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Research Paper

Falls as the result of interplay between nurses, patient and the environment: Using text-mining to uncover how and why falls happen

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ABSTRACT

Objectives: This study aimed to explore, from the perspectives of nurses, how patients, the environment, and the practice of nurses interact with each other to contribute to patient falls.

Methods: A retrospective review of incident reports on patient falls, registered by nurses between 2016 and 2020, was conducted. The incident reports were retrieved from the database set up for the project of the Japan Council for Quality Health Care. The text descriptions of the “background of falls” were extracted verbatim, and analyzed by using a text-mining approach.

Results: A total of 4,176 incident reports on patient falls were analyzed. Of these falls, 79.0% were unwitnessed by nurses, and 8.7% occurred during direct nursing care. Document clustering identified 16 clusters. Four clusters were related to patients, such as the decline in their physiological/cognitive function, a loss of balance, and their use of hypnotic and psychotropic agents. Three clusters were related to nurses, and these included a lack of situation awareness, reliance on patient families, and insufficient implementation of the nursing process. Six clusters were concerned with patients and nurses, including the unproductive use of a bed alarm and call bells, the use of inappropriate footwear, the problematic use of walking aids and bedrails, and insufficient understanding of patients' activities of daily living. One cluster, chair-related falls, involved both patient and environmental factors. Finally, two clusters involved patient, nurse, and environmental factors, and these falls occurred when patients were bathing/showing or using a bedside commode.

Conclusions: Falls were caused by a dynamic interplay between patients, nurses, and the environment. Since many of the patient factors are difficult to modify in a short time, the focus has to be placed on nursing and environmental factors to reduce falls. In particular, improving nurses' situation awareness is of foremost importance, as it influences their decisions and actions to prevent falls.

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What is known?

- Falls are commonly observed incidents in healthcare settings.
- Certain patient and environmental characteristics contribute to the risk of falling.

What is new?

- Falls were caused by a dynamic interplay between patients, nurses, and the environment.
- Nurses' situation awareness influences their decisions and actions, and their actions can prevent falls as well as increase the chance of falls.

- The use of traditional fall prevention strategies such as installing bedrails and bed alarms may increase the risk of falling or fall-related injuries.

1. Introduction

Falls are commonly observed incidents in healthcare settings. The rate of falls in hospitals ranged approximately from two to 10 per 1,000 patient days [1–3], which converts to 700 to 3,500 falls each year in a hospital where 1,000 beds are occupied. Falls are prevalent among the elderly with physiological and cognitive impairments. Consequently, the number of falls is projected to increase, as the patient population is aging [4].

A fall is an important issue in health care as it imposes physiological, psychological, emotional, and financial burdens on those

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who fall and those who care for them. The preceding studies reported that approximately 25%–30% of falls resulted in injury [5,6], and 2%–3% of them caused major harm, such as fracture, head trauma, spinal cord injury, or even death [6,7]. The length of hospital stay was also prolonged by 7–25 days due to medical treatments and rehabilitation [8,9]. Moreover, regardless of whether patients are injured or not, the experience of falls could result in a post-fall syndrome that induces anxiety and a fear of falling, which leads patients to a state of immobilization, dependence, and restriction in daily living [4,10]. Hence, a greater demand is placed on family members to care for patients with a history of falling. In addition, patients' injuries require additional expenditure by hospitals of USD 1,000 to 4,000 [11,12] for treatment.

A multitude of risk factors for falls have been identified, and these are usually categorized into intrinsic and extrinsic factors [13,14]. The intrinsic factors include the characteristics of a patient, such as sex [15], the types of disease [16,17], decline in physical function [6,18], elimination and sleeping problems [18,19], confusion and impaired understanding [20], the types of medication used [6,17,21], and patients' predisposition such as "doing everything on one's own" [20]. The extrinsic factors involve the use of unsafe footwear including slippers [22], tubes and drains attached to patients [21], and wet and slippery floors [23]. These intrinsic and extrinsic factors have been incorporated into several fall-screening tools to identify those at risk of falling so that precautions can be taken to prevent falls. However, continuous patient falls may suggest a possibility of other factors playing an important role.

Nurses are in the best position to identify how and why falls happen since the majority of falls occur during patients' daily activities, which nurses are responsible for assisting with [24]. Studies show that more than half of falls happen in patients' rooms, followed by bathrooms and shower rooms [6], and 60.9% of falls are attributable to nursing care [1]. Nurses have myriad opportunities to accumulate fall risk data. Despite these facts, nurses' perceptions of the risk factors have rarely been explored [25]. A few studies [14,25] have explored nurses' judgment of fall risk factors using a survey questionnaire, but these studies involved a limited sample and did not explore what had happened in real fall situations.

