Factors associated with proximal femoral fractures in older adults during hospital stay: a cross-sectional study

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ABSTRACT

Background Proximal femoral fractures in older adults affect prognosis, quality of life and medical expenses. Therefore, identifying patients with an elevated risk for proximal femoral fractures and implementing preventive measures to mitigate their occurrence are crucial.
Objective This study aimed to develop an accurate in-hospital fracture prediction model that considers patients' daily conditions and medical procedure status. Additionally, it investigated the changes in their conditions associated with fractures during hospital stays.
Design A retrospective observational study.
Setting(s) Acute care hospitals in Japan.
Participants Participants were 8 514 551 patients from 1321 medical facilities who had been discharged between April 2018 and March 2021 with hip and proximal femoral fractures.
Methods Logistic regression analysis determined the association between patients' changes in their ability to transfer at admission and the day before fracture, and proximal femoral fracture during hospital stays.
Results Patients were classified into fracture and non-fracture groups. The mean ages were 77.4 (SD: 7.7) and 82.6 (SD: 7.8), and the percentages of women were 42.7% and 65.3% in the non-fracture and fracture groups (p<0.01), respectively. Model 4 showed that even if a patient required partial assistance with transfer on the day before the fracture, the fracture risk increased in each category of change in ability to transfer in the following order: 'declined', 'improved' and 'no change'.
Conclusions Patients showing improved ability to transfer during their hospitalisation are at a higher risk for fractures. Monitoring patients' daily conditions and tracking changes can help prevent fractures during their hospital stays.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Proximal femoral fractures are an important and debilitating in-hospital complication.
⇒ Numerous predictive models have been developed to prevent falls during hospitalisation, but they do not include information about the patients' walking stability and how that changes.

WHAT THIS STUDY ADDS

⇒ This study reveals that patients are at a higher risk if their walking stability improves during their hospital stay compared with their admission status.
⇒ The model developed in this study demonstrated higher accuracy than models that capture walking stability at admission or the day before the fracture in a cross-sectional manner.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ We identified patients at high risk for fractures during hospitalisation using data from daily nursing records. This model may be useful for identifying patients who would benefit from measures to reduce fall risk.

BACKGROUND

The proportion of Japan's population aged 65 years or older is projected to reach 37.16 million in 2030 and 39.21 million in 2040. A previous study estimated that fracture incidence in this age group would reach approximately 250 000 in 2020 and 300 000 in 2040.[1] This incidence is expected to further increase as the population ages.[1 2] Proximal femoral fractures represent age-related fragility. Their occurrence during hospital stays has been linked to increased mortality rates.[3] Studies have indicated that the 30-day and 1-year mortality rates are approximately double in cases of proximal femoral fractures within communities.[4]

Proximal femoral fractures are predominantly caused by falls.[5 6] Numerous predictive models have been developed to prevent falls during hospital stays.[7–9] However, older adults are at an increased risk of falling due to declining physical function, and advanced age is considered a high-risk factor in these models. In countries with ageing populations, many hospitalised patients are at a high risk of falling, making it challenging for medical professionals to efficiently assess this risk.

Proximal femoral fractures in older adults have a significant impact on patient prognosis, quality of life and medical expenses. This situation is undesirable for the patient and from a national financial perspective. Therefore, identifying patients with an elevated risk of proximal femoral fractures and preventing their occurrence are necessary.

The primary risk factors for proximal femoral fractures are age, sex and body mass index (BMI).[8 10] Other risk factors include a diminished ability to perform activities of daily living and maintain balance.[9–11] Falls account for 80%–98% of proximal femoral fractures.[5] Diminished activities of daily living capacity, balance and muscle strength have also been identified as fall risk factors.[12] Ability to transfer and balance may change depending on the patient's condition during their hospital stay. In older adults, activities of daily living changes depend on illness and treatment status. Even patients who can walk independently may need considerable help completing their activities of daily living. Monitoring the patient's condition is necessary to prevent fractures due to such changes.

Japan's medical system has achieved universal health insurance,[13] ensuring access to medical services for all citizens. This robust insurance system has contributed to Japan achieving one of the highest average life expectancies in the world and maintaining a low infant mortality rate.[14–16] However, the challenges of a rapidly ageing population and prolonged economic stagnation have led to a notable increase in the proportion of national medical expenses relative to the gross national product.[17] In addition, Japan has more hospital beds per capita and longer hospital stays than other developed countries.[18] Therefore, in recent years, efforts have been made to improve the efficiency of medical costs by shortening hospitalisation periods, among other measures.[17 19]

The reality of Japan's rapidly ageing population is important when considering the future of other older adult income countries. In the USA, it is anticipated that the number of people over 65 years old will exceed 40% in the near future.[20] Under these circumstances, preventing accidents that occur during hospitalisation is essential, even if the incidence is low.

We often encounter situations where risk assessment for changes in a patient's condition during hospitalisation is not done in time, resulting in a fall. Therefore, we aimed to develop a more accurate predictive model for fractures during hospital stays, considering the patient's daily condition and medical process status. Additionally, we sought to identify patient condition factors contributing to fractures during hospital stays.

METHODS

Data source

We used two databases: the Diagnosis Procedure Combination (DPC) and the Severity of a Patient's Condition and the Extent of a Patient's Need for Medical/Nursing Care (SCNMN).

