Scandinavian Journal of Caring Sciences
EMPIRICAL STUDIES
doi: 10.1111/scs.12733

Falls in hospital: a case–control study

Gudrun Cathrine Lindgren de Groot MS (Physical therapist)[1], **Ahmad Al-Fattal** MD (Physician, Geriatrician)[1] and **Irene Sandven** MPH, PhD[2]

[1]Department of Medicine, Telemark Hospital, Skien, Norway and [2]Oslo Centre of Biostatistics and Epidemiology, Research Support Services, Oslo University Hospital Sogn Arena, Oslo, Norway

Scand J Caring Sci; 2019

Falls in hospital: a case–control study

Aims: Falls among inpatients are common. The method used by The Norwegian Patient Safety Campaign to measure the adverse events is the Global Trigger Tool, which does not look at the causation for falls. This study was aimed at investigating major risk factors for falls in the hospital setting.
Methods: This retrospective case–control study was conducted at Telemark Hospital in Norway, in the period from September 2012 to August 2014. A total of 842 patients from three wards were included, whereof 172 cases had experienced one or more fall(s) during hospitalisation and 670 random controls had not fallen. Data were analysed according to a pragmatic strategy.
Results: Compared with patients who did not fall, patients who fell were 21 times more likely to have poor balance (OR = 21.50, 95% CI: 10.26–45.04) and 19 times more likely to have very poor balance (OR = 19.62, 95% CI: 9.55–40.27), twice as likely to be men (OR = 1.82, 95% CI: 1.24–2.68), and 50% increased probability of fall with every 10 year increase of age (OR = 1.51, 95% CI: 1.34–1.69). Furthermore, the patients who fell were more likely to use antidepressant drugs (OR = 3.85, 95% CI: 1.09–13.63), antipsychotic drugs (OR = 3.27, 95% CI: 1.94–5.51), anxiolytic/hypnotic drugs (OR = 1.80, 95% CI: 1.22–2.67) and antiepileptic drugs (OR = 1.13, 95% CI: 1.11–4.06) than patients who did not fall.
Conclusions: During hospital stay, patients who fell had a higher risk profile than patients who did not fall. Clinicians should work to improve patients' safety and reduce the risk of falls by accurately assessing balance and mobility as a form of primary prevention. We recommend that a review of the patient medications should be conducted upon falling, as a form of a secondary preventive strategy against falls.

Keywords: falls, drugs, antidepressants, hospital, balance.

Submitted 5 November 2018, Accepted 2 June 2019

Introduction

Falls among inpatients are common, and the incidence varies from 3, 4 cases per bed annually in the acute rehabilitation of stroke patients to an average fall rate of 4.8 falls per 1000 patient days in acute hospitals (1,2). Falls in the elderly may cause loss of independence, injuries and sometimes death as a result of the injury (3). In 2017, falls accounted for 13.7% of all adverse events reported from Norwegian hospitals (4). Most frequent were falls due to loss of balance, falls out of bed or in connection with going to the toilet (4). Risk factors for falls are well documented (5). Still, there is inconclusive evidence for the effectiveness of most preventive strategies (1,6). There is evidence that multifactorial interventions reduce falls in hospitals, although subgroup analysis suggests this may apply mostly to a subacute setting, but the evidence for risk of falling was uncertain (3). Effective interventions are important to detect, because they will have significant health benefits for older people.

In 2012, Telemark Hospital was selected to be a pilot project in the Norwegian Patient Safety Program, 'In safe hands,' and therefore started the registration of all accidental falls (7). In a two-year period, 172 falls were registered in three hospital wards (Neurology, Respiratory medicine and Acute Geriatric medicine). The hospital quality assurance register suggested that these three wards had the highest number of falls registered among elderly patients between the ages of 76 and 85 years. An earlier study demonstrated an extensive use of drugs given in hospitals, where the average drug consumption was over seven drugs per patient (8). Central nervous system (CNS) active drugs, such as neuroleptics, benzodiazepines and antidepressants, appear to be the most common drugs associated with falls (5). It is claimed that the

Correspondence to:
Gudrun Cathrine Lindgren de Groot, Department of Medicine, Telemark Hospital, Postboks 2900 Kjørbekk, 3710 Skien, Norway.
E-mail: cathrine.degroot@sthf.no

use of drugs is one of the most modifiable fall risks in hospital (5). Based on this evidence, one might assume that a medication review is a key factor to preventing falls in the acute hospital setting. It may, however, prove difficult to change a patient's medication in the hospital setting. An Irish study from 2014 demonstrated a higher possibility for change of on-demand drugs as compared with regular medication (9).

