

Original

Human Factors Affecting the Frequency of Incidents by Years of Nursing Experience:

Analysis of Acute Care Hospital Nurses of Regional Cities in Japan

Mika Nakamura¹ and Hiroko Kondo¹¹ Department of Nursing, Gunma University Graduate School of Health Sciences, 3-39-22 Showa-machi, Maebashi, Gunma 371-8514, Japan

Abstract

Background & Aims: Medical safety measures for nurses are an important issue. The present study aimed to clarify the human factors affecting the frequency of incidents by years of experience.

Methods: The participants were 1,489 nurses working in acute care hospitals with more than 400 beds. An anonymous, self-administered questionnaire survey was conducted. The survey included the frequency of incidents in the last six months and a “Questionnaire on Work Situations Commonly Associated with Nursing-Related Incidents.” Multiple logistic regression analysis was performed. Explanatory variables were extracted from the questionnaire items through principal component analysis. The objective variable was incident frequency. The analysis was conducted by years of experience.

Results: Valid responses were obtained from 716 nurses. Extracted variables were: unsafe execution of work, psychological stress, physical stress, busy work environment. Significant associations with incident frequency was found for busy work environment, psychological stress, and unsafe execution of work for nurses with up to 1 year, 4-10 years, and 11 or more years of experience, respectively.

Conclusion: The human factors affecting incident frequency were shown to differ depending on the nurses’ years of experience. Thus, preventive measures based on nursing experience are necessary: improving support systems to reduce busyness, improve psychological support, and address role familiarity for nurses with up to 1 year, 4-10 years, and 11 or more years of experience, respectively.

Article Information

Key words:

Incidents,
Nursing experience,
Incident-affecting factors,
Human factors,
Patient safety

Publication history:

Received: April 10, 2020
Revised: September 15, 2020
Accepted: September 17, 2020

Corresponding author:

Mika Nakamura
Department of Nursing, Gunma University Graduate
School of Health Sciences, 3-39-22, Showa-machi, Mae-
bashi, Gunma 371-8514, Japan
Tel: +81-27-220-7111
E-mail: nmika@gunma-u.ac.jp

I. Introduction

Patient safety is of utmost importance in terms of the quality of healthcare services,¹ and is of great interest to the medical community across the globe. It is important to prevent patient safety incidents (hereafter referred to as incidents) caused by nurses because they come into contact with patients more frequently compared to any other health professionals.

The U.S. Institute of Medicine published a report titled *To Err is Human*,¹ which suggested that organizational efforts are essential in accident prevention, as all humans make mistakes. This report became the impetus for major reforms to patient safety measures.

In 2018, Japan reported 4,030 adverse events, and over half were reported to involve nurses.² The risk of being involved in an incident is higher for nurses than other health professionals because they provide direct care to patients and their work requires multi-tasking skills at all times.³ Many different safety measures have been implemented thus far, but the number of incidents has not decreased. It is therefore necessary to devise new strategies for nurses.

There are two approaches to human error: the human approach and the system approach.⁴ The human approach focuses on the reduction of unsafe behaviors by individuals from the perspective of human factors —

namely forgetfulness, inattention, and recklessness. However, with this approach, there is a tendency to place blame on those involved when inadequate medical care is provided or when an accident or error occurs.⁵ Further, when individuals fear being blamed they are less likely to report incidents, making the method ineffective at reducing the risk that an incident will occur.⁶ As a result, the system approach has become the primary method for improving patient safety measures in recent years. This approach takes an organizational perspective, focusing on the background factors that are present higher up in the system. This method presupposes that all humans make mistakes and therefore concentrates on developing safeguards to reduce their likelihood. Therefore, the authors expected that understanding the human factors likely to lead to errors would yield insights necessary for developing an organizational support system.

Previous studies on nursing-related incidents identified a variety of human factors, including psychological stress (e.g., anxiety, nervousness, and depression),⁷⁻¹⁴ physical stress (e.g., drowsiness, lack of sleep, and exhaustion),¹⁴⁻²⁰ the safe execution of work,^{8,21} and busyness (e.g., workload and time pressure).^{8,14,20,22-25} However, these studies pointed out the problem areas of individual nurses that were likely to result in an incident, rather than seeing them as organizational problems. Further, although several studies have shown an association between fewer years of nursing experience and incidents,^{8,14,18,25-27} very few have considered years of experience in their analyses.^{11,21} It has also been pointed out that errors made by an individual nurse may be attributable to a lack of experience, and that different preventive measures are therefore required depending on the nurse's years of experience.²⁸ Therefore, the authors believe that clarifying what human factors affect incident frequency by years of experience would yield suggestions for organizational measures.

The present study aims to clarify the human factors affecting the frequency of incidents by years of experience and to consider what preventive measures are necessary regarding patient safety for nurses by experience level.

II. Operational definition

Incident

An incident is defined as an event that led to or could have led to an unintended consequence due to nursing negligence. According to the Incident Impact Classification of the National University Hospital Council of Japan,²⁹ patient safety incidents are classified and defined as follows: Level 0 — While an error or issue with a pharmaceutical product or medical tool was observed, the product or tool was not used on a patient; Level 1 — There was no actual harm to the patient; Level 2 — No treatment was given; Level 3a — Simple treatment was needed; Level 3b — Intensive treatment needed; Level 4a — Permanent disability or sequelae, although without significant impairment or cosmetic problems; Level 4b-Permanent disability or sequelae

with significant dysfunction or cosmetic problems; and Level 5 — Death. As this was a study of factors affecting the errors made by nurses themselves, only incidents caused by a nurse as a result of a nursing error were examined.

III. Methods

1. Study participants

Study participants were recruited from 1,489 permanent nursing staff working either the day or night shift at three acute-care hospitals in regional cities in the Kanto region of Japan. Each hospital had at least 400 beds. Nurses who did not directly provide care to patients (such as head nurses) were excluded.

2. Study period

The study was conducted from October to November 2019.

3. Study procedure

An anonymous, self-administered questionnaire survey was conducted. The researchers asked the nursing directors to distribute the participant information sheets and questionnaires to potential participants. The nursing directors provided the questionnaires to the head nurse of each department, who in turn distributed the questionnaires to nurses.

