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Seasonal ambient changes influence inpatient falls

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Abstract

Background: falls by inpatients often result in serious injuries and deterioration in a patient's physical abilities and quality of life, especially among older individuals. Although various factors have been found to be associated with falls, the combined effects of behavioural and ambient factors are not fully evaluated.

Objective: we investigated the influence of both behavioural and ambient factors on inpatient falls, focusing on seasonal and diurnal variations.
Design: retrospective study.
Methods: we surveyed the incident reports related to falls from April 2010 to March 2014 and examined the relationship between the incidents and seasonal and diurnal variations in behavioural and ambient factors, including the sunrise time, the night-time length and temperature.
Results: we identified 464 fallers from 3,037 incident reports. The average fall-rate of the study population was 1.4 ± 0.5/1,000 occupied bed-days. The seasonal and diurnal variations in falls were compared. The number of falls around dawn in October–February was higher than that in April–September. Toileting was the behaviour most frequently related to the falls (56.9%, $n = 264$), and 57.1% of the falls occurred at night. A multivariate analysis showed that the night-time length was significantly related to an increase in night-time falls ($P = 0.047$).
Conclusion: these results suggested that the inpatient falls increased in the early morning from November to March and tended to be related to toileting activities. Considering these results, additional attention and support during the higher risk hours and seasons, especially in relation to toileting activities, might help to reduce the incidence of falls.
Clinical trial name, URL and registration number: N/A (Because of retrospective nature).

Keywords: *falls, nocturia, dawn, diurnal and seasonal variations, older people*

Introduction

Falls are among the most common incidents to involve hospitalised older patients [1]. Falls affect over one-third of patients who are ≥65 years of age and 40% of patients who are >80 years of age [2, 3]. Fall-related injuries are reported in 15–50% of falls, with major injuries in 1–10% of cases [4–9]. Age is the strongest risk factor for falls (due to a decrease in lower-limb muscle strength and/or vision) followed by chronic disease and dementia [10]. Many advanced nations have ageing societies in which >25% of the population is ≥65 years of age [11]. A rapid increase in the incidence of falls, both in homes and medical facilities, is therefore expected.

Although various risk factors for falls have been recognised and discussed, there has not been a sufficient decrease in the incidence. The intrinsic risk factors for falls can be physical and/or demographic and are closely related to the individual's health status. Falls can also be related to extrinsic factors and a better understanding of the environmental factors may help in implementing more efficient preventive measures. Thus, investigating the factors that should receive more attention is important for reducing the risks of falls and/or fall-related injuries.

We investigated the risk factors for falls using an incident reporting system, and paid special attention to both behavioural and environmental factors, with a focus on seasonal and/or diurnal variations.

Methods

Settings and data collection

We performed this survey in a secondary emergency medical facility with 260 beds in a suburb of Fukuoka City, Japan (latitude, 33°; longitude, 130°; mean annual temperature, 16.4°C).

All of the incidents/accidents that occur in hospitals are immediately reported to the Medical Safety Management Office of each facility, and are systematically accumulated as incident/accident records. We collected the following fall-related data: date, time, location, circumstances that triggered the incident, contributing factors, detailed behaviours, the site and severity of the injury and the patient's demographic information.

Definitions

We defined a 'fall' as an events in which an individual finds themselves on the floor unintentionally [2]. The fall-rate was expressed as the number of fallers of a certain period per 1,000 occupied bed-days (OBDs), which was normalised based on the number of occupied beds for each period. As for fall-rates at daytime or night-time, we divided the summed number of fallers at daytime or night-time by the occupied bed numbers of the day × daytime or night-time hours/24 in order to unify the scale to OBD for evaluation of the seasonal (monthly) and diurnal (hourly) variations.

We obtained meteorological data (sunrise/sunset times and the daily average ambient temperatures) from the Japan Meteorological Agency (see Supplementary data, Appendix Table 1, available in *Age and Ageing* online). The times at which falls occurred were both analysed and categorically observed during night-time and daytime (according to the daily sunrise/sunset times). The sunrise times in the 5 months from November to March were from 6:30 a.m. to 7:30 a.m. At these times, the inpatients had already started to get out of bed and move about. These months were also accompanied by low ambient temperatures of <15°C.

Statistical analysis

We compared the differences in the characteristics and the fall-rate using Welch's *t*-test, the Mann–Whitney *U*-test and

the chi-squared test. A general linear model (GLM) was used for assessment of the risk factors for falls. Variables with a *P*-value of <0.10 in the univariate regression analysis were included as potential confounders in a multivariate analysis. All statistical analyses were performed using the SPSS ver. 22.0 software program (IBM Corp. Chicago, IL, USA). Two-sided *P*-values of <0.05 were considered to indicate statistical significance.

Results

Among the 3,037 incident reports from April 2010 to March 2014, 516 fallers were identified. We excluded 41 falls in emergent and/or unstable conditions in the outpatient emergency room, intensive care unit or dialysis room. Eleven falls were excluded because they were considered to have occurred due to the patient's medical condition (e.g. convulsions, high fever, etc.). Thus 464 patients were included in the analysis. The average fall-rate among all hospitalised patients was 1.4 ± 0.5/1,000 OBDs . The clinical characteristics of the fall-patients are shown in Table 1. The mean age was 76.4 ± 11.0 years; 263 patients were male. The most prevalent comorbidity was hypertension (40.5%). The most frequent fall-related behaviour was toileting (56.9%).

