

ORIGINAL ARTICLE

Association between nursing care delivery models and patients' health outcomes in a university hospital: A retrospective cohort study based on the Diagnostic Procedure Combination database

Miki Higaonna¹ | Takeshi Morimoto² | Shinichiro Ueda³

¹Gerontological Nursing, School of Health Sciences, Faculty of Medicine, University of the Ryukyus, Okinawa, Japan

²Department of Clinical Epidemiology, Center for Clinical Research and Education, Hyogo College of Medicine, Nishinomiya, Japan

³Department of Clinical Pharmacology & Therapeutics, Graduate School of Medicine, University of the Ryukyus, Okinawa, Japan

Correspondence

Miki Higaonna, Gerontological Nursing, School of Health Sciences, Faculty of Medicine, University of the Ryukyus, 207 Uehara, Nishihara, Okinawa, 903-0215, Japan.
Email: miki51@med.u-ryukyu.ac.jp

Funding information

JSPS KAKENHI, Grant/Award Number: 18K17461; University of the Ryukyus Research Project Promotion Grant for Women Researchers, Grant/Award Number: 17SP05107

Abstract

Aim: This study aims to examine the association between nursing delivery models (fixed-team nursing model and Partnership Nursing System[®] [PNS[®]]) and patients' health outcomes (30-day in-hospital mortality and functional decline, indicated by a decline in Barthel Index or in-hospital mortality).

Methods: This study used a retrospective cohort design based on the data from the Diagnostic Procedure Combination database, which included routinely collected health data for Japanese administrative claims. Participants were inpatients aged 20–99 years admitted between July 2010 and August 2012 (fixed-team nursing period) and July 2014 and August 2017 (PNS[®] period) to an academic teaching hospital in Japan. Odds ratios and 95% confidence intervals were estimated using multivariable logistic models.

Results: We included 24,108 and 23,872 patients for the analyses of 30-day in-hospital mortality and functional decline, respectively (median age: 62 years; 52% women). The 30-day mortalities in both fixed-team nursing and PNS[®] groups were 0.5%. There was no significant association between the nursing delivery models and 30-day in-hospital mortality (adjusted odds ratio = 1.15, 95% confidence interval = 0.78–1.70). However, the PNS[®] group was found to have a higher proportion of patients with functional decline (2.7%) than the fixed-team nursing group (2.2%; $p = .030$). The adjusted odds ratio of declined function in the PNS[®] group, compared to the fixed-team nursing group, was 1.40 (95% confidence interval = 1.17–1.68, $p < .001$).

Conclusions: Further studies are needed to examine how the PNS[®] model influences patient outcomes, especially nurse-sensitive patient outcomes.

KEYWORDS

activities of daily living, hospitals, mortality, nursing, outcome assessment (health care)

1 | INTRODUCTION

Nursing care delivery models are used to organize and provide nursing care to patients in hospitals. The most

common delivery models are functional nursing, team nursing, total patient care, and primary nursing; hospital nurse leaders choose a model or a combination of models to deliver high-quality and safe patient care (Jennings,

2008). Additionally, the fixed-team nursing model and the Partnership Nursing System[®] (PNS[®]) have been gaining popularity in Japanese hospitals, and the proportion of national university hospitals implementing PNS[®] and fixed-team nursing in 2017 was 52 and 24%, respectively (Higaonna & Morimoto, 2019).

The fixed-team nursing model combines team nursing and primary nursing. In this model, ward nurses are divided into several teams consisting of a leader and staff nurses, and the team members are fixed for a certain period (usually a year). Each patient has a primary nurse who develops an individualized care plan, and the patient's daily care is handled by a primary nurse or a team member to maintain continuity of care (Nishimoto & Sugino, 2001).

In PNS[®], fixed pairs of nurses provide daily nursing care and conduct hospital-wide or ward-level committee activities for a year (Tachibana & Kamiyama, 2016). PNS[®] was devised by nurses from Fukui University Hospital to overcome quality and safety concerns raised regarding nursing care in acute care hospitals when the nurse-to-patient ratio in Japan improved from 1:10 to 1:7 (Central Social Insurance Medical Council, 2007). The concerns were raised because of a sudden increase in the number of new graduate nurses hired over a short period to fulfill hospital requirements, despite extensive evidence suggesting that an improvement in the nurse-to-patient ratio decreases patient mortality (Griffiths et al., 2018).

Previous research has not adequately explored the relationship between nursing delivery models and patient or nurse outcomes (Butler et al., 2019; King, Long, & Lisy, 2015). Regarding nurse-related outcomes, Cochrane systematic reviews were unable to confirm an association between the primary nursing model and nurses' turnover and costs (Butler et al., 2019) or one between nursing models (team nursing vs. total patient care) and nurses' wellbeing (King et al., 2015) due to only a small number of well-designed studies. Similarly, there are limited studies on PNS[®], and the few studies that have examined it have focused on nurse-related outcomes: an improvement in communication and collaboration among nurses (Maruoka et al., 2015); a decrease in the perceived burden of high job quality and workload, a reduction in anxiety, and an increase in support from colleagues and job satisfaction (Kamijo, Naganuma, Jinguji, Isobe, & Amemiya, 2015); and a decline in the turnover rate of new graduate nurses (Shimoji, Oshiro, Toguchi, & Kajiki, 2015).

Further, regarding patient outcomes, a survey of medical-surgical nurses in Canada found that nurses following a team-based nursing model reported more missed care and more frequent occurrence of adverse events than those following a total patient care model (Havaei, MacPhee, & Dahinten, 2019). Moreover, in a survey of 88 Japanese hospitals, more than 70% of staff nurses

reported that the implementation of PNS[®] resulted in an improvement in patients' physical assessment, a decline in missed assessment/observation, and a decrease in near-miss or medical incidents (Maruoka et al., 2015). However, contrary to what might be expected from the results of the survey by Maruoka and colleagues, Japanese hospitals that employed the paired nursing delivery model, including PNS[®], showed a non-significant declining linear trend in in-hospital mortality, while non-partnership-nursing hospitals exhibited a significant decline in hospital mortality (Higaonna & Morimoto, 2019). The unit of analysis in this study was the hospital, and differences in patients' characteristics were not used for adjustment. These findings suggest a need to examine the association between nursing delivery models and patient outcomes, because more missed care reported by nurses was shown to have a significant association with 30-day mortality among surgical patients (Ball et al., 2018).

Nurses are key professionals who promote patients' ambulation and support patients in performing activities of daily living (ADLs) during hospitalization, in collaboration with other medical staff (Japanese Nursing Association, 2018; The Hartford Institute for Geriatric Nursing, 2019). While patient factors such as confusion and disorientation, urinary catheter use, and higher independence in ADLs at admission have been shown to increase patient risk of reduced independence in ADLs during hospitalization, more care provided by nursing assistants than registered nurses (RNs) doubles the risk of reduced independence in ADLs (Palese et al., 2016). A decline in patients' ADLs during hospitalization is significantly associated with patients' mobility levels during hospitalization (Zisberg et al., 2011); however, 76–91% of nurses reported that the frequency of missed patient ambulation was always, frequently, or occasionally missed (Kalisch, Tschannen, Lee, & Frieze, 2011; Palese et al., 2015).

1.1 | Study aims

Nursing delivery models have a significant impact on nursing practice in hospitals; however, whether or how these models influence patient outcomes has not been studied well. The developers of PNS[®] claim that it improves nurses' effective ratio by increasing nursing capacity such that the relative effect of one nurse could be more than one (Tachibana & Kamiyama, 2016). This possible change in effective ratio could affect the amount of missed care, which has been shown to be an explanatory factor linking nurse staffing level and inpatient mortality (Ball et al., 2018; Griffiths et al., 2018). Therefore, this study aimed to examine the association between nursing delivery models (fixed-team nursing and PNS[®])

and 30-day in-hospital mortality and functional decline among adult inpatients.

2 | METHODS

2.1 | Theoretical framework

The study was guided by the Quality Health Outcomes Model that includes the following four segments: system characteristics, interventions, client characteristics, and outcomes (Mitchell, Ferketich, & Jennings, 1998; Figure 1). The model describes the direct reciprocal relationships between the outcomes and the system or clients' characteristics and states that interventions always influence the outcomes through the system and the clients.