Completed questionnaire forms were collected either by mail or in person (the placement method). Nursing directors selected their preferred collection method. One hospital selected the mailing method and two selected the placement method. The researchers also asked the nursing directors at the two hospitals who chose the placement method to collect the completed questionnaires.

4. Study materials

1) Participant attributes

Participants were asked about the following attributes: age group, years of nursing experience, affiliated department, title (such as deputy head nurse), and qualification (such as certified nurse specialist or certified nurse).

2) Frequency of incidents in the last six months

Participants were asked about the number of incidents that they were aware they caused and could recall over the previous six months. Incidents discovered by the participant or those not caused by him/her were excluded.

The classification system for the impact of incidents by the National University Hospital Council of Japan²⁹ was shown in the questionnaire so that the participants could refer to it when necessary.

3) Evaluation of human factors commonly associated with nursing-related incidents

The present study used an author-developed questionnaire titled "Questionnaire on Work Situations Com-

monly Associated with Nursing-Related Incidents” (43 items). In creating the questionnaire, the authors first drew on preceding studies conducted in Japan and selected items related to the following human factors that tend to be related to incidents involving nurses: psychological and physical states during work and the state of execution of work. Thereafter, a pilot study⁸ was conducted with reference to such factors. The questionnaire was comprised of 62 items related to moods such as anxiety, nervousness and confusion; having an obedient personality; work-related stress; physical stress due to such causes as pain, fatigue, and sleep disorders; perceptions of the state of execution of work, including checking, decision-making, and collaboration; and perception of the work environment, such as busyness and time pressure. In the present study, 40 items were used after removing similar items based on the results of the pilot study. Ambiguous expressions in the items were revised before they were adopted. Moreover, with reference to cases of adverse events that have been made public,³⁰ an additional three items (“I check whether my patient understands treatments and examinations that they are undergoing,” “I sometimes perform unfamiliar tasks on my own,” and “I sometimes perform familiar tasks without fully checking all of the details”) were added to the questionnaire. Also, since differences in the range of tasks between nurses may affect the occurrence of incidents, the authors drew on preceding studies and records of past adverse events in Japan when creating the questionnaire.

In order to ensure the appropriateness of the questionnaire, three researchers with expertise in nursing management studies developed the questions. The questionnaire was then checked by two medical safety managers in acute care hospitals. Moreover, two researchers with expertise in nursing management studies double-checked the questionnaire to make sure that the items accurately reflected real-world situations. Supervision was also provided by three researchers in nursing studies who had a deep knowledge of questionnaire survey methods, so as to ensure the adequacy of the questionnaire.

The questionnaire on factors related to incidents used a five-point scale, ranging from 1 = “not at all” to 5 = “always.” Reverse scoring was used for positive items.

5. Analysis methods

A multiple logistic regression analysis was performed to clarify which variables affect incident frequency among those extracted from the question items.

1) Participant stratification by years of experience

Participants were divided into four strata by their years of experience. The strata were as follows: Entry-level — up to 1 year; basic level — 2-3 years; mid-career level — 4-10 years; and senior level — 11 or more years. For the levels of experience, the levels of skill acquisition in Benner’s nursing theory³¹ were referred to, as well as findings from past studies that a nurse improves their

practical nursing skills during the first year of their career³² and nurses’ degree of professional autonomy varies after 3 and 10 years of experience.³³

2) Frequency of incidents involving a nurse in the last six months

The χ^2 test was performed to reveal whether there were differences in the distribution of incident frequency in the last six months according to years of experience.

3) Extraction of variables representing the human factors commonly associated with nursing-related incidents

We conducted a principal component analysis of the scores of the questionnaire. Principal component analysis is a method used to summarize the variables into a smaller set of principal components (synthesized variables). Principal components obtained in a principal component analysis are calculated in a way such that the variance of the score of each item is maximized and shown as a variable that effectively indicates the difference in score between participants. In this study, 43 items were summarized into a smaller set of principal components.

The process was as follows: the authors calculated the mean score and standard deviation of each item, and verified the floor and ceiling effects, in order to select items that would be used for the principal component analysis. Next, the principal component analysis was conducted with the items of the “Questionnaire on Work Situations Commonly Associated with Nursing-Related Incidents” and principal components were extracted. Varimax rotation was used to simplify the interpretation of the principal components.³⁴ For the purpose of assessing the goodness of fit of the principal component analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s test of sphericity were performed.

4) Mean principal component scores for work situations commonly associated with nursing-related incidents by years of experience

Mean principal component scores by years of experience were calculated to understand trends in the principal component scores by experience level. A principal component score refers to a score that was obtained for each participant using the following steps: the scores of all participants for each item were standardized in such a way that the mean and variance would be 0 and 1, respectively; the standardized scores were then multiplied by the principal component score coefficient; and the obtained values were summed for all items. The range of principal component scores ranged from negative (−) to positive (+) values.

5) Analysis of variables affecting the frequency of incidents

Multiple logistic regression analyses (forced entry method) were performed for participants by years of experience to reveal variables related to incident fre-

quency among those extracted through the principal component analysis of the “Questionnaire on Work Situations Commonly Associated with Nursing-Related Incidents” items. The objective variable was the incident frequency (0 or 1). Incident frequency was classified into groups of low, moderate, and high with frequencies of 0, 1-2, and 3 or more incidents, respectively. The moderate group was excluded from the analysis due to its narrow distribution of incident frequency, and thus the low and high frequency groups were entered as “0” and “1,” respectively. Explanatory variables were the principal components.

The statistical software SPSS ver. 25.0 for Windows was used for the statistical analysis. Two-tailed tests were performed for all analyses, and the level of statistical significance was set at 5%.

6. Ethical considerations

The present study was approved by the Gunma University Ethical Review Board for Medical Research Involving Human Subjects (September 30, 2019; approval number: HS2019-139) as well as the institutional review boards of the participating hospitals (October 4, 2019; approval number: 2019-31 and October 25, 2019; approval number: 2019-36). The researchers provided the nursing directors of the participating hospitals with written and verbal information on the aim, methods, and ethical considerations of the study. Consent was subsequently obtained from the nursing directors. The researchers provided potential participants with a participant information sheet that described the aim and methods of the study. It also explained that participation in the study was voluntary, participants would not suffer any disadvantages even if they decided not to participate, data would be appropriately managed, and the anonymity of the participants would be assured if the results of the study were published. It was determined that consent from a participant was obtained upon the receipt of a completed questionnaire from them.

