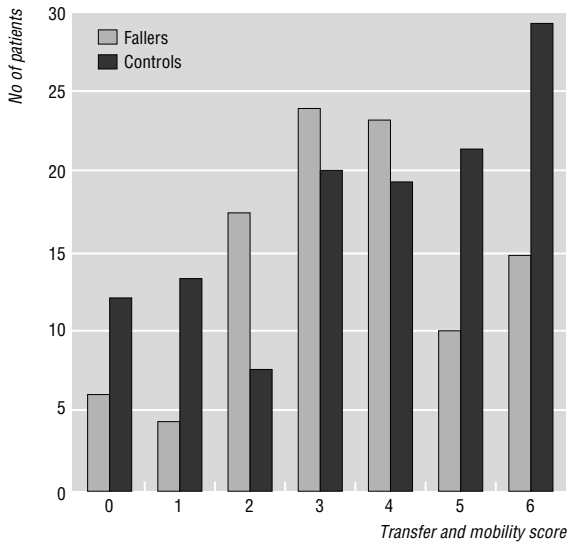
- Age
- Current Barthel index (range 0-20)
- Current transfer and mobility score (0-6), by combining the transfer and mobility sections of the Barthel index*
- Most recent documented abbreviated mental test score (0-10)
- Use of walking aid? (Yes/No)
- Catheter or drip in situ? (Yes/No)
- Was a fall a presenting complaint on admission to hospital or at any previous time during current admission? (Yes/No)
- Current medication:
  - Antidepressants? (Yes/No)
  - Diuretics? (Yes/No)
  - Vasodilators? (Yes/No)
  - Antiarrhythmics? (Yes/No)
  - Antiparkinsonian drugs? (Yes/No)
  - Sedative or hypnotics? (Yes/No)
  - Opiates? (Yes/No)
  - Drugs in two or more of the above categories? (Yes/No)
- Nurses' judgments about patient's current clinical characteristics:
  - Agitated? (Yes/No)
  - In need of especially frequent toileting? (Yes/No)
  - Has visual impairment which seems to affect functioning on the ward? (Yes/No)
  - Has hearing impairment which seems to affect functioning on the ward? (Yes/No)
  - Has language impairment which seems to affect functioning on the ward? (Yes/No)
  - Has an unstable gait? (Yes/No)

*Transfer score: 0 = unable, 1 = major help needed (one or two people, physical aids), 2 = minor help (verbal or physical), 3 = independent.
Mobility score: 0 = immobile, 1 = independent with aid of wheelchair, 2 = walks with help of one person, 3 = independent.

Within 48 hours of each fall the patient's primary nurse was interviewed and the case notes reviewed. For each fall and each control, 21 separate pieces of information were recorded (see box). These included the abbreviated mental test score,[18] modified Barthel index,[19] and a transfer and mobility score (range 0-6) obtained by combining the transfer and mobility sections of the Barthel index (each with ranges 0-3). Several nursing judgments were also obtained. No attempt was made to standardise the formation of these judgments as the aim was to produce an easily useable risk assessment tool.

Phase 2: investigation of risk assessment tool in local cohort (St Thomas's Hospital)

The five risk factors found to be significantly and independently associated with falling (see table 1) were



Transfer and mobility scores of elderly inpatients who subsequently fell and of control patients in phase 1 of study

tested on a cohort of patients in the same unit. A simple unweighted scoring system (STRATIFY (St Thomas's risk assessment tool in falling elderly inpatients)) was used in which the presence or absence of each risk factor (yes = 1, no = 0) gave a risk score of 0-5 for each patient. By interviewing patients' primary nurses, we obtained a STRATIFY score once a week over eight weeks for all inpatients in the unit. Falls were determined from ward incident books as described for phase 1. Nurses were not made aware of the scores obtained. For each week of the study, the risk scores of patients who had fallen during that week were compared with the scores of patients who had not fallen.

Phase 3: investigation of risk assessment tool in remote cohort (Kent and Canterbury Hospital)

We obtained a STRATIFY score for all inpatients on the elderly care wards on admission (within 24 hours) and weekly over an eight week period. The risk assessment was completed by ward nurses themselves, who were asked not to instigate specific measures on the basis of the score obtained. Falls were documented in the same way as for phase 2.