From 2010 to 2012, the proportion of adverse events reported from Norwegian hospitals decreased from 16 to 13.9% at the national level (10). Since then, the proportions have been stable, but the risk of moderately serious patient injury has probably increased (10). The method used to measure these numbers is the Global Trigger Tool, which does not look at the causation between these adverse events (10). By improving our knowledge about today's clinical situation, we will have a better understanding of how to weigh interventions in order to reduce the number of falls. Therefore, we see the need for more knowledge with regard to clinical practice in relation to evidence-based practice. Consequently, this study was aimed at investigating which major risk factors had the strongest association with the falls that have occurred.

Material and methods

A retrospective case–control study was conducted at Telemark Hospital in Norway. Eligible for inclusion were adults, 18 years or older, admitted to the hospital from September 2012 to August 2014. Participants were recruited from three wards: Neurology, Respiratory medicine and Acute Geriatric medicine. From the total number of patients admitted to these three wards during the study period (source population), we included all the patients registered with one or more falls (cases) during hospitalisation and a random sample of patients who did not fall (controls). The procedure of random controls was to remove 172 cases from the total 5957 patients at the three wards during the study period leaving 5785 not with falls. Weighting was done according to the total number of patients at the three wards: Respiratory medicine (2585), Neurology (3058) and Acute Geriatric medicine (142). Considering four controls per case, we estimated the number of controls needed from each ward. The random sample was generated in STATA version 11.0 (Statacorp, College Station, TX, USA) with sampling fractions at the Respiratory medicine ward, the Neurology ward and the Acute Geriatric medicine ward of 11.7, 11.7 and 11.9%, respectively.

Fall was defined as 'an event resulting in a person coming to rest inadvertently on the ground, floor or other lower level, whether there is any damage caused by the fall' (7). The major risk factors for falls were considered most relevant for an acute hospital setting based on the earlier mentioned pilot project. These factors include age, sex, balance, chronic diseases, renal function and drugs. Increased inpatient fall risk has been associated with older age and poor health status (1), and therefore, the diagnosis and the number of chronic diseases were registered. Patients with previous history of falls, reduced balance and poor gait are at an increased risk for future falls (11). The information on balance was clinically assessed to be either of good balance (patient was able to walk without a walking aid), or of poor balance (patient was walking unsteadily but had no documented walking aid) or of very poor balance (patient was walking unsteadily and had a documented walking aid). Patients with poor renal function are less able to excrete drugs. Rowe (12) cited in Rochon (13) claims that decreased drug clearance may also result from the natural decline in renal function with age, even in the absence of renal disease. This increases the risk that the patient is being exposed to a higher dosage of the drug, as compared to a patient with normal renal function (14). The renal function was measured as good (glomerular filtration rate (GFR) >60), moderate (GFR 30–60) or poor (GFR <30). Polypharmacy is also a known risk factor associated with falls (13). Each medication was therefore registered upon admission, during hospital stay and at discharge. The following six CNS active drug groups were considered potential risk factors for falls: antidepressants, cardiovascular and antihypertensives, opioids, antiepileptics, antipsychotics, and anxiolytic and hypnotic drugs.

Registration of patient data was based on information from (1) the pilot project, (2) the hospital's safety system Total Quality Management (TQM) and (3) the patient's medical records. A case report form (CRF) was developed and a database built in EPIDATA ENTRY version 3.1 (The EpiData Association, att. Jens Lauritsen, Denmark, Europe).

Sample size estimation was performed considering antidepressant drugs as a potential risk factor for falls. Based on an estimated prevalence of antidepressant use among stroke patients of 30% (15) and users being 1.68 times more likely to fall compared with non-users (16), we would need a minimum of 167 cases and 668 controls considering four controls per case, a type I error of 5% and power of 80%.