IV. Results

The questionnaire was distributed to 1,489 nurses, of whom 773 returned a completed form (mailing method: 155; placement method: 618). From among the 773 collected questionnaires, 57 were excluded from analysis because they had missing data on the years of nursing experience, frequency of incidents, or other items. The survey yielded a total of 716 valid responses, which were used for the analysis (valid response rate: 48.1%). The valid response rate for responses collected via the mailing method was 32.6% (140 responses) and that via the placement method was 54.4% (576 responses).

1. Participant attributes

Participant attributes are presented in Table 1. Approximately 50% of participants were in their 20s. Approximately 40% of all participants had 4-10 years of nursing experience. This group accounted for the largest proportion, followed by those with 11 or more years of

experience (approximately 30% of the total). About 70% of all participants were working in a ward. Approximately 10% of all participants had a title such as deputy head nurse or held a qualification such as specialist nurse or certified nurse.

Table 1 Participant attributes n=716

	n	(%)
Age (years)		
20s	342	(47.8)
30s	227	(31.7)
40s	117	(16.3)
50s	25	(3.5)
60s	2	(0.3)
No answer	3	(0.4)
Years of experience		
Up to 1 year	60	(8.4)
2-3 years	118	(16.5)
4-10 years	289	(40.4)
11 or more years	249	(34.8)
Median (inter – quartile range)	7.00	(4.00–13.00)
Affiliated department		
Ward	524	(73.2)
ICU/HCU/NICU etc	105	(14.7)
Operating room	48	(6.7)
Outpatient	26	(3.6)
Other	10	(1.4)
No answer	3	(0.4)
Title (deputy head nurse/CNS/CN)		
None	629	(87.8)
Yes	84	(11.7)
No answer	3	(0.4)

CNS: Certified nurse specialist

CN: Certified nurse

2. Frequency of incidents involving a nurse in the last six months

Table 2 shows the distribution of the participants' incident frequency in the last six months by years of experience. The distribution differed depending on their years of experience ($p < .001$). An incident frequency of 0 was most common among participants with 11 or more years of experience ($n = 128$, 51.4%), followed by those with 4-10 years ($n = 109$, 37.7%), those with 2-3 years ($n = 41$, 34.7%), and was least common in those with up to 1 year of experience ($n = 15$, 25.0%). An incident frequency of 3 or more was most common in those with up to 1 year of experience ($n = 24$, 40.0%), followed by those with 2-3 years ($n = 26$, 22.0%), those with 4-10 years ($n = 53$, 18.3%), and was least common in those with 11 or more years of experience ($n = 28$, 11.2%).

3. Extraction of variables representing the human factors commonly associated with nursing-related incidents

Table 3 shows the mean score (standard deviation) and floor/ceiling effect results for each item of the “Questionnaire on Work Situations Commonly Associated with Nursing-Related Incidents.” No floor or ceiling

Table 2 Frequency of incidents involving a nurse in the last six months

Participant	Frequency of nursing incidents								Chi-square test <i>p</i> -value
	0 times		1 time		2 times		3 times or more		
	n	(%)	n	(%)	n	(%)	n	(%)	
Over all participants	293	(40.9)	190	(26.5)	102	(14.2)	131	(18.3)	
Years of experience									<.001
Up to 1 year	15	(25.0)	10	(16.7)	11	(18.3)	24	(40.0)	
2–3 years	41	(34.7)	32	(27.1)	19	(16.1)	26	(22.0)	
4–10 years	109	(37.7)	86	(29.8)	41	(14.2)	53	(18.3)	
11 or more years	128	(51.4)	62	(24.9)	31	(12.5)	28	(11.2)	

Table 3 Mean item scores and floor/ceiling effects of the “Questionnaire on Work Situations Commonly Associated with Nursing-Related Incidents”
n=716

	Mean	(SD)	Floor effects	Ceiling effects
1 I am nervous.	3.33	(0.99)	2.34	4.33
2 I feel restless.	2.84	(1.01)	1.83	3.84
3 I sometimes have persistent negative thoughts.	2.90	(1.07)	1.84	3.97
4 I cannot concentrate.	2.46	(0.89)	1.57	3.36
5 I do not have motivation to do any work.	2.80	(1.04)	1.76	3.84
6 I feel frustrated.	2.90	(1.04)	1.86	3.94
7 I am confused.	2.37	(1.00)	1.37	3.37
8 I am forgetful.	2.75	(1.00)	1.75	3.75
9 I cannot say what I am thinking.	2.67	(1.04)	1.63	3.71
10 I am modest and passive.	2.58	(1.05)	1.53	3.63
11 I am susceptible to others' reactions and words.	3.18	(1.09)	2.09	4.27
12 I tend to be excessively patient when the situation is difficult.	3.02	(1.07)	1.95	4.10
13 I cannot fall asleep.	2.47	(1.22)	1.25	3.68
14 I sometimes wake up in the middle of the night.	2.60	(1.25)	1.35	3.85
15 I feel sleepy.	2.73	(1.10)	1.63	3.83
16 I am deprived of sleep.	3.08	(1.17)	1.91	4.24
17 I have fatigue.	3.77	(1.01)	2.77	4.78
18 I feel unwell.	2.77	(1.07)	1.70	3.84
19 I am experiencing pain such as lower back pain.	2.81	(1.34)	1.47	4.16
20 I do not feel like going out on my days off.	2.60	(1.15)	1.45	3.75
21 I feel psychological stress from work.	3.16	(1.17)	1.99	4.32
22 I am satisfied with my work. (R)	3.39	(0.96)	2.43	4.35
23 My supervisor will listen to me when I face a difficult situation. (R)	2.57	(1.03)	1.54	3.60
24 I collect information from various aspects (treatment progress, test results) in relation to patients whom I take care of. (R)	2.14	(0.81)	1.33	2.94
25 I carefully observe the condition of patients whom I take care of. (R)	1.96	(0.74)	1.21	2.70
26 I check whether my patient understands treatments and examinations that they are undergoing. (R)	2.26	(0.82)	1.43	3.08
27 I fully understand the methods and steps of treatments and procedures for patients whom I take care of. (R)	2.18	(0.74)	1.44	2.91
28 I fully understand the therapeutic effects, adverse effects, and complications of treatments that are provided to patients whom I take care of. (R)	2.31	(0.73)	1.57	3.04
29 I fully understand nursing procedures and operation manuals. (R)	2.44	(0.75)	1.69	3.19
30 I sometimes perform unfamiliar tasks on my own.	2.66	(0.92)	1.73	3.58
31 I exchange information necessary in performing treatments and procedures for patients with other nurses and people in other professions. (R)	2.20	(0.82)	1.38	3.02
32 I regularly report and communicate information and consult relevant people. (R)	1.70	(0.71)	1.00	2.41
33 I always check the work procedure. (R)	1.86	(0.71)	1.15	2.57
34 I am sometimes distracted.	2.89	(0.81)	2.07	3.70
35 I sometimes perform familiar tasks without fully checking all details.	2.22	(0.84)	1.38	3.06
36 I make appropriate decisions. (R)	2.39	(0.70)	1.69	3.09
37 When I have to handle multiple tasks at the same time, I assign them an order of priority. (R)	1.92	(0.74)	1.18	2.66
38 When I have to handle multiple tasks at the same time, I seek help from other staff. (R)	2.12	(0.84)	1.28	2.96
39 I tend to be behind schedule when providing care and performing procedures.	2.90	(0.86)	2.04	3.76
40 I feel pressure due to time constraints.	3.25	(1.11)	2.14	4.36
41 My work is interrupted by events such as nurse calls.	3.77	(1.18)	2.59	4.96
42 I cannot finish my work within the allocated time.	3.71	(1.14)	2.56	4.85
43 I do not have time for a break because I am too busy at work.	3.07	(1.12)	1.95	4.19