Statistical analysis

Phase 1—To compare the fallers and controls we used Student's *t* tests for continuously distributed data, Wilcoxon's non-parametric test for categorical scales (abbreviated mental test score, Barthel index, and transfer and mobility scores), and logistic regression for categorical data. To select variables for construction of the risk assessment tool, we calculated odds ratios for all differences.

Phases 2 and 3—We determined the specificity and sensitivity of STRATIFY scores ≥2 and ≥3 (0.5) in predicting falls in the following week from the proportions of fallers and non-fallers correctly identified. Exact confidence intervals for the proportions were calculated. Each week was treated as a separate datum, and no adjustment was made for repeated measures on the same patient.

Table 1 Prevalence of putative risk factors in elderly inpatients who fell and control patients (phase 1). Values are numbers (percentages) unless stated otherwise

Characteristic	Controls (n=116	Cases (n=116)	Odds ratio (95% confidence interval)
Mean (SD) age (years)	82.3 (7.4)	84.6 (7.0)	2.28 (0.42 to 4.14)
Median (interquartile range) abbreviated mental test score	7 (4-10)	6 (4-9)	–0.5 (–1.5 to 0)
Median (interquartile range) Barthel index	13 (7-17)	10.5 (6.5-14)	–2 (–3.5 to 0)
Median (interquartile range) transfer and mobility score*	4 (2-5.5)	3 (2-4.5)	–0.5 (–1 to 0)
Transfer and mobility score of 3 or 4†	34 (29)	54 (46)	2.10 (1.22 to 3.61)
Agitation†	9 (8)	74 (64)	20.9 (9.62 to 45.62)
Fall as presenting complaint†	23 (20)	62 (53)	4.64 (2.59 to 8.33)
Visual impairment†	5 (4)	16 (14)	3.55 (1.26 to 10.05)
Frequent toileting†	9 (8)	20 (17)	2.48 (1.08 to 5.70)
Walking aid	64 (55)	71 (61)	0.80 (0.61 to 1.04)
Hearing impairment	15 (13)	21 (18)	1.49 (0.72 to 3.60)
Unstable gait	40 (34)	90 (78)	6.58 (3.68 to 11.75)
Catheter or drip in situ	11 (9)	7 (6)	0.61 (0.23 to 1.64)
Drugs:			
Opiates	11 (9)	18 (16)	1.75 (0.79 to 3.90)
Sedatives	7 (6)	16 (14)	2.49 (0.98 to 6.31)
Anticonvulsants	7 (6)	12 (10)	1.80 (0.68 to 4.74)
Vasodilators	30 (26)	23 (20)	0.71 (0.38 to 1.31)
Diuretics	16 (14)	20 (17)	1.30 (0.64 to 2.66)
Antidepressants	25 (22)	14 (12)	0.50 (2.45 to 1.02)
Antiarrhythmics	2 (2)	31 (27)	20.79 (4.84 to 89.27)
Antiparkinsonian	13 (11)	4 (3)	0.28 (0.89 to 0.90)
Drugs in ≥2 of above classes	28 (24)	31 (27)	1.15 (0.63 to 2.07)

*Transfer and mobility score (range 0-6) obtained by combining the transfer and mobility sections of the Barthel index (each with ranges 0-3).
†Characteristics used in the final risk assessment (STRATIFY) score. Although differences for antiarrhythmics and unstable gait were significant, these factors were not used for methodological reasons (see main text for details).

Results

Phase 1: case-control study

One hundred and sixteen falls were recorded. Only seven risk factors were found to be significantly and independently more prevalent among fallers than controls (table 1). These were agitation, need for frequent toileting, unstable gait, visual impairment (all as judged by the patient's primary nurse), fall as a presenting complaint, and a transfer and mobility score of 3 or 4. There was no significant difference between fallers and controls in the median transfer and mobility score, but the distributions were significantly different (see figure). A transfer and mobility score of 3 or 4 (that is, the patient could stand with minimal or no assistance but had limited mobility with a walking aid) was significantly associated with risk of falling compared with higher or lower scores ($\chi^2 = 24.4$, $P < 0.001$).

In selecting only five variables for the final risk assessment score (see box), we bore several considerations in mind. We chose only variables that showed significant differences in univariate analysis. Two variables that gave significant results in multiple regression were not used. At the time of a patient's admission the nurses felt that they were less able to assess instability of gait than to use the objective transfer and mobility score. Treatment with antiarrhythmic drugs was not used as some ward nurses might not easily be able to assess which drugs were in this category.