The DPC classification method was developed in Japan for acute inpatients. In 2003, the Ministry of Health, Labour and Welfare initiated its operation as a lump-sum per-diem payment system. It is used for acute inpatient care and medical resource allocation. Acute care hospitals participate in this system and report clinical information related to medical procedures to the government.[21] As of 2020, the DPC database has been implemented in 1757 facilities with 483 180 beds, covering 24.5% of general hospitals and 54.4% of hospital beds in Japan. The DPC database contains information such as the patient's age, sex, medical information, such as primary diagnosis, pre-existing comorbidities and postadmission complications presented with International Classification of Diseases, Tenth Revision codes, admission and discharge dates, hospital admission route, discharge destinations and outcomes and surgical procedures. Numerous epidemiological studies have been conducted on this data's reliability.[7 22 23]

The SCNMN is an index developed in Japan to measure the nursing services required by hospitalised patients. It is primarily used as a standard for paying basic hospitalisation fees and other medical expenses for acute care. The index comprises 21 items divided into three categories: Item A (seven items), which pertains to highly specialised nursing care, including monitoring and treatment; item B (seven items), which encompasses patients' functional status, such as activities of daily living affecting medical care and item C (seven items), which pertains to medical management such as medical treatment related to surgery and emergency care. Items A and C data can be obtained from treatment records. These items are evaluated daily for each patient and compiled into a database.[24]

Study population

The target population for this study comprised 14 632 368 patients aged 65 and older who were admitted and discharged from the hospital between 1 April 2018 and 31 March 2021. Among these patients, those who met any of the following criteria were excluded: (1) were bedridden (requiring complete assistance with transfer from admission to discharge) or had (2) physical trauma or pathological fractures (including bone tumours, femoral head necrosis, pathological femoral fractures and periprosthetic fractures) or (3) other conditions requiring the same surgical procedures as proximal femoral fracture reduction (such as rheumatoid arthritis or complications associated with surgery and procedures, including loosening artificial joints).

Outcome

Hip fractures were the outcome variable. Patients were considered to have a hip fracture if they met one of the following criteria: (1) underwent any of the following surgeries during hospital stay: open reduction surgery (Receipt code: K0461), intra-articular open reduction surgery (K0731), hip hemiarthroplasty (K0811) or hip arthroplasty (K0821) and had a proximal femoral fracture recorded as a postadmission complication or (2) did not undergo any of the surgeries above but had a hip fracture recorded as a post-admission complication. The fracture date was defined as the day before the most recent surgery or traction procedure when the patient required full assistance with the transfer. If no surgery or traction procedure was performed, it was defined as the day before the patient's ability to transfer deteriorated from independent or partially to fully assisted and remained in that state for at least 2 days.

Variables

The following variables were used in this study: age, sex, length of hospital stay, Charlson comorbidity index (CCI) score,[25 26] BMI, use of antithrombotic or coagulant agents, use of sedative-hypnotic drugs, use of psychotropic medications, surgical interventions, medical treatment and ability to transfer. Ability to transfer was defined as the transfer status of walking or using a wheelchair. Even if a patient uses a wheelchair, if assistance is not required, the patient is considered 'without assistance'. This variable primarily focuses on the degree of need for assistance, is based on the functional independence measure and is set as part of item B of the SCNMN used in Japan (see the Methods and Variables section). Additionally, we multiplied the change in ability to transfer from the time of admission to the day before the fracture occurred by this variable. Furthermore, we considered hospital factors such as nurse staffing, designation status as an academic hospital and hospital classification based on bed capacity.

The CCI score was calculated by including the primary diagnosis, admission precipitating diagnosis, most resource-consuming diagnosis and second most resource-consuming diagnosis and pre-existing comorbidities. The ability to transfer was categorised as 'without assistance', 'partly assisted' and 'fully assisted' at two points: (1) the time of admission and (2) the day before the fracture. Next, we established a variable to represent (3) the difference from admission to the day before the fracture, classified as 'declined', 'no change' and 'improved'. Furthermore, a combined variable was introduced, incorporating (4) the difference from the