Figure 1A shows the fall-rate of daytime and night-time for each month. The fall-rate of night-time was significantly higher than that of daytime (1.6 ± 0.8 vs. 1.2 ± 0.7/1,000 OBDs, $P = 0.001$). Especially, in November, January and February, the fall-rate of night-time was greater than the fall-rate of daytime (2.4 ± 0.7 vs. 1.4 ± 0.2/1,000, 1.9 ± 0.6 vs. 1.1 ± 1.3/1,000 and 2.2 ± 0.7 vs. 1.0 ± 0.4/1,000 OBDs; respectively). For the assessment of the diurnal change of falls, we summed the fall-rate of each month (Figure 1B). Each bar included all of the fall-rate at the time of day for the 12 months. A high number of falls occurred during night-time and dawn (2, 5, 6 and 7 a.m.) in winter (especially, November, January and February), falls were most frequently reported at 7 a.m. in February (6.7/1,000 OBDs). To assess the diurnal change, we used a chi-squared test to investigate the differences in the proportion of falls between the examined time and other times of the day. The numbers of falls at 2 a.m. and 7 a.m. were significantly higher than those at other times of the day ($P = 0.02$).

Next, we examined the factors predicting an increase in falls using a GLM (see Supplementary data Appendix Table 2, available at *Age and Ageing* online). Female sex and night-time length were significantly associated with an increase in whole-day falls ($\beta = 0.24$, $P = 0.01$ and $\beta = 0.39$, $P = 0.007$; respectively); however, this relationship did not remain significant after adjustment. For daytime falls, female sex was also associated with an increase of falls in the multivariate analysis ($\beta = 0.35$, $P = 0.01$; both). A longer night-time was associated with an increased number of night-time falls in both the univariate and multivariate analyses ($\beta = 0.32$, $P = 0.03$ and $\beta = 0.27$, $P = 0.047$; respectively).

Discussion

The current study, which was based on the incident reports of 464 falls over a 4-year-period, examined the influence of the combined effects of behavioural and ambient factors on the number of falls experienced by older patients. The number of falls increased with toileting activities in the early

Table 1. The clinical characteristics and behaviours associated with falls

	Total	Night-time fall	Daytime fall	*P*-value
Number, *n*	464	265	199	–
Age, years	76.4 ± 11.0	76.3 ± 10.4	76.5 ± 11.9	0.35
Male, *n* (%)	263 (56.7)	156 (58.9)	107 (53.8)	0.30
Comorbidities, *n* (%)				
Hypertension	209 (40.5)	122 (46.0)	87 (43.7)	0.64
Cardiovascular disease	123 (26.5)	78 (29.4)	45 (22.6)	0.11
Diabetes	108 (23.3)	68 (25.7)	40 (20.1)	0.18
Cerebrovascular disease	90 (19.4)	56 (21.1)	34 (17.1)	0.29
Dyslipidaemia	30 (6.5)	18 (6.8)	12 (6.0)	0.85
Chronic renal failure (dialysis)	23 (5.0)	17 (6.4)	6 (3.0)	0.13
Urological disease	18 (3.9)	11 (4.2)	7 (3.5)	0.81
Behaviours at falling, *n* (%)				
Toileting activities	264 (56.9)	166 (62.6)	98 (49.2)	0.004
Standing or moving, including walking	80 (17.2)	35 (13.2)	45 (22.6)	0.009
Picking up something	23 (5.0)	12 (4.5)	11 (5.5)	0.67
Bathing or changing clothes	21 (4.5)	6 (2.3)	15 (7.5)	0.01
Opening or closing a window	12 (2.6)	6 (2.3)	6 (3.0)	0.77
Eating	8 (1.7)	0 (0.0)	8 (4.0)	0.001
Behaviour due to dementia or delirium	6 (1.3)	4 (1.5)	2 (1.0)	0.70
Other	16 (3.4)	10 (3.8)	6 (3.0)	–
Unknown	34 (7.3)	26 (9.8)	8 (4.0)	–

We compared differences between night-time falls and daytime falls.

