ORIGINAL ARTICLE

Predictors of falls in a high risk population: results from the prevention of falls in the elderly trial (PROFET)

J C T Close, R Hooper, E Glucksman, S H D Jackson, C G Swift

Emerg Med J 2003;**20**:421–425

See end of article for authors' affiliations

Correspondence to: Dr J C T Close, King's College Hospital (Dulwich), East Dulwich Grove, London SE22 8PT, UK; jacqueline.close@kcl.ac.uk

Accepted for publication 27 February 2003

Objectives: The prevention of falls in the elderly trial (PROFET) provides evidence of the benefits of structured interdisciplinary assessment of older people presenting to the accident and emergency department with a fall. However, the service implications of implementing this effective intervention are significant. This study therefore examined risk factors from PROFET and used these to devise a practical approach to streamlining referrals from accident and emergency departments to specialist falls services.

Methods: Logistic regression analysis was used in the control group to identify patients with an increased risk of falling in the absence of any intervention. The derived predictors were investigated to see whether they also predicted loss to follow up. A second regression analysis was undertaken to test for interaction with intervention.

Results: Significant positive predictors of further falls were; history of falls in the previous year (OR 1.5 (95%CI 1.1 to 1.9)), falling indoors (OR 2.4 (95%CI 1.1 to 5.2)), and inability to get up after a fall (OR 5.5 (95%CI 2.3 to 13.0)). Negative predictors were moderate alcohol consumption (OR 0.55 (95%CI 0.28 to 1.1)), a reduced abbreviated mental test score (OR 0.7 (95%CI 0.53 to 0.93)), and admission to hospital as a result of the fall (OR 0.26 (95%CI 0.11 to 0.61)). A history of falls (OR 1.2 (95%CI 1.0 to 1.3)), falling indoors (OR 3.2 (95%CI 1.5 to 6.6)) and a reduced abbreviated mental test score (OR 1.3 (95%CI 1.0 to 1.6)) were found to predict loss to follow up.

Conclusions: The study has focused on a readily identifiable high risk group of people presenting at a key interface between the primary and secondary health care sectors. Analysis of derived predictors offers a practical risk based approach to streamlining referrals that is consistent with an attainable level of service commitment.

The prevention of falls in the older population is a challenge faced by many disciplines and agencies. Accidents continue to be a key priority area with national and international policy directed towards a reduction in mortality and morbidity yet published statistics suggest that the number of deaths from falls in the older population continues to rise; age standardised death rate from accidental falls in women aged 65+ has risen from 60/100 000 in 1992 to 72/100 000 population in 1997.[1 2]

Most falls in this age group occur as a result of a dynamic interaction between intrinsic and extrinsic factors and as such interdisciplinary and multiagency intervention is likely to have the greatest impact. Lack of a simple cause and effect relation in elderly people who fall creates a diagnostic challenge and while many studies have highlighted risk factors for falling,[3–12] only recently have studies shown that appropriate modification of risk factors may change outcome.[10 13–20]

PROFET (prevention of falls in the elderly trial) is a UK based randomised controlled clinical trial that has shown the benefits of a structured interdisciplinary assessment of older people attending the accident and emergency (A&E) department with a fall.[17] A single medical and occupational therapy assessment, with onward referral to existing services where appropriate, produced a significant reduction in the number of falls, number of people falling, and number of recurrent fallers in the one year follow up period. There was also evidence that this model of good clinical practice preserved function. A health economics analysis has shown the study to be cost neutral (unpublished data).

The service implications of implementing this effective intervention in practice are significant. We therefore examined those risk factors from PROFET found to be predictive of further falls and used these to derive a practical approach to streamlining referrals from A&E departments to specialist falls services

METHODS

General

The detailed methodology of PROFET has been described previously.[17] (Outlined in fig 1). Patients were eligible if they were aged 65+, lived in the local community, and had attended A&E primarily as a result of a fall. Patients with a significant cognitive deficit and no live in carer were excluded as were those whose fall was directly related to alcohol intoxication. Consenting persons were invited to complete a baseline questionnaire detailing the nature of the index fall, previous falls, medical and drug history, and sociodemographic data. Randomisation was by a random number table and the code held independently of the clinical investigators.