Phase 2: local validation study

The risk assessment tool was completed 395 times on 217 patients, among whom 71 falls occurred in the

STRATIFY risk assessment tool

1 Did the patient present to hospital with a fall or has he or she fallen on the ward since admission?
(Yes = 1, No = 0)

Do you think the patient is (questions 2-5)
2 Agitated?
(Yes = 1, No = 0)
3 Visually impaired to the extent that everyday function is affected?
(Yes = 1, No = 0)
4 In need of especially frequent toileting?
(Yes = 1, No = 0)
5 Transfer and mobility score of 3 or 4?
(Yes = 1, No = 0)

Total score

week after an assessment (table 2). A risk score of 2 or more was calculated for 66 (93%) of the 71 fallers and for only 40 (12%) of the 324 non-fallers. Thus, in correctly predicting a fall in the week after assessment, a risk score of 2 or more had a sensitivity of 93% and a specificity of 88% (table 3). A score of three or more identified 49 (69%) of the fallers and 12 (4%) of the non-fallers—that is, a sensitivity of 69% and specificity 96%.

Phase 3: remote validation study

A total of 446 risk assessments were completed on 331 patients, who sustained 79 falls (table 2). In predicting falls in the following week, a risk score of 2 or more had a sensitivity of 92% and a specificity of 68%, and a score of three or more had a sensitivity of 54% and specificity of 88% (table 3).

Discussion

The initial case-control study showed that seven of the putative risk factors for falling were significantly more prevalent in the patients who fell than in the controls. Five of these factors were used to construct the risk assessment tool. These were the factors that were readily assessable by ward nurses based on their day to day observation of patients and could be performed shortly after admission to hospital. This conferred the advantage of generating a pragmatic risk assessment tool, taking about one minute per patient per week and requiring no formal measurements, additional training, or equipment. In the validation study at St Thomas's Hospital a score of 2 as a definition of "high risk" identified 93% of falls that occurred in the following week. At any one time only five or six patients on a 26 bed ward had a score of 2 or more. This could allow targeting of strategies to prevent falls on a small group of ward patients without "missing" many future fallers. In the validation study at Kent and Canterbury Hospital a risk score of 2 or more identified 70% of patients who subsequently fell, with a high (98%) negative predictive value, so again few future fallers were not identified.

At least three factors might explain the reduced power of the risk assessment tool at Kent and Canterbury Hospital. Firstly, the predictive power of risk factors is likely to be specific to one unit or patient group. Secondly, the risk assessment tool was completed by the nurses themselves, rather than by interview of the nurses, which might have reduced consistency of assessment. Thirdly, nurses aware of the predictive power of the score demonstrated elsewhere might have altered their care of "high risk" patients, thus preventing some falls (the Hawthorne effect[20]).

In choosing the appropriate "cut off" score that defines high risk, there is a trade off between a score that confers high sensitivity or high specificity. It may be that a prospective validation is necessary in any hospital unit before use of the risk assessment tool since case mix, ward design, and nursing philosophy and skills vary widely. A high cut off score that gave high specificity would lose sensitivity, thereby missing many patients who would fall. However, a low score, with high sensitivity, might define more than half the ward patients as high risk, which would be of no practical benefit.

There are examples of unit based programmes to prevent falls in Ireland[21] and the United States[2 15 22-24]

Key points

- Falls among elderly inpatients are common and result in morbidity, loss of independence, and higher healthcare costs
- Preventive strategies to reduce falls require identification of high risk patients
- In a case-control study investigating 21 possible risk factors we identified five factors significantly associated with falls
- We used these five factors to construct a risk assessment tool, which showed high sensitivity and specificity in predicting falls when tested in two elderly care units
- This simple assessment tool could be used in hospital to target prevention programmes to patients at high risk of falling

Table 2 Distribution of risk assessment scores in case-control study (phase 1) local validation study (phase 2) and remote validation study (phase 3)

	Case-control		Local validation		Remote validation	
Risk assessment score	Controls (n=116)	Falls (n=116)	Non-falls (n=324)	Falls (n=71)	Non-falls (n=363)	Falls (n=79)
0	58	13	181	1	134	3
1	41	25	103	4	114	3
2	12	38	28	17	70	30
3	5	35	10	34	36	33
4	0	5	2	13	5	5
5	0	0	0	2	4	5