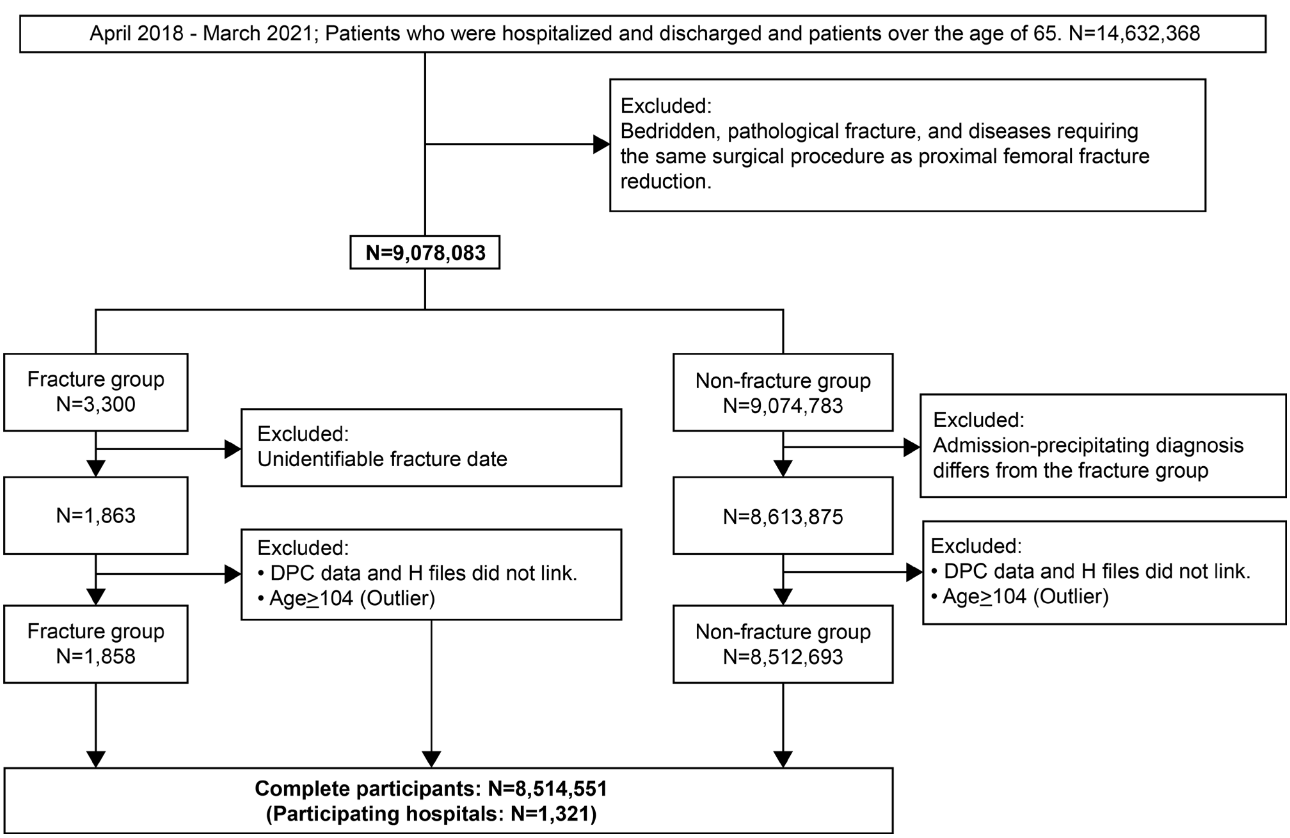

Figure 1 Flowchart of sample selection. Showing the flow of selecting subjects for analysis in this study. DPC, Diagnosis Procedure Combination.

Table 1 Participant characteristics (N=8 514 551)

	Non-fracture group (N = 8 512 693)		Fracture group (N = 1858)		P
Age, mean, SD	77.4	±7.7	82.6	±7.8	<0.01
Age class, n, %					<0.01
65–74	3 393 995	39.9	314	16.9	
75–84	3 457 215	40.6	740	39.8	
≥85	1 661 483	19.5	804	43.3	
Sex, n, %					<0.01
Female	3 638 153	42.7	1214	65.3	
Male	4 874 540	57.3	644	34.7	
Length of stay, mean, SD	15.4	±17.3	56.9	±38.6	<0.01
CCI (Quan) score, n, %					<0.01
0	2 965 370	34.8	426	22.9	
1	661 048	7.8	147	7.9	
2	3 139 215	36.9	682	36.7	
≥3	1 747 060	20.5	603	32.5	
BMI, mean, SD	22.3	±3.7	20.3	±3.7	<0.01
BMI class, n, %					<0.01
<18.5	1 217 619	14.3	563	30.3	
18.5–24.9	5 038 431	59.2	983	52.9	
≥25.0	1 817 612	21.4	183	9.8	
Unknown	79 031	0.9	129	6.9	
Antithrombogenic/anticoagulants drug, n, %	4 074 961	47.9	807	43.4	<0.01
Sedative hypnotics, n, %	3 216 177	37.8	719	38.7	0.42
Psychotropic, n, %	3 420 706	40.2	726	39.1	0.33
Surgery or emergency care, n, %*	2 709 539	31.8	284	15.3	<0.01
Transfer (admission date)					<0.01
Without assistance	5 097 971	59.9	524	28.2	
Partly assisted	2 164 018	25.4	742	39.9	
Fully assisted	1 250 704	14.7	592	31.9	
Transfer (day before fracture)†					<0.01
Without assistance	4 881 247	57.3	939	50.5	
Partly assisted	2 432 319	28.6	880	47.4	
Fully assisted	852 289	10.0	39	2.1	
Unknown	346 838	4.1			
Transfer difference‡					<0.01
Declined	1 450 602	17.0	208	11.2	
No change	5 006 629	58.8	826	44.5	
Improved	1 708 624	20.1	824	44.3	
Unknown	346 838	4.1			
Transfer (Day Before Fracture)×Transfer Difference					<0.01
Without Assistance×No Change	3 544 898	41.6	326	17.5	
Without Assistance×Improved	1 336 349	15.7	613	33.0	
Partly Assisted×No Change	1 183 946	13.9	479	25.8	
Partly Assisted×Declined	876 098	10.3	190	10.2	
Partly Assisted×Improved	372 275	4.4	211	11.4	
Fully Assisted×No Change	277 785	3.3	21	1.1	
Fully Assisted×Declined	574 504	6.7	18	1.0	
Unknown	346 838	4.1	0	0.0	
Nurse staffing					<0.01
7:1 patient-to-nurse ratio	7 760 133	91.2	1624	87.4	
10:1 or 13:1 patient-to-nurse ratio	661 491	7.8	216	11.6	
Unknown	91 069	1.1	18	1.0	
Academic hospital	1 419 580	16.7	211	11.4	<0.01