(R): Reverse-scored items

Table 4 Extraction of variables representing the human factors commonly associated with nursing incidents

n=716

		Component loading			
		1 Unsafe execution of work	2 Psycho- logical stress	3 Physical stress	4 Busy work environ- ment
25	I carefully observe the condition of patients whom I take care of. (R)	.783	-.068	.000	.015
27	I fully understand the methods and steps of treatments and procedures for patients whom I take care of. (R)	.772	.139	-.040	.033
28	I fully understand the therapeutic effects, adverse effects, and complications of treatments that are provided to patients whom I take care of. (R)	.770	.078	-.060	.087
24	I collect information from various aspects (treatment progress, test results) in relation to patients whom I take care of. (R)	.739	-.007	-.026	-.007
29	I fully understand nursing procedures and operation manuals. (R)	.690	.077	-.027	.036
32	I regularly report and communicate information and consult relevant people. (R)	.690	.052	.075	-.048
26	I check whether my patient understands treatments and examinations that they are undergoing. (R)	.678	-.009	-.039	-.065
33	I always check the work procedure. (R)	.673	.010	.094	.042
37	When I have to handle multiple tasks at the same time, I assign them an order of priority. (R)	.641	.219	-.032	.049
31	I exchange information necessary in performing treatments and procedures for patients with other nurses and people in other professions. (R)	.637	.082	.104	-.069
36	I make appropriate decisions. (R)	.603	.188	-.011	.030
38	When I have to handle multiple tasks at the same time, I seek help from other staff. (R)	.536	.265	-.053	.078
35	I sometimes perform familiar tasks without fully checking all details.	.285	.108	.133	.067
2	I feel restless.	.082	.718	.242	.136
10	I am modest and passive.	.189	.705	.061	.010
11	I am susceptible to others' reactions and words.	.100	.705	.224	.068
7	I am confused.	.161	.701	.160	.177
9	I cannot say what I am thinking.	.156	.693	.110	.043
3	I sometimes have persistent negative thoughts.	.074	.693	.325	.106
1	I am nervous.	-.030	.639	.128	.239
12	I tend to be excessively patient when the situation is difficult.	-.043	.632	.351	.058
8	I am forgetful.	.133	.555	.182	.099
4	I cannot concentrate.	.196	.524	.410	.016
21	I feel psychological stress from work.	.047	.470	.453	.319
34	I am sometimes distracted.	.104	.405	.063	.205
18	I feel unwell.	-.020	.222	.741	.084
16	I am deprived of sleep.	-.007	.129	.692	.150
17	I have fatigue.	-.044	.241	.660	.298
14	I sometimes wake up in the middle of the night.	-.063	.119	.650	-.092
15	I feel sleepy.	.093	.050	.628	.008
13	I cannot fall asleep.	.005	.288	.627	-.068
19	I am experiencing pain such as lower back pain.	-.039	-.015	.581	.114
5	I do not have motivation to do any work.	.110	.318	.540	.123
6	I feel frustrated.	.081	.286	.533	.106
20	I do not feel like going out on my days off.	-.020	.194	.526	.115
42	I cannot finish my work within the allocated time.	.004	.182	.087	.837
43	I do not have time for a break because I am too busy at work.	-.011	.172	.229	.751
41	My work is interrupted by events such as nurse calls.	-.004	.081	.144	.732
40	I feel pressure due to time constraints.	.101	.519	.110	.560
39	I tend to be behind schedule when providing care and performing procedures.	.136	.409	.036	.556
	Eigenvalue	6.01	5.90	4.82	2.93
	Contribution ratio (%)	15.02	14.74	12.05	7.32
	Cumulative contribution ratio (%)	15.02	29.76	41.81	49.12

(R): Reverse-scored items

Table 5 Mean principal component scores for the human factors commonly associated with nursing-related incidents by years of experience

Participant	Principal Component 1 Unsafe execution of work	Principal Component 2 Psychological stress	Principal Component 3 Physical stress	Principal Component 4 Busy work environment
Up to 1 year	0.220	0.999	-0.605	0.275
2-3 years	0.223	-0.043	-0.272	0.014
4-10 years	0.056	-0.043	0.007	-0.024
11 or more years	-0.224	-0.170	0.266	-0.045