2.2 | Study design and setting

The study used a retrospective cohort design and was conducted at a 600-bed Japanese academic teaching hospital, which included 17 clinical specialties (internal medicine, surgery, neurosurgeries, orthopedics, plastic and reconstructive surgery, oral and maxillofacial surgery, obstetrics/gynecology, dermatology, urology, otorhinolaryngology, ophthalmology, radiology, anesthesiology, neuropsychiatry, pediatrics, emergency and critical care, and intensive care). Bed utilization ranged from 84.3–87.7% (Table 1).

2.3 | Nursing skill mix and staffing ratio

Nursing skill mix and staffing ratio are shown in Table 1. There were four types of licensed nurses employed at the

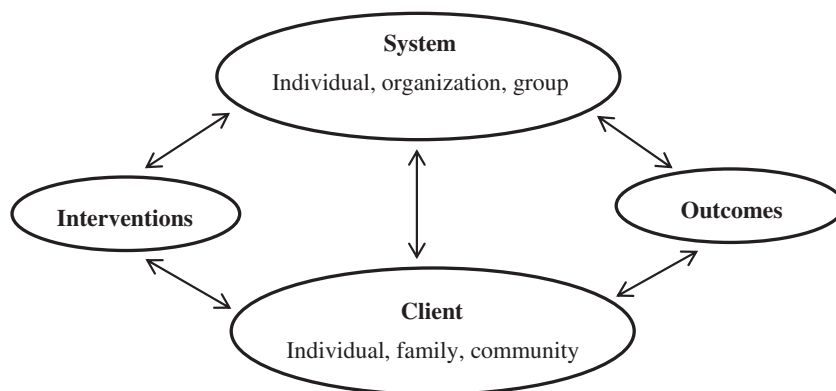


FIGURE 1 Quality Health Outcomes Model reprinted with the permission of the copyright owner

TABLE 1 Hospital's inpatient bed utilization, nurse staffing ratio, and skill mix

Variables	Fixed-team nursing			PNS			
	2010	2011	2012	2014	2015	2016	2017
Inpatient bed utilization, %	85.9	84.5	85.7	84.3	85.6	87.7	86.1
RN-to-patient ratio							
General wards	1:7	1:7	1:7	1:7	1:7	1:7	1:7
Intensive care unit	1:2	1:2	1:2	1:2	1:2	1:2	1:2
Emergency ward	^a	^a	^a	^a	1:5	1:5	1:5
Nurse assistant-to-patient ratio	1:50	1:50	1:50	1:25	1:25	1:25	1:25
RNs ^b , n	477	513	572	597	601	608	621
CNs, n	5	6	8	8	13	17	19
CNs (intensive care), n	0	1	1	1	1	1	2
CNSs, n	0	0	0	0	1	1	2
New graduate RNs, n (%)	35 (7.3)	55 (10.7)	78 (13.6)	67 (11.2)	49 (8.2)	51 (8.4)	52 (8.4)
Permanent employment RNs, n (%)	296 (62.1)	336 (65.5)	336 (58.7)	341 (57.1)	383 (63.7)	399 (65.6)	422 (68.0)

Abbreviations: CNs: certified nurses; CNSs, certified nurse specialists; PNS, Partnership Nursing System; RNs, registered nurses.

^aInpatient beds for the specialty of emergency medicine were located in the general wards prior to April 2015.

^bThe number includes all RNs employed at the hospitals (RNs in management positions, CNs, CNSs) as of April 1 of each year.

hospital: RNs, RNs with midwifery license, certified nurses (CNs), and certified nurse specialists (CNSs). RNs can provide medical treatment prescribed by a physician and support patients in performing ADLs. CNs are RNs with additional education and training in certain fields, while CNSs are RNs with a master's degree in specific programs; the specialty of the CNSs employed after 2015 was cancer nursing. CNs and CNSs provide advanced nursing care to patients usually referred by healthcare professionals, offer consultations, and educate nurses. More CNs and CNSs were employed in the PNS[®] period than in the fixed-team nursing period. The average proportion of new graduate nurses was higher in the fixed-team nursing period (10.5%) than in the PNS[®] period (9.5%). Approximately two-thirds of the RNs were employed with permanent status in both periods.

Nursing assistants are not allowed to provide medical treatment but can provide ADLs care to patients when delegated by RNs as the care does not require nursing judgment (Japanese Nursing Association, 2019). Unlike the USA, the UK, and Australia, nursing assistants in Japan are not allowed to take patients' vital signs.

Throughout the study periods, the hospital's nurse-to-patient ratio was 1:7 in inpatient general wards and 1:2 in the intensive care unit (ICU). The nurse-to-patient ratio in the emergency ward (six beds) established in April 2015 was 1:5, and inpatient beds for emergency medicine specialty were allocated in general wards prior to the establishment of the emergency ward. The nurse-to-patient ratio differed according to shift (day/night) and was reported as an average over a 24-hr period. Typically, the number of patients assigned to a nurse per shift is adjusted according to patients' severity. In general wards, more nurses are scheduled for day shifts on weekdays than for day shifts on weekends/holidays and night shifts. All nurses at the hospital were RNs. Nursing assistants were not included in the ratio. When scheduled nurses are absent, off-duty nurses—not float nurses or agency nurses—report to duty if the ratio cannot be maintained. Nursing assistants-to-patient ratio was 1:50 during the fixed-team nursing period and 1:25 during the PNS[®] period (Table 1).

2.4 | Participants

We included patients aged 20 to 99 years who were initially (a) admitted between July 2010 and August 2012 and discharged between July 2010 and September 2012, and (b) admitted between July 2014 and August 2017 and discharged between July 2014 and September 2017 (Figure 2). We included patients in general wards, ICU, and emergency ward. PNS[®] was introduced in two wards of the study hospital in October 2012 and in all wards, including the ICU, in January 2014; therefore, we eliminated the period between September 2012 and June 2014, to avoid mixed results from the two nursing systems. As a result, July 2010 to August 2012 was the term of fixed-team nursing and July 2014 to August 2017 was the term of PNS[®]. We only included the first admission during the study periods because patients' characteristics between first admission and readmission would differ. Exclusion criteria comprised the following: patients admitted with psychiatric disorders (International Classification of Diseases codes: F00–F99), length of hospital stay less than 2 days, and participation in a clinical trial. We excluded patients with psychiatric disorders as a primary diagnosis because studies on nurse staffing and patient mortality in acute hospitals have included medical and/or surgical patients. Further, patients with a length of hospital stay of less than 2 days were excluded as the occurrence of the outcomes would likely be related to factors prior to admission, not nursing care. Finally, patients in clinical trials were excluded because they received non-standard treatment. For the analyses of functional decline, we further excluded patients with missing information about ADLs (either at admission or discharge). We included 24,108 patients and 23,872 patients for the analyses of 30-day in-hospital mortality and functional decline, respectively.

2.5 | Outcomes segment

The primary outcome was 30-day in-hospital mortality. The secondary outcome was functional decline, a composite outcome of a decline in Barthel Index or the occurrence of in-hospital death, irrespective of length of hospital stay. A

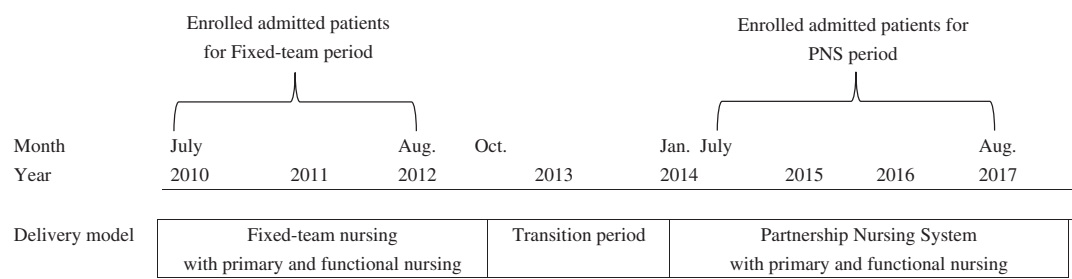


FIGURE 2 Transition of nursing delivery models and patient enrollment for the study

decline in Barthel Index was defined as a decline of five or more points in patients' Barthel Index scores noted between admission and discharge. We calculated the Barthel Index score in accordance with the method proposed by Mahoney and Barthel (1965). One difference between the Barthel Index scoring by Mahoney and Barthel and the DPC (Diagnostic Procedure Combination) is that the DPC does not specify the minimum distance of 50 yards to assess patients' walking ability.