The intervention group underwent a single detailed medical assessment by a geriatrician in the day hospital followed by an occupational therapist home assessment with onward referral to appropriate specialties and services where need was identified.

Both the control and intervention groups were followed up by postal questionnaire at 4, 8, and 12 months detailing further falls, fall related injury, service use, and functional ability.

Method for analysis of risk factors

Prediction of further falls and loss to follow up (control group)

To identify patients with an increased risk of falling in the absence of any intervention, logistic regression, with any fall

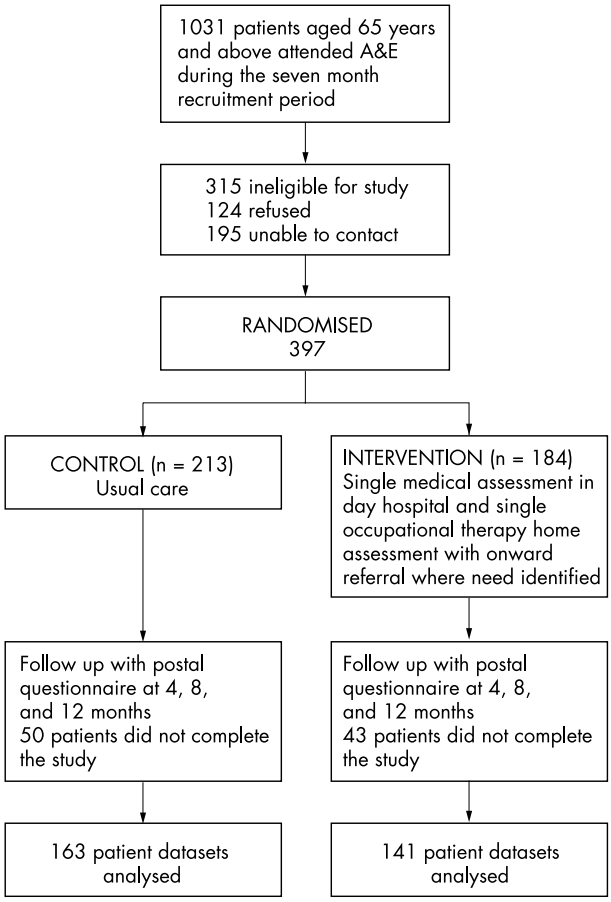

Figure 1 Summary of study design.

in the 12 month follow up period as the dependent variable, was applied to the control group alone. A range of independent variables as possible risk factors were investigated (table 1). Backwards elimination of these variables (where $p>0.05$) was used to arrive at a parsimonious regression model for the risk of falling. This analysis was restricted to patients who were followed up to 12 months. To further aid the interpretation of results, factors identified as independent predictors of falling were investigated to see whether they also predicted loss to follow up.

Interactions with intervention

We previously showed that intervention reduced the risk of subsequent falling.[17] If it can be assumed that intervention reduces the risk of falling proportionately across all subgroups, then intervention should be targeted on those patients at greatest risk of falling, as the number needed to treat to prevent one patient from falling will then be smallest. To check this assumption we added data on patients who had received intervention to the data on control patients, and entered these into a second regression analysis examining interactions between intervention and the risk factors already identified as independent predictors of falling in the control group.

Variables covered by the assessments

In addition, a list (available on request) of 34 potentially predictive variables derived from the medical examination and occupational therapy assessment was drawn up in the intervention group alone. Entering these into a logistic regression enabled a parsimonious regression model for the risk of falling in the intervention group to be derived.