Table 6 Analysis of the variables affecting the frequency of incidents

	OR	95%CI	p-value
Over all participants (n=424)			
Principal Component 1 : Unsafe execution of work	1.54	1.24 ~ 1.92	<.001
Principal Component 2 : Psychological stress	1.82	1.44 ~ 2.30	<.001
Principal Component 3 : Physical stress	0.81	0.65 ~ 1.00	.051
Principal Component 4 : Busy work environment	1.51	1.21 ~ 1.90	<.001
Up to 1 year of experience (n=39)			
Principal Component 1 : Unsafe execution of work	1.67	0.71 ~ 3.93	.236
Principal Component 2 : Psychological stress	2.13	0.77 ~ 5.89	.146
Principal Component 3 : Physical stress	1.19	0.54 ~ 2.64	.667
Principal Component 4 : Busy work environment	3.72	1.34 ~ 10.31	.011
2-3 years of experience (n=67)			
Principal Component 1 : Unsafe execution of work	1.42	0.88 ~ 2.30	.150
Principal Component 2 : Psychological stress	1.73	0.93 ~ 3.20	.083
Principal Component 3 : Physical stress	0.61	0.36 ~ 1.05	.074
Principal Component 4 : Busy work environment	1.39	0.80 ~ 2.44	.243
4-10 years of experience (n=162)			
Principal Component 1 : Unsafe execution of work	1.17	0.83 ~ 1.66	.366
Principal Component 2 : Psychological stress	1.69	1.17 ~ 2.44	.005
Principal Component 3 : Physical stress	0.93	0.67 ~ 1.31	.690
Principal Component 4 : Busy work environment	1.38	0.99 ~ 1.92	.054
11 or more years of experience (n=156)			
Principal Component 1 : Unsafe execution of work	2.18	1.37 ~ 3.47	.001
Principal Component 2 : Psychological stress	1.33	0.82 ~ 2.14	.248
Principal Component 3 : Physical stress	0.90	0.56 ~ 1.44	.658
Principal Component 4 : Busy work environment	1.44	0.90 ~ 2.29	.128

OR=Odds ratio, CI=Confidence interval

effects were observed, and all 43 items were used in the principal component analysis.

Table 4 shows the results of the principal component analysis with the items rearranged in order of highest principal component loading to lowest. First, a principal component analysis was performed by using an eigenvalue of 1. Four principal components were then selected with reference to a scree plot. In the second analysis, three items that differed from the principal component interpretation were removed and a principal component analysis was performed again. The cumulative contribution rate of the four principal components was 49.12%. The principal components were named as follows: [Unsafe execution of work] for Principal Component 1; [Psychological stress] for Principal Component 2; [Physical stress] for Principal Component 3; and [Busy work environment] for Principal Component 4. The KMO measure of sampling adequacy was .911; Bartlett's test of sphericity was $p < .001$.

4. Mean principal component scores for the human factors commonly associated with nursing-related incidents by years of experience

Table 5 shows the mean principal component scores by years of experience. The mean score for the first principal component, "Unsafe execution of work," was highest among participants with up to 1 year (0.220) or 2-3 years (0.223) of experience, and lowest among those with 11 or more years of experience (-0.224). The mean scores for the second and fourth principal components, "Psychological stress" and "Busy work environment," were highest among participants with up to 1 year of experience at 0.999 and 0.275, respectively. The mean score for the third principal component, "Physical stress," was lowest among participants with up to 1 year of experience (-0.605) and highest among those with 11 or more years of experience (0.266).

5. Analysis of the variables affecting the frequency of incidents

Table 6 shows the results of the multiple logistic regression analysis.

1) Over all participants

When analyzing overall incident data for the overall participants, the second principal component, "Psychological stress" (odds ratio: 1.82, 95% CI 1.44-2.30, $p < .001$), had the strongest impact on incident frequency and was found to have a significant association. This was followed by significant associations with the first principal component, "Unsafe execution of work" (odds ratio: 1.54, 95% CI 1.24-1.92, $p < .001$), and the fourth principal component, "Busy work environment" (odds ratio: 1.51, 95% CI 1.21-1.90, $p < .001$; model χ^2 test $p < .001$, Hosmer-Lemeshow test $p = .057$, Nagelkerke $R^2 = .185$, correct classification rate 74.1%). No significant associations were found for the third principal component, "Physical stress."

2) By years of experience

A significant association with incident frequency was found for the fourth principal component, "Busy work environment" (odds ratio: 3.72, 95% CI=1.34-10.31, $p = .011$), for participants with up to 1 year of experience (model χ^2 test $p = .006$, Hosmer-Lemeshow test $p = .771$, Nagelkerke $R^2 = .418$, correct classification rate 79.5%). No significant associations were found for rest of the principal components.

The regression model did not fit participants with 2-3 years of experience (model χ^2 test $p = .091$).

A significant association with incident frequency was found for the second principal component, "Psychological stress" (odds ratio: 1.69, 95% CI=1.17-2.44, $p = .005$), for participants with 4-10 years of experience (model χ^2 test $p = .011$, Hosmer-Lemeshow test $p = .201$, Nagelkerke $R^2 = .108$, correct classification rate 71.6%). No significant associations were found for rest of the principal components.

A significant association with incident frequency was found for the first principal component, "Unsafe execution of work" (odds ratio: 2.18, 95% CI=1.37-3.47, $p = .001$), for participants with 11 or more years of experience (model χ^2 test $p = .003$, Hosmer-Lemeshow test $p = .920$, Nagelkerke $R^2 = .161$, correct classification rate 82.7%). No significant associations were found for rest of the principal components.

V. Discussion

1. Human factors affecting nursing incident frequency by years of nursing experience

An analysis by the years of nursing experience indicated that human factors that affect the frequency of incidents vary depending on the years of nursing experience. This is a novel finding. What follows is a discussion of factors affecting the frequency of incidents by years of nursing experience.