Continued

Table 1 Continued

	Non-fracture group (N = 8 512 693)		Fracture group (N = 1858)		P
Bed size (non-academic hospital)	7 002 044	82.3	1629	87.7	<0.01
<200	903 406	10.6	275	14.8	
200–399	2 197 935	25.8	596	32.1	
400–599	2 468 385	29.0	494	26.6	
≥600	1 432 318	16.8	264	14.2	

*Surgery and emergency care are craniotomy, thoracotomy, laparotomy, bone surgery, thoracoscopic/laparoscopic surgery, general anaesthesia/spinal anaesthesia surgery, percutaneous endovascular treatment, treatment such as percutaneous myocardial ablation, invasive gastrointestinal treatment in SCNMN Item C.
†Non-fracture group: between admission and random days in hospital.
‡Non-fracture group: between admission and random days in hospital, fracture group: between admission and day before the fracture day.
§Continuous variable: Mann–Whitney U test, Discrete variable: $\chi2$ test.
BMI, body mass index; CCI, Charlson comorbidity index.

time of admission to the day before the fall and ability to transfer ('without assistance', 'partly assisted' and 'fully assisted'). We used item A from the SCNMN, which includes treatment and treatment-related variables as well as monitoring information. The 18 subitems within item A were consolidated through factor analysis. Among these, four subitems that accounted for less than 2% of patients (86 437 people) in item A were excluded. The remaining subitems were analysed using the principal factor method and Promax rotation. Two subitems, 'management of oral administration of anticancer drugs' and 'management of oral, transdermal and rectal administration of narcotics', which had a communality of less than 0.05, were not consolidated with other subitems and were used as independent variables instead. Another factor analysis was performed on the remaining 12 items, extracting five factors (online supplemental etable 1). Seven treatment-related variables (SCNMN Item A) were ultimately established. Item C from the SCNMN was used for variables related to surgeries and invasive procedures. Patients who underwent any procedure listed in item C were included. A logistic regression analysis was conducted to investigate whether the effect of these procedures on the occurrence of proximal femoral fractures during hospital stay varied depending on the details of the procedures performed. The analysis revealed that the impact of the procedures on the occurrence of proximal femoral fractures during hospital stay was equivalent when examining each surgery or invasive procedure separately and when considering the implementation of any surgical and invasive procedures together (online supplemental etable 2).

Regarding medications and surgery, the data acquisition period for the non-fracture group encompassed the entire hospital stay. For the fracture group, it spanned from the date of admission to the fracture date. Data on ability to transfer and variables related to medical treatment were obtained from the day preceding the fracture date for the fracture group and from a randomly selected day within the hospital stay for the non-fracture group. Ability to transfer (unassisted, partly or fully assisted) was based on item B from the SCNMN.

Statistical analyses

An intergroup comparison was conducted for each variable based on the occurrence status of proximal femoral fractures during hospital stay using the Mann-Whitney U and χ^2 tests. Logistic regression analysis using the forced entry method was performed with variables that showed significant differences in the intergroup comparison. These variables included patients' characteristics such as age, sex, length of stay, CCI score and BMI. They also included variables related to the implementation of medical procedures (seven variables), surgeries or invasive procedures and hospital-related factors (nurse staffing, designation status as an academic hospital, classification based on bed capacity) as independent variables. To address multicollinearity, only one variable was selected for those with a correlation coefficient (r) greater than 0.5.

SPSS (IBM, Chicago, Illinois) V.28 was used for all statistical analyses, with a significance level set at 5%. The participating medical institutions provided comprehensive consent by posting the form on the hospital website. Patients who did not agree to participate in the research had the option to opt out.

RESULTS

The analysis included 8 514 551 patients and 1321 target facilities (figure 1).

Among the target facilities, 78 (5.9%) were academic hospitals and 930 (70.4%) had a patient-to-nurse ratio of 7:1 (online supplemental etable 3). The number of patients without fractures was 8 512 693 (99.98%), whereas the number with fractures was 1858 (0.02%) (table 1). Among the patients with fractures, 968 (52.1%) underwent surgery for proximal femoral fractures.