2.6 | System and intervention segments: Nursing delivery models

Nursing delivery models at the hospital are shown in Figure 3. For both the fixed-team nursing and PNS[®] periods, one nurse per patient was assigned to be responsible for the nursing care throughout the patient's hospital stay (primary nursing model), and medical treatment such as intravenous therapy and dressing change was provided by nurses who were assigned that role for the shift (functional nursing model).

Fixed-team nursing and PNS[®] differed in the following ways. First, each nurse had a "partner" who was fixed for a year in PNS[®], but not in the fixed-team nursing. Second, patient assignment for a shift was determined by the assignment of a primary nurse to a particular patient in PNS[®] compared to one based on the location of the patient's room in the ward in fixed-team nursing. Third, the number of nurses assigned per patient per shift was two in PNS[®] vs. one in fixed-team nursing. Two nurses responsible for

the same patients for a shift are called a "pair" in PNS[®]. When the partner nurse is available for a shift, the nurse and the partner preferentially become a pair for the shift. When the partner is not available, two nurses from the same nursing group become the pair for the shift. Typically, the shift begins with a pair of nurses sharing patient information and discussing a plan to provide the required care to the assigned patients. Then, the pair visits a patient's bedside together, and one nurse takes vital signs and conducts the initial assessment of the patient while the other nurse documents the findings in the electronic chart. After the initial assessment, the pair of nurses does not need to provide care together all the time (Tachibana & Kamiyama, 2016). Although this study did not observe what proportion of the shift the nurse pairs actually worked together in the study hospital, a previous study in a university hospital indicated that nurse pairs were physically together for an average of 25.7% of the shift (Okita & Tachibana, 2015).

2.7 | Client segment

We collected data on patients' age, gender, acuity (emergency admission), comorbidities at admission (updated Charlson Comorbidity Index; Quan et al., 2011), and the Barthel Index score at admission. We classified patients' age and the comorbidity index into groups based on 30-day in-hospital mortality because only 12 parameters could be included in the multivariable logistic regression model for the primary outcome per the recommendation of Peduzzi, Concato, Kemper, Holford, and Feinstein (1996). Age at

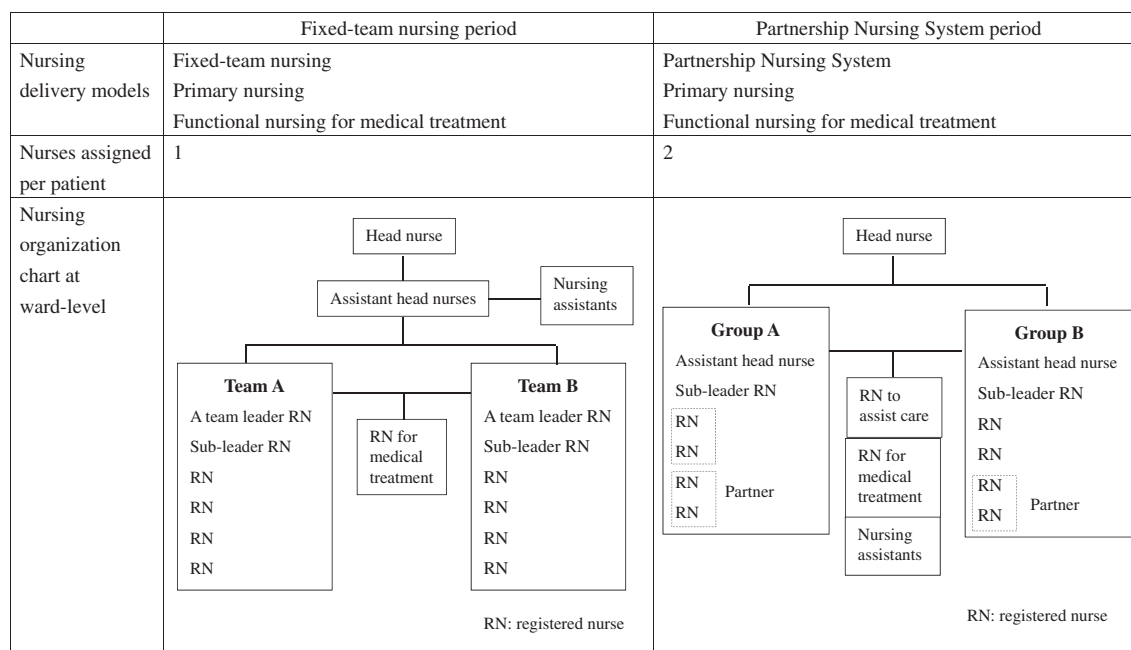


FIGURE 3 Nursing delivery models at the hospital

admission was classified into three groups according to patients' similarities in their 30-day in-hospital mortality calculated in increments of 10 years: 20–49 years, 50–79 years, and 80–99 years (Figure S1). For acuity of patients' conditions, we used emergency admission status determined by a physician's medical examination for patients who urgently needed to be hospitalized for poor general condition because of hematemesis, hemoptysis, or severe dehydration; unconsciousness or coma; severe respiratory failure or heart failure; acute drug intoxication; shock; severe metabolic impairment; extensive burns; severe condition resulted by trauma or tetanus; or a condition requiring emergency surgical procedure.

We calculated the updated Charlson Comorbidity Index score in total (Quan et al., 2011) using information of primary diagnosis at admission and four comorbidities at admission, and we followed the coding algorithms by Quan et al. (2005). We further classified the updated Charlson Comorbidity Index score into four groups (0, 1–2, 3–5, and ≥ 6) based on similarities in 30-day in-hospital mortality in the present study and that reported in a study by Quan et al. (2011); Figure S2). The updated Charlson score showed a good discriminating ability for in-hospital mortality in patients aged 18 years and older in Japanese hospital discharge data (C-statistic: 0.727; Quan et al., 2011).

The Barthel Index score at admission was classified into four groups according to Shah, Vanclay, and Cooper (1989): 91–100 (slight to no disability), 61–90 (moderate disability), 0–60 (total or severe disability), and not documented. Additionally, we included length of hospital stay for multivariable analysis of functional decline. Length of hospital stay was classified into four groups according to the first, second, and third quartiles observed for patients in this study: 2–4 days, 5–8 days, 9–17 days, and ≥ 18 days.

2.8 | Database and data collection

Per researchers' request, the hospital's information systems department extracted the information from DPC data stored in the hospital. The DPC is an administrative claims system for acute hospital admissions administered by the Japanese Ministry of Health, Labour and Welfare (Yasunaga, Matsui, Horiguchi, Fushimi, & Matsuda, 2015). The hospital implemented the DPC system in April 2003, and it has utilized DPC data to claim payment from the national health insurance through the DPC/Per-Diem Payment System. DPC data have been widely used in healthcare research in Japan (Akiyama et al., 2013; Morita, Matsui, Fushimi, & Yasunaga, 2017; Morita, Matsui, Yamana, et al., 2017; Sakata, Okumura, Fushimi, Nakanishi, & Ogawa, 2018). We used patients' identification codes and dates of birth to avoid using data from more than two admissions of the same patient.

2.9 | Statistical analyses

Categorical variables are described as frequencies and percentages and compared using Pearson's Chi-square test. Continuous variables were presented as median and first and third quartiles and compared using Mann–Whitney's *U* test. We estimated C-statistics for 30-day in-hospital mortality when predicted by the updated Charlson score, updated Charlson score with age and gender, and a multi-variable logistic model. We estimated the odds ratios (ORs) and their 95% confidence intervals (CIs) of PNS[®] on 30-day in-hospital mortality or functional decline using univariable and multivariable logistic regression analyses. For 30-day in-hospital mortality, we simultaneously included age, gender, status of admission (emergency), the updated Charlson Comorbidity Index, and the Barthel Index at admission as risk-adjustment variables. We further added surgeries and length of hospital stay, in addition to the abovementioned variables, to assess the effect of PNS[®] on the functional decline model, because we believed that these variables influence patients' ADL status at discharge. Nevertheless, we performed a sensitivity analysis without length of hospital stay because it could be an intermediate variable. SPSS version 19 (IBM Corp, Armonk, NY, USA) and MedCalc Statistical Software version 14.12.0 (MedCalc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2014) were used for statistical analyses. Two-tailed *p* values $< .05$ were considered statistically significant.