Table 1 Variables investigated as possible risk factors for falling, on presentation at A&E among 163 patients with a fall

Variable	Description
Age	in years
Sex	M/F
Admitted to hospital	Y/N
Type of admission	surgical/medical (if admitted)
Duration of admission	in days (if admitted)
Falls in previous year	number of falls
Location of fall	indoors/outdoors
Cause of fall	slip or trip/other
Able to get up after fall	Y/N
Time spent on floor	<5 min/5–59 min/1–4 h/ >4 h
Any injury	Y/N
Prescribed drugs	number of drugs
Living alone	Y/N
Type of accommodation	house/flat or bungalow
Borough of London	Lambeth/Southwark/other
Use of personal social services:	
home help	Y/N
meals on wheels	Y/N
district nurse	Y/N
day centre	Y/N
day hospital	Y/N
other	Y/N
Previous adaptations	Y/N
Perceived ability to go out	able/not able
Mobility	independent/stick/frame/wheelchair
Smoking	current smoker/past smoker/never smoked
Alcohol intake	units of alcohol per week
AMT	
Barthel	

RESULTS

During the seven month recruitment period, 1031 patients aged 65 years and above attended the A&E department with a primary diagnosis of a fall (representing 20% of all attendees and 14% of emergency admissions in this age group). Of the 1031 people attending, 716 fulfilled the eligibility criteria, of whom 397 (55%) were ultimately randomised, providing the database for this analysis. Table 2 outlines the breakdown of all attendees.

Prediction of further falls (control group)

Six factors in the absence of intervention were shown by this model to have independent predictive significance (table 3). Increased alcohol intake, reduced abbreviated mental test score (AMT) score, and admission to hospital emerged as negative predictors of further falls. Conversely, falling within the previous year, falling indoors, and inability to get up after the index fall emerged as positive predictors.

Prediction of loss to follow up (control group)

At 12 month follow up, 163 (77%) of the 213 control group subjects remained in the study. Eighteen (8%) had moved to institutional care, 27 (13%) had died, and five (2%) had been lost to follow up. Of the six variables identified in table 3, falls in the previous year, location of fall, and AMT were also found individually to predict loss to follow up. Their effects were all in the anticipated direction:

- every fall in the previous year increased the odds of loss to follow up by 1.2 (95% confidence intervals 1.0 to 1.3, $p=0.008$)
- if the presenting fall occurred indoors rather than outdoors the odds of loss to follow up were increased by 3.2 (95% confidence intervals 1.5 to 6.6, $p=0.001$)
- a decrease of one scale point on AMT increased the odds of loss to follow up by 1.3 (95% confidence intervals 1.0 to 1.6, $p=0.017$).

Table 2 Baseline comparison all patients (1031) attending A&E with a primary diagnosis of a fall during study period

	Number (%)	Age (y)*	Female (%)	Admitted (%)
All patients	1031	78.2 (7.6)	709 (67)	315 (30)
Randomised	397 (39)	78.2 (7.5)	269 (68)	147 (37)
Institutional care†	117 (11)	82.3 (7.1)	85 (73)	46 (39)
Dementia and no live in carer†	60 (6)	84.2 (6.2)	48 (80)	36 (60)
Refused†	124 (12)	76.9 (7.4)	94 (76)	12 (10)
No contact	195 (19)	76.9 (7.2)	122 (63)	29 (15)
Other†	138 (13)	75.3 (7.0)	76 (55)	47 (34)

*Mean age (SD). †Did not fulfil study eligibility criteria.