An intergroup comparison of patients' characteristics between the groups revealed that the fracture group had a significantly higher mean age (77.4 years

Table 2 Frequency distribution of monitoring and treatment and surgery and emergency care (N=8 514 551)

	Number of applicable patients	Non-fracture group* (N = 8 512 693)		Fracture group*(N = 1858)		
		N	%	N	%	P
Monitoring and treatment						
Wound treatment (excluding treatment of pressure ulcer)	380 113	380 054	4.5	59	3.2	<0.05
Treatment of pressure ulcer	9317	9303	0.1	14	0.8	<0.01
Respiratory care (except for only sputum aspiration)	939 119	938 842	11.0	277	14.9	<0.01
Management of three or more intravenous lines simultaneously	303 349	303 264	3.6	85	4.6	<0.05
ECG monitor management	1 998 355	1 997 922	23.5	433	23.3	0.74
Syringe driver management	242 308	242 268	2.8	40	2.2	0.07
Management of blood transfusion and blood product	123 958	123 903	1.5	55	3.0	<0.01
Use of antineoplastic agents (injection only)	352 443	352 435	4.1	8	0.4	<0.01
Management of oral administration of antineoplastic agents	141 711	141 691	1.7	20	1.1	<0.05
Use of narcotics (injection only)	333 377	333 355	3.9	22	1.2	<0.01
Internal use of narcotics, application, management of suppositories	92 792	92 753	1.1	39	2.1	<0.01
Radiation therapy	55 394	55 376	0.7	18	1.0	0.09
Immunosuppressant management	550 487	550 382	6.5	105	5.7	0.13
Use of pressor agent (injection only)	245 587	245 568	2.9	19	1.0	<0.01
Use of antiarrhythmic agent (injection only)	59 067	59 060	0.7	7	0.4	0.10
Use of continuous infusion of antithrombotic embolic drug	790 718	790 646	9.3	72	3.9	<0.01
Drainage management	454 193	454 136	5.3	57	3.1	<0.01
Treatment in a sterile treatment room	29 532	29 525	0.3	7	0.4	0.84
Any monitoring and treatment	4 323 367	4 322 498	50.8	869	46.8	-
Surgery and emergency care						
1_Craniotomy	37 838	37 832	0.44	6	0.32	0.431
2_Thoracotomy	83 085	83 064	0.98	21	1.13	0.498
3_Laparotomy	315 606	315 558	3.71	48	2.58	<0.05
4_Bone surgery	224 364	224 328	2.64	36	1.94	0.06
5_Thoracoscopic/laparoscopic surgery	455 015	454 990	5.34	25	1.35	<0.01
6_General anaesthesia/spinal anaesthesia surgery	1 616 814	1 616 644	18.99	170	9.15	<0.01
7_Percutaneous endovascular treatment	459 840	459 802	5.40	38	2.05	<0.01
8_Treatment such as percutaneous myocardial ablation	203 725	203 710	2.39	15	0.81	<0.01
9_Invasive gastrointestinal treatment	539 223	539 151	6.33	72	3.88	<0.01
Any surgery from 1 to 6	1 641 671	1 641 495	19.28	176	9.47	<0.01
Any emergency care 7 to 9	1 185 802	1 185 683	13.93	119	6.40	<0.01
Any surgery and emergency care	2 709 823	2 709 539	31.83	284	15.29	<0.01

*Non-fracture group: between admission and random days in hospital, fracture group: between admission and day before fracture.

(SD 7.7) vs 82.6 years (SD 7.8), p<0.01), percentage of women (42.7% vs 65.3%, p<0.01) and percentage of patients with a BMI below 18.5 (14.3% vs 30.3%, p<0.01). Moreover, significant differences were observed in most variables except sedative-hypnotic drug use, psychotropic drug use and cardiovascular and respiratory care (tables 1 and 2).

An intergroup comparison of transfer-related variables, showing the differences between prefracture ability to transfer and that from the time of admission, was performed. Compared with the non-fracture group, a higher percentage of patients in the fracture group fell into the following three categories: 'WIthout Assistance × Improved' (15.7% vs 33.0%), 'Partially Assisted × No Change' (13.9% vs 25.8%) and 'Partially Assisted × Improved' (4.4% vs 11.4%) (p<0.01) (table 1).

An analysis of ability to transfer's impact on proximal femoral fracture risk was performed (table 3, online supplemental etable 4). In each model, almost all the variables were statistically significant, except medication management. In model 1, which examined the effect of ability to transfer at the time of admission, the ORs for 'partly assisted' and 'without assistance' were 1.75 (p<0.01) and 1.49 (p<0.01), respectively, using 'fully assisted' as the reference. In model 3, which examined the changes in ability to transfer between the time of admission and the day before the fracture, the OR for 'no change' and 'improved' was 1.58 (p<0.01) and 2.65 (p<0.01), respectively. This result suggests

Table 3 Logistic regression analysis of the effect of fracture in hospital

	(Model 1)		(Model 2)		(Model 3)		(Model 4)	
	ORs	P	ORs	P	ORs	P	ORs	P
Transfer (admission date)								
Fully assisted	ref							
Partly assisted	1.75	<0.01						
Without assistance	1.49	<0.01						
Transfer (day before fracture)*								
Fully assisted			ref					
Partly assisted			14.14	<0.01				
Without assistance			12.61	<0.01				
Transfer difference†								
Declined					ref			
No change					1.58	<0.01		
Improved					2.65	<0.01		
Transfer (Day Before Fracture)×Transfer Difference								
Fully Assisted×Declined							ref	
Fully Assisted×No Change							0.94	0.85
Partly Assisted×Declined							10.01	<0.01
Partly Assisted×No Change							14.93	<0.01
Partly Assisted×Improved							13.38	<0.01
Without Assistance×No Change							8.30	<0.01
Without Assistance×Improved							15.05	<0.01

*Non-fracture group: between admission and random days in hospital.
†Non-fracture group: between admission and random days in hospital; fracture group: between admission and day before the fracture day.

that patients whose ability to transfer improved from admission to the day before the fracture had a higher risk of proximal femoral fracture than those whose status remained unchanged. Sufficiently high ORs were observed in some model-specific variables concerning transfer, where the number of patients who were 'fully assisted' was very small. The implication of this will be discussed later.

