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Risk of falls for hospitalized patients: A predictive model based on routinely available data

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Abstract

The incidence rate of falls is often used as an indicator of nursing care outcome. Comparing outcome between different settings should, however, make allowance for case mix. To measure the incidence of falls, describe their circumstances and develop a prediction model based on routinely collected data to allow comparison between hospital settings with different case mix. A dynamic population of patients hospitalized over a year in which a case was defined as any accidental fall systematically reported on an ad hoc form. A Swiss university hospital of 800 beds; 634 falls were reported for 26,643 hospitalizations over 236,307 hospitalization days. First fall rates were analyzed using a Poisson regression model with routinely computerized discharge data as independent variables. The incidence rate of first falls was 2.2 per 1000 patient-days. For subsequent falls the rates of incidence increased with the number of falls. Five independent variables played a significant role: age, gender, morbidity predisposition, surgical procedure and length of stay. Two of the interactions between these variables were significant and remained in the model (length of stay with age, morbidity with age). The model offers good medical plausibility and satisfactory predictive performance. The proposed model can be used by national health agencies to compute expected first fall rates accounting for case mix. Hospitals can use these rates for evaluation. Recommendations for measuring, monitoring and assessing fall rates are also given.

Keywords: Accidental falls; Incident reporting; Hospital; Risk factors; Case mix; Incidence

1. Introduction

Many hospitals routinely report inpatient falls. As a matter of fact, falls are the most frequently noted incidents [1,2]. Quality assurance programs insist upon the importance of monitoring adverse events and often use fall rates as an indicator of nursing outcome [3–5]. Wide variations in fall rates have been reported among institutions for the elderly (0.2–3.6 per bed per year) [6]. Studies in acute-care hospitals are less numerous, but also show notable variations: 2–15% of inpatients experience at least one fall [1,7–10], the range of published incidence rates of falls is wide (0.3–19 for 1000 patient-days) [1,7,8,10–15]. Comparing fall rates among various institutions may be helpful but raises concerns. The lack of an accurate definition of the occurrence indicator compromises data comparability [16,17]. The unit of measurement is often the number of events per patient-days but multiple falls by the same individuals are variably reported, and falls that do not result in visible injuries are sometimes not reported at all. What is more important is that, to clarify the issue of nursing care quality, factors outside the direct influence of hospital policy should be controlled for. Interpreting an outcome must therefore account for variations linked to case mix. Although falls are a traditional target of risk management, comparative data are too scant to set a benchmark determining an acceptable level of falls [18].

Controlling for patient risk is required to evaluate quality differences between care settings. Most research to date has focused on elderly persons living in the community or in nursing homes. A number of researchers have investigated symptoms that may contribute to a fall in these environments: gait and balance disorders [13,19–21], dizziness or vertigo [21,22], visual deficit [23], incontinence [24], cognitive impairment and sedation [6,19,24,25]. Selected risk

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factors have been used to derive relatively simple assessment tools identifying patients liable to be targeted for preventive strategies [13,24,26]. Because these data have to be extracted from medical or nursing records, they are not readily available for comparison across care units or hospitals. Furthermore, many of those variables escape detection because they are not regularly recorded in medical records [25]. It has been shown that in acute-care settings a few variables could identify patients prone to falls: falls during hospitalization are more common in confused patients and those with greater comorbidity [25]. Several diseases have been shown to increase the risk of fall such as Alzheimer's disease [27], Parkinson's disease [28] and stroke [10]. These findings suggest that risk measures relying only on routinely collected data could perform quite well for hospitalized patients and favorably compare with methods requiring additional record abstracting.

A further concern is the necessity to adopt a probabilistic approach, due to the fact that it is usually difficult to determine whether a fall might have been avoided on a case-by-case basis. Data about the proportion of potentially avoidable falls are scarce; a systematic medical records review of adverse events in hospitalized patients judged that over half of 200 falls with injuries resulted from substandard care [29]. Few falls can be clearly prevented, for instance by suppressing a form of medication or an environmental hazard. Some are probably unavoidable, such as in a unit trying to improve the independent living skills of its patients [30]. Most patients fall because factors related to patients and to environmental hazards interact. In fact, only multifactorial interventions targeting both intrinsic and environmental risk factors have been shown to significantly reduce the number of falls in high-risk populations [31–33].