Table 3 Usefulness of risk assessment scores of ⩾2 and ⩾3 in predicting falls among elderly inpatients in local and remote validation cohorts (phases 2 and 3). Values are percentages (95% confidence intervals)

	Local validation cohort		Remote validation cohort	
	Score ⩾2	Score ⩾3	Score ⩾2	Score ⩾3
Sensitivity	93.0 (84.3 to 97.7)	69.0 (56.9 to 79.5)	92.4 (84.2 to 97.2)	54.4 (42.8 to 65.7)
Specificity	87.7 (83.6 to 91.0)	96.3 (93.6 to 98.1)	68.3 (63.3 to 73.1)	87.6 (83.8 to 90.8)
Positive predictive value*	62.3 (52.3 to 71.5)	80.3 (68.2 to 89.4)	38.8 (31.8 to 46.2)	48.4 (38.1 to 59.8)
Negative predictive value†	98.3 (96.0 to 99.4)	93.4 (90.2 to 95.8)	97.6 (94.9 to 99.1)	89.8 (86.2 to 92.8)

*Positive predictive value=No of falls with score ⩾*n*/No of all scores ⩾*n*.
†Negative predictive value=No of falls with score <*n*/No of all scores <*n*.

which successfully extended standard nursing practice to prevent falls in inpatients. A similar programme may be effective in Britain. STRATIFY may be applicable to many acute hospital elderly units. Further study is needed to determine whether the falls of inpatients identified as high risk can be prevented by a targeted intervention.

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Impact of mild cognitive impairment on survival in very elderly people: cohort study

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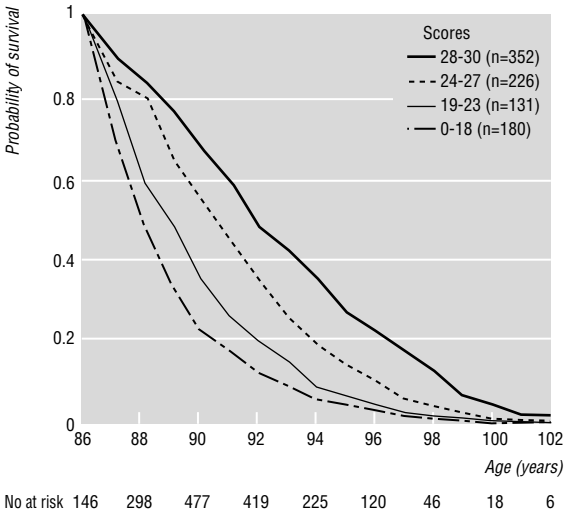
Severe cognitive impairment is associated with increased mortality, but the impact of mild cognitive impairment on survival remains unclear.[1 2] Although there is doubt whether a simple test such as the mini-mental state examination has sufficient discriminatory power to detect mild cognitive impairment in elderly people,[3] we determined the impact of borderline scores in this particular examination on survival in very elderly people.

Subjects, methods, and results

As part of the Leiden 85-plus study[4] we followed a cohort of 891 subjects (641 women, 250 men) aged 85 years and over (median age 90 (range 85 -103) years) from 1986 onwards. At entry to the study the score on the mini-mental state examination (Dutch version) was assessed by a physician during a home visit. In cooperation with the local government all but two subjects were followed for survival up to 1 October 1996. In all, 790 subjects died. Relative risks of mortality were estimated in a Cox proportional hazards model, which was adjusted for sex and for age at baseline.

During the first year of follow up, the annual mortality risk for subjects with mild cognitive impairment (score 24-27 points, n = 226) was twice as high (relative risk 1.8 (95% confidence interval 1.1 to 3.0)) as the annual mortality risk for subjects with a normal cognitive function (score 28-30 points, n = 352). This difference in risk remained similar until the seventh year of follow up, after which the annual mortality risk decreased to unity.



Survival probabilities from age of 86 years onwards for various categories of scores in the mini-mental state examination. Survival probabilities are calculated on data for 889 individuals followed for seven years, using actuarial method allowing individuals to enter survival table at different years of age (left censoring)

The cumulative mortality risk of the subjects with a mild cognitive impairment during the first seven years of follow up was 1.7 (1.4 to 2.0). This risk estimate was similar for men and women and for subjects below and over 90 years of age at baseline. Compared with subjects with a normal cognitive function, the cumulative mortality risk for subjects with a moderate cognitive impairment (score 19-23 points, n = 131) was

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