In addition, falls, like any other adverse events, resulting from the dynamic interplay of multiple factors involving the behaviors and conditions of a patient, treatment regimen, environment and system characteristics, and the practice of health professionals, who endeavor to prevent falls [26]. Nurses can prevent falls but can also increase the risk of falling if they do not accurately perceive appropriate cues, comprehend them correctly, and then predict the possibility of falls. Whether or not nurses can prevent or contribute to falls is also dependent on their decisions concerning which fall prevention strategy to choose, and how they implement the chosen strategy [27]. Therefore, it is important to explore how the interplay between patients, the environment, and the practice of nurses contributes to patient falls, rather than examining each factor separately. This approach would provide a more comprehensive picture of fall-inducing situations, and help to develop appropriate countermeasures. Thus, this study aimed to explore, from the perspectives of nurses, how patients, the environment, and the practice of nurses interact with each other to contribute to patient falls.

2. Methods

2.1. Study design

A retrospective review of incident reports was conducted. Incident reports were chosen as the data source, as they provide rich

information regarding systems problems [28]. Analysis of the reports allows a researcher to explore how nurses perceived and judged the risk of falling, and how they interacted with a patient and the environment before and at the time of falls.

2.2. Sample

Incident reports on patient fall, registered between 2016 and 2020, were extracted from the database set up for the project of the Japan Council for Quality Health Care (JCQHC) to collect medical near miss/adverse event information. Approximately 1,500 medical institutions participated in this project. Reports on adverse events or near misses about patient falls that occurred in health care institutions and were reported by nurses were included in the study. Reports on falls of visitors and staff, and falls that occurred outside the institutions (e.g., falls during an overnight stay at home) were excluded.

A total of 55,071 reports were registered between 2016 and 2020. Of these, 4,525 (8.2% of the total reports) were reports of falls, and included both adverse events (i.e., falls with injuries) and near misses (i.e., falls without injuries; or falls intercepted by either patients or nurses, but that resulted in injuries, etc.) happening in healthcare institutions or long-term care facilities (both adverse and near miss events are referred to as falls, hereafter). A total of 4,228 falls (93.4% of the total falls) were reported by nurses. Fifty falls occurred outside the institutions and two falls happened to patient visitors. Excluding these 52 reports left 4,176 reports (92.3% of the total falls) for analysis.

2.3. Data collection

The incident reports of the JCQHC include 159 items, such as the characteristics of patients, nurses, and facilities involved in falls; the working context of nurses; the descriptions and outcomes of falls; and the measures suggested to prevent falls. Of these, the following items were retrieved for this study: the number of reports registered by nurses each year; the sex and age of patients who fell; the length of experience of nurses involved in falls; and the time, location, and situations (whether falls were witnessed by nurses and happened during nursing care), and the outcomes of falls were extracted from the database. The information regarding the situations and outcomes of falls was extracted from the "description of incident" column of the database, which provides a reporters' explanation (i.e., text data) of what has happened in the incidents.

In addition, nurses' perceptions of the factors contributing to falls were extracted from the "background of falls" column of the database, which also provides a reporter's explanation of why an incident happened. The extraction was carried out verbatim. Before analyzing these text data, synonym words were integrated into one word. An example is "bed alarm", which refers to a bed-exit alarm, a sensor mattress, a sensor clip, an infrared sensor, and the product names of these devices. Another example is "walking aids", which includes a walker, a cane, a wheelchair, or any other assistive device for patient transfer.

2.4. Data analysis

Text-mining was used to analyze the nurses' descriptions of factors contributing to falls. Text-mining is "the computational process of extracting useful information from massive amounts of digital data by mapping low-level data into richer, more abstract forms and by detecting meaningful patterns implicitly present in the data" [29]. The analysis proceeded as follows. First, the textual data were cleaned up by removing stop-words and stemming

words, combining dismantled characters into a meaningful words using a dictionary function, and integrating synonyms. Second, the frequencies of words appearing in the descriptions were examined. Third, a co-occurrence network, which shows the words with high degrees of co-occurrence across report documents (i.e., incident reports) connected by lines [30], was created based on cosine distance. Finally, document clustering, which categorizes documents into groups based on the similarity of patterns in word appearance [30], was conducted by applying the term frequency-inverse document frequency (TF-IDF) approach, calculating cosine distance, and then clustering documents using Ward’s method. Text-mining was done by using KH Coder 3, which is free software developed by Higuchi [31] and available from <http://kxcoder.net/dl3.html>.