The objectives of the study were: (1) to measure the incidence of falls and to describe the circumstances under which they occur, and (2) to use routinely collected information to develop a prediction model, making it possible to compare observed rates accounting for the identifiable patients' risks.

Hospital characteristics, such as the type of care unit and the patient:nurse ratio, were intentionally not taken into account in order to use only case mix variables clearly beyond the hospital's control.

2. Methods

The Centre Hospitalier Universitaire Vaudois (CHUV) offers an appropriate setting to observe falls, document their circumstances and measure potential risk factors. It generates intense activity (more than 200,000 hospitalization days per annum) for a comprehensive panel of patients—all surgical and medical services provided to patients of all ages with all specialized areas of medicine represented except ophthalmology and psychiatry. Thus, the CHUV presents a large spectrum of predictive variables and a homogeneous nursing context (policies, staffing, endowment, ongoing training, etc.). It is moreover equipped with a complete computerized hospital information system that integrates validated administrative and medical data and provides an easy link between the registry of falls and the studied population [34].

The population studied consisted of inpatients hospitalized at the CHUV between October 1, 1998 and September 30, 1999. Inclusion criteria required a length of stay of more than 24 hr, or a stay that ended in death or transfer to another hospital. The data concerning age, gender, discharge diagnostic category according to All Patient-Diagnosis Related Groups (AP-DRG) [35] and length of stay were obtained from the hospital information system. A case was defined as any accidental fall observed by the nurses themselves or reported to them by the patient, as well as a patient found lying on the floor by the staff [19]. Falls were reported on an ad hoc form by the person who noted the incident. The report described:

- the circumstances of the fall, classified by the tenth International Classification of Diseases (ICD-10, codes W00-W19);
- the consequences of the fall, categorized as no injury, minor injuries (superficial wound, haematoma) or major injuries (fractures, trauma of an internal organ);
- measures that should have been taken to avoid the incident: properly fitting footwear, adequate lighting, bedrails or other physical restraint devices, easy access to a calling device, avoiding wet floors, other environmental interventions, educational support such as instructing the patient or the family to request assistance in moving.

Case reporting was encouraged by a multidisciplinary group of head nurses who provided regular information to nursing staff and were backed by the heads of the hospital's quality of care monitoring program. Departments that declared no falls were contacted regularly.

To account for the different lengths of patient follow-up, the study outcome was the incidence rate of falls per 1000 patient-days.

The determinants studied were based on routinely available hospitalization data likely to favor a fall: age, gender, morbidity predisposition. Diseases were considered predisposing to a fall when associated with symptoms that have been proven to increase fall incidence in health care settings: gait disorders [36,37], cognitive impairment and confusion [25,37,38], chronic use of alcohol or other psychoactive drugs [39,40]. These risk factors are generally present among hospitalized patients with disorders of the central nervous system or drug addiction. High fall rates have been found in certain other hospitalized patient groups: patients with mental disorders especially depression [1,9,41], patients with complicated heart diseases [12,40,42]. A systemic infection or a major complication were also considered as plausible risk for falls, since dizziness and ataxia are frequent in these acute situations. Categorization of predisposing diseases was based on AP-DRG (see Appendix A for details). Length of stay was included as a severity index of illness. Stays with a surgical procedure in an operating room were also identified on the basis of AP-DRGs (see Appendix A). Two reasons justified this choice; some patients are hospitalized in a surgical unit without being operated upon, and the unit where the patient is admitted may not be routinely available.

Only the first fall was modeled in order to ensure the independence of events so that statistical approaches based on the Poisson distribution are valid. Indeed, a first fall may increase the risk of subsequent events and may also affect behavioral factors, as the patient is inclined to restrain his/her mobility and the nurses increase surveillance. Fall relapses were included in the descriptive analysis.