A decline in ability to transfer from admission appeared to be associated with an increased fracture risk in patients who required full assistance the day before. The area under the curve (AUC) for models 1 to 4 ranged from 0.908 to 0.918 ($p<0.01$), with model 4 having the highest AUC value (AUC=0.918, $p<0.01$).

Adjusted for age, sex, length of stay, CCI, BMI, antithrombogenic/anticoagulant drug, Surgery or emergency care, Monitoring and treatment (SCNMN Item A), bed size, 7:1 patient-to-nurse ratio (online supplemental etable 4).

DISCUSSION

To our knowledge, this study is the first to demonstrate that information about patients' daily ability to transfer can improve the accuracy of fracture prediction during hospital stays compared with relying solely on status at admission. Additionally, this study reveals that patients are at a higher risk if their ability to transfer during their hospital stay tends to improve compared with their admission status. Furthermore, this study indicates that using the nearest ability to transfer, which reflects changes in condition during hospital stays, combined with basic patient information at admission, such as age and sex, helps identify patients with a high proximal femoral fracture risk during hospital stays with high accuracy.

Falls are the leading cause of proximal femoral fractures, accounting for 74% of cases.[27] Furthermore, falls and slips are the primary cause of femoral neck fractures during hospital stays.[6] Identifying patients at risk of severe outcomes, such as proximal femoral fractures, during hospital stay based on changes in their capacity to perform activities of daily living may help determine priorities and tailor care support, contributing to hospital safety management.

This study established several primary factors that increase the risk of proximal femoral fractures, including being aged 85 or older, female sex, being underweight and changes (or lack thereof) in ability to transfer from admission to the day before the fracture. These findings align with previous studies that described fracture risks, including age, sex, and body mass index.[8 10]

Previous research has indicated that patients who require partial assistance when performing activities of daily living have an increased risk of falling.[12] Furthermore, independent walking on flat ground has been associated with a reduced risk of fractures,[9] whereas poor physical balance increases the risk.[11] In this study, ability to transfer was classified into three levels. Patients required partial assistance with transfer, include those who had difficulty walking independently or had poor physical balance, consistent with the findings of previous research.[11] Moreover, evaluating the modulation of ability to transfer from admission, such as 'deteriorated', 'no change' and 'improved', revealed a clinically valuable finding. Despite having the same ability to transfer on admission, patients whose conditions improve or do not change during their hospital stay must be monitored to prevent fractures. Older adults tend to overestimate their physical abilities, and this has been shown to be associated with falls.[28–31] In the process of improving transfer ability and increasing activity as a result of recovery, older age and differences in perception of changes in transfer ability related to hospitalisation may lead to falls and fractures during hospitalisation. Conversely, the key to preventing falls and fractures during admission is to provide a safe environment for older patients, including ensuring communication between healthcare professionals and patients, and staff education[32,33]

Furthermore, the model developed in this study, combining ability to transfer changes from admission to the day before the fracture and current ability to transfer, demonstrated higher accuracy than the model that captures ability to transfer at admission or the day before the fracture in a cross-sectional manner. Compared with patients whose ability to transfer worsened from the time of admission and who received full assistance, the risk of fracture during hospitalisation was higher in patients with 'Partly Assisted×No Change' and 'Partly Assisted×Improved'. These results suggest that risk assessment based on daily patient conditions helps prevent fractures during hospital stays.

In Japan, the number of days of hospitalisation at acute care institutions has been gradually decreasing owing to national policy, but length of hospital stay is still longer than in Western countries.[18] In our study, the length of stay for patients who sustained a fracture during hospitalisation averaged 56.9 days (SD 38.6), with some patients staying for nearly 2 months. While the current situation poses challenges for national politics, it is possible to observe changes in the patient's recovery process, offering valuable insights when transitioning to home care. Although fractures due to falls during hospitalisation can occur in any country, they are considered to be particularly important in Japan, where hospitalisation periods tend to be long. In this study, several risk factors that are considered common in other countries have been identified. Our findings indicate that surgery does not increase the risk of fractures. These factors often include patients' underlying illnesses, such as dementia.[8] However, information accuracy concerning comorbidities recorded at admission in the DPC data varies by illness.[22] Therefore, rather than analysing disease-based factors, focusing on those related to patients' daily condition, such as ability to transfer and medical treatment the day before the fracture. This is because patient conditions, particularly for older adults, are changeable.

Regarding hospital factors, a higher nurse-to-patient ratio has been associated with a decreased risk of proximal femoral fractures.[7,34] In contrast, in this study, a 7:1 (one nurse-to-seven patients) ratio system (the highest nurse placement standard among general wards in acute care facilities in Japan) increased the fracture risk. These advanced acute care hospitals admit a certain percentage of critically ill patients. Therefore, this variable may reflect patient status that is not fully accounted for by those used. Moreover, these facilities may have systems to accept hospitalised patients with fractures from other hospitals for additional medical procedures or treatments, such as surgery, which could contribute to the increased risk.