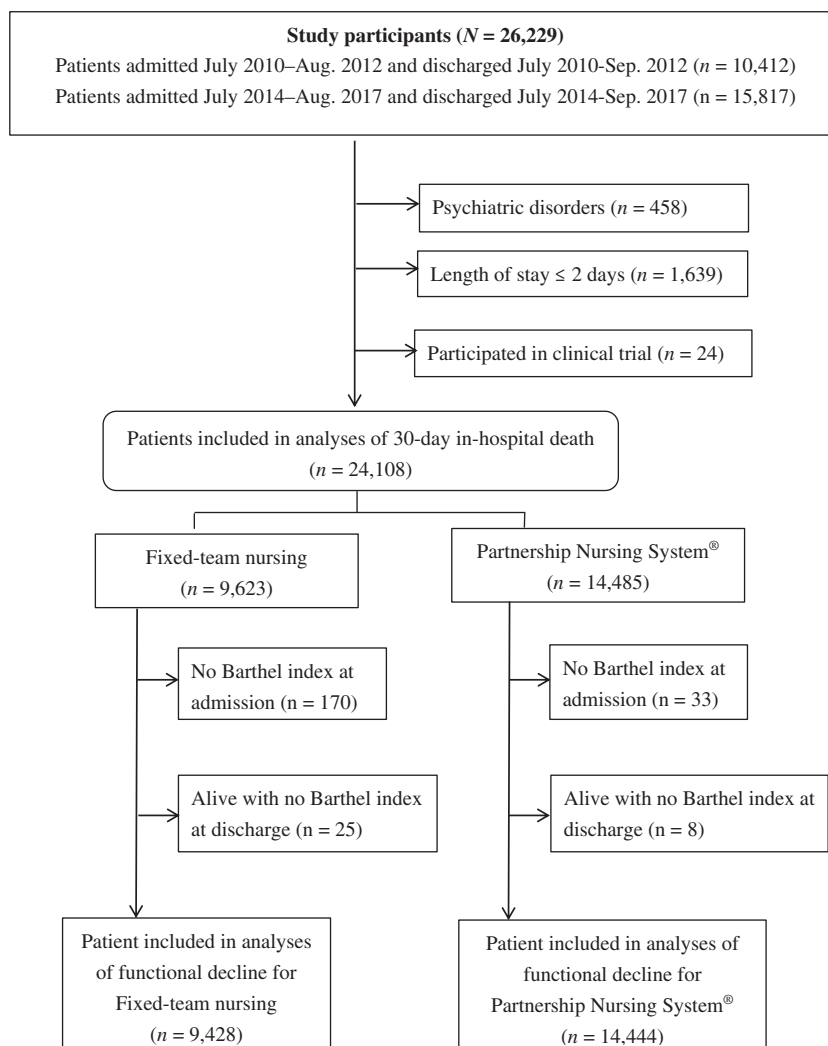
2.10 | Ethical considerations

The study protocol was approved by the Ethics Committee for Medical and Health Research Involving Human Subjects of the first author's university (approval #1159). Study information was posted at the hospital to ensure opt-out opportunity following the Japanese ethical guidelines for medical and health research involving human subjects (Ministry of Health, Labour and Welfare, and Ministry of Education, Culture, Sports, Science and Technology, 2014).

3 | RESULTS

3.1 | Thirty-day in-hospital mortality

Study flow and patients' characteristics are described in Figure 4 and Table 2, respectively. Among the 26,229 patients admitted to the hospital for the first time during the study periods (42.9% of the admissions), 24,108 patients (median age: 62 years; 47.8% men) were included for the analyses of 30-day in-hospital mortality.

FIGURE 4 Flowchart of patient selection

Neoplasms were the most prevalent primary diagnosis for all patients at admission (27.4%), followed by disease of eye and adnexa (22.6%) and disease of the circulatory system (11.9%). Two-thirds of patients were surgical patients. Most patients (84.2%) presented slight to no disability on admission. A total of 280 patients (1.2%) died during hospitalization, including 123 patients (0.5%) who died within 30 days of admission (Table 3).

The number of patients included for the fixed-team nursing group analyses was 9,623, and that for the PNS® group was 14,485. Patients in the fixed-team nursing group were younger than those in the PNS® group (median age: 61 vs. 63 years; $p = .001$) and had a longer hospital stay (median: 9 vs. 7 days; $p < .001$). While the fixed-team nursing group included a slightly larger proportion of patients with emergency admission (6.5%) than the PNS® group (5.4%, $p = .001$), the former (64.1%) included a smaller proportion of surgical patients than the latter (65.9%, $p = .004$). Neoplasms were the most prevalent primary diagnosis for both groups.

The 30-day mortality was 0.5% for both fixed-team nursing and PNS® ($p = .45$; Table 3). C-statistics and 95% CIs for 30-day in-hospital mortality by the updated Charlson score, updated Charlson score with age and gender, and the multi-variable logistic model were 0.75 (95% CI 0.74, 0.75), 0.78 (95% CI 0.77, 0.79), and 0.91 (95% CI 0.90, 0.91), respectively.

Table 4 presents the ORs with 95% CIs of 30-day in-hospital mortality analyzed using univariable and multi-variable logistic analyses. The ORs of patients dying within 30 days of admission did not differ significantly across the two models either in the unadjusted model (OR = 1.15, 95% CI 0.80, 1.66, $p = .450$) or the adjusted model (OR = 1.15, 95% CI 0.78, 1.70, $p = .477$).

3.2 | Functional decline

We excluded 236 patients with an unknown Barthel Index score at admission and/or at live discharge (Figure 4). Compared to patients included in the analysis, excluded patients were significantly older, had a longer

TABLE 2 Characteristics of patients included in the analyses of 30-day in-hospital mortality and functional decline

Variables	30-day in-hospital mortality					Functional decline				
	Fixed-team nursing (N = 9,623)		PNS (N = 14,485)		p value	Fixed-team nursing (N = 9,428)		PNS (N = 14,444)		p value
	n	%	n	%		n	%	n	%	
Age group										
20–49 years	2,758	28.7	4,095	28.3	<.001	2,712	28.8	4,088	28.3	<.001
50–79 years	5,880	61.1	8,623	59.5		5,777	61.3	8,599	59.5	
80–99 years	985	10.2	1,767	12.2		939	10.0	1,757	12.2	
Male	4,631	48.1	6,884	47.5	.362	4,514	47.9	6,865	47.5	.596
Emergency admission	622	6.5	782	5.4	.001	581	6.2	777	5.4	.011
Surgeries	6,173	64.1	9,550	65.9	.004	6,079	64.5	9,528	66.0	.018
Primary diagnosis ^a										
Neoplasms	2,547	26.5	4,068	28.1		2,510	26.6	4,060	28.1	
Eye/adnexa	2064	21.4	3,373	23.3		2048	21.7	3,367	23.3	
Circulatory system	1,184	12.3	1,695	11.7		1,133	12.0	1,681	11.6	
Genitourinary	573	6.0	753	5.2		561	6.0	750	5.2	
Others	3,255	33.8	4,596	31.7		3,176	33.7	4,586	31.8	
Updated Charlson Index ^a										
0	5,689	59.1	8,760	60.5	<.001	5,570	59.1	8,740	60.5	<.001
1–2	3,252	33.8	4,563	31.5		3,197	33.9	4,548	31.5	
3–5	384	4.0	642	4.4		371	3.9	639	4.4	
6+	298	3.1	52	3.6		290	3.1	517	3.6	
Barthel Index ^a										
91–100	8,067	83.8	12,227	84.4	<.001	8,055	85.4	12,224	84.6	<.001
61–90	361	3.8	201	1.4		359	3.8	200	1.4	
0–60	1,025	10.7	2024	14.0		1,014	10.8	2020	14.0	
Unknown	170	1.8	33	0.2		0	0.0	0	0.0	
	Median	(Q1, Q3)	Median	(Q1, Q3)		Median	(Q1, Q3)	Median	(Q1, Q3)	
Age, years	61	(46, 73)	63	(47, 74)	.001	61	(46, 73)	62	(47, 73)	.001
Length of stay, days	9	(5, 21)	7	(3, 15)	<.001	9	(5, 21)	7	(3, 15)	<.001

Abbreviations: PNS, Partnership Nursing System; Q1, first quartile; Q3, third quartile.