2.5. Ethical considerations

This study is based on incident reports which have been de-identified and made available to the public. Thus, no ethical approval was required according to the ethical guidelines of the institution where the study was conducted.

3. Results

Between 2016 and 2020, approximately 750–850 falls were reported each year. The majority of falls were female (55.7%), and were aged between 70 and 89 years (67.6%). Nearly 45.0% of nurses who reported falls had no more than five years of clinical experience. The falls occurred mostly in patients’ rooms (60.3%). Most of

the reported falls resulted in injuries (93.0%). The most prevalent outcomes were fractures (68.1%), followed by minor injuries (34.6%). Moreover, 1.7% of falls resulted in death due to a direct or indirect impact of the falls (Table 1).

The findings also showed that 79.0% of the falls were unwitnessed by nurses, and 8.7% of the falls occurred during direct nursing care. Some falls were unwitnessed by nurses even during nursing care, because nurses temporarily left a patient unattended, or had turned their back on a patient, when he/she fell (Table 2).

Fig. 1 presents a co-occurrence network of words, with their frequencies, which nurses used to describe their understanding of factors contributing to the patients’ falls. For instance, when the word “Fall” was used to describe the causes of falls by nurses, other words such as “Nurse,” “Patient,” “Walk,” “Toilet,” and “Call bell” were also used to describe them. However, this does not mean that all words were used in the same report. If nurses frequently described the causes of falls using the words “Fall” and “Toilet” in some reports, and used the words “Fall” and “Call bell” in other reports, “Toilet” and “Call bell” would be connected to “Fall”. To understand what was described in each report and identify similarities in the descriptions, document clustering was conducted to group the reports that had similar patterns of word appearance. As a result, 16 clusters were extracted (Table 3). Reviewing the content of reports revealed that these clusters were concerned with: the patient; nursing; a combination of patient and nursing factors; and a combination of environment, patient, and/or nursing factors.

Four clusters (Clusters 1, 11, 15, 16) are related to patient factors. Clusters 1 and 16 are about the use of hypnotic and psychotropic (including sedative) agents and indicate that patients often fall

Table 1
Characteristics of patients and nurses involved in falls and the time and locations of falls (n = 4,176).

Variables	n (%)	Variables	n (%)
Number of reports by year		Time of falls	
2016	758 (18.15)	0:00–5:59	1,066 (25.53)
2017	896 (21.46)	6:00–11:59	1,225 (29.33)
2018	825 (19.76)	12:00–17:59	943 (22.58)
2019	844 (20.21)	18:00–23:59	919 (22.01)
2020	853 (20.43)	Unclear	23 (0.55)
Sex of patients (fallers)		Number of patients injured	
Female	2,324 (55.65)	Not injured/Not indicated	293 (7.02)
Male	1,850 (44.30)	Injured	3,883 (92.98)
Unspecified	2 (0.05)	Types of injuries (Multiple outcomes)	
Age of patients (fallers)		1) Minor injuries ^a	
50–59	224 (5.36)	Yes	1,443 (34.55)
60–69	565 (13.53)	No or not indicated	2,733 (65.45)
70–79	1,251 (29.96)	2) Fractures	
80–89	1,570 (37.60)	Yes	2,845 (68.13)
90–99	408 (9.77)	No or not indicated	1,264 (30.27)
Others	158 (3.78)	Suspected based on X-ray	67 (1.60)
Experience of nurses (year)		3) Intracranial injuries	
<1	292 (6.99)	Yes	357 (8.55)
1–5	1,647 (39.44)	No or not indicated	3,799 (90.97)
6–10	759 (18.18)	Suspected based on X-ray	20 (0.48)
11–15	460 (11.02)	4) Dislocation of joints	
16–20	341 (8.17)	Yes	45 (1.08)
21–25	267 (6.39)	No or not indicated	4,129 (98.87)
26–30	263 (6.30)	Suspected based on X-ray	2 (0.05)
>30	147 (3.52)	5) Deaths	
Locations of falls		Yes	73 (1.75)
Patient rooms	2,518 (60.30)	No or not indicated	4,103 (98.25)
Corridors	595 (14.25)	6) Others ^b	
Toilet	367 (8.79)	Yes	83 (1.99)
Bath/Shower rooms	107 (2.56)	No or not indicated	4,093 (98.01)
Outpatient waiting rooms	43 (1.03)		
Others	546 (13.07)		

Note.
^a Minor injuries include bleeding, contusions, bruising and lacerations.
^b Others include organ damage, spinal cord injuries, ruptured eyeballs, and so forth.