1) Over all participants

Unsafe execution of work, psychological stress, and a busy work environment were found to affect the frequency of incidents. The results for the overall participants in the present study were largely consistent with previous research.^{7-14,20-25}

2) Nurses with up to 1 year of experience

For nurses with up to 1 year of experience, the mean principal component scores were high for three of the four principal components: unsafe execution of work, psychological stress, and a busy work environment. In other words, it can be surmised that nurses with up to 1 year of experience often execute work in an unsafe manner, perceive high psychological stress, and feel extremely busy. However, among these components, only a busy work environment impacted incident frequency. The heavier a participant felt their workload to be, the more incidents they caused. A busy work environment was not associated with incident frequency for other levels of experience. This may be a result of low nursing competency. Yomura et al.³⁵ found that a feeling of incompetence impacted the sense of busyness in industrial organizations, and that this relationship was mediated by the sense of highly concentrated work. A feeling of incompetence refers to a feeling that one lacks the ability necessary to execute one's job. In other words, workers who felt that they lacked knowledge or skills were more likely to feel that their workload was heavy, leading to an increased sense of busyness. As a result, they may become overwhelmed, leading to a reduced ability to make accurate judgments and making them more likely to cause incidents. Further, Yomura et al.³⁵ found that receiving little support also impacted the sense of busyness and that this relationship was mediated by the sense of highly concentrated work. Receiving little support refers to not receiving support from coworkers. Thus, the perceived sense of busyness may increase when one feels that they must cope on their own. Previous research has shown that nurses in their first year attempt to accomplish tasks in any way possible, even when doing so is difficult, and are hesitant to seek help from others.³⁶ Receiving little support may exacerbate feelings of being overwhelmed, thereby increasing the likelihood of an incident.

Busy situations also result in delayed care and time pressure as many tasks pile up simultaneously.²⁴ Such time pressure has been found to reduce nurses' performance³⁷ and may result in higher chances of causing an incident.

The above findings suggest that measures for improving systems of team support, in order to reduce busyness for nurses with up to 1 year of experience, are necessary. Easier access to support from coworkers for first-year nurses may help to prevent incidents.

3) Nurses with 2-3 years of experience

No human factors impacting incident frequency were identified for nurses with 2-3 years of experience.

A busy work environment affected incident fre-

quency in nurses with up to 1 year of experience, but this was not the case for those with 2-3 years of experience. Previous research found that competency in first-year nurses increased over their first 12 months in the field.³² Increased practical ability may be accompanied by reduced feelings of incompetence, thereby diminishing the perceived sense of busyness and making incidents less likely to occur. Nurses in their second and third years are able to determine their priorities and respond flexibly, even when busy, and have developed the foresight to carry out their work. Thus, they are thought to be less likely to feel overwhelmed and therefore less likely to cause an incident. Preceding studies have reported that second-year nurses experience stress from anxiety about working independently.³⁸ The questions used in this study might not have been able to illuminate the psychological stress that second- and third-year nurses experience. Going forward, we need to review the questions pertaining to psychological stress in the questionnaire.

4) Nurses with 4-10 years of experience

Psychological stress levels affected incident frequency in nurses with 4-10 years of experience. At this level of experience, nurses begin to take charge of patients in a serious condition. These nurses are thought to be more likely to cause an incident due to a lack of communication; for example, being unable to ask other staff members about things they do not understand even when they are feeling anxious or nervous. A nurse with 4-10 years of experience is required to demonstrate leadership and make work-related arrangements between nurses as well as nurses and other professionals such as physicians. As a mid-career nurse takes on a greater leadership role, they increase their sense of responsibility and become susceptible to stress from relationships.³⁹ Feeling high levels of psychological stress at being unable to adjust to this new role may be a factor that impacts incident frequency. Arimura et al.¹³ found that when mental health is poor, attention and memory abilities are also reduced, making errors more likely. Thus, these results suggest that measures for improving psychological support for nurses with high psychological stress are necessary for those with 4-10 years of experience.

5) Nurses with 11 or more years of experience

Nurses with 11 or more years of experience had the lowest mean principal component score for the unsafe execution of work when compared by years of experience. In other words, these nurses performed fewer unsafe practices. However, because the unsafe execution of work affected their incident frequency, it was surmised that some of these nurses were not adequately observing patients, checking their work, or collaborating with others. The unsafe execution of work is likely not a result of insufficient skills, but instead arises due to habituation. Haga⁴⁰ reported that experts tend to act automatically and unconsciously. Thus, they are more likely to make mistakes when they are required to follow a differ-

ent approach. In order to improve operational efficiency, it is important for a nurse to familiarize themselves with their role. In addition, it has been reported that a nurse with many years of experience tends to underestimate their work and stops to thoroughly perform checks.⁴¹ Hollnagel⁴² defines habituation as “response decrement as a result of repeated stimulation.” A nurse who is very familiar with their role is likely to unconsciously develop a habit that has negative implications, such as making decisions based on speculations and skipping necessary procedures.⁴³ While experienced nurses are knowledgeable and skillful, they can be overconfident and complacent. This may be a factor that affects the frequency of incidents. Therefore, this study’s findings suggest that measures for improving support systems that address role familiarity are necessary for nurses with 11 or more years of experience. Previous studies found that better teamwork inhibits trivial incidents⁴⁴ and leads to fewer omissions of scheduled care.^{45,46} Improving teamwork (for example, through team members keeping an eye on each other and offering advice) is essential to increasing safety.

2. Suggestions for patient safety measures and future prospects

Accumulating experience as a nurse was shown to change the issue to be prioritized regarding safety. Understanding the human factors affecting the frequency of incidents by years of experience and preparing team support systems is expected to lead to new organizational measures. In the future, the authors propose that organizations incorporate safety education for nurses based on their years of experience.

As the distribution of incident frequency in the present study was uneven, it was difficult to analyze it as an objective variable. Some research, from countries outside of Japan, used care oversights by nurses as an indicator of nursing safety.^{45,46} In the future, it will be necessary to consider what variables are appropriate for studies on nursing safety. While a cumulative contribution ratio of at least 80% is considered favorable in principal component analysis,⁴⁷ the ratio in the present study was low (49.12%). As the present study used a questionnaire comprised of a variety of perspectives (psychological, physical, work performance, etc.) to evaluate work situations commonly associated with nursing-related incidents, the cumulative contribution ratio in the principal component analysis was low and the analysis did not yield sufficient explanatory power. Hence, it will be necessary to re-evaluate the questionnaire for use in future studies.