The underlying hypothesis to the multivariate analysis was that the number of first falls in a risk stratum follows a Poisson probability distribution. The Poisson model is appropriate to investigate the incidence of unrelated binary events (first fall during a hospitalization), whose occurrence is rare (most patients don't fall). It directly estimates the risks linked to each determinant (incidence rate ratio, IRR). An observation unit is constituted by a group of hospitalizations, with similar characteristics, expressed as nominal or ordinal independent variables. The dependent variable is the number of first falls in each risk group; exposure time is indicated by the sum in each stratum of the number of days elapsed from the admission of the patient (after September 30, 1998) until the first fall or the end of the stay (before October 1,1999). The Poisson model assumes independence of the observations and constant risk over time. In consequence it was verified that the probability of a fall did not vary too much during the stay, as a function of the rank of the day. All analyses were performed using Stata statistical software (release 6.0, Stata Corporation, College Station, TX). In the univariate analysis, the significance of variables was based on the IRRs observed in each stratum. In the multivariate analysis, only independent variables which were significant at $P < 0.10$ were entered in the model. The contribution of each variable to the model was evaluated by the log-likelihood ratio test. All first-order interactions between independent variables were also tested. Observations with missing values were excluded for the multivariate analysis.

The model's goodness of fit was assessed by the Pearson chi-square test, comparing predicted and observed values.

To ensure satisfaction of the Poisson assumption, it was shown that there was no evidence of overdispersion, using a gamma distribution to model the data and testing the null hypothesis of the α parameter [43]. The α parameter was not significantly different from 0 suggesting there was no overdispersion ($P = 0.999$).

3. Results

3.1. Description of falls

Six hundred thirty-four falls were reported during 236,307 hospitalization days, corresponding to a global rate of 2.7 falls per 1000 days. The proportion of inpatients falling was 1.8% (488/26,643). The incidence rate was 2.2 first falls per 1000 days. Twenty percent of patients with a first fall relapsed (100/488) during the follow-up period. The incidence rate of a second fall by patients who had fallen previously was 12.7 per 1000 days (100/7893). The incidence rate of a subsequent fall increased with the number of falls: 17.1 ‰ (26/1517) for the third fall and 23.0 ‰ for the fourth one (9/391).

Fall rates varied from one department to the next (0–12 ‰). Some departments (gynecology, obstetrics, pediatric intensive care) reported no falls. Falls were more frequent in medical departments than in surgical ones. The highest fall rate was observed in the department of geriatric rehabilitation.

Circumstances of fall are described in Table 1. Nearly half the patients concerned were moving about in their room, with peak frequencies between 9 and 11 a.m. and between 5 and 6 p.m., that is during hours they are more active. Falls from bed represented a quarter of all cases, with two peak frequencies: 0–1 a.m. and 3–4 a.m. Most departments reported more than 10 falls. The most likely cause of a fall was slipping, but in some departments a fall from bed was the most frequent circumstance.

No significant variations in the rate of falls by day of the week were observed. The incidence rate of first falls was relatively constant throughout the stay (Fig. 1). The slump in the rate at the end of the stay was due to the fact that the last day is shorter (the patient often leaves the hospital before 2 p.m.).

Four hundred falls (63%) resulted in no injuries at all, 215 (34%) resulted in minor injuries and 18 (3%) in major injuries: 14 fractures, 1 luxation, 2 cranial trauma, one patient found dead on the floor beside his bed.

In 37% of cases, the fall was judged avoidable by the person who notified the incident. Inappropriate material (loose wheelchair brakes, unlocked bed table, for instance)

Table 1
Fall circumstances

	First falls		All falls	
Fall circumstances	*n*	%	*n*	%
Fall due to slipping, tripping and stumbling	205	42	267	42
Fall involving bed	129	26	152	24
Unspecified fall	58	12	78	12
Fall involving chair	33	7	42	7
Fall involving wheelchair	30	6	51	8
Fall from or off toilet	18	4	25	4
Fall while being carried or supported by other persons	6	1	10	2
Fall due to collision with another person	4	0	4	1
Fall involving other furniture than bed or chair	2	0	2	0
Fall on and from stairs and steps	2	0	2	0
Fall from, out of or through building or structure	1	0	1	0
	488	100	634	100

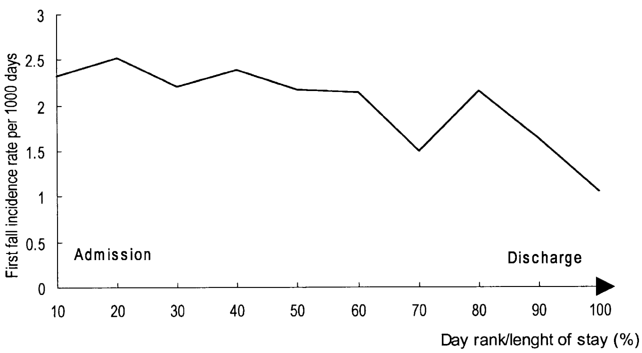

Fig. 1. Incidence rate of first falls (per 1000 days) during the stay.

or environmental problems (wet floor, insufficient lighting, obstacle) caused 8% of falls. From the nurses' point of view, about half the falls from bed could have been prevented by bedrails or restraints. Only 32% of slipping falls could have been avoided, for instance with adequate instructions to patient or more appropriate footwear. Falls from a wheelchair or a chair appeared avoidable in more than 50% of the cases, often by means of seat belts.