Table 2
The number of falls occurred during care and witnessed by nurses.

Falls witnessed by nurses	Falls during nursing care			Total [n (%)]
	Yes	No	Unclear	
Yes	326	84	3	412 (9.87)
No	34	3,221	42	3,298 (78.98)
Unclear	3	29	434	466 (11.16)
Total [n (%)]	363 (8.69)	3,334 (79.84)	479 (11.47)	4,176 (100.00)

Note: Based on nurses' descriptions of falls, the contexts of the falls were classified as follows: 1) Falls witnessed by nurses (Yes = witnessed, No = unwitnessed, and Unclear = unable to determine in the reports), and 2) Falls occurring during nursing care (Yes = during nursing care, No = not during nursing care, and Unclear = unable to determine in the reports). A patient's fall that a nurse did not see was not classified as witnessed. Falls were not judged as having occurred during nursing care if nurses were merely responding to call bells or bed alarms of patients who fell, or and if nurses had left patients to attend to other patients' needs (e.g., a nurse assisted a patient to a bathroom, but a fall occurred after the nurse left him/her to attend to another patient).

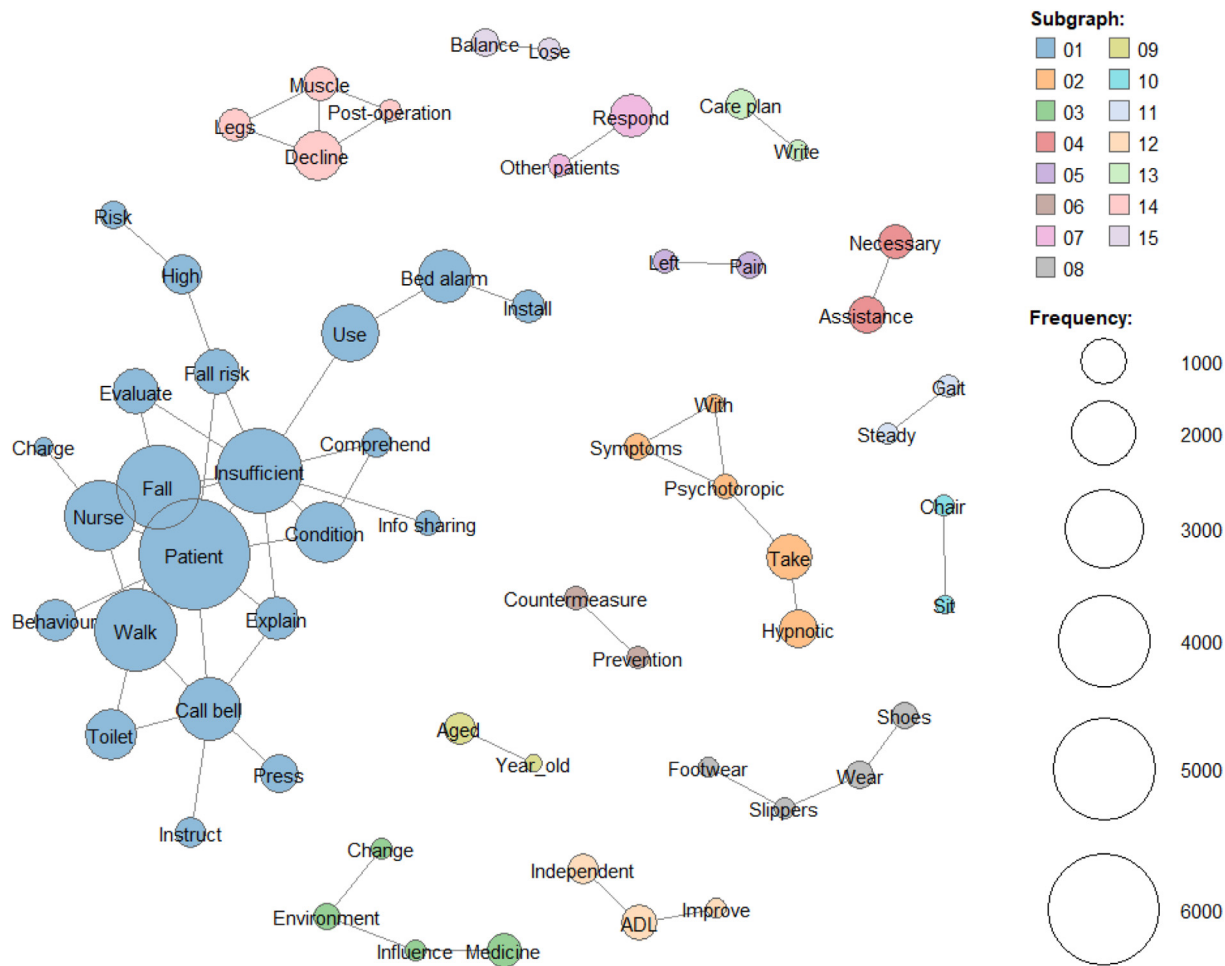


Fig. 1. Co-occurrence network of words used by nurses to describe factors contributing to falls and the relationships between the words (Only the top 60 words in frequency are displayed).

when they were walking to the toilet, after taking their usual dose or additional hypnotic or psychotropic agents before sleep. Cluster 11 refers to a loss of balance as the cause of falls. Patients tended to lose their postural balance when they stumbled over a step, when they were making a turn or bending down, or when they were carrying luggage in their hands. Falls also occurred because patients could not put their hands out when they fell, or hold on to something to support their bodies. Cluster 15 indicates that a decline in muscle strength and cognitive function of patients were causes of falls perceived by nurses.

Three clusters (Clusters 8–10) are related to nursing practice.

Cluster 8 describes nurses' reflections on the reliance on and lack of education of patient families. Nurses tended to think that patients would be ok when their families accompanied them. Nonetheless, falls still happened because nurses had not informed and educated family members about the risk of falling and fall prevention strategies. This lack of instruction resulted in family members leaving a patient (temporarily) unattended, or unsafely transferring a patient to a wheelchair and maneuvering it. Cluster 9 illustrates the insufficient implementation of nursing processes. This includes a lack of fall risk assessment, not writing, revising, and sharing nursing care plans, and using standardized care plans instead of

Table 3
The results of document clustering describing nurses' perceptions of contributing factors to falls.

Cluster	Extracted words
Cluster 1 (n = 123)	Tablet (0.265), Hypnotic (0.263), Take (0.157), Before sleep (0.111), Insomnia (0.103), Sleep (0.081), Medicine (0.077), Addition (0.068), Everyday (0.063), Give (0.063)
