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Relationship between the legal nurse staffing standard and patient survival after perioperative cardiac arrest: A cross-sectional analysis of Korean administrative data

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ABSTRACT

Background: Nurses play crucial roles in cardiopulmonary resuscitation after perioperative cardiac arrest (PCA), and the level of nurse staffing is thought to influence the survival rate for cardiac arrest. However, no previous study has investigated the survival rate after PCA in Korea. In addition, nurse staffing levels in Korea are relatively low and their legal standard is not widely followed.
Objectives: This study investigated the relationships between nurse staffing level and survival after PCA in Korean hospitals using inpatient National Health Insurance (NHI) claim data.
Methods: The study used NHI claim data on patient and hospital characteristics for 2140 patients undergoing craniotomy or percutaneous angioplasty from January to December 2009. Because the information about nurse staffing in NHI claim data categorized nursing grade according to the nurse-to-bed ratio, the nurse staffing level was transformed from the nurse-to-patient ratio using the bed occupancy rate. The general ward and ICU nurse staffing levels were then categorized into major violation, violation, adherence, and major adherence according to the medical law standard. The association between nurse staffing level and survival after PCA was analyzed using logistic regression analyses with a generalized estimation model.
Results: The survival rate was higher for patients in hospitals with major adherence [odds ratio (OR) = 1.53, 95% confidence interval (CI) = 1.13–2.07] ICUs nurse staffing than for those in hospitals with adherence nurse staffing, and lower for patients in hospitals with violation (OR = 0.50, 95% CI = 0.26–0.93) or major violation (OR = 0.45, 95% CI = 0.21–0.97) general ward nurse staffing than for those in hospitals with adherence nurse staffing. Policies to ensure adherence to the medical law standard for nurse staffing levels is necessary to enhance the safety of patients experiencing PCA in Korea.

What is already known about the topic?

- The nurse staffing level is related to the risk of cardiac arrest.
- The nurse staffing level is related to survival after in-hospital cardiac arrest.

What this paper adds

- The nurse staffing level is also related to survival after perioperative cardiac arrest.
- A general ward nurse staffing level below that required by the medical law standard is significantly related to lower survival after cardiac arrest among perioperative patients in Korea.
- The survival rate after perioperative cardiac arrest is higher in tertiary hospitals that have more ICU nurses than the number prescribed by the medical law.

1. Introduction

Perioperative cardiac arrest (PCA) is an uncommon event that can lead to serious neurological complications or even death (Chowdhury et al., 2015). Although the incidence of PCA varies somewhat with patient type, available facilities, and the infrastructure and efficiency of the support system, this incidence has

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remained similar due to increases in the use of more-complex procedures (Nair et al., 2016). In contrast, the survival rate after PCA has improved over the years due to positive effects of various factors (Moretti et al., 2007). Survival after cardiac arrest is one of the most important issues for patient safety and quality of care, and unexpected events can compromise patient safety or even become life-threatening if appropriate equipment, protocols, and help are not readily available (Nair et al., 2016). It is therefore important to find modifiable factors that can enhance survival (Merchant et al., 2014), which should then be applied to implement changes that improve the hospital treatment environment.

One important aspect is the impact of the nurse staffing level on survival after PCA. Nurses are usually the first responders and initial rescuers performing cardiopulmonary resuscitation (CPR) (Heng et al., 2011). As members of the CPR team, nurses also perform defibrillation and manage airways and ventilation, lines, drugs, and tubes, and they ensure that all follow-up actions are completed (Kim et al., 2012a; Heng et al., 2011). A big-data analysis of the National Registry of Cardiopulmonary Resuscitation identified the nurse-to-bed ratio as a modifiable factor related to survival after in-hospital cardiac arrest (Chen et al., 2013). Another study found that ensuring that nurses had a reasonable workload improved survival after in-hospital cardiac arrest (McHugh et al., 2016). These results demonstrate that nurses play crucial roles in CPR from in-hospital cardiac arrest.