We analysed the data according to a pragmatic strategy, which means that the priority was not given to a specific hypothesis. The association between potential risk factors and falls was quantified by the odds ratio (OR) and its 95% confidence interval (CI). We explored the importance of patients' age by stratifying age according to the 25, 50 and 75% percentiles, and estimated the association and gradient effect of each risk factor along the four age groups by a chi-square test for trend. To identify the independent risk factors for falls, we performed a manual backward stepwise elimination procedure using the logistic regression model (22). Multivariable analyses were preceded by the estimation of correlations between variables. The criteria for sequential elimination of candidate risk factors were variables' strength and significance on the association with fall, and optimal calibration and discrimination of the model. The predictive accuracy of the model was evaluated by calibration and discrimination. Calibration measures the ability of the model to assign the appropriate risk and was evaluated by the Hosmer and Lemeshow (H-L) goodness-of-fit test. A statistically nonsignificant H-L result (p-value > 0.05) suggests that the model predict accurately on average. Discrimination measures the model's ability to differentiate between patients who fall and not fall and was evaluated by the analysis of the area under the ROC curve. If the area under the curve is greater than 0.7, it can be concluded that the model has an acceptable discriminatory capability.

Results

A total of 842 patients were included in the study, whereof 172 fallers (cases) and 670 nonfallers (controls). The clinical profile and the distribution of potential risk factors are presented in Table 1. Compared with controls, cases were 12 years older (median age 78 vs. 66), more frequently males (58.7% vs. 46.7%), with poor balance (39.0% vs. 15.5%) or very poor balance (54.1% vs. 23.7%), having multiple chronic diseases (60.5% vs. 50.1%) and getting the following drugs: antidepressants (2.9% vs. 1.0%), cardiovascular/antihypertensive drugs (22.7% vs. 12.2%), opiates (32.0% vs. 22.4%), antiepileptic drugs (13.4% vs. 5.2%), antipsychotic drugs (19.2% vs. 6.4%) and anxiolytics/hypnotic drugs (47.1% vs. 25.2%).

Our results showing the association between the different age groups and the different risk factors are summarised in Table 2. With increasing age, there was an increasing frequency of patients with poor balance, poor renal function, multiple chronic diseases, use of cardiovascular/antihypertensive drugs and anxiolytic/hypnotic drugs. The frequency of men and the use of antiepileptic drugs decreased with increasing age. All these associations showed a gradient effect with highly significant test for trend. There was no association between the use of opioids, antipsychotic drugs and antidepressant drugs with increasing age.

The final analysis, in order to highlight the independent risk factors for falls, is shown in Table 3. Due to the association between age and the presence of poor or very poor balance, poor renal function, chronic diseases, male sex and the use of cardiovascular/antihypertensive drugs, anxiolytic/hypnotic drugs and antiepileptic drugs, two multivariate models were needed to avoid collinearity problems. Model A shows that the patients who fell had 21 times (OR = 21.50, 95% CI: 10.26–45.04) the prevalence of poor balance and 19 times (OR = 19.62, 95% CI: 9.55–40.27) the prevalence of very poor balance as compared to the patients who did not fall. Furthermore, this group was twice as likely to consist of men (OR = 1.82, 95% CI: 1.24–2.68), and using/receiving the following drugs: anxiolytic/hypnotic drugs (OR = 1.80, 95% CI: 1.22–2.67), antiepileptic drugs (OR = 1.13, 95% CI: 1.11–4.06) and antipsychotic drugs (OR = 2.01, 95% CI: 1.15–3.51). Model B informs us that the probability of falling increased with 50% with every 10-year increase of age (OR = 1.51, 95% CI: 1.34–1.69). Furthermore, the patients who fell used three times more antipsychotics (OR = 3.27, 95% CI: 1.94–5.51) and antidepressant drugs (OR = 3.85, 95% CI: 1.09–13.63) than the patients who

Table 1 Clinical profile of patients with fall (cases) vs. no fall (controls)