Cluster 2 (n = 202)	Bed alarm (0.223), Visit patient room (0.152), Install (0.145), Activate (0.137), Detect (0.134), Go off (0.129), Respond (0.128), Bed (0.089), Cognitive function (0.086), Use (0.067)
Cluster 3 (n = 129)	Overbed table (0.313), Bedrails (0.278), Bed (0.121), Lock (0.114), Climb over (0.109), Interspace (0.086), Install (0.078), Get out (0.077), Foot (0.074), Head (0.065)
Cluster 4 (n = 146)	Slippers (0.285), Wear (0.272), Footwear (0.231), Shoes (0.180), Heel (0.119), Sandals (0.115), Slip (0.081), Sole (0.054), Step (0.054), Instruct (0.052)
Cluster 5 (n = 113)	Transfer (0.168), Walking aid (0.146), Place (0.086), Use (0.046), Wish (0.045), Usage (0.044), Assistance (0.044), Toilet (0.042), Eye (0.042), Left (0.040)
Cluster 6 (n = 98)	Bed alarm (0.305), Bedside (0.141), Position (0.124), Install (0.106), Place (0.079), Transfer (0.065), Reach (0.058), Diaper (0.056), Elimination (0.048), Bed (0.047)
Cluster 7 (n = 499)	Call bell (0.194), Press (0.189), Toilet (0.175), Alone (0.140), Walk (0.137), Nurse (0.124), Eliminate (0.123), Patient (0.118), Explanation (0.113), Move (0.113)
Cluster 8 (n = 74)	Family (0.270), Attendance (0.104), Visit patient (0.07), Visit hospital (0.067), Accompany (0.055), Away overnight (0.051), Outpatient (0.048), Risk (0.048), Absence (0.046), Consent (0.044)
Cluster 9 (n = 125)	Care plan (0.187), Write (0.186), Evaluate (0.134), Score (0.116), Revision (0.101), Information sharing (0.092), Implement (0.089), Conference (0.086), Risk (0.082), Countermeasures (0.080)
Cluster 10 (n = 602)	Insufficient (0.170), Patient (0.162), Behavior (0.158), Nurse (0.156), Respond (0.149), Condition (0.145), Predict (0.137), Comprehend (0.130), Observe (0.123), Leave (0.121)
Cluster 11 (n = 114)	Lose (0.269), Balance (0.221), Hand (0.160), Have (0.135), Support (0.061), Luggage (0.057), Finger (0.051), Result (0.049), Foot (0.047), Turn (0.043)
Cluster 12 (n = 42)	Chair (0.321), Sit (0.108), Backrest (0.085), Armrest (0.070), Waiting room (0.064), Pipe (chair) (0.061), Table (0.060), Back (0.059), Linen (0.058), Space (0.057)
Cluster 13 (n = 87)	Bathing/Showering (0.346), Slip (0.177), Wet (0.143), Undress (0.137), Floor (0.122), Bathroom (0.120), Bath tub (0.100), Mattress (0.066), Towel (0.062), Handrails (0.055)
Cluster 14 (n = 1,353)	Walk (0.236), Admission (0.171), Explain (0.145), Do (0.137), Think (0.132), Activities of daily living (0.130), High (0.119), Fracture (0.116), Independent (0.113), Rehabilitation (0.101)
Cluster 15 (n = 138)	Muscle (0.177), Leg (0.137), Decline (0.129), Cognitive function (0.069), Lower body part (0.065), Weaken (0.060), Judgment (0.056), Long-term (0.055), With (0.053), Difficulty (0.052)
Cluster 16 (n = 306)	Medicine (0.180), Influence (0.153), Psychotropic (0.148), Take (0.146), Insomnia (0.132), Possibility (0.131), Awaken (0.118), Hypnotic (0.112), Night (0.107), History (0.095)