Hospitals in Korea are characterized by the wide availability of medical experts, state-of-the-art medical equipment, large numbers of patients, and the use of digital information systems (Kim, 2012). However, nurse staffing levels are relatively low, with the mean number of practicing nurses per 1000 inhabitants being very low compared with those in other Organisation for Economic Co-operation and Development (OECD) countries. In 2015, the average number of practicing professional nurses per 1000 populations was 7.4 across all OECD countries (Hong and Cho, 2017), but only 3.1 in Korea (OECD), although it had improved from 1.38 in 2000 ("OECD Statistics," 2016). Nurse reported excessive job demands impair their job outcomes (Cho et al., 2014), and inadequate nurse staffing has been found to be related to job dissatisfaction among nurses (Lee et al., 2014). This situation indicates that there is a need to determine whether nurse staffing levels in Korea are sufficient for producing an acceptable survival rate among cardiac-arrest patients. This could be investigated by analyzing patients who have undergone surgical treatment, which can ensure that the characteristics of the patients are as homogeneous as possible among those presenting with in-hospital cardiac arrest.

To ensure an adequate nurse staffing level, the Korean government has two guidelines involving medical legal requirements and a fee incentive system for the nurse staffing level. In the medical law enacted in 1962, hospitals must have 2 nurses per 5 inpatients, with 12 outpatients equating to 1 inpatient (Ministry of Health and Welfare, 2018a). This regulation does not vary with the type of department, such as general wards, delivery room, or emergency room (ER), or the hospital type, such as hospitals, general hospitals, and tertiary hospitals. The medical law was revised in 2008 such that ICUs required 1 nurse to care for 1.2 inpatients (Ministry of Health and Welfare, 2018a). Nurse staffing of ICU and general ward was aggregated at the hospital level and the nurse staffing measurement in medical law in Korea uses the method of average daily census, not shift nurse to patient ratio (Ministry of Health and Welfare, 2018a). However, there is a limitation that punishment for violation of medical law is weak, and law enforcement is not kept well. If the hospital does not have sufficient nurse staffing, it may be ordered to restrict or prohibit the use of all or part of the facilities or equipment for a certain period of time until the violations are corrected (Ministry of Health and Welfare, 2018a). A study investigating the nurse staffing level found that 75% of general and hospitals failed to meet the legal standard required by this medical law (Cho et al., 2016).

In contrast, the fee incentive policy for the nurse staffing level does consider the types of hospital and nursing department. This policy was developed and implemented in 1999, and involves admission fees paid by the National Health Insurance Corporation (NHIC) being based on the nurse staffing level (Ministry of Health and Welfare, 2018b). The nurse staffing level is quantified as the mean number of beds used over 3 months divided by the mean number of nurses in a ward over the same period (Ministry of Health and Welfare, 2018b). The incentive of admission fees being paid depending on the nurse-to-bed ratio resulted in nurse staffing levels improving in metropolitan areas and in large hospitals (Kim and Kim, 2015). However, the overall nurse staffing levels remain low, and also vary widely across medical institutions (Kim and Kim, 2015).

Several studies have investigated the relationship between the nurse staffing level using nurse-to-bed ratio and patient outcomes in Korea (Kim et al., 2012b; Kim and Bae, 2018). It is important to quantify the nurse staffing level based on medical law regulations, since this defines a minimum standard for patient safety (Cho et al., 2016), of which survival after PCA is an important component. It is therefore necessary to determine whether a nurse staffing level lower than that required by the medical law is safe for patients experiencing cardiac arrest during surgery.

Meanwhile, the nurse staffing level in Korea varies according to hospital type. Korean hospital types are recorded in Articles 3–2 to 3–4 of the Medical Service Act (Ministry of Health and Welfare, 2018a). There are hospitals, general hospitals, and tertiary hospitals. Hospitals have 30≥ beds, general hospitals have ≥100 beds plus specialized medical departments with specialist medical practitioners, and tertiary hospitals are general hospitals specialized in providing medical services requiring a high level of expertise for treating serious diseases (Ministry of Health and Welfare, 2018a). Tertiary hospitals have >20 specialized departments and provide training to people who intend to become medical specialists (Ministry of Health and Welfare, 2018a).