3.2. Univariate analysis

Because infants under 18 months are theoretically not exposed to falls, they were excluded from the analysis. Obstetrical stays were also excluded, as the risk of fall is probably close to zero in this group which represented almost one-third of patients under 45 years. Only one fall was reported in infants; no falls were reported in the obstetrical unit.

The incidence rate of the first fall was higher for males ($P = 0.08$) and in the presence of morbidity predisposition ($P < 0.001$). The incidence rate was relatively constant until age 45 years. Subsequently it increased with age in linear fashion. The rate also rose with length of stay ($P < 0.001$), but the incidence rate ratio was relatively stable when the length of stay exceeded 20 days (Table 2). The incidence rate was lower in surgical patients than medical ones.

3.3. Multivariate analysis

All explanatory variables identified in the univariate analysis (gender, age, length of stay, morbidity predisposition, admission with or without a procedure in an operating room) were included in the model as nominal (binary) independent variables, and their interactions were tested.

Based on the results of the univariate analysis, only two categories were retained for length of stay (more or less than 20 days) and six age categories, with all classes below 45 years aggregated. Ultimately, these six categories were reduced to four (⩽55, 56–75, 76–85, >85). For the computation of IRRs, reference categories were always those with smaller rates (female, younger patients, short stay, no morbidity predisposition, surgical procedure).

Table 2
Univariate analysis of first fall incidence rate

	No. of first falls	No. of person-days	Incidence per 1000 days	IRR (95% Confidence Intervals)
All hospitalizations	485[a]	197,716	2.45	
Gender				
Female	218	96,682	2.25	1
Male	267	101,034	2.64	1.17 (0.98; 1.41)
Age (mean) in years				
1.5–15 (7.25)	8	8218	0.97	1
15–25 (20.6)	4	7519	0.53	0.55 (0.16; 1.81)
25–35 (30.3)	12	12,285	0.98	1.00 (0.41; 2.45)
35–45 (40.1)	10	15,062	0.66	0.68 (0.27; 1.73)
46–55 (50.5)	30	23,247	1.29	1.33 (0.61; 2.89)
56–65 (60.1)	54	31,327	1.72	1.77 (0.84; 3.72)
66–75 (70.1)	92	40,253	2.29	2.34 (1.14; 4.84)
76–85 (79.6)	172	41,458	4.15	4.26 (2.10; 8.66)
>85 (89.0)	103	18,346	5.61	5.77 (2.81; 11.84)
Length of stay (mean) in days				
⩽10 (3.8)	69	58,015	1.19	1
Between 10 and 20 (13.7)	110	48,444	2.27	1.90 (1.41; 2.58)
Between 20 and 30 (24.2)	83	26,905	3.08	2.59 (1.88; 3.57)
Between 30 and 40 (34.6)	54	16,822	3.21	2.70 (1.89; 3.85)
>40 (76.3)	169	47,530	3.56	2.99 (2.26; 3.96)
Medical condition				
No morbidity predisposition	229	119,441	1.92	1
Morbidity predisposition	211	63,324	3.33	1.74 (1.43; 2.10)
Missing or invalid diagnoses	45	14,950	3.01	1.57 (1.14; 2.16)
Procedure in an operating room				
Yes	137	84,894	1.61	1
No	303	97,871	3.10	1.74 (1.43; 2.10)
Missing variable	45	14,950	3.01	

[a]One fall of an infant, and two falls with missing data were excluded.