Note: *n* indicates the number of reports (documents) classified into each cluster. A total of 25 documents were not classified into the above clusters. The top 10 words characteristic of each cluster are listed. The numbers in the brackets are Jaccard coefficients.

making individualized plans. Cluster 10 alludes to a lack of situational awareness of nurses, and this consists of insufficient observation, comprehension, and prediction of patient behaviors and conditions by nurses.

Six clusters (Clusters 2–5, 7 and 14) describe the combination of patient and nursing factors. Cluster 2 is concerned with the unproductive use of a bed alarm. Nurses installed a bed alarm to detect a patient's attempt to get out of bed. However, because they did not check if the alarm was activated and set to the right mode every time they visited the patient's room, the alarm system did not work as expected. There were also times that alarm systems did not work, for instance, because a clip sensor was disconnected, or a sensor mattress was misplaced by either nurses or patients. Some patients avoided activating a sensor by stepping over it when they got out of bed. Even if the alarm went off, nurses could not respond to the patient's needs before the patient moved.

Cluster 3 describes the risky use of bedrails and overbed tables by nurses. Nurses used bedrails and overbed tables to surround a bed to prevent a patient from getting out of it. However, this strategy led to patients engaging in even more dangerous behaviors, such as climbing over the bedrail, exiting from the interspace between bedrails, or exiting underneath an overbed table. Not installing bedrails also contributed to patient falls. This happened when nurses forgot to use a bedrail, or intentionally reduced the use of bedrails based on their belief that a patient could not move. At other times, the patient removed the bedrails.

Clusters 4 and 5 describe risks associated with patients walking. Cluster 4 is concerned with the use of inappropriate footwear, e.g., wearing slippers, shoes without heels, shoes with slippery soles, and sandals. A lack of instruction by nurses and a lack of recognition and cooperation by patients regarding the use of appropriate shoes

contributed to falls. Cluster 5 illustrates the problematic use of walking aids. Examples of nursing factors included unsafe operation of walking aids (e.g., placing a wheelchair in a distant position), and not observing, assessing, or advising on patients' usage of walking aids. Examples of patient factors included patients ambulating (e.g., going to the toilet) with a walking aid without the assistance of nurses, and patients walking to the toilet without a walking aid.

Cluster 7 depicts the under-use of call bells. Despite nurses' instructions to patients to call for them, patients tended to walk to the toilet alone without pressing the call bell. This happened because they had impaired cognitive function, were hesitant to call nurses or were confident in their activities of daily living (ADL). In some cases, a lack of explanation by nurses regarding the use of call bells contributed to patients walking alone. In addition, nurses' expectation that patients would press the call bell resulted in nurses leaving patients unattended in the toilet. This was one of the major causes of falling in a toilet.