Studies investigating the effect of a fee incentive policy have found tertiary hospitals to be better staffed than general hospitals (Kim et al., 2005; Kim and Kim, 2015), which is due to tertiary hospitals providing more-specialized medical care. Moreover, the Korea Institute for Healthcare Accreditation assesses general hospitals every 3 years for whether to designate them as tertiary hospitals, and there are now 42 tertiary hospitals in Korea (KOIHA (Korea Institute for Healthcare Accreditation) (2018)). The criteria for designating a tertiary hospital include a nurse staffing standard of a nurse-to-patient ratio of 2.3 in general wards and of 1.2 in the ICUs (KOIHA (Korea Institute for Healthcare Accreditation) (2018)). The relationship between the nurse staffing level and survival after PCA therefore should be investigated according to hospital type.

The present study examined the relationship between the nurse staffing level and perioperative patient outcomes using an inpatient National Health Insurance (NHI) database, with the aim of providing evidence for helping to persuade policymakers and other stakeholders of the importance of adequate nurse staffing levels.

The goals of this study were addressed as follows. First, PCA survival was investigated according to patient characteristics (age, sex, type of operation, disease severity status, and hospitalization path) and hospital characteristics (hospital type, hospital ownership, physician staffing level, and resident staffing level). Second, the relationship between the nurse staffing level and cardiac-arrest survival was examined while adjusting for patient and hospital characteristics. Third, the relationship between the nurse staffing level and survival after cardiac arrest was explored according to hospital type.

2. Materials and methods

2.1. Data source and sample

NHI claim data from 2009 as classified by the Korean Diagnosis-Related Group (KDRG) were used to identify the surgery types with the four highest death rates: major craniotomy, other type of craniotomy, craniotomy for trauma treatment, and percutaneous angioplasty. There were 67,771 patients who received a craniotomy or percutaneous angioplasty from January to December 2009.

To make the data similar to the American Heart Association's Get With The Guidelines In-hospital Cardiac Arrest-Resuscitation (GWTG-R) database (Jacobs et al., 2004), only patients who received CPR were included in this study. The sampling process was presented in Fig. 1. The records of 2140 patients with PCA who received a craniotomy or percutaneous angioplasty during 2009 were identified, of which 336 were excluded due to incomplete patient data. We also excluded 6 patients younger than 20 years and 36 older than 85 years, **to ensure that the age distribution of the analyzed adult patients was consistent with that in previous studies (**Aiken et al., 2003; Kutney-Lee and Aiken, 2008**).** A further five patients who underwent **surgery for accidental trauma such as car collisions and occupational injuries** were **also excluded to ensure homogeneity of the patient treatment processes**. PCA cases at medical institutions that treated fewer than two cardiac arrest cases ($n = 61$) were also excluded from this study **to include only hospitals that had sufficient case volumes.** The final analytical sample therefore comprised 1696 patients from 121 hospitals. These data were used to investigate nurse staffing levels and other factors related to the survival to discharge after PCA.

2.2. Measurement

2.2.1. Nurse staffing level

The NHI claim data quantified nurse staffing levels using the nursing grade, which is based on the nurse-to-bed ratios in general wards and the ICUs. The nursing grades in general wards were categorized into six levels in tertiary hospitals and seven levels in general hospitals. For example, nurse-to-bed ratios below 2.5 are classed as grade 2 in tertiary hospitals and grade 1 in general hospitals, while ratios below 2 are grade 1 in tertiary hospitals, and there is no corresponding nursing grade in general hospitals. We therefore adjusted the nurse staffing level by creating a grade of 0 to consider nursing grade in all types of hospitals together, for consistency with the categorization method used in previous studies (Kim and Kim, 2015).