Table 3 Predictors of further falls in 163 patients fulfilling the eligibility criteria and randomised to the control group

Variable	Odds ratio (95% CI)	p Value
Falls in previous year:		
for every fall	1.5 (1.1 to 1.9)	0.001
Location of index fall:		
indoors	2.4 (1.1 to 5.2)	0.021
Able to get up:		
no	5.5 (2.3 to 13.0)	<0.0005
Alcohol intake:		
for an increase of 10 units per week	0.55 (0.28 to 1.1)	0.034
AMT:		
for a decrease of one scale point	0.70 (0.53 to 0.93)	0.012
Admitted:		
yes	0.26 (0.11 to 0.61)	0.001

Interaction of risk factors with intervention

Only one of these interactions—with location of fall—was significant (p=0.021). Table 4 shows the effects of the other risk factors after adjusting for this interaction, as well as the effect of intervention estimated separately for presenting falls that occurred indoors and outdoors. The intervention appears to be useful only where the presenting fall occurred indoors. The interaction is not significant if a Bonferroni correction is made to adjust for the number of interactions considered. (Bonferroni corrects statistical level of significance taking into account the potential interaction of the intervention with six different risk factors—that is, $p<0.05/6=0.0083$.)

Factors identified from the assessments

In the regression analysis of listed variables from the medical and occupational therapy assessments, only one factor emerged as significant: multiple drug use, as defined by the use of four or more prescribed drugs (odds ratio 4.3, 95% confidence intervals 1.9 to 9.6, $p<0.0005$).

Assuming that intervention will lead to benefit in terms of risk reduction, figure 2 illustrates a very simple, hierarchical approach to selecting patients to be referred for a detailed falls assessment based on the results in table 3. Of the initial 397 consenting people in our study, these criteria would have identified 96 (24.2%) for referral. Based on what happened to the intervention and control subjects respectively who were followed up in the study, only 31% of those referred would have gone on to fall in the following year compared with 86% had they not been referred.

DISCUSSION

This study has focused on a readily identifiable high risk group presenting at a key interface between primary and secondary health care sectors. The risk factors we found to be predictive of further falls are easily detectable in the A&E setting, may be a useful tool in deciding the degree of priority for further assessment, and may assist in the realistic planning of a service (A&E form avaliable to view on the journal web site, www.emjonline.com/supplemental). As with all models, however, they serve only as a guide and should not be used to exclude referral on the basis of perceived clinical need.

Falls in the previous year and falling indoors predict both loss to follow up and (in those who are followed up) subsequent falling. Of the group lost to follow up, the cause in 90% was either death or moving to institutional care. Loss to follow up in any programme therefore in itself signals high risk and a requirement to intervene. Interestingly, admission

Table 4 Predictors of further falls, among 141 patients fulfilling the eligibility criteria and randomised to the intervention group taking account of intervention as well as the risk factors previously identified

Variable	Odds ratio (95% CI)	p Value
Falls in previous year:		
for every fall	1.4 (1.2 to 1.6)	<0.0005
Location of fall:		
indoors	2.2 (1.0 to 4.4)	0.019
Able to get up:		
no	3.4 (1.9 to 6.3)	<0.0005
Alcohol intake:		
for an increase of 10 units per week	0.61 (0.39 to 0.95)	0.006
AMT:		
for a decrease of one scale point	0.69 (0.54 to 0.87)	<0.0005
Admitted:		
yes	0.43 (0.23 to 0.80)	0.006
Intervention:		
yes – indoor fall	0.17 (0.07 to 0.40)	<0.0005
– outdoor fall	0.63 (0.30 to 1.3)	0.222