^aDiagnosis or scores on admission.

hospital stay, and showed a larger proportion of male patients, emergency admission, and primary diagnosis of disease of the circulatory system (Table S1).

Approximately 85% of patients had slight to no disability on ADLs in both groups; the PNS[®] group had more patients with severe to total disability. Differences in patient characteristics between the fixed-team nursing group and the PNS[®] group are consistent with the data showing patients' characteristics included for the analyses of 30-day in-hospital mortality (Table 2).

At discharge, 594 patients (2.5%) showed functional decline (269 patient deaths; 325 patients with a decline in the Barthel Index score) and 23,278 (97.5%) showed improved or stable functional status. The PNS[®] group demonstrated a higher proportion of patients whose functional status declined compared to the fixed-team nursing group (2.7 vs. 2.2%, $p = .030$; Table 3). Further, the PNS[®] group demonstrated a significantly higher proportion of declined function on all 10 ADLs than the fixed-team nursing group (Table S2).

TABLE 3 Patients' conditions at discharge

Variables	30-day in-hospital mortality					Functional decline				
	Fixed-team nursing (N = 9,623)		PNS (N = 14,485)		p value	Fixed-team nursing (N = 9,428)		PNS (N = 14,444)		p value
	n	%	n	%		n	%	n	%	
30-day in-hospital death	45	0.5	78	0.5	.450	38	0.4	78	0.5	.137
Functional decline ^a	220	2.3	385	2.7	<.001	209	2.2	385	2.7	.030
Status at discharge										
Died	127	1.3	153	1.1	<.001	116	1.2	153	1.1	<.001
Declined BI score ^b	93	1.0	232	1.6		93	1.0	232	1.6	
Improved or stable BI score ^b	9,219	95.8	14,059	97.1		9,219	97.8	14,059	97.3	
BI score ^b not documented	184	1.9	41	0.3						

Abbreviations: BI, Barthel Index; PNS, Partnership Nursing System.

^aFunctional decline was a composite outcome of a decline in BI score or the occurrence of in-hospital death.^bBI score was calculated using information on activities of daily living documented in the Diagnostic Procedure Combination. Comparing BI score from admission to discharge, a decrease in BI score ≥ 5 points is expressed as "decline," maintaining the same score is expressed as "stable," and an increase in BI score ≥ 5 points is considered as "improved."**TABLE 4** Odds ratio and 95% CI of 30-day in-hospital mortality by univariable and multivariable logistic regression analyses

Variables	Total N	30-day in-hospital death		Crude OR		Adjusted OR	
		n	%	OR (95% CI)	p value	OR (95% CI)	p value
Nursing model							
Fixed-team	9,623	45	0.5	1.0		1.0	
PNS	14,485	78	0.5	1.15 (0.80, 1.66)	.450	1.15 (0.78, 1.70)	.477
Age (years)							
20–49	6,853	11	0.2	1.0		1.0	
50–79	14,503	86	0.6	3.71 (1.98, 6.95)	<.001	2.48 (1.30, 4.73)	.006
80–99	2,752	26	0.9	5.93 (2.93, 12.02)	<.001	2.23 (1.07, 4.63)	.032
Gender							
Female	12,593	60	0.5	1.0		1.0	
Male	11,515	63	0.5	1.15 (0.81, 1.64)	.442	0.92 (0.63, 1.33)	.646
Admission status							
Non-emergency	22,704	87	0.4	1.0		1.0	
Emergency	1,404	36	2.6	6.84 (4.62, 10.13)	<.001	3.33 (2.13, 5.19)	<.001
Charlson Index							
0	14,449	27	0.2	1.0		1.0	
1–2	7,815	46	0.6	3.16 (1.96, 5.09)	<.001	2.95 (1.81, 4.80)	<.001
3–5	1,026	13	1.3	6.85 (3.53, 13.33)	<.001	4.48 (2.26, 8.85)	<.001
6+	818	37	4.5	25.31 (15.33, 41.78)	<.001	19.92 (11.68, 33.95)	<.001
Barthel Index at admission							
91–100	20,294	37	0.2	1.0		1.0	
61–90	562	2	0.4	1.96 (0.47, 8.13)	.357	1.23 (0.29, 5.21)	.780
0–60	3,049	77	2.5	14.18 (9.57, 21.03)	<.001	8.05 (5.21, 12.44)	<.001
Not documented	203	7	3.4	19.55 (8.61, 44.40)	<.001	15.21 (6.31, 36.66)	<.001

Abbreviations: CI, confidence interval; OR, odds ratio; PNS, Partnership Nursing System.

TABLE 5 Odds ratio and 95% CI of functional decline by univariable and multivariable logistic regression analyses

Variables	Total	Functional decline		Crude OR		Adjusted OR with LoS		Adjusted OR without LoS	
	N	n	%	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
Nursing model									
Fixed-team	9,428	209	2.2	1.0		1.0		1.0	
PNS	14,444	385	2.7	1.21 (1.02, 1.43)	.030	1.40 (1.17, 1.68)	<.001	1.23 (1.03, 1.48)	.021
Age (years)									
20–49	6,800	69	1.0	1.0		1.0		1.0	
50–79	14,376	386	2.7	2.69 (2.08, 3.48)	<.001	1.94 (1.49, 2.54)	<.001	1.97 (1.51, 2.57)	<.001
80–99	2,696	139	5.2	5.30 (3.96–7.10)	<.001	2.90 (2.13, 3.94)	<.001	2.75 (2.02, 3.73)	<.001
Gender									
Female	12,493	281	2.2	1.0		1.0		1.0	
Male	11,379	313	2.8	1.23 (1.04, 1.45)	.013	1.05 (0.89, 1.25)	.553	1.09 (0.92, 1.30)	.303
Admission status									
Non-emergency	22,514	506	2.2	1.0		1.0		1.0	
Emergency	1,358	88	6.5	3.01 (2.39, 3.81)	<.001	1.37 (1.05, 1.78)	.020	1.61 (1.24, 2.09)	<.001
Surgeries									
No	8,265	267	3.2	1.0		1.0		1.0	
Yes	15,607	327	2.1	0.64 (0.54, 0.76)	<.001	0.92 (0.77, 1.09)	.326	0.95 (0.80, 1.13)	0.571
Charlson Index									
0	14,310	193	1.3	1.0		1.0		1.0	
1–2	7,745	251	3.2	2.45 (2.03, 2.96)	<.001	1.52 (1.24, 1.86)	<.001	2.18 (1.79, 2.65)	<.001
3–5	1,010	53	5.2	4.05 (2.97, 5.53)	<.001	1.60 (1.15, 2.22)	.005	2.79 (2.02, 3.85)	<.001
6+	807	97	12.0	9.99 (7.74, 12.90)	<.001	4.49 (3.40, 5.94)	<.001	7.62 (5.80, 10.02)	<.001
Barthel Index at admission									
91–100	20,279	284	1.4	1.0		1.0		1.0	
61–90	559	61	10.9	8.62 (6.45, 11.53)	<.001	5.86 (4.30, 7.99)	<.001	7.20 (5.30, 9.79)	<.001
0–60	3,034	249	8.2	6.29 (5.29, 7.50)	<.001	3.03 (2.48, 3.71)	<.001	4.47 (3.67, 5.44)	<.001
LoS (days)									
2–4	7,682	41	0.5	1.0		1.0			
5–8	5,481	45	0.8	1.54 (1.01, 2.36)	.045	1.51 (0.99, 2.32)	.058		
9–17	4,857	110	2.3	4.32 (3.01, 6.19)	<.001	3.22 (2.23, 4.65)	<.001		
18+	5,852	398	6.8	13.60 (9.84, 18.79)	<.001	7.46 (5.31, 10.47)	<.001		

Abbreviations: CI, confidence interval; LoS, length of stay; OR, odds ratio; PNS, Partnership Nursing System.