The total number of beds used in calculating the general ward nurse-to-bed ratio includes those in general inpatient wards, maternity wards, and open psychiatric wards, and excludes the ER, nursery, delivery room, ICU, closed psychiatric wards, artificial kidney room, and isolation room (Ministry of Health and Welfare, 2018b).

Meanwhile, the medical law standard for the nurse staffing level uses the nurse-to-patient ratio, which is calculated as the average daily census of patients divided by the number of nurses in the institution. For hospitals, the required nurse staffing level is calculated by dividing the daily number of inpatients by 2.5, with 12 outpatients counted as 1 inpatient. Because we only had information on the number of beds in each hospital and the medical law standard for the nurse staffing level uses the nurse-to-patient ratio, we utilized the bed occupancy rate to convert from the nurse-to-bed ratio to the nurse-to-patient ratio; the bed occupancy rate of general wards and the ICUs was reportedly 86% in 2012 (Im et al., 2013). We further categorized the nurse staffing level into major violation, violation, adherence, and major adherence according to the requirements of the medical law. Because the nurse staffing level at nursing grades 5–7 is very low in general wards, we categorized this as major violation. When the nurse staffing level in general wards or the ICUs was lower than the requirements of the medical law (nursing grades 2–4 for general wards and nursing grades 7–9 for the ICUs), we categorized this as violation. When the nurse staffing level in general wards or the ICUs met the requirements of the medical law (nursing grades 0 and 1 for general wards and 4–6 for the ICUs), we categorized the nurse staffing level as adherence. When the nurse staffing level in the ICUs was the best (nursing grades 1–3), we categorized this as major adherence.

Table 1 presents the nursing grade, nurse-to-patient ratio based on the bed-occupancy rate, and categorization of adherence of medical law.

2.2.2. Hospital characteristics

Hospital type among 121 hospitals was categorized into the following three groups according to the standards in the Medical Service Act considering hospital size and number of specialized departments: hospital, general hospital, and tertiary hospital. Hospital ownership in this study was categorized into medical corporation, education foundation, **and** public. Several hospitals in Korea that are private and run in a not-for-profit manner can be categorized as hospitals operated by medical corporations. Hospitals operated by education foundations belonging to universities that strengthen the teaching role were categorized

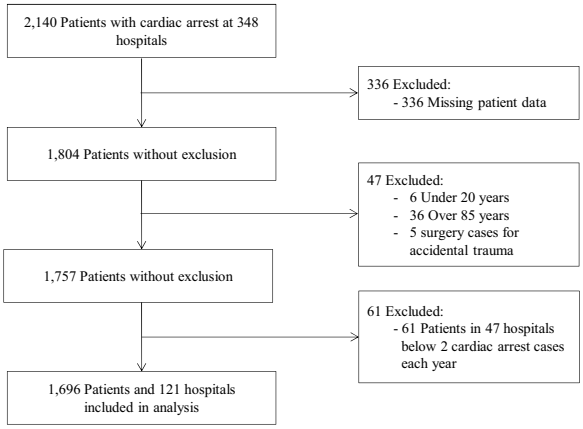

Fig. 1. Study cohort exclusion/inclusion criteria.

Table 1
Nurse-to-patient ratio determined from the nurse staffing level.

Category	Nursing grade	Nurse staffing level (nurse-to-bed ratio)	Nurse-to-patient ratio*	Categorization according to the medical law standard**
ICU nurse staffing level	1	<0.5	0.43	Major adherence
	2	<0.63	0.54	
	3	<0.77	0.66	
	4	<0.88	0.76	Adherence
	5	<1.00	0.86	
	6	<1.25	1.08	
	7	<1.50	1.29	Violation
	8	<2.00	1.72	
	9	≥2.00	1.72	
General ward nurse staffing level	0	<2.00	1.72	Adherence
	1	<2.50	2.15	
	2	<3.00	2.58	Violation
	3	<3.50	3.01	
	4	<4.00	3.44	
	5	<4.50	3.87	Major violation
	6	<6.00	5.16	
	7	≥6.00	5.16	

* Nurse-to-bed ratio converted to nurse-to-patient ratio using an occupancy rate of 86%.
** Medical law standard: ratio of nurses to average annual number of patients in ICU = 1.2; ratio of nurses to average annual number of patients in general wards = 2.5.

as being owned by education foundations. Public hospitals are funded by local or central governments and public corporations such as the NHIC. Physician and resident staffing levels were calculated as the number of doctors per 100 beds, and were dichotomized based on the median numbers of physicians and residents of 18 and 16 doctors per 100 beds as used in previous studies (Dickstein et al., 2016), respectively, due to right-skewed distributions.