VI. Conclusions

In conclusion, the findings of the study demonstrated that the human factors affecting the frequency of incidents by years of experience were: a busy work environment for nurses with up to 1 year of experience, psychological stress for nurses with 4-10 years of experience, and the unsafe execution of work for nurses

with 11 or more years of experience. These results suggest that measures based on years of nursing experience are necessary. Specifically, improving support systems to reduce busyness, improve psychological support, and improving support systems addressing role familiarity for nurses with up to 1 year, 4-10 years, and with 11 or more years of experience, respectively.

Accumulating experience as a nurse was shown to change the issue regarding safety. It is essential to consider organizational measures that take nurses' different levels of experience into consideration.

VII. Limitations of the present study and issues that need to be addressed going forward

The present study adopted a cross-sectional design; thus, it could not examine changes at the individual level. Additionally, as the study examined three acute-care hospitals in regional cities in Japan, its results cannot be widely generalized. Going forward, more research with a greater number of participating facilities and individuals is required.

VIII. Acknowledgments

We would like to extend our sincere gratitude to the nursing directors and nurses who participated in the present study. We are also deeply grateful to Dr. Haruyasu Fujita of Akagi Hospital for his advice regarding data analysis methods. This study is part of a research project funded by the Gunma University Academic Research Grant for Women.

IX. Conflict of interests

The authors declare they have no conflict of interests.

References

- Kohn LT, Corrigan JM, Donaldson MS. *To Err is Human: Building a Safer Health System*. Washington, DC: National Academy press, 2000.
- Koeki zaidan hojin nippon iryo kino hyoka kiko, Iryo jiko boshi jigyoubu (Japan Council for Quality Health Care, Division of Adverse Event Prevention). *Iryo jiko joho shushu to jigyo 2018 nen nempo (Project to Collect Medical Near-miss/ Adverse Event Information 2018 Annual Report) (March 2020)* http://www.med-safe.jp/pdf/year_report_english_2018.pdf
- Yatsushiro R, Matsunari Y, Kakehashi M. The factors related to the "occurrence of the medication error" in nursing practice, trends of the research and issues. *Nippon Shokugyo Saigai Igakkaishi (Jpn J Occup Med Traum)* 2004; 52: 299-307 (Abstract in English).
- Reason J. Human error: Models and management. *BMJ* 2000; 320: 768-770.
- World Health Organization. *Patient Safety Curriculum Guide, Multi-professional Edition 2011 (July 2020)* https://apps.who.int/iris/bitstream/handle/10665/44641/9789241501958_eng.pdf;jsessionid=B6ABDC20491FAA1688AC65B-9041CE09E?sequence=1
- Wu AW. Medical error: The second victim. *BMJ* 2000; 320: 726-727.
- Amano H, Sakai T, Sakai J. Analysis of the relationship between incidents caused by human factors and attributes of individuals to prevent medical accidents. *Personality Kenkyu (Jpn J Pers)* 2007; 16: 92-99 (Abstract in English).
- Nakamura M, Kondo H, Iwanaga K, et al. Study on factors related to repeated incidents and accidents caused by nursing professionals. *Kitakanto Med J* 2016; 66: 279-288 (Abstract in English).
- Ito T, Kaneko S. Tendency to depression in pediatric wards nursing staff and its relation to medical safety and turn-over intention. *Nippon Sekijuu kyushu Kokusai Kango Daigaku kiyu (Bull Jpn Red Cross Kyushu Int College Nurs)* 2012; 11: 1-9 (Abstract in English).
- Yoshida Y, Otsubo T, Tanaka K, et al. The factors related to accident proneness among hospital nurses. *Seishin Igaku (Clinic Psych)* 2004; 46: 723-730 (in Japanese).
- Sakai T, Sakai J, Amano H. Research on the relationship between the occurrences tendencies of mistakes in medical care, and personality traits due to nurses' age and years of experience. *Iryo Kikigaku (Jpn J Med Instr)* 2010; 80: 607-613 (Abstract in English).
- Suzuki K, Ohida T, Kaneita Y, et al. Mental health status, shift work, and occupational accidents among hospital nurses in Japan. *Ind Health* 2004; 46: 448-454.
- Arimura M, Imai M, Okawa M, et al. Sleep, mental health status, and medical errors among hospital nurses in Japan. *Ind Health* 2010; 48: 811-817.
- Kaneko S, Koinuma N, Ito M. Relationship between risk factors related medical errors and working conditions of nurses in acute care settings. *Nippon Kango Kanri Gakkaishi (Jpn Acad Nurs Adm Pol)* 2008; 12: 5-15 (Abstract in English).
- Johnson AL, Jung L, Brown KC, et al. Sleep deprivation and error in nurses who work the night shift. *J Nurs Adm* 2014; 44: 17-22.
- Suzuki K, Ohida T, Kaneita Y, et al. Daytime sleepiness, sleep habits and occupational accidents among hospital nurses. *J Adv Nurs* 2005; 52: 445-453.
- Gold DR, Rogacz S, Bock N, et al. Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. *Am J Public Health* 1992; 82: 1011-1014.
- Saito K, Muramatsu Y, Yoshimine F, et al. Influence of sleep disorder and burn-out upon near-accidents of medical errors in nurses. *Shinshin Igaku (Jpn J Psych Med)* 2012; 52: 955-962 (Abstract in English).
- Arakawa C, Kanoya Y, Sato C. Factors contributing to medical errors and incidents among hospital nurses: Nurses' health, quality of life, and workplace predict medical errors and incidents. *Ind Health* 2011; 49: 381-388.
- Arakawa C, Kanoya Y, Sato C. Factors affecting accidents and/or incidents in female nurses working shift system. *Nippon Kango Kanri Gakkaishi (J Jpn Acad Nurs Adm Pol)* 2010; 14: 42-50 (Abstract in English).
- Kasahara Y, Shimazaki K, Ishida T. Behavioral characteristics of nurses administering oral medications. *Nippon Iryo Management Gakkaishi (J Jpn Soc Health Care Manag)* 2011; 12: 140-147 (Abstract in English).
- Kaneko S, Koinuma N, Ito M, et al. Relationship among nursing services, healthcare manpower, and occurrence of near misses/errors in acute-care units. *Nippon Iryo Byoin Kanri Gakkaishi (J Jpn Soc Healthcare Adm)* 2011; 48: 7-15 (Abstract in English).
- Kaneko S, Koinuma N, Ito M. Relationship between patient safety and nursing service in acute care settings. *Iryo No Shitsu Anzen Gakkaish (Jpn J Qual Saf Healthcare)* 2010; 5: 221-225 (in Japanese).
- Seki Y, Yamazaki Y. Effects of working conditions on intra-