Table 3
Multivariate analysis of the risk of first falls[a]

Variables retained in the model	Adjusted estimated coefficients (β)	Standard error of β (se)	P	Adjusted IRR (95% CI)
Reference category[b]				1
Age (55–75) years	0.464	0.155	0.003	1.59 (1.17, 2.15)
Age >(75–85) years	1.660	0.203	<0.001	5.39 (3.66, 7.93)
Age >85 years	1.923	0.218	<0.001	7.02 (4.63, 10.63)
Length of stay >20 days	0.901	0.153	<0.001	2.46 (1.83, 3.32)
Length of stay >20 days × age >75 years	−0.488	0.201	0.016	0.61 (0.41, 0.91)
No procedure in operating room	0.563	0.106	<0.001	1.76 (1.42, 2.16)
Morbidity predisposition	0.469	0.148	0.002	1.60 (1.20, 2.13)
Morbidity predisposition × age >75 years	−0.402	0.195	0.040	0.67 (0.46, 0.98)
Male	0.481	0.100	<0.001	1.62 (1.33, 1.97)
Constant	−8.040	0.186		

[a]The analysis was performed on 440 events and 182,766 person-days.
[b]The reference category comprises female inpatients under 55, with length of stay ≤20 days, with an operating room procedure and no morbidity predisposition.

Coefficients and the IRRs of the multivariate model are listed in Table 3. Only two significant interactions were found: length of stay with age, morbidity predisposition with age. The effect of these interactions was to considerably reduce the effects of length of stay and morbidity predisposition in the elderly. In other words, the age effect was so strong in the elderly that length of stay (partially) and morbidity predisposition (totally) lost their impact as witnessed by the estimated coefficient. The interaction terms in patients over 75 were not significantly different for age 75–85 versus age over 85. In a model including only age and length of stay, the IRR of patients over 75 equal 1.37 versus 2.46 for younger. A similar observation was made for morbidity predisposition: IRRs were relatively constant for all age categories, but weaker for the elderly, dropping from 2.1 to 1.22 in a model including only the two variables. Age over 75 years (IRR ≥ 5.39) was the most contributory variable followed by length of stay in patients under 75 years (IRR = 2.46), no surgical procedure (IRR = 1.77), gender (IRR = 1.60) and morbidity predisposition in patients under 75 years (IRR = 1.60).

Table 4 (for medical patients) and Table 5 (for surgical patients) show the observed and predicted number of falls in each risk stratum. As indicated above, the effect of morbidity predisposition was taken into account only for patients under 75. They show an acceptable correspondence between observed and predicted values ($\chi^2 = 36.3$, 39 *df*, P = 0.41). The estimated incidence rates per each stratum may serve as references in the comparison of different care centers.

4. Comments

The multivariate model offers good predictive performance. Poisson modeling is adequate and data do not present over-dispersion. The range of predicted rates is large, varying from a low of 0.32 per 1000 days to 9.87 in the high- risk group. The age variable is the most significant factor, which comes as no surprise from a medical point of view. The fact that morbidity predisposition and length of stay show similar contributions suggests that AP-DRGs do not sufficiently account for the severity of illnesses. We tried to use additional morbidity categories based on AP-DRGs, but were not successful in this attempt. Further research should use more refined groups, as APR-DRGs [44], to obtain a better description of the contribution of the patient's clinical status. It is important to keep in mind that length of stay was used as a severity index, independently of the length of exposure. This approach is meaningful because the incidence rate was not associated with rank of the day of first fall. Weaker fall risk in operated patients can be explained by the decubitus due to the intervention. Other authors have documented the weak contribution of gender in predicting fall risk [1,12]. Risk ratio heterogeneity has only been detected for patients over 75 years of age.

Not surprisingly, the effect of morbidity (severity or fall prone condition) was less important in the elderly, who often present disabilities predisposing to falls without a definite disease. For the oldest female category, the observed incidence rate was similar in short and long stays. We observed that a greater proportion of elderly females with a short stay were discharged to nursing homes; so the patients with the most severe incapacities may have been discharged sooner. This observation does not apply to males who are less frequently discharged to a nursing home (probably because males generally do not live alone).

A few cells in Table 4 reveal a considerable lack of fit which is attributable to the triple interaction between sex, length of stay and age in non-surgical patients. The impact of sex is higher in the oldest patients with a long stay but negligible in the youngest ones. Owing to physiological decline, it is not surprising that the oldest men have more incapacities than their female counterparts. This is also expressed in the fact that the intra-hospital mortality rate was particularly high in men over 85 years with a long stay.