The ORs of functional decline among patients in the PNS[®] group, compared to the fixed-team nursing group, were 1.21 (95% CI 1.02, 1.43, $p = .03$) in the univariable analysis and 1.40 (95% CI 1.17, 1.68, $p < .001$) in the multivariable analysis (Table 5). In the sensitivity analysis excluding length of hospital stay from the multivariable analysis, patients in the PNS[®] group showed significantly higher odds of functional decline compared to those in the fixed-team nursing group (OR = 1.23, 95% CI 1.03, 1.48, $p = .02$). C-statistics of the multivariable logistic model

with and without length of hospital stay were 0.85 (95% CI 0.85, 0.86) and 0.79 (95% CI 0.79, 0.80), respectively.

4 | DISCUSSION

We found no significant association between nursing delivery models (fixed-team nursing and PNS[®]) and 30-day in-hospital mortality; however, the results of the present study revealed a significant increase in the odds

of patients experiencing a functional decline at discharge in the PNS[®] group.

4.1 | Nursing models and 30-day in-hospital mortality

There are no previous studies examining nursing delivery models and patient mortality using data at the patient level. The wide 95% CIs of ORs in the association found in this study warrant a need for further investigation of this topic. The current study results are in line with a hospital-level study that reported no significant decline in patients' in-hospital mortality among Japanese hospitals employing PNS[®] (Higaonna & Morimoto, 2019). However, the present results are inconsistent with what might be expected in terms of 30-day mortality from a survey of nurses in 88 Japanese hospitals, which reported that PNS[®] resulted in an improvement in patients' physical assessment, a decline in missed assessment/observation, and a decrease in near-miss and medical incidents (Maruoka et al., 2015). Further, missed care reported by nurses showed a significant association with 30-day mortality among surgical patients (Ball et al., 2018), while the current study, which included both medical and surgical patients, does not fully support this finding.

One possible explanation is that PNS[®] requires an advanced level of interpersonal and communication skills to be effective (Tachibana & Kamiyama, 2016), and the nurses may not have fully developed such skills. When the developers of PNS[®] inspected the study hospital in 2014, they indicated the need for improving “partnership mind” which includes self-independence, altruism, and multiple viewpoints. Moreover, a Canadian study that compared team nursing and total patient care indicated that nurses' communication and collaboration skills have a greater influence on some models than others (Havaei et al., 2019).

Another explanation is that both overestimation and underestimation factors exist in this study, which offset each other. We included several variables related to nurses' workload (patients' age, acuity, comorbidities, and independence in ADLs); however, we could assume that nurses' workload related to patient turnover was higher in the PNS[®] group than in the fixed-team nursing group based on the former having a shorter length of hospital stay or slightly higher bed occupancies than the latter group (84.5–85.9% in the fixed-team nursing period; 84.3–87.7% in the PNS[®] period). While an association between patient turnover and in-hospital mortality was not significant in a study conducted in the USA (Needleman, Liu, Shang, Larson, & Stone, 2020), a study in the UK demonstrated a significant association

(Griffiths et al., 2019). Further, 30-day in-hospital mortality could be much higher without the implementation of PNS[®] because the nurse-to-patient ratio in general wards of this study (1-to-7; an equivalent of 3.5 RN hours per patient day [HPPD]) is less than that in Griffiths et al. (2019; 4.75 RN HPPD), and thus, more burden for RNs is expected with a high patient turnover.

Additionally, it is likely that the higher proportion of severe patients requiring more intensive medical and nursing care in the PNS[®] group compared to the fixed-team nursing group resulted in more workload in the PNS[®] group, although we attempted to adjust for this difference by including several variables. The proportion of severe patients required for basic medical fee reimbursement for hospitals with 1:7 nurse-to-patient ratio in the PNS[®] period was higher than that in the fixed-team nursing period, although the definition of “severe patients” differed: there was no requirement for the proportion of severe patients in fiscal year (FY) 2010–2011, $\geq 15\%$ in FY 2012–2015, and $\geq 25\%$ in FY 2016–2017 (Ministry of Health, Labour and Welfare, n.d.; Table S3). An increase in nurses' workload is associated with missed care (Tubbs-Cooley, Mara, Carle, Mark, & Pickler, 2019). Thus, the finding of no significant difference in 30-day in-hospital mortality between patients in these two periods could mean that PNS[®] may have a protective effect by directly reducing nurses' perceived workload (Kamijo et al., 2015) or decreasing the number of missed care incidents.

On the other hand, the association could be underestimated because the PNS[®] group had better nurse staffing than the fixed-team nursing group. First, the nurse-to-patient ratio for 99% of inpatients was maintained at 1:7, but the PNS[®] group had a better ratio for inpatients in emergency medicine, which ought to decrease patient mortality (Aiken et al., 2014; Cho et al., 2015; Griffiths, Ball, Murrells, Jones, & Rafferty, 2016; Needleman et al., 2011), while the influence could be minimal, as emergency beds occupied only 1%. Second, there were more CNs specialized in intensive care in the PNS[®] group than in the fixed-team nursing group. The number of CNs and CNSs in the ICU per 10 beds was associated with a 3% reduction in the odds of mechanically ventilated patients dying within 30 days of hospitalization (Morita, Matsui, Yamana, et al., 2017). The number of CNs and CNSs in other specialties was also higher in the PNS[®] group, but this may not have influenced patient mortality (Butler et al., 2019). Third, the PNS[®] group had a better nurse assistant-to-patient ratio (1:25) than the fixed-team nursing group (1:50). Studies in the USA (Needleman et al., 2020) and Australia (Twigg et al., 2016) have demonstrated a significant decrease in inpatient mortality when nurse

assistants increase; however, either low or high nurse assistant staffing was associated with increased in-hospital mortality in a study conducted in the UK (Griffiths et al., 2019). Differences in RN staffing and nurse assistants' roles by countries may explain this difference in the study results. There is no study examining the association between nurse assistants and patient mortality in Japan, but nurse assistants in Japan do not take patients' vital signs. Therefore, if missed vital sign observation is an explanatory factor linking nurse assistant staffing and patient mortality, then the difference in this ratio between the two groups in this study would not have much influence on the results.

4.2 | Nursing models and functional decline

Unexpectedly, patients in the PNS[®] group depicted significantly higher odds of functional decline compared to patients in the fixed-team nursing group. Palese et al. (2016) demonstrated that more care provided by nursing assistants instead of RNs doubles the risk of declining functional status, and thus, an increase in nurse assistant-to-patient ratio could be a possible explanation for functional decline in patients in the PNS[®] group. However, it is necessary to conduct further exploration on how an increase in the proportion of severe patients changes RNs' practices and how the implementation of PNS[®] influences nursing care for supporting patients' ADLs.

This result could also be explained by the fact that the PNS[®] group, compared to the fixed-team nursing group, was likely to include more patients with intensive medical and nursing needs, which could increase nurses' workload, as mentioned earlier. Consequently, opportunities for nurses to support patients' self-care regarding ADLs may be reduced. Additionally, the medical treatment that patients received during hospitalization (e.g., chemotherapy), restrain use, bed-rest order, and patient cognition were not adjusted in the multivariable analysis, and this could have influenced the results.

4.3 | Limitations

This study had several limitations. First, because of the pre-post cohort design, the results might be affected by the time-fixed effect, which meant that the nursing delivery models but also other factors may have influenced the results, such as changes in the characteristics of nurses (e.g., skill mix, experience, and educational level), physicians, other healthcare professionals. Additionally,

in 2015, the emergency department of the study hospital expanded its capacity to accept more severe patients, and emergency inpatients were treated at an emergency ward (six beds) with a higher nurse-to-patient ratio of 1:5.

Second, adjustments in the multivariable logistic regression models may have been insufficient for patient-level covariates, despite the heterogeneous population. A study with a larger sample size is warranted to include more information that could influence patient outcomes (such as ICU stay, consciousness level at admission, medical procedures, and medications). Furthermore, the number of comorbidities that could be recorded in DPC was increased from four to 10 in FY 2016; however, this study only used the first four comorbidities recorded to be the same as prior to 2016. Moreover, when comorbidities in DPC (up to four diagnoses) and patients' charts were compared, sensitivity varied by diagnoses ranging from 0.0% in hemiplegia/paraplegia to 83.5% in malignancy (Yamana et al., 2017). Nevertheless, the C-statistic for 30-day in-hospital mortality in this study showed a better fit than a previous study by Quan et al. (2011).