	Casesn = 172 (%)	*Controlsn = 670 (%)*	*OR (95% CI)*	*p-Value*
Age in years, median (IQR)	78 (68–85)	66 (49–79)		0.001
Men	101 (58.7)	313 (46.7)	1.62 (1.16–2.28)	0.005
Balance[a]				
Good	9 (5.2)	353 (52.7)	(reference)	
Poor	67 (39.0)	104 (15.5)	25.27 (12.18–52.40)	0.001
Very poor	93 (54.1)	159 (23.7)	22.94 (11.29–46.63)	0.001
Poor renal function	47 (27.3)	189 (28.2)	0.96 (0.66–1.39)	0.818
Multiple chronic diseases	104 (60.5)	336 (50.1)	1.52 (1.08–2.14)	0.016
Drugs				
Antidepressants	5 (2.9)	7 (1.0)	2.84 (0.89–9.05)	0.078
Cardiovascular/Antihypertensive	39 (22.7)	82 (12.2)	2.10 (1.37–3.22)	0.001
Opiates	55 (32.0)	149 (22.4)	1.64 (1.14–2.38)	0.008
Antiepileptics	23 (13.4)	35 (5.2)	2.80 (1.61–4.88)	0.001
Antipsychotics	33 (19.2)	43 (6.4)	3.46 (2.12–5.65)	0.001
Anxiolytics/Hypnotic	81 (47.1)	169 (25.2)	2.64 (1.87–3.73)	0.001
Polypharmacy	78 (45.3)	170 (25.4)	2.44 (1.69–3.49)	0.001

CI, confidence interval; IQR, interquartile range; OR, odds ratio.

[a]Missing 57 (6.7%).

did not fall. The H-L goodness-of-fit test was nonsignificant for model A with five risk factors (p-value = 0.6486) and model B with three risk factors (p-value = 0.9763). This indicates a useful goodness of fit for the two models and that they predict accurately on average and suitable for use in low- to high-risk patients. Additionally, model

Table 2 Gradient effect of age interval by quartiles and frequency of risk factors

	Age (years)					
	≤51	*52–68*	*69–80*	*≥81*	*Total*	*p-Value trend*
Fall						
Yes (cases)	13	37	56	66	172	0.0001
No (controls)	198	181	156	135	670	
Total	211	218	212	201	842	
Frequency (%)	6.2	17.0	26.4	32.8	20.4	
OR (95% CI)	1.0	3.1 (1.6–6.0)	5.5 (2.9–10.4)	7.4 (4.0–14.0)		
Sex						
Male	101	130	95	88	414	0.0037
Female	110	88	117	113	428	
Total	211	218	212	201	842	
Frequency	52.1	47.9	59.6	44.8	43.8	
OR (95% CI)	1.0	1.6 (1.1–2.4)	0.9 (0.6–1.3)	0.8 (0.6–1.3)		
Balance						
Poor	62	98	142	178	480	0.0001
Good	149	120	70	23	362	
Total	211	218	212	201	842	
Frequency (%)	29.4	45.0	67.0	88.6	57.0	
OR (95% CI)	1.0	2.0 (1.3–2.9)	4.9 (3.2–7.4)	18.6 (11.0–31.5)		
Renal function						
Poor	29	35	68	104	236	0.0001
Good	182	183	144	97	606	
Total	211	218	212	201	842	
Frequency (%)	13.7	16.1	32.1	51.7	28.0	
OR (95% CI)	1.0	1.2 (0.7–2.0)	3.0 (1.8–4.8)	6.7 (4.2–10.9)		
Chronic diseases						
≥4	45	103	140	152	440	0.0001
<4	166	115	72	49	402	
Total	211	218	212	201	842	
Frequency (%)	21.3	47.2	66.0	75.6	52.3	
OR (95% CI)	1.0	3.3 (2.2–5.0)	7.2 (4.6–11.1)	11.4 (7.2–18.1)		
Cardiovascular/Antihypertensive drugs						
Yes	7	22	44	48	121	0.0001
No	204	196	168	153	721	
Total	211	218	212	201	842	
Frequency (%)	3.3	10.1	20.8	23.9	14.4	
OR (95% CI)	1.0	3.3 (1.4–7.8)	7.6 (3.4–17.4)	9.1 (4.0–20.8)		
Anxiolytic/Hypnotic drugs						
Yes	30	58	82	80	250	0.0001
No	181	160	130	121	592	
Total	211	218	212	201	842	
Frequency (%)	14.2	26.6	38.7	39.8	29.8	
OR (95% CI)	1.0	2.2 (1.3–3.6)	3.8 (2.4–6.1)	4.0 (2.5–6.4)		
Antiepileptic drugs						
Yes	19	19	17	3	58	0.0241
No	192	199	195	198	784	
Total	211	218	212	201	842	
Frequency (%)	9.0	8.7	8.0	1.5	6.9	
OR (95% CI)	1.0	1.0 (0.5–1.9)	0.9 (0.4–1.7)	0.2 (0.04–0.5)		