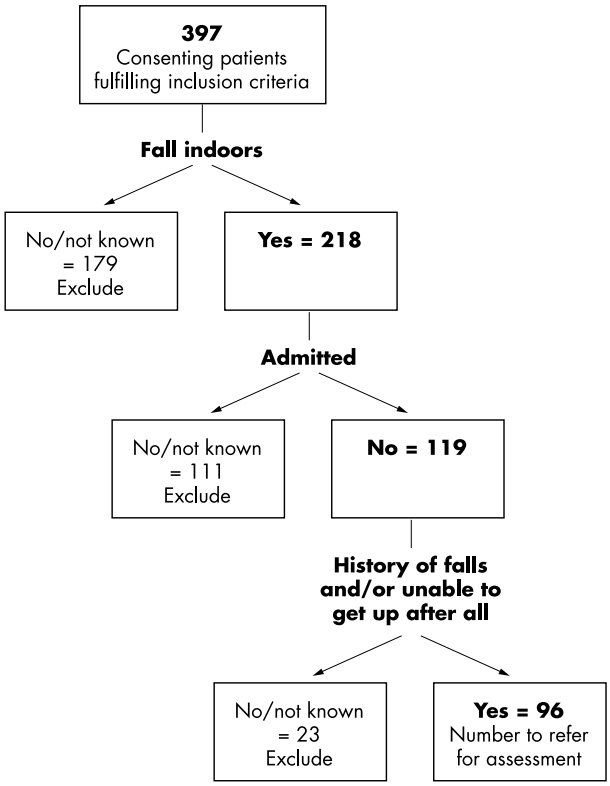

Figure 2 Model showing the number of patients with potential to benefit from specialist falls service using identified predictors.

to hospital did not predict loss to follow up although these people were not recruited until the point of discharge thus eliminating those deaths occurring as a direct result of the fall and admission to hospital.

Impaired cognition (reduced AMT) in this analysis was associated with a reduced likelihood of subsequent falling in those completing, but also predicted loss to follow up. As other studies have found cognitive impairment to be a significant risk factor for falls this somewhat anomalous finding probably reflects a selection bias of this study, which excluded those with an AMT of <7 unless they had a live in carer.[4 6 8 9 12] The presence of a carer may well be protective in this group. The positive association of alcohol consumption with a reduced odds ratio is in keeping with observations that moderate alcohol consumption is associated with a reduced risk of hip fracture.[21]

Multiple drug consumption is an accepted risk factor for falls,[6 11 12] and our findings support the view that the number is as important as the class of prescribed drug. Caution is required in interpreting results from the medical and occupational therapy assessments, as the data do not contain the effects of these variables in the absence of intervention.

When reviewing those who fall outdoors, the results in table 3 could be a chance finding (significance is lost if a Bonferroni correction is applied for the number of interactions examined). None the less, the data probably suggest that intervention may not be useful where the presenting fall occurred outdoors.

The number of specialist falls services in the UK is growing despite a relative weak evidence base on those patients most likely to benefit. PROFET provides evidence that people who fall and present to A&E are a high risk population who benefit from skilled intervention. In addition, the recently published National Service Framework for Older People,[22] is clear in its statement that older people presenting to A&E with a fall should have access to a specialist falls service.

This analysis of derived predictors uses easily identifiable risk factors as a way of streamlining referrals from busy A&E departments and is consistent with an attainable level of service commitment for specialist falls services.

Key points

- Evidence from a randomised controlled trial has shown benefit in assessing older people presenting to A&E with a fall—prevention of falls in the elderly trial (PROFET).
- Using derived predictors of risk, it is possible to streamline referrals from the A&E department to a specialist falls service that is consistent with an attainable level of service commitment.
- Risk factors identified from PROFET as predictive of falling are;
  - a history of one or more falls in the previous year,
  - the fall occurring indoors,
  - inability to get off the floor as a result of the fall
  - polypharmacy (4+ regularly prescribed drugs).

Contributors

Jacqueline Close was the principal investigator and involved in the design, execution, and analysis of the study and the lead author for the paper. Richard Hooper provided the statistical advice during the study design and undertook the detailed analysis and interpretation of data. Edward Glucksman and Stephen Jackson both contributed to the original design of the study and provided advice on interpretation of outcomes and in the writing of the paper. Cameron Swift was the academic supervisor of the lead author and was involved in all aspects of the study from inception to outcome. The guarantor is Jacqueline C T Close.

A copy of the falls assessment form is available on the journal web site (www.emjonline.com/supplemental).