Third, factors from the wards or units other than the implication of PNS[®] might affect mortality or functional decline among patients. The wards/unit composition between the fixed-team nursing group and the PNS[®] group differed because of an emergency ward established in 2015. We did not track information regarding the ward to which patients were initially admitted or intra-hospital transfers.

Fourth, we did not evaluate nurse partners' or pairs' attitudes toward each other, while the developers of PNS[®] emphasized the importance of mutual respect and effective collaboration between partners or nurse pairs (Tachibana & Kamiyama, 2016). Fifth, the complete case analysis used in this study could cause bias because missing Barthel Index assessments did not occur at random and presumably occurred systematically. To examine this potential bias, we compared patients with and without Barthel Index assessments and explored the differences. Consequently, the study findings on functional decline may not be applicable to patients with conditions that make a Barthel Index assessment difficult to complete. Sixth, generalization of the findings to other hospital settings is limited because this study was conducted at a single hospital. Finally, the results are not applicable to all nurse pairs since all nurses in this study were RNs.

This study is the first empirical study to examine an association between nursing delivery models and patient mortality or functional decline at the patient-level after adjusting for several patient characteristics. While the findings of this study should be interpreted with caution due to several limitations mentioned above, the findings

of this study will call nurses' attention to observe and evaluate the influence of PNS[®] on not only nurse-related outcomes but also patient-related outcomes. The findings from this study highlight the need for further investigations in this field, and they will aid other researchers to calculate the sample size for their studies.

5 | CONCLUSIONS

Nursing delivery models (fixed-team nursing and PNS[®]) showed no statistically significant association with 30-day in-hospital mortality; however, the uncertainty of this finding is high because of the wide 95% CI. Patients cared for under PNS[®] presented with a significantly higher likelihood of functional decline during hospitalization, compared to patients cared for with fixed-team nursing. Future research investigating the association between nursing delivery models and patient health outcomes, especially nurse-sensitive patient outcomes, is needed.

ACKNOWLEDGEMENTS

The hospital's information systems department contributed to extracting data from the DPC database stored in the study hospital. Dr. Arata Sashinami, Mr. Atsushi Sunagawa, Mr. Eiji Yukitake, Dr. Hiromi Konishi, and Mr. Munetoshi Nagahama contributed toward the development of the basic idea of the study during participation at the 9th Summer Clinical Research Workshop in 2016.

DISCLOSURE OF INTERESTS

The authors declare no conflict of interest associated with this manuscript. Outside the submitted work, Shinichiro Ueda received grants from Kowa Soyaku, Bayer, and Bristol Myers Squibb, and received personal fees (lectures) from MSD, Boeringer Ingelheim, Eisai, Novartis, and Chugai.

AUTHOR CONTRIBUTIONS

M.H. contributed to the conception and design, acquisition of data, and analysis and interpretation of data, and drafted the manuscript. T.M. and S.U. contributed to the design and critically revised the manuscript. All authors have agreed on the final version of the manuscript.

ORCID

Miki Higaonna  <https://orcid.org/0000-0002-4506-0723>

REFERENCES

- Aiken, L. H., Sloane, D. M., Bruyneel, L., Van den Heede, K., Griffiths, P., Busse, R., ... RN4CAST Consortium. (2014). Nurse staffing and education and hospital mortality in nine European countries: A retrospective observational study. *Lancet*, 383, 1824–1830. [https://doi.org/10.1016/S0140-6736\(13\)62631-8](https://doi.org/10.1016/S0140-6736(13)62631-8)
- Akiyama, T., Chikuda, H., Yasunaga, H., Horiguchi, H., Fushimi, K., & Saita, K. (2013). Incidence and risk factors for mortality of vertebral osteomyelitis: A retrospective analysis using the Japanese diagnosis procedure combination database. *BMJ Open*, 3(3), e002412. <https://doi.org/10.1136/bmjopen-2012-002412>
- Ball, J. E., Bruyneel, L., Aiken, L. H., Sermeus, W., Sloane, D. M., Rafferty, A. M., ... RN4CAST consortium. (2018). Post-operative mortality, missed care and nurse staffing in nine countries: A cross-sectional study. *International Journal of Nursing Studies*, 78, 10–15. <https://doi.org/10.1016/j.ijnurstu.2017.08.004>
- Butler, M., Schultz, T. J., Halligan, P., Sheridan, A., Kinsman, L., Rotter, T., ... Drennan, J. (2019). Hospital nurse-staffing models and patient- and staff-related outcomes. *Cochrane Database of Systematic Reviews*, 4, CD007019. <https://doi.org/10.1002/14651858.CD007019.pub3>
- Central Social Insurance Medical Council (2007). *Proceedings of the 107th General Assembly, held in Tokyo on July 11, 2007*. (in Japanese). Retrieved from <http://www.mhlw.go.jp/shingi/2007/07/txt/s0711-1.txt>
- Cho, E., Sloane, D. M., Kim, E. Y., Kim, S., Choi, M., Yoo, I. Y., ... Aiken, L. H. (2015). Effects of nurse staffing, work environments, and education on patient mortality: An observational study. *International Journal of Nursing Studies*, 52, 535–542. <https://doi.org/10.1016/j.ijnurstu.2014.08.006>
- Griffiths, P., Ball, J., Bloor, K., Bohning, D., Briggs, J., Dall'Ora, C., ... Smith, G. (2018). Nurse staffing levels, missed vital signs and mortality in hospitals: Retrospective longitudinal observational study. *Health Services and Delivery Research*, 6(38). <https://doi.org/10.3310/hsdr06380>
- Griffiths, P., Ball, J., Murrells, T., Jones, S., & Rafferty, A. M. (2016). Registered nurse, health care support worker, medical staffing levels and mortality in English hospital trusts: A cross-sectional study. *BMJ Open*, 6(2), e008751. <https://doi.org/10.1136/bmjopen-2015-008751>
- Griffiths, P., Maruotti, A., Recio-Saucedo, A., Redfern, O. C., Ball, J. E., Briggs, J., ... Missed Care Study Group. (2019). Nurse staffing, nursing assistants and hospital mortality: Retrospective longitudinal cohort study. *BMJ Quality & Safety*, 28(8), 609–617. <https://doi.org/10.1136/bmjqs-2018-008043>
- Griffiths, P., Recio-Saucedo, A., Dall'Ora, C., Briggs, J., Maruotti, A., Meredith, P., ... Missed Care Study Group. (2018). The association between nurse staffing and omissions in nursing care: A systematic review. *Journal of Advanced Nursing*, 74(7), 1474–1487. <https://doi.org/10.1111/jan.13564>
- Havaei, F., MacPhee, M., & Dahinten, V. S. (2019). The effect of nursing care delivery models on quality and safety outcomes of care: A cross-sectional survey study of medical-surgical nurses. *Journal of Advanced Nursing*, 75(10), 2144–2155. <https://doi.org/10.1111/jan.13997>
- Higaonna, M., & Morimoto, T. (2019). Effect of the partnership nursing model on in-hospital mortality in Japan. *Ryukyu Medical Journal*, 38, 89–97.
- Japanese Nursing Association. (2018). *2017 Survey of hospital nursing*. (in Japanese; access limited to Japanese Nursing Association members). Retrieved from <https://www.nurse.or.jp>
- Japanese Nursing Association. (2019). *Guideline and practical guide regarding care provided by registered nurses, license practical nurses, nursing assistants in nursing team* (in Japanese).