Table 2 (Continued)

	Age (years)					
	≤51	52–68	69–80	≥81	Total	p-Value trend
Opioids						
Yes	56	40	56	52	204	0.1383
No	155	178	156	149	638	
Total	211	218	212	201	842	
Frequency (%)	26.5	18.3	26.4	25.9	24.2	
OR(95% CI)	1.0	0.6 (0.4–1.0)	1.0 (0.6–1.5)	1.0 (0.6–1.5)		
Antipsychotics						
Yes	20	14	16	26	76	0.1115
No	191	204	196	175	766	
Total	211	218	212	201	842	
Frequency (%)	9.5	6.4	7.5	12.9	9.0	
OR (95% CI)	1.0	0.7 (0.3–1.3)	0.8 (0.4–1.5)	1.4 (0.8–2.6)		
Antidepressants						
Yes	3	7	2	0	12	0.2168
No	208	211	210	201	830	
Total	211	218	212	201	842	
Frequency (%)	1.4	3.2	0.9	0.0	1.4	
OR (95% CI)	1.0	2.3 (0.6–9.0)	0.7 (0.1–4.0)	–		

CI; confidence interval; OR; odds ratio.

A demonstrated an excellent discriminatory capability (AUC = 0.8306) and model B demonstrated an acceptable discriminatory capability (AUC = 0.7164).

Discussion

Results from this study suggest that antiepileptic drugs, antipsychotic drugs, anxiolytic/hypnotic drugs and antidepressant drugs could be important risk factors for falls during hospital stay along with well-known risk factors such as age, sex and balance.

Among the risk factors for falls investigated in this study, the most clinically important identified risk factor was balance. The prevalence of poor balance and very poor balance was high (39.0 and 54.1%) among patients who experienced a fall during hospital stay. We know from earlier studies that intrinsic factors such as sensory input, muscle activation patterns, lower extremity function and gait speed are all factors known to decline due to old age and thus reduce balance and mobility (17,18). Acute illness in combination with sedentary behaviour among older patients during hospital stay reduces balance and mobility even further. A study investigating the characteristics and circumstances of falls in a hospital setting found lost balance to be the most common adverse event reported in connection to falls and ambulation to be the most common performed activity at the time of the fall (19). Results from our study indicate a high risk of falling on both clinically assessed levels of impaired balance, which may help identify patients most likely to benefit from preventive interventions. Personal assistance or a walking aid can in many cases prevent a fall, but these resources were not investigated in the current study. In clinical practice, we often see that the injury caused by a fall is often treated without assessing balance or investigating other possible causes of the fall (5). A reason for this could be that these investigations often consume a longer time than to treat the injury itself. Another reason could be lack of knowledge among the staff. Hence, based on our findings, we suggest a greater need for accurately assessing balance and mobility. This can help clinicians identify early signs of functional decline and assist with the individual's interventions goal setting, and also with discharge planning. The latter is especially important considering that exercise improving strength and balance is known to prevent falls among community-dwelling older adults (20,21).

The drugs with the highest association to a fall were not unexpectedly the antidepressants drugs (OR = 3.85) and the antipsychotic drugs (OR = 3.27). This association is well known (22). However, we found that the frequency was very low for use of antidepressants (1.4%) and relatively low for the antipsychotics (9%). This could indicate that clinicians had been wisely cautious in prescribing these drugs in old age.