The incidence rate of first falls in the CHUV is rather low in comparison to other hospitals, but the global rate (2.7 per 1000 days), as well as specific rates per risk strata (see Tables 4 and 5), are compatible with published values in

Table 4
Observed and predicted values of first fall in medical patients

	Females		Males	
	No morbidity predisposition	Morbidity predisposition	No morbidity predisposition	Morbidity predisposition
Age ⩽55				
LOS ⩽20 days[a]				
Observed (expected) first falls	7 (4.2)	5 (2.0)	3 (7.7)	3 (4.3)
Observed IR per 1000 days	0.95	2.32	0.36	1.02
Expected IR per 1000 days (95% CI)	0.57 (0.41–0.80)	0.93 (0.6–1.35)	0.93 (0.66–1.29)	1.46 (1.02–2.04)
LOS >20 days				
Observed (expected) first falls	4 (2.7)	5 (3.5)	5 (4.5)	5 (7.2)
Observed IR per 1000 days	2.06	3.15	2.50	2.51
Expected IR per 1000 days (95% CI)	1.39 (0.98–2.01)	2.21 (1.70–3.15)	2.25 (1.60–3.20)	3.61 (2.61–5.01)
Age (55–75)				
LOS ⩽20 days				
Observed (expected) first falls	4 (5.3)	4 (4.0)	13 (11.7)	9 (11.0)
Observed IR per 1000 days	0.69	1.46	1.63	1.91
Expected IR per 1000 days (95% CI)	0.91 (0.65–1.25)	1.46 (1.02–2.04)	1.47 (1.08–1.99)	2.34 (1.70–3.21)
LOS >20 days				
Observed (expected) first falls	7 (6.5)	9 (11.2)	8 (8.8)	23 (25.9)
Observed IR per 1000 days	2.41	2.86	3.30	5.12
Expected IR per 1000 days (95% CI)	2.24 (1.62–3.03)	3.56 (2.70–4.67)	3.63 (2.68–4.87)	5.76 (4.52–7.36)
Age (75–85)				
LOS ⩽20 days				
Observed (expected) first falls	16 (19.6)		27 (26.9)	
Observed IR per 1000 days	2.50		4.98	
Expected IR per 1000 days (95% CI)	3.06 (2.37–3.95)		4.97(3.91–6.31)	
LOS >20 days				
Observed (expected) first falls	36 (34.9)		39 (32.1)	
Observed IR per 1000 days	4.81		9.17	
Expected IR per 1000 days (95% CI)	4.66 (3.74–5.80)		7.55 (6.09–9.43)	
Age >85				
LOS ⩽20 days				
Observed (expected) first falls	18 (15.8)		13 (13.0)	
Observed IR per 1000 days	4.55		6.46	
Expected IR per 1000 days (95% CI)	3.99 (3.01–5.26)		6.46 (4.82–8.65)	
LOS >20 days				
Observed (expected) first falls	20 (27.6)		20 (12.7)	
Observed IR per 1000 days	4.40		15.5	
Expected IR per 1000 days (95% CI)	6.08 (4.73–7.77)		9.87 (7.46–12.9)	

[a]LOS = length of stay.

non-selected populations of acute-care hospitals [1,13]. We did not find any indication that falls were under-reported. Reporting falls is an old custom in this hospital, with the entire staff aware of the fact that hospital management wants to document these incidents, especially for liability-related reasons; only departments with very low expected rates had no falls. The relatively constant number of falls per month suggests that our data were rather reliable.

When all data required to categorize risk strata are routinely available in a hospital (and they usually are in developed countries), expected rates for a given setting are easily computed, using the stratum specific expected incidence rates provided in Tables 4 and 5 as the set of weights. Standardized rate ratio (observed rates divided by expected rates) may be used to compare health care providers. The selection of the independent variables for modeling fall rates is of course a major concern. Using easily available data does not account for sufficient information on disabilities or comorbidity that might strongly influence the outcome. Variables scoring cognition or mobility impairment, might improve the model's performances [19,26], but it would be costly to systematically gather this information on all acute-care inpatients. The use of standardized rate ratio should be restricted to surveillance purposes. It might reveal that a particular setting has unusually high rates. The evaluation of care must be assessed in greater detail at the local level to confirm that a quality problem exists and to determine its cause. As most studies about inpatient falls were confined to geriatrics or rehabilitation care, the present study shows that falls occurred in most units including the pediatric one, stressing the importance of monitoring falls in all units. Environmental causes for a fall, which are indeed beyond the control of the hospital services, are certainly more frequent in younger people.