- Retrieved from https://www.nurse.or.jp/nursing/kango_seido/guideline/index.html.
- Jennings, B. M. (2008). Care models. In R. G. Hughes (Ed.), *Patient safety and quality: An evidence-based handbook for nurses* (pp. 1–10). Rockville, MD: Agency for Healthcare Research and Quality.
- Kalisch, B. J., Tschannen, D., Lee, H., & Friese, C. R. (2011). Hospital variation in missed nursing care. *American Journal of Medical Quality*, 26, 291–299. <https://doi.org/10.1177/1062860610395929>
- Kamijo, Y., Naganuma, M., Jinguji, M., Isobe, S., & Amemiya, M. (2015). Impact of partnership nursing system on nurses' workload and job satisfaction. *Journal of the Japan Academy of Nursing Evaluation*, 5, 53–60 (in Japanese). <https://doi.org/10.11463/jja.5.53>
- King, A., Long, L., & Lisy, K. (2015). Effectiveness of team nursing compared with total patient care on staff wellbeing when organizing nursing work in acute care wards: A systematic review. *JBI Database Systematic Reviews and Implementation Reports*, 13(11), 128–168. <https://doi.org/10.11124/jbisrir-2015-2428>
- Mahoney, F. I., & Barthel, D. W. (1965). Functional evaluation: The Barthel index. *Maryland State Medical Journal*, 14, 61–65.
- Maruoka, N., Tamura, Y., Tanbo, K., Tachibana, S., Kamiyama, K., Matsumura, E., ... Maruki, H. (2015). The effect of introducing the partnership nursing system and problems with its establishment. *Ishikawa Journal of Nursing*, 12, 75–83 (in Japanese).
- Ministry of Health, Labour and Welfare. (n.d.) *Revision of medical fee* (in Japanese). Retrieved from <https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000106602.html>.
- Ministry of Health, Labour and Welfare, and Ministry of Education, Culture, Sports, Science and Technology. (2014). *Ethical guidelines for medical and health research involving human subjects*. [Hito wo taisyoutosuru igakukei kenkyu ni kansuru rinri shishin] (in Japanese).
- Mitchell, P. H., Ferketich, S., & Jennings, B. M. (1998). Quality health outcomes model. American academy of nursing expert panel on quality health care. *Image—The Journal of Nursing Scholarship*, 30, 43–46. <https://doi.org/10.1111/j.1547-5069.1998.tb01234.x>
- Morita, K., Matsui, H., Fushimi, K., & Yasunaga, H. (2017). Association between nurse staffing and in-hospital bone fractures: A retrospective cohort study. *Health Services Research*, 52, 1005–1023. <https://doi.org/10.1111/1475-6773.12529>
- Morita, K., Matsui, H., Yamana, H., Fushimi, K., Imamura, T., & Yasunaga, H. (2017). Association between advanced practice nursing and 30-day mortality in mechanically ventilated critically ill patients: A retrospective cohort study. *Journal of Critical Care*, 41, 209–215. <https://doi.org/10.1016/j.jcrc.2017.05.025>
- Needleman, J., Buerhaus, P., Pankratz, V. S., Leibson, C. L., Stevens, S. R., & Harris, M. (2011). Nurse staffing and inpatient hospital mortality. *New England Journal of Medicine*, 364(11), 1037–1045.
- Needleman, J., Liu, J., Shang, J., Larson, E. L., & Stone, P. W. (2020). Association of registered nurse and nursing support staffing with inpatient hospital mortality. *BMJ Quality & Safety*, 29(1), 10–18. <https://doi.org/10.1136/bmjqs-2018-009219>
- Nishimoto, K., & Sugino, M. (2001). *Development and management of nursing team: Aiming for continuity in nursing care*. Tokyo, Japan: Igaku Shoin (in Japanese).
- Okita, M., & Tachibana, S. (2015). The proportion of the shifts nurse pairs worked together in partnership nursing system. *Nihon Kangogakkai Ronbunshu*, 45, 3–6 (in Japanese).
- Palese, A., Ambrosi, E., Prosperi, L., Guarnier, A., Barelli, P., Zambiasi, P., ... Saiani, L. (2015). Missed nursing care and predicting factors in the Italian medical care setting. *Internal and Emergency Medicine*, 10(6), 693–702. <https://doi.org/10.1007/s11739-015-1232-6>
- Palese, A., Gonella, S., Moreale, R., Guarnier, A., Barelli, P., Zambiasi, P., ... ESAMED Group. (2016). Hospital-acquired functional decline in older patients cared for in acute medical wards and predictors: Findings from a multicentre longitudinal study. *Geriatric Nursing*, 37(3), 192–199. <https://doi.org/10.1016/j.gerinurse.2016.01.001>
- Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology*, 49(12), 1373–1379.
- Quan, H., Sundararajan, V., Halfon, P., Fong, A., Burnand, B., Luthi, J. C., ... Ghali, W. A. (2005). Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Medical Care*, 43(11), 1130–1139. <https://doi.org/10.1097/01.mlr.0000182534.19832.83>
- Quan, H. D., Li, B., Couris, C. M., Fushimi, K., Graham, P., Hider, P., ... Sundararajan, V. (2011). Updating and validating the Charlson comorbidity index and score for risk adjustment in-hospital discharge abstracts using data from 6 countries. *American Journal of Epidemiology*, 173(6), 676–682. <https://doi.org/10.1093/aje/kwq433>
- Sakata, N., Okumura, Y., Fushimi, K., Nakanishi, M., & Ogawa, A. (2018). Dementia and risk of 30-day readmission in older adults after discharge from acute care hospitals. *Journal of the American Geriatrics Society*, 66, 871–878. <https://doi.org/10.1111/jgs.15282>
- Shah, S., Vanclay, F., & Cooper, B. (1989). Improving the sensitivity of the Barthel index for stroke rehabilitation. *Journal of Clinical Epidemiology*, 42, 703–709. [https://doi.org/10.1016/0895-4356\(89\)90065-6](https://doi.org/10.1016/0895-4356(89)90065-6)
- Shimoji, T., Oshiro, K., Toguchi, H., & Kajiki, Y. (2015). Implementation of PNS in all hospital wards in 2nd year. In S. Tachibana (Ed.), *Practice guide for PNS & Reports from the hospitals with PNS* (pp. 273–285). Nagoya, Japan: Nissoken (in Japanese).
- Tachibana, S., & Kamiyama, K. (2016). *Textbook of implementing and operating Partnership Nursing System (PNS)®* (pp. 7–15). Nagoya, Japan: Nissoken (in Japanese).
- The Hartford Institute for Geriatric Nursing, New York University Rory Meyers College of Nursing. (2019). *Reducing functional decline in older adults during hospitalization: A best practice approach*. Retrieved from <https://consultgeri.org/try-this/general-assessment/issue-31>.
- Tubbs-Cooley, H. L., Mara, C. A., Carle, A. C., Mark, B. A., & Pickler, R. H. (2019). Association of nurse workload with missed nursing care in the neonatal intensive care unit. *JAMA Pediatrics*, 173(1), 44–51. <https://doi.org/10.1001/jamapediatrics.2018.3619>
- Twigg, D. E., Myers, H., Duffield, C., Pugh, J. D., Gelder, L., & Roche, M. (2016). The impact of adding assistants in nursing to acute care hospital ward nurse staffing on adverse patient outcomes: An analysis of administrative health data. *International*

Journal of Nursing Studies, 63, 189–200. <https://doi.org/10.1016/j.ijnurstu.2016.09.008>

Yamana, H., Moriwaki, M., Horiguchi, H., Kodan, M., Fushimi, K., & Yasunaga, H. (2017). Validity of diagnoses, procedures, and laboratory data in Japanese administrative data. *Journal of Epidemiology*, 27, 476–482. <https://doi.org/10.1016/j.je.2016.09.009>

Yasunaga, H., Matsui, H., Horiguchi, H., Fushimi, K., & Matsuda, S. (2015). Clinical epidemiology and health services research using the diagnosis procedure combination database in Japan. *Asian Pacific Journal of Disease Management*, 7, 19–24. <https://doi.org/10.7223/apjdm.7.19>

Zisberg, A., Shadmi, E., Sinoff, G., Gur-Yaish, N., Srulovici, E., & Admi, H. (2011). Low mobility during hospitalization and functional decline in older adults. *Journal of the American Geriatrics Society*, 59, 266–273. <https://doi.org/10.1111/j.1532-5415.2010.03276.x>

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Higaonna M, Morimoto T, Ueda S. Association between nursing care delivery models and patients' health outcomes in a university hospital: A retrospective cohort study based on the Diagnostic Procedure Combination database. *Jpn J Nurs Sci*. 2020;17:e12319. <https://doi.org/10.1111/jjns.12319>