The prevalent use of medication was highest for anxiolytic/hypnotic drugs (29.8%). These drugs were given to 47% of the fallers and 25% of the nonfallers. Looking through the patients' medical records, we found that the anxiolytic/hypnotic drugs are a widely prescribed

Table 3 Risk factors differentiating patients with fall versus no fall using the multivariate logistic model

Risk factors	*Level*	*OR (95% CI)*	*p-Value*
Model A			
Male sex	Yes/no	1.82 (1.24–2.68)	0.002
Balance	Good	(reference)	
	Poor	21.50 (10.26–45.04)	0.001
	Very poor	19.62 (9.55–40.27)	0.001
Anxiolytics/Hypnotic drugs	Yes/no	1.80 (1.22–2.67)	0.003
Antiepileptic drugs	Yes/no	1.13 (1.11–4.06)	0.022
Antipsychotic drugs	Yes/no	2.01 (1.15–3.51)	0.014
Model B			
Age	10 year increase	1.51 (1.34–1.69)	0.001
Antipsychotic drugs	Yes/no	3.27 (1.94–5.51)	0.001
Antidepressants	Yes/no	3.85 (1.09–13.63)	0.037

CI, confidence interval; OR, odds ratio.
Two-model presentation was used to avoid the problem of collinearity between the risk factors of fall

group of drugs before and during hospital stay, and often in unsuitable combination with other drug groups. This puts an important emphasis on the careful and precautious administration of these drugs, especially in the presence of other risk factors such as old age and poor balance. Browne et al. (9) concluded that 80% of the fall risk medications suitable for intervention came from four drug classes: anti-emetics, opioid analgesics, anti-cholinergic agents acting on the bladder and benzodiazepines/hypnotics (9). Among six groups of central nervous system (CNS) active drugs investigated in the current study, four groups were identified as independent risk factors for falls. All four drug groups fall within these four classes. To prevent falls in the hospital setting, we suggest a more targeted fall risk medication review, with a particular focus on antidepressants, antiepileptics, antipsychotics and anxiolytic/hypnotic drugs.

From the time of hospital admission to discharge, we observed that the number of drugs administered during that period was higher and increased more during hospital stay, for the fallers as compared to the nonfallers. This is of a great concern knowing that the interaction of drugs themselves can lead to falls. Thus, we see the need for a more organised, targeted and systematic cooperation concerning medication prescribed during hospital stay and the discontinuation of medications upon discharge (23).

The association between old age and falls is long known, but in the clinical setting, age limit is still discussed when considering fall risk. In the literature, an increased fall risk is described among community-dwelling people 65 years or older, and Hitcho et al. found an average age of 63 among hospital fallers (5,19). In the present study, the median age of the patients was 69 years, and patients who fell were on average 12 years older than those with no fall. We further observed a gradient association between patient's age and fall, and that age was associated with the majority of risk factors considered. Therefore, we argue that age, in itself, is still a factor that always needs to be considered when aiming to prevent falls, and especially in relation to poor balance and mobility.

As for the other risk factors considered in our study, kidney function, chronic diseases and opioids, they were not significantly associated with falls, had minimal confounding effect and did not change the model's predictive and discriminatory ability. Given the utility for clinical practice, we excluded these variables from the model presented, keeping those regarded most clinically relevant.

Strengths of the study include minor probability of selection bias as all patients registered with falls (cases), and a random sample of controls were selected from the same source population during the same time period. Limitations include the possibility of information bias because case status and risk factor status were assessed in retrospect from medical records. However, the resident physicians were masked to our research questions, and the potential misclassification would be nondifferential creating a bias towards the null effect (24). Due to the lack of information in the medical records, there is a possibility of unmeasured risk factors such as poor vision, dizziness and cognitive status of the patient. Elderly adults are particularly dependent on vision to maintain postural stability (25). Dizziness is a known reported cause to falls in the elderly and a well-known adverse effect of medications (1,26). Cognitive impairment contributes to falls in the hospital setting (1). On the other hand, and since poor vision, dizziness and cognitive impairment are all associated with impaired balance, and we argue that this has been taken into account by considering the balance factor (1,25,26). A further limitation in our study is the difficulty in establishing a correct temporal relationship between the risk factors and fall events. This is also the experience from one hospital, which raises the question of generalizability, but the sample of patients, both cases and controls, was taken from three different wards.