One strength of this analysis is its large sample size, with 8 512 693 cases across 1321 facilities, providing high validity. The incidence of femoral fractures during hospital stays is extremely low, with only 3–5 cases (0.02%–0.05%) occurring yearly at one medical facility.[6] Therefore, elucidating the relationship between factors related to a patient's condition and femoral fractures during hospital stays might be challenging. Findings based on large data sets are essential for patient safety. Furthermore, by excluding bedridden patients and those with pathological fractures from the analysis and focusing on patients with a high likelihood of falling, the study appropriately assessed the risk of traumatic fractures during hospital stays, which may have been overestimated in the past.

In addition to femoral fractures, head trauma resulting from falls during hospital stays is another adverse event that significantly affects patient outcomes. Therefore, future studies should consider including head injuries when examining the risks associated with falls during hospital stays.

Limitations

This study has several limitations. First, the exact fracture time was not determined in this study. The fracture date was estimated based on the patient's ability to transfer and daily activities of daily living scores during their hospital stay, assuming that the date of fracture corresponded with the point at which the patient's ability to transfer suddenly deteriorated and they became bedridden. However, validating the accuracy of this estimated fracture date remains a challenge. Another limitation is that the input variables were limited to the range represented by medical records in the DPC data. Previous falls[11] and delirium[35] are a risk factor for falls, leading to proximal femoral fractures. Older adults may be prescribed a large number of drugs from multiple medical institutions, and multiple drug prescriptions and falls among this population have also been reported.[36,37] It is difficult to accurately obtain information on the prescription status using DPC data, and there are limits to the effects of drugs in this study. However, this study did not include it as a variable because it is not recorded in the DPC data. Furthermore, medical institutions not covered by the lump-sum per-diem payment system also admit patients with hip fractures. By considering only medical institutions accepting 'hip fracture' as the study population, medical institutions not covered by the daily allowance lump-sum system are excluded. Therefore, the generalisability of the hospital factor findings is limited. Nonetheless, this study provides valuable insights into how the risk of fracture during a hospital stay can vary depending on patients' daily conditions and changes in their condition.

Furthermore, the statistical analyses of this study may have room for improvement. Regarding selection of independent variables in the logistic regression model building, our method was based on pairwise association between the dependent and independent variables. We expected the final selected influential variables to most likely show similar associations as the variable alone. However, it must be noted that this may not hold in the presence of complex confounding factors. Additionally, we used age and BMI variables in the regression model to reflect possible non-linearity. However, fitting splines to these variables as continuous ones without categorisation or setting justifiable cut-off points may have been better. Using these variables as continuous ones without categorisation by adopting the spline method or setting a justifiable cut-off point may have been helpful. The results of the logistic regression revealed some high ORs; however, those were possibly because of biases caused by a very small number of patients with fractures who were 'fully assisted'. Considering the above, caution must be exercised in interpreting the results.

Conclusions

This study identified risk factors for proximal femoral fractures immediately before their occurrence using daily records. Monitoring patients' daily condition and changes can help prevent fractures during hospital stays, particularly in older patients. Medical information systems that store daily information on patient conditions and treatment outcomes can help reduce adverse events and improve hospital stays.