Authors' affiliations
J C T Close, S H D Jackson, C G Swift, Clinical Age Research Unit, Department of Health Care of the Elderly, Guy's, King's and St Thomas' School of Medicine, King's College, London, UK
R Hooper, Department of Public Health Medicine, Guy's, King's and St Thomas' School of Medicine King's College
E Glucksman, Department of Accident and Emergency Medicine, King's College Hospital, London

Funding: this study was funded by an NHS R&D Project Grant.

Conflicts of interest: none declared.

REFERENCES

1 **Secretary of State for Health**. *Saving lives: our healthier nation*. (CM4386). London: The Stationery Office, 1999: chapter 7.
2 **Office of National Statistics**. *Mortality figures for accidental falls*. London: Office of National Statistics, 1998. (www.ons.co.uk)
3 **Nevitt MC**, Cummings SR, Kidd S, *et al*. Risk factors for recurrent non-syncopal falls. A prospective study. *JAMA* 1989;**261**:2663–8.
4 **Tinetti ME**, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988;**319**:1701–7.
5 **Tinetti ME**, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med* 1986;**80**:429–34.
6 **Rubenstein LZ**, Josephson KR, Robbins AS. Falls in the nursing home. *Ann Intern Med* 1994;**121**:442–51.
7 **Studenski S**, Duncan PW, Chandler J. Postural responses and effector factors in persons with unexplained falls: results and methodological issues. *J Am Geriatr Soc* 1991;**39**:229–34.
8 **Prudham D**, Evans JG. Factors associated with falls in the elderly: a community study. *Age Ageing* 1981;**10**:141–6.
9 **Lord SR**, Clark RD. Simple physiological and clinical tests for the accurate prediction of falling in older people. *Gerontology* 1996;**42**:199–203.
10 **Hornbrook MC**, Stevens VJ, Wingfield DJ, *et al*. Preventing falls among community-dwelling older persons: results from a randomized trial. *Gerontologist* 1994;**34**:16–23.
11 **Campbell AJ**, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. *J Gerontol* 1989;**44**:M112–17.

12 **Buchner DM**, Larson EB. Falls and fractures in patients with Alzheimer-type dementia. *JAMA* 1987;**257**:492–5.
13 **Tinetti ME**, Baker DI, McAvay G, *et al*. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med* 1994;**331**:821–7.
14 **Wolf SL**, Barnhart HX, Kutner NG, *et al*. Reducing frailty and falls in older persons: an investigation of Tai Chi and computerized balance training. Atlanta FICSIT Group. Frailty and Injuries: Cooperative Studies of Intervention Techniques. *J Am Geriatr Soc* 1996;**44**:489–97.
15 **Ray WA**, Taylor JA, Meador KG, *et al*. A randomized trial of a consultation service to reduce falls in nursing homes. *JAMA* 1997;**278**:557–62.
16 **Campbell AJ**, Robertson MC, Gardner MM, *et al*. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* 1997;**315**:1065–9.
17 **Close JCT**, Ellis M, Hooper R, *et al*. Prevention of falls in the elderly trial (PROFET): a randomised controlled trial. *Lancet* 1999;**353**:93–7.
18 **Buchner DM**, Cress ME, de Lateur BJ, *et al*. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *J Gerontol A Biol Sci Med Sci* 1997;**52**:M218–24.
19 **Campbell AJ**, Robertson MC, Gardner MM, *et al*. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: a randomized, controlled trial. *J Am Geriatr Soc* 1999;**47**:850–3.
20 **Cumming RG**, Thomas M, Szonyi G, *et al*. Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomized trial of falls prevention. *J Am Geriatr Soc* 1999;**47**:1397–402.
21 **Cummings SR**, Nevitt MC, Browner WS, *et al*. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. *N Engl J Med* 1995;**332**:767–73.
22 **Secretary of State for Health**. *National Service Framework for older people*. London: Department of Health, 2001.