Clinical implications

Clinicians should work to improve patient's safety and reduce the risk of falls by accurately assessing balance and mobility among older patients as a form of primary prevention. We recommend that a review of the patient medications should be conducted upon falling, as a form of a secondary preventive strategy against falls. While at the same time prompting a more robust and pragmatic primary preventive strategy against falls, even before the fall happening, including a more dynamic approach to the patient medications upon hospital admission,under hospital stay, and upon discharge, especially in the presence of one or more of the important risk factors for falls.

More clinical studies, preferably prospective studies, are needed to be done with regard to the clinicians approach to the patients' medications before and after falls as a form of primary and secondary prevention strategy accordingly.

Acknowledgement

An acknowledgement page is not included, since there has been no state founding or support in the form of grants given to this study.

Conflict of interest

The authors report no conflicts of interest in this work. In the preparations of this manuscript, all tips for publishing ethics are followed.

Author contribution

The authors worked together to perform the case–control study. The first author was mainly responsible for preparing the manuscript. The second author was vital in the gathering of the clinical and medical data, and had an expertise in the field of medical care for the elderly. The third author was responsible for the accuracy of the analysis and interpretation of the results. The authors report no conflicts of interest in this work. The three authors G. Cathrine L. de Groot, Ahmad Al-Fattal and Irene Sandven meet the Scandinavian Journal of Caring Sciences criteria for contribution to authorship.

Ethical approval

This study was registered at the Norwegian Social Science Data Services (NSD) on 3 June 2015, with the registration number 43162. Enrolment of patients started in February 2016. No ethical approval typical for empirical studies was needed.

References

1 Berry S, Kiel DP, Schmader KE, Falls Sokol NH. *Prevention in nursing care facilities and the hospital setting [Database]*. Waltham, MA: UpToDate; 2018, https://www.uptodate.com/contents/falls-prevention-in-nursing-care-facilities-and-the-hospital-setting?source=search_result&search=falls%20in%20the%20hospital&selectedTitle=2~150 (Last accessed 17 June 2019).

2 Healey F, Scobie S, Oliver D, Pryce A, Thomson R, Glampson B. Falls in English and Welsh hospitals: a national observational study based on retrospective analysis of 12 months of patient safety incident reports. *Qual Saf Health Care* 2008; 17: 424–30.

3 Cameron ID, Dyer SM, Panagoda CE, Murray GR, Hill KD, Cumming RG, Kerse N. Interventions for preventing falls in older people in care facilities and hospitals. *Cochrane Database Syst Rev* 2018; 9: CD005465.

4 Saastad E. *Årsrapport 2017. Meldeordningen for uønskede hendelser i spesialisthelsetjenesten*, 2018, Oslo, Helsedirektoratet, 1–32.

5 Kiel DP, Schmader KE, Sokol NH. *Falls in older persons: Risk factors and patient evaluation [Database]*. Waltham, MA, UpToDate Inc.; 2018. https://www.uptodate.com/contents/falls-in-older-persons-risk-factors-and-patient-evaluation?source=search_result&search=falls%20in%20elderly&selectedTitle=1~150 (last accessed 30 November 2016).

6 Holte HH, Underland V, Hafstad E. Oppsummering av systematiske oversikter om forebygging av fall i institusjoner. Rapport fra Kunnskapssenteret nr.13-2015. 2015; Oslo: Nasjonalt kunnskapssenter for helsetjenesten.

7 Helsedirektoratet. Tiltakspakke for Forebygging av fall i helseinstitusjoner. 2014, Helsedirektoratet, Oslo, 27.

8 Uleberg JK, Johnsson ER, Sletvold O, Helbostad JL. Fallprosjektet i Helseregion Midt-Norge. Konsekvenser av fall i sykehus. Kommunestudien 2012. Fylkesmannen i Sør-Trøndelag, 2012.