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REFERENCES

1 Orimo H, Yaegashi Y, Hosoi T, *et al*. Hip fracture incidence in Japan: estimates of new patients in 2012 and 25-year trends. *Osteoporos Int* 2016;27:1777–84.
2 Werner M, Macke C, Gogol M, *et al*. Differences in hip fracture care in Europe: a systematic review of recent annual reports of hip fracture registries. *Eur J Trauma Emerg Surg* 2022;48:1625–38.
3 Sáez-López P, Brañas F, Sánchez-Hernández N, *et al*. Hip fracture registries: utility, description, and comparison. *Osteoporos Int* 2017;28:1157–66.
4 Johal KS, Boulton C, Moran CG. Hip fractures after falls in hospital: a retrospective observational cohort study. *Injury* 2009;40:201–4.
5 Hagino H, Endo N, Harada A, *et al*. Survey of hip fractures in Japan: recent trends in prevalence and treatment. *J Orthop Sci* 2017;22:909–14.
6 Toba M, Moriwaki M, Yokouchi K, *et al*. Develop a monitoring procedure for cases of bone fractures and intracranial bleeding due to falls based on integrating adverse event data extracted from medical fee information and other data (Japanese article). *JJQSH* 2017;12:270–8.
7 Morioka N, Moriwaki M, Tomio J, *et al*. Structure and process of dementia care and patient outcomes after hip surgery in elderly people with dementia: a retrospective observational study in Japan. *Int J Nurs Stud* 2020;102:S0020-7489(19)30277-9.
8 Zapatero A, Barba R, Canora J, *et al*. Hip fracture in hospitalized medical patients. *BMC Musculoskelet Disord* 2013;14:15.
9 Tamiya H, Yasunaga H, Matusi H, *et al*. Hypnotics and the occurrence of bone fractures in hospitalized dementia patients: a matched case-control study using a national inpatient database. *PLOS ONE* 2015;10:e0129366.
10 De Laet C, Kanis JA, Odén A, *et al*. Body mass index as a Predictor of fracture risk: a meta-analysis. *Osteoporos Int* 2005;16:1330–8.
11 Jokinen H, Pulkkinen P, Korpelainen J, *et al*. Risk factors for Cervical and Trochanteric hip fractures in elderly women: a population-based 10-year follow-up study. *Calcif Tissue Int* 2010;87:44–51.
12 Kim J, Lee E, Jung Y, *et al*. Patient-level and organizational-level factors influencing in-hospital falls. *J Adv Nurs* 2022;78:3641–51.
13 Ikegami N, Yoo B-K, Hashimoto H, *et al*. Japanese universal health coverage: evolution, achievements, and challenges. *Lancet* 2011;378:1106–15.
14 OECD. Life expectancy at birth, Available: https://data.oecd.org/healthstat/life-expectancy-at-birth.htm
15 OECD. Life expectancy at 65, Available: https://data.oecd.org/healthstat/life-expectancy-at-65.htm#indicator-chart
16 OECD. Infant mortality rates, Available: https://data.oecd.org/healthstat/infant-mortality-rates.htm#indicator-chart
17 Ikegami N, Rice T. Controlling spending for health care and long-term care: Japan's experience with a rapidly aging society. *Health Affairs* 2023;42:804–12.
18 OECD Data. Length of hospital stay, Available: https://data.oecd.org/healthcare/length-of-hospital-stay.htm
19 Iijima K, Arai H, Akishita M, *et al*. Toward the development of a vibrant, super-aged society: the future of medicine and society in Japan. *Geriatr Gerontol Int* 2021;21:601–13.
20 Administration for Community Living. 2020 Profile of Older Americans. Washington, DC: ACL, Available: https://acl.gov/aging-and-disability-in-america/data-and-research/profile-older-americans
21 Hayashida K, Murakami G, Matsuda S, *et al*. History and profile of diagnosis procedure combination (DPC): development of a real data collection system for acute inpatient care in Japan. *J Epidemiol* 2021;31:1–11.
22 Yamana H, Moriwaki M, Horiguchi H, *et al*. Validity of diagnoses, procedures, and laboratory data in Japanese administrative data. *J Epidemiol* 2017;27:476–82.
23 Ogawa T, Yoshii T, Morishita S, *et al*. Seasonal impact on surgical site infections in hip fracture surgery: analysis of 330,803 cases using a nationwide inpatient database. *Injury* 2021;52:898–904.
24 Hayashida K, Moriwaki M, Murakami G. Evaluation of the condition of Inpatients in acute care hospitals in Japan: a retrospective multicenter descriptive study. *Nurs Health Sci* 2022;24:811–9.
25 Charlson ME, Pompei P, Ales KL, *et al*. A new method of classifying Prognostic Comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
26 Quan H, Li B, Couris CM, *et al*. Updating and validating the Charlson Comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol* 2011;173:676–82.
27 Hagino H, Nakamura T, Sakamoto K, *et al*. Nationwide survey of hip fractures in Japan. *J Orthop Sci* 2004;9:1–5.
28 Nakano H, Murata S, Shiraiwa K, *et al*. Increased time difference between imagined and physical walking in older adults at a high risk of falling. *Brain Sci* 2020;10:332.
29 Kluft N, Bruijn SM, Weijer RHA, *et al*. Does Misjudgement in a stepping down paradigm predict falls in an older population *R Soc Open Sci* 2019;6:190786.
30 Hayashi S, Misu Y, Sakamoto T, *et al*. n.d. Cross-sectional analysis of fall-related factors with a focus on fall prevention self-efficacy and self-cognition of physical performance among community-dwelling older adults. *Geriatrics*8:13.
31 Fujimoto A, Hori H, Tamura T, *et al*. Relationships between estimation errors and falls in healthy aged dwellers. *Gerontology* 2015;61:109–15.
32 Klenk J, Becker C, Palumbo P, *et al*. Conceptualizing a dynamic fall risk model including intrinsic risks and exposures. *J Am Med Dir Assoc* 2017;18:921–7.
33 Hill A-M, McPhail SM, Waldron N, *et al*. Fall rates in hospital rehabilitation units after Individualised patient and staff education programmes: a pragmatic, stepped-wedge, cluster-randomised controlled trial. *Lancet* 2015;385:2592–9.
34 Morita K, Matsui H, Fushimi K, *et al*. Association between nurse staffing and in-hospital bone fractures: a retrospective cohort study. *Health Serv Res* 2017;52:1005–23.
35 Hshieh TT, Yue J, Oh E, *et al*. Effectiveness of Multicomponent Nonpharmacological delirium interventions: a meta-analysis. *JAMA Intern Med* 2015;175:512–20.
36 Seppala LJ, Petrovic M, Ryg J, *et al*. Stoppfall (screening tool of older persons prescriptions in older adults with high fall risk): a Delphi study by the Eugms task and finish group on fall-risk-increasing drugs. *Age Ageing* 2021;50:1189–99.
37 van der Velde N, Seppala LJ, Hartikainen S, *et al*. European position paper on Polypharmacy and fall-risk-increasing drugs recommendations in the world guidelines for falls prevention and management: implications and implementation. *Eur Geriatr Med* 2023;14:649–58.