The present study shows that the performance of the proposed model was satisfactory for its purpose, measuring an outcome indicator making allowance for case mix in a cost-effective manner. It seems sufficiently precise and medically plausible to compare first fall rates between hospitals. Even if studies in other institutions were to modify the coef-

Table 5
Observed and predicted values of first fall in surgical patients

	Females		Males	
	No morbidity predisposition	Morbidity predisposition	No morbidity predisposition	Morbidity predisposition
Age ⩽55				
LOS ⩽20 days[a]				
Observed (expected) first falls	3 (2.3)	0 (0.6)	3 (4.3)	1 (1.5)
Observed IR per 1000 days	0.41	0.00	0.60	0.57
Expected IR per 1000 days (95% CI)	0.32 (0.22–0.47)	0.54 (0.36–0.81)	0.52 (0.36–0.72)	0.86 (0.57–1.26)
LOS >20 days				
Observed (expected) first falls	1 (2.5)	2 (2.3)	7 (6.8)	8 (5.5)
Observed IR per 1000 days	0.31	1.10	1.32	3.00
Expected IR per 1000 days (95% CI)	0.79 (0.57–1.13)	1.27 (0.88–1.82)	1.28 (0.92–1.79)	2.06 (1.46–2.88)
Age (55–75)				
LOS ⩽20 days				
Observed (expected) first falls	3 (2.6)	2 (1)	6 (6.3)	6 (3.4)
Observed IR per 1000 days	0.60	1.66	0.79	2.33
Expected IR per 1000 days (95% CI)	0.52 (0.36–0.72)	0.83 (0.58–1.16)	0.83 (0.61–1.15)	1.32 (0.93–1.90)
LOS >20 days				
Observed (expected) first falls	4 (6.1)	11 (5.1)	17 (12.7)	8 (12.6)
Observed IR per 1000 days	0.82	4.32	2.73	2.08
Expected IR per 1000 days (95% CI)	1.26 (0.93–1.73)	2.00 (1.49–2.71)	2.04 (1.53–2.73)	3.27 (2.49–4.26)
Age (75–85)				
LOS ⩽20 days				
Observed (expected) first falls	5 (4.9)		9 (8.7)	
Observed IR per 1000 days	1.77		2.92	
Expected IR per 1000 days (95% CI)	1.74 (1.28–2.34)		2.83 (2.11–3.74)	
LOS >20 days				
Observed (expected) first falls	10 (11.4)		15 (18.5)	
Observed IR per 1000 days	2.32		3.47	
Expected IR per 1000 days (95% CI)	2.65 (2.04–3.42)		4.28 (3.33–5.49)	
Age >85				
LOS ⩽20 days				
Observed (expected) first falls	4 (2.3)		1 (1.8)	
Observed IR per 1000 days	3.90		2.04	
Expected IR per 1000 days (95% CI)	2.24 (1.56–3.21)		3.67 (2.65–5.09)	
LOS >20 days				
Observed (expected) first falls	8 (9.8)		3 (4.1)	
Observed IR per 1000 days	2.81		4.13	
Expected IR per 1000 days (95% CI)	3.44 (2.57–4.60)		5.65 (4.00–7.58)	

[a]LOS = length of stay.

ficients of the model, it is unlikely that the ranking of compared hospitals would show important change because age, morbidity predisposition, length of stay and gender will have similar impact on the risk of falls. Its validity needs to be established on other data sets than those from which it was derived, however. Evaluating its performance on subsequent patients within the same center would not guarantee that the model is transportable to other hospitals; etiology of falls may differ from one country or one hospital to the next. Although we believe that such differences in context cannot completely modify risk ratios between risks groups, scientific validity of the model can only be ascertained by subsequent studies.

More than one-third of falls were judged avoidable by the nurses who completed the incident report. The analysis of causes suggests intervention in the following safety domains—a better assessment of patient risk by the caregivers, instructing patients in safer way to move about, safety recommendations for wheelchair use. Nurses in this hospital continued to advocate bedrails as a preventive device, mostly in confused or sedated patients, although current evidence-based recommendations have restricted their use to rare and well-documented situations [45,46]. This is not really surprising since studies have suggested that the use of restraints is more common than desirable especially in such patients [47,48].