9 Browne C, Kingston C, Keane C. Falls prevention focused medication review by a pharmacist in an acute hospital: implications for future practice. *Int J Clin Pharm* 2014; 36: 969–75.

10 Deilkås ET. *Pasientskader i Norge 2016 målt med Global Trigger Tool*. 2017, Helsedirektoratet, Oslo.

11 Ganz DA, Bao Y, Shekelle PG, Rubenstein LZ. Will my patient fall? *JAMA* 2007; 297: 77–86.

12 Rowe JW, Andres R, Tobin JD, Norris AH, Shock NW. The effect of age on creatinine clearance in men: a cross-sectional and longitudinal study. *J Gerontol.* 1976; 31: 155–63.

13 Rochon PA, Schmader KE, Sokol NH. *Drug prescribing for older adults [Database]*. Waltham, MA: UpToDate Inc.; 2016. https://www.uptodate.com/contents/drug-prescribing-for-older-adults?source=search_result&search=falls%20in%20elderly&selectedTitle=8~150 (last accessed 10 November 2016).

14 Ruths S, Straand J. *G10 Eldre og legemidler*. 2015. In: Norsk Legemiddelåndbok [Internet]. Oslo: Foreningen for utgivelse av Norsk

legemiddelhåndbok. http://legemiddelhandboka.no/Generelle/153198 (last accessed 12 August 2016).

15 Indredavik B, Salvesen R, Thorsvik HND. *Nasjonal retningslinje for behandling og rehabilitering ved hjerneslag*. 2010, Oslo, Helsedirektoratet, 196.

16 Huang AR, Mallet L, Rochefort CM, Eguale T, Buckeridge DL, Tamblyn R. Medication-related falls in the elderly: causative factors and preventive strategies. *Drugs Aging* 2012; 29: 359–76.

17 Soares Menezes KVR, Auger C, de Souza Menezes WR, Guerra RO. Instruments to evaluate mobility capacity of older adults during hospitalization: a systematic review. *Arch Gerontol Geriatr* 2017; 72: 67–79.

18 Woollacott MH, Shumway-Cook A, Nashner LM. Aging and posture control: changes in sensory organization and muscular coordination. *Int J Aging Hum Dev.* 1986; 23: 97–114.

19 Hitcho EB, Krauss MJ, Birge S, Claiborne Dunagan W, Fischer I, Johnson S, Nast PA, Costantinou E, Fraser VJ. Characteristics and circumstances of falls in a hospital setting: a prospective analysis. *J Gen Intern Med* 2004; 19: 732–9.

20 Sherrington C, Fairhall NJ, Wallbank GK, Tiedemann A, Michaleff ZA, Howard K, Clemson L, Hopewell S, Lamb SE. Exercise for preventing falls in older people living in the community. *Cochrane Database Syst Rev* 2019; 1: CD012424.

21 Sherrington C, Michaleff ZA, Fairhall N, Paul SS, Tiedemann A, Whitney J, Cumming RG, Herbert RD, Close JCT, Lord SR. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med.* 2017; 51: 1750–8.

22 Bakken MS, Engeland A, Engesaeter LB, Ranhoff AH, Hunskaar S, Ruths S. Increased risk of hip fracture among older people using antidepressant drugs: data from the Norwegian Prescription Database and the Norwegian Hip Fracture Registry. *Age Ageing.* 2013; 42: 514–20.

23 Metsälä E, Vaherkoski U. Medication errors in elderly acute care – a systematic review. *Scand J Caring Sci* 2014; 28: 12–28.

24 Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic Research: Principles and Quantitative Methods*. 1982, Van Nostrand Reinhold, New York, NY.

25 Osoba MY, Rao AK, Agrawal SK, Lalwani AK. Balance and gait in the elderly: a contemporary review. *Laryngoscope Investig Otolaryngol* 2019; 4: 143–53.

26 Branch WT, Barton JJ, Aminoff MJ, Deschler DG, Wilterdink JL. *Approach to the patient with dizziness [Database]*. Waltham, MA: UpToDate Inc., 2016. https://www.uptodate.com/contents/approach-to-the-patient-with-dizziness?search=dizziness%20adult&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1 (last accessed 20 October 2014).