Cluster 14 highlights the insufficient understanding of ADL by both patients and nurses. Patients sometimes ignored nurses' safety instructions and walked by themselves because they thought they could do so without the assistance of a nurse. Improvement in ADL through rehabilitation boosted patients' confidence and motivation to walk by themselves. On other occasions, a lack of explanation about fall risks and prevention strategies by nurses resulted in patients walking on their own. This happened because nurses had overestimated patients' ADL while ignoring other important risk factors (e.g., walking with a cane, and gait problems), or had not recognized a change, either an improvement or a decline, in their ADL status.

Two other clusters are concerned with a combination of patient,

nurse, and environmental factors. Cluster 6 illustrates the unsafe use of a bedside commode. Examples include a bedside commode not placed/installed in the correct position by nurses (e.g., a distant position) or lacking a supportive structure (e.g., lacking handrails or durability) for a patient with reduced mobility. Another example includes patients transferring to a commode without asking for nursing assistance. The removal of a commode prevents patients from reaching it by themselves. But such a decision by nurses sometimes backfired on them because patients committed an even more adventurous act of walking to a room toilet. Cluster 13 describes falls that occurred when patients were bathing/showering and undressing in a bathroom. A wet/slippery floor and the absence of handrails contributed to falls. Moreover, the risk of falling increased if patients experienced hypotension, emotional uplift, or muscle weakness. These risks of falling were exacerbated by nurses not attending to patients at risk of falling during showering, and not taking appropriate fall prevention measures (not using non-slip mattresses).

Finally, one cluster involved environment and patient factors. Cluster 12 describes chair-related falls. A patient fell because he/she missed a chair (i.e., did not check the location of the chair when sitting) or his/her foot got caught in a chair. Falls also occurred when a patient had syncope or lost balance when sitting in an unsafe chair, such as a pipe chair or a chair without a backrest and/or armrest.

The results of the text-mining showed that nurses perceived a wide range of fall risk factors, which are classified into the patient, nurse, and environmental factors. The findings also illustrated that most of the falls were caused by the interplay between these three factors.

4. Discussion

This study explored nurses' perceptions of factors that contributed to patient falls based on incident reports. As a result, this study identified 16 major fall factors, attributed to the patient, nurse, and/or the environment. The decline in muscle strength and cognitive function, loss of balance, and the use of hypnotic and psychotropic agents are patient factors that nurses perceived contributed to patient falls. These factors have also been identified as increasing the risk of falling in prospective and retrospective epidemiological studies [2,16,18] as well as in studies that explored nurses' perceptions of fall risks [14,25]. Apart from the patient biological factors, nurses also identified that a slippery floor, the use of unsafe footwear, and unsupportive chairs and commodes increased the risk of falling. A slippery floor and unsafe footwear are environmental factors that have constantly been identified as increasing the risk of falling [22,23]. Thus, the results of this study are consistent with the previous findings as regards patient and environmental factors.

What this study adds to the existing body of knowledge is how nursing practice increases the risk of falling. Traditionally, the risk of falling has been investigated through patient records using mathematical modeling [16,18,21]. Hence, how nurses' perceptions, comprehensions, decisions, and actions affect the risk of falling have rarely been examined. The Quality Health Outcomes Model [32] maintains that nurses' perceptions of a patient and the environment affect nurses' decisions on which intervention to choose. In turn, nurses' interventions affect a patient and the environment, the result of which leads to either a desired or undesired outcome. A review of incident reports helped to identify this reciprocity between the nurse, patient, and environment. A few issues are worthy of attention.

The first issue is nurses' situation awareness. To reduce fall-inducing situations, nurses have to be aware of risk-related cues

exhibited by both patients and the environment, understand the current situation, and predict future events. This state of knowledge about a situation is termed "situation awareness" [33]. Situation awareness serves as a basis of subsequent decision-making and performance [33], thus being aware of the current situation enables nurses to make appropriate decisions to prevent incidents [34,35]. The findings of this study indicated that nurses were aware of multiple factors that have the potential to induce falls. But the findings also illustrated that some nurses did not understand patients' ADL status. This happened because they did not recognize the change in patient's functional status, or paid more attention to a certain factor (e.g., independence with ADL) and less to the others (e.g., walking with a cane, and gait problems). Cognitive biases such as blinding to new information and selectively attending to and weighing certain factors lead to misjudgment [36]. As a result, nurses failed to make nursing care plans and did not provide safety instructions to patients and their families. Since some patients are unaware of their fall risks [37] or tend to overestimate their physical functions [38,39], a lack of nursing interventions would result in patients' engaging in activities without the assistance of nurses, which would increase the risk of falling.