- venous medication errors in a Japanese hospital. *J Nurs Manag* 2006; 14: 128-139.
25. Tanaka K, Otsubo T, Tanaka M, et al. Similarity in predictors between near miss and adverse events among Japanese nurses working at teaching hospitals. *Ind Health* 2010; 48: 775-782.
 26. Tang FI, Sheh SJ, Yu S, et al. Nurses relate the contributing factors involved in medication errors. *J Clin Nurs* 2007; 16: 447-457.
 27. Tanaka M, Tanaka K, Takano T, et al. Analysis of risk of medical errors using structural-equation modelling: A 6-month prospective cohort study. *BMJ Quality Safety* 2012; 21: 784-790.
 28. Yamauchi K, Yamauchi T. The psychological mechanism of awareness of making errors, near-accidents of motormen and nurses. *Kitakyushu Daigaku Bungakubu Kiyo (J Fac Humanities, Univ Kitakyushu)* 1997; 4: 73-84 (Abstract in English).
 29. Kokuristu daigaku byoincho kaigi (National University Hospital Council of Japan). Incident no eikyodo bunrui (Classification of incident impact). (July 2019) (in Japanese) http://www.univhosp.net/guide_cat_04_4-2.pdf
 30. Koeki zaidan hojin nippon iryo kino hyoka kiko (Japan Council for Quality Health Care). Iryo jiko joho shushu to jigyo, Jirei kensaku (Project to Collect Medical Near-miss/Adverse Event Information, case search) (in Japanese) (December 2018) <http://www.med-safe.jp/mpsearch/SearchReport.action>
 31. Benner P. The Dreyfus model of skill acquisition applied to nursing. From novice to expert: Excellence and power in clinical nursing practice. New Jersey: Prentice Hall, Inc, 2001: 13-38.
 32. Yamaguchi D, Asakawa K, Yanagisawa S, et al. Relationship between clinical nursing competence of newly graduated nurses and support from other staff: The investigation which are the 6th month and the 1st year after getting a job in a university hospital. *Nippon Knago Kenkyu Gakkaishi (J Jpn Soc Nurs Res)* 2017; 40: 131-140 (Abstract in English).
 33. Kikuchi A, Harada T. A study on the measurement of professional autonomy in nursing. *Shizuoka Daigaku Kyoiku Gakubu Kenkyu Hokoku, Jimbun/Shakaikagaku Hen (Bull Fac Edu, Shizuoka Univ, Lib Arts Soc Sci Ser)* 1997; 47: 241-254 (Abstract in English).
 34. Hayashi K, Tomita M, Tanaka Y. Rotation of axes for principal component analysis. *Keisanki Tokei Gaku (Bull Comput Stati Jpn)* 2006; 19: 89-101 (Abstract in English).
 35. Yomura T, Shi G, Sakuda H, et al. A study of the influential factors on the sense of busyness in the industrial organization: Towards the construction of a cognitive structure model of busyness. *Rodo Kagaku (J Sci Lab)* 2013; 89: 166-173 (Abstract in English).
 36. Mori M, Kameoka T, Sadahiro W, et al. A qualitative study on new graduate nurses' behavior. *Kango Kyoikugaku Kenkyu (J Res Nurs Ed)* 2004; 13: 51-64 (Abstract in English).
 37. Thompson C, Dalglish L, Bucknall T, et al. The effects of time pressure and experience on nurses' risk assessment decisions: A signal detection analysis. *Nurs Res* 2008; 57: 302-311.
 38. Takiguchi Y, Oe M, Sengo H, et al. An investigation into the support needs and desires of second year nurses: The role of assistant nursing managers in providing educational support. *Tokushima Sekijyuji Byoin Igakuzasshi (Tokushima Red Cross Hosp Med J)* 2013; 18: 88-92 (Abstract in English).
 39. Kajitani (Shiba) M, Uchida H, Tsumoto Y. Self-management ability and its influence factors in knowledgeable nurses. *Nippon Kango Kenkyu Gakkaishi (J Jpn Soc Nurs Res)* 2012; 35: 67-74 (Abstract in English).
 40. Haga S. Ukkari misu wa naze okiru, human error no ningen kagaku (Why do slips occur? The Science of human error). Tokyo: Chuo rodo saigai boshi kyokai, 2014: 52-97 (in Japanese).
 41. Ishida R. The inspection of the effect of the self monitoring that assumed an everyday life action a reinforcement factor: focus to the confirmation act of the injection duties of the nurses. *Kokusai Iyo Fukushi Daigaku Kiyo (Bull Int Univ Health Welf)* 2010; 14: 49-57 (in Japanese).
 42. Hollnagel E. Safety-I and Safety-II: The past and future of safety management. Boca Raton, FL: CRC Press, 2014: 38.
 43. Hirayae M, Isobe A, Hakariya S. Understanding of tendencies of accident-prone human errors caused by ward nursing staffs. *Kyosai Iho (The Kyosai Medical Journal)* 2016; 65: 73-76 (in Japanese).
 44. Misawa R, Sasou K, Yamaguchi H. Development of the teamwork measure for nursing teams. *Shakai Shinrigaku Kenkyu (Jpn J Soc Psych)* 2009; 24: 219-232 (Abstract in English).
 45. Kalisch BJ, Lee KH. The impact of teamwork on missed nursing care. *Nurs Outlook* 2010; 58: 233-241.
 46. Chapaman R, Rahman A, Courtney M, et al. Impact of teamwork on missed care in four Australian hospitals. *J Clin Nurs* 2016; 26: 170-181.
 47. Tsushima E. SPSS de manabu iryokei taehenryo data kaiseki (Learning multivariate data analysis in health studies with SPSS). Tokyo: Tokyo Tosho Co Ltd, 2014: 137-166 (in Japanese).