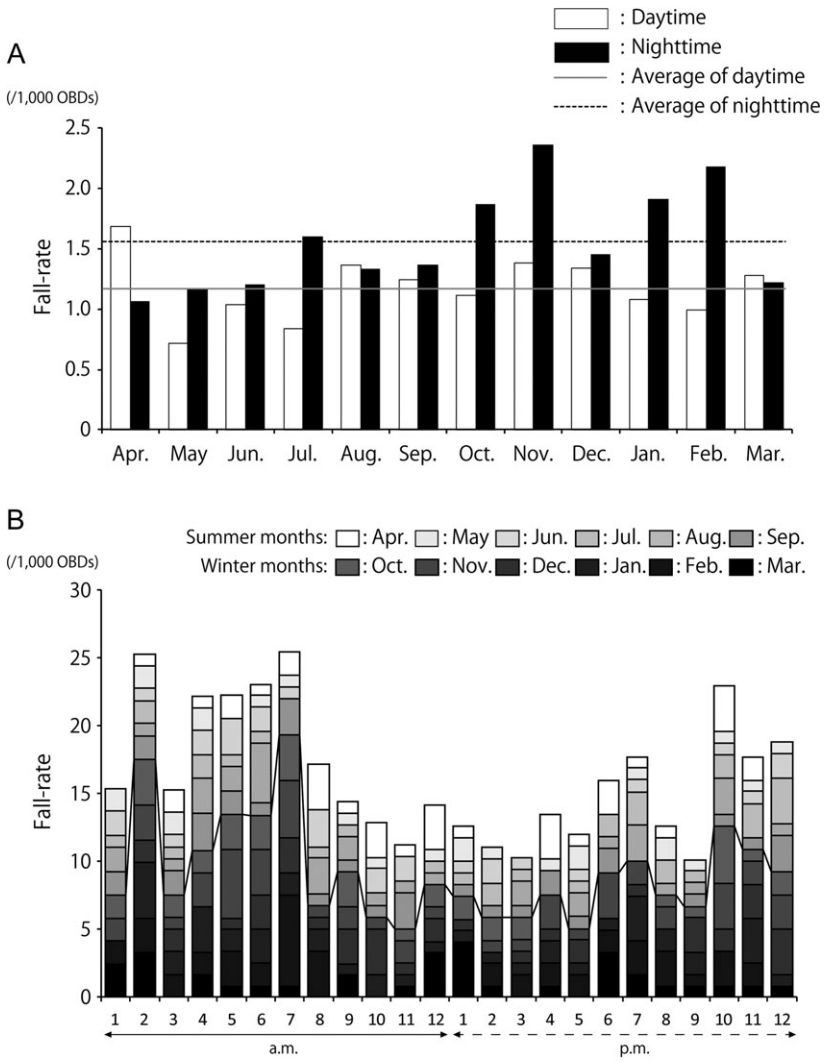

Figure 1. The seasonal and diurnal variations in the fall-rate. (A) The monthly variations in the fall-rate at daytime and night-time. The fall-rates at night-time was significantly higher the fall-rates at daytime ($P = 0.001$). (B) Diurnal variations in the sum of the fall-rates of all months. The winter months are shown in darker grey scale, while the summer months are shown in lighter grey scale. The winter months (October–March) are shown by polygonal lines, while the summer months (April–September) are shown by lines.

morning from November to February. These results suggested that toileting activities soon after waking in a gloomy environment increased the risk of falls.

The monthly average sunrise time in this area ranged from 5:11 a.m. (July) to 7:23 a.m. (January). Although the hospital ward was illuminated from 6 a.m. to 9 p.m. throughout all seasons, the patient rooms appeared to be dimly lit and cold before dawn in winter (November–February). Given these conditions, we considered that the reasons for the increase in the fall-rate in the early morning during winter were as follows: during these months, it was still relatively dark and cold in the early morning, even if the hospital rooms were illuminated; the patients performing toileting activities in the early morning might still be half-awake. Thus, the darker and/or colder conditions in the early morning were associated with a higher risk of falls.

The additive effects of a patient's clinical background and seasonal factors associated with polyuria might have synergistically affected the increase in falls during winter. A previous study reported that patients with nocturia who required ≥2 toilet visits per night had a significantly higher risk of fall [12], while the risk of fall was 28% higher amongst those requiring ≥3 toilet visits per night [13]. In this study, ageing, various comorbidities (including hypertension, cardiovascular disease and diabetes mellitus), and a decrease in sweating due to a sedentary life might have increased the rate of nocturia. Since the management of risks associated with nocturia has been emphasised in previous reports [14, 15], determining the specific reasons for nocturia would help in the development of specific strategies to reduce the incidence of falls in individual patients.

Our study is associated with certain limitations. Because incident reports were used to retrospectively gather information about falls, we could not determine the specific cause, the severity or the details of each fall. Furthermore, we could not obtain information on the brightness or

temperature in each of the rooms in which a fall occurred. A prospective study should be conducted in which the light and temperature environment is precisely recorded at the time of each fall in order to further elucidate the relationships among urination, ambient factors and falls. Furthermore, the number of falls in this single hospital was not so high, and the calculation of normalised fall-rate might have been unstable. Multi-centre studies or a longer study period will be needed to accumulate a greater number of cases and overcome these limitations.

Conclusions

The recognition that 62.6% of nocturnal falls were associated with toileting activities and that the number of falls was particularly increased during the early morning hours in winter might help to reduce the incidence of falls.

Key points

- The inpatient fall-rate increased at dawn in the period from October to February.
- The most influential factors related to such falls were toileting activities.
- The fall-rate of night-time was significantly higher than that of daytime falls.
- Paying closer attention and providing greater care during the high-risk hours and seasons might help to reduce the incidence of inpatient falls.

Supplementary data

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

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Conflicts of interest

None declared.

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