The second issue is the nurses' decision to use a bed alarm. Systematic reviews indicated that the use of bed alarms did not reduce the rate of falling [40,41], or even increased it [42]. As indicated in the findings, a bed alarm is difficult to manage, especially for those who attempt to escape from it (e.g., by disconnecting the alarm). This means relying on bed alarms to prevent falls of uncooperative patients may be ineffective. The overuse of bed alarms also causes alarm fatigue and desensitization to alarm sounds [43], which delay nurses' responses to the alarms. On the other hand, a sensor alarm is rarely used in a toilet, where patients need privacy. The findings showed that many falls in toilets occurred because nurses left patients unattended. Nurses' decisions on how to utilize alarm systems could also increase or decrease the patients' risk of falling.

The third issue is nurses' decisions and actions regarding removing a bedside commode and surrounding a bed with bedrails and overbed tables to prevent patients from ambulating by themselves. These strategies, however, produced opposite effects to nurses' intention and resulted in patients walking to a room toilet or climbing over bedrails, which increased the risks of falling and injury. This is consistent with the results of a systematic review, which suggested that the use of bedrails could not prevent falls but increased patient injuries [44]. Trying to prevent falls, while facing multiple competing tasks with frequent interruptions, can cause a target fixation that narrows down nurses' attention and prevents them from seeing the big picture of the situation [45]. This target fixation inhibits nurses from foreseeing the consequence of their actions. The current study implies that patients' risky behaviors are not only caused by patients' characteristics, but also induced by the interplay between a patient, nurse, and the context of nursing practice.

4.1. Implications for clinical practice and management

The present study shows that patients' falls result from a complex and dynamic interplay among patients, nurses, and environmental factors. Since many of the patient factors, such as physiological/cognitive decline and the use of medication, are difficult to modify in a short period, the focus has to be placed on nursing and environmental factors to prevent falls.

As indicated above, nursing factors underlay many of the fall-inducing situations. These included a lack of situation awareness, and inappropriate decision-making and actions. The situation awareness served as the basis of the subsequent factors [33], thus it

is important to increase nurses' capacity for it. Training and rehearsing in a simulated fall-inducing environment is helpful to increase nurses' situation awareness [35,45]. Opening up a communication channel among nurses, doctors, rehabilitation staff and pharmacists also provides nurses with important information regarding the risks of patient falls [46].

There is also a need to support nurses' decision-making in how to respond to fall-inducing situations. Nurses sometimes need to make difficult decisions, such as whether to install or remove a bedside commode for an uncooperative patient, in order to prevent falls. External support is necessary to help nurses arrive at correct decisions. Providing up-to-date evidence-based information assists nurses in choosing the correct interventions. Nurses also need to be educated about when to shift their focus from preventing falls to minimizing fall-related injuries. Not all falls are preventable, and trying to avoid every fall may trigger patients' risky behaviors. Since specific fall prevention guidelines for cognitively impaired older patients are scarce [47], the development of fall prevention algorithms for these patients is vital to support nurses' decisions.

Finally, organizations should help nurses to prevent falls. Replacing slippery bathroom floors with non-slippery floor materials, and exchanging unsupportive chairs/commodes with durable ones with armrests and backrests would reduce the incidence of fall-inducing situations. This in turn would reduce nurses' workload in preventing and responding to falls, so more attention could be devoted to other fall-inducing situations.

4.2. Limitations

Although the present study identified 16 clusters that explained the causes of patient falls, these are based on the reflections of nurses. Thus, the validity of the factors needs to be examined by future studies. The study also revealed that most falls were unwitnessed, and resulted in injuries. These findings may suggest the under-reporting of incidents, which would prevent a full understanding of factors contributing to falls.

5. Conclusions

This study explored how a patient, the environment, and the practice of nurses interact with each other to contribute to patient falls from the perspectives of nurses. While patients' physiological, cognitive, and behavioral factors contribute to falls, these factors may not be modifiable. Thus, interventions need to be directed toward other factors. The nursing practice would reduce the chances of falls as much as increase them. Healthcare organizations need to create a system and an environment that foster nurses' abilities to detect fall-inducing situations and respond to them quickly and appropriately. There is also a need to reduce environmental hazards contributing to falls.

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Declaration of competing interest

No conflicts of interests.

Data availability statement

The datasets used and analyzed during the current study are

available from the corresponding author on reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnss.2022.12.003>.

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