About one-fifth of first falls were followed by at least one more fall. The rate of recurrent events is important, because a high rate of recurrent fall may especially increase the risk of injury [6]. Consequently, some have argued for the use of all observed falls rates, defined as the number of falls possibly including multiple falls per person divided by the total person-days of exposure, rather than first fall rates [17]. Biostatistics literature offers strategies to deal with the dependence of recurrent events when assessing their risk factors [49,50]. The analysis of overall rates assumes, however, that risk factors are the same for all recurrences. Because nursing staff and patients are both likely to change their habits whenever a fall occurs, the validity of this assumption is not guaranteed. Separate models for first and subsequent events seem therefore more appropriate.

The present study gives rise to several recommendations. Falls should be clearly defined, notably by separately identifying first falls, and including all sources of information, regardless of whether falls were witnessed by staff or not. Distinguishing a first fall from subsequent falls warrants independence of observations and averts bias due to underreporting of multiple falls. It is not enough to report falls. Fall-related data should be systematically computerized in order to periodically monitor occurrence rates of first fall by using an appropriate unit of measurement (e.g., inpatient first falls per 1000 inpatient days). Hospitals could send their number of first falls to a national agency, which on the basis of known case mix would provide them with feedback on the lower and upper limit of their expected number of first falls. To avoid under-reporting, results should be published without naming the hospital.

Except for falls resulting from an overwhelming intrinsic or environmental cause it is difficult to classify the causes of falls into discrete reproducible categories such as avoidable and not avoidable. Quality evaluation based uniquely on a case-by-case review is not only time consuming but probably of not much use to target preventive actions. Benchmarking creates opportunities to learn about the quality of care and to improve it. When observed incidence rates for first falls exceed the upper limit of expected rates, a causal analysis based on an investigation of circumstances surrounding falls should be performed. The prevention of falls related to extrinsic environmental hazards entails activities that differ substantially from activities involving intrinsic factors. If a hospital or department appears to show results that are high but lie within the boundaries of expected falls, it may be appropriate to extend the period of analysis in order to increase the precision of observed rates. The incidence rate of subsequent falls may be viewed as a proxy of the efficacy of secondary prevention.

In conclusion, the proposed model provides a simple and clinically credible tool. It can be used by national health agencies and hospitals alike to compare fall occurrence rates between hospitals, to identify the need of prevention activities, and to follow prevention programs. Its reliability should nonetheless be evaluated by other researchers on new series of patients in different settings.

Appendix A

AP-DRG classification system assigns patients into clinically coherent groups that demonstrate similar consumption of hospital resources and length of stay patterns. They are based on routinely available data and widely used in most developed countries [51]. For more details see the documentation: All Patients Diagnosis Related Groups (AP-DRGs) version 12.0; 3M Health Information Systems, Wallingford, CT.

AP-DRGs predisposing to fall:

Craniotomy and spinal surgery: 1–2, 4, 737–739, 792
Neoplasm, infections, degenerative and cerebrovascular disorders of the central nervous system: 9–17, 20–22
Alteration of consciousness: 23, 761–767
Heart disease with cardiovascular complications: 110, 115, 121, 123, 127, 129–130, 135, 138, 141, 144, 478, 796, 808
Systemic infections: 415–423, 702
Mental disorders: 424–432
Alcohol or psychoactive drug abuse: 743–751
Rehabilitation: 462
Hospitalization with major complications: 530–587, 633, 703, 708–710, 714, 793–794

AP-DRGs with an operating room procedure:
1, 2, 4–8, 36–42, 49–63, 75–77, 103–108, 110–120, 146–171, 191–201, 209–213, 216–234, 257–261, 263–270, 285–293, 302–315, 334–345, 353–365, 377, 381, 392–394, 400–402, 406–408, 415, 424, 439, 440–443, 461, 468, 471–472, 476–480, 482–483, 491, 493–494, 530–531, 534, 536, 538–539, 545–550, 556–559, 564–565, 567, 571, 573, 575, 579, 581, 583, 585, 700–704, 730–732, 737–739, 755–759, 786–787, 789–793, 795–798, 805–807, 809.

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