2.2.3. Patient characteristics

The patient characteristics considered were age, sex, type of operation, disease severity status, and hospitalization path. The participants were divided into three groups for age and four categories for the type of operation (major craniotomy, other craniotomy, craniotomy for trauma treatment, and percutaneous angioplasty). The disease severity status was categorized into three groups according to complications and comorbidities (none, minor, and moderate) using version 3.3 of the patient classification system of the KDRG (HIRA (Health Insurance Review and Assessment Service), 2009). The hospitalization path was categorized into outpatient and ER.

2.2.4. Study outcomes

The outcome of interest was cardiac-arrest survival, which was defined as survival of the patient at the end of their hospital stay. A cardiac-arrest CPR event was defined as a pulseless cardiopulmonary arrest that required chest compressions and/or defibrillation (Jacobs et al., 2004). The operational definition of a CPR intervention was based on the inpatient medical-claim data, and Korean Current Procedural Terminology (KCPT) codes M5870 and M5880 were included. KCPT codes M5870 and M5880 were used to identify cases of CPR and defibrillation administration, respectively, among the patients with cardiac arrest (HIRA (Health Insurance Review and Assessment Service), 2009).

2.3. Data analysis

Descriptive statistics of numbers and percentages were used to quantify hospital characteristics. The chi-square test was used to assess differences in survival after PCA according to patient and hospital characteristics. Logistic regression applied with a generalized estimation model in order to adjust clustered data was used to analyze the associations between the nurse staffing level and survival after cardiac arrest. The same analysis was performed for the hospital type. Hospitals and general hospitals were categorized into one group, with tertiary hospitals classified separately. SAS (version 9.4, SAS Institute, Cary, NC, USA) was used to analyze the data.

2.4. Ethics statement

Official approval was obtained from the NHIC to use the data in the present study (Official document no. NHIS-NRDD-2013-23). This study was exempted from the need to obtain approval from the institutional review board (IRB no. EUIRB2017-41) because it used public NHI claim data. The data were tagged using temporary IDs in order to prevent patient identification, and external data leakage was avoided by only performing analyses in a designated big-data laboratory.

3. Results

The characteristics of the hospitals included in this study are presented in Table 2. The 121 hospitals comprised 36.4% tertiary hospitals and 60.3% general hospital. There were 52 (43.0%), 50 (41.3%), and 19 (15.7%) hospitals owned by medical corporations, education foundations, and publicly, respectively. There were 64

Table 2
Hospital characteristics ($n = 121$).

Variable	Categories	Hospitals n (%)
Type	Hospital	4 (3.3)
	General hospital	73 (60.3)
	Tertiary hospital	44 (36.4)
Hospital ownership	Medical corporation	52 (43.0)
	Education foundation	50 (41.3)
	Public	19 (15.7)
Physician staffing level (per 100 beds)	Under 18	64 (52.9)
	18 and higher	57 (47.1)
Resident staffing level (per 100 beds)	Under 16	59 (48.8)
	16 and higher	62 (51.2)
ICU nurse staffing level	Major adherence	70 (57.9)
	Adherence	41 (33.9)
	Violation	10 (8.3)
General ward nurse staffing level	Adherence	14 (11.6)
	Violation	36 (76.0)
	Major violation	15 (12.4)

(52.9%) hospitals with fewer than 18 physicians per 100 beds and 59 (48.8%) with fewer than 16 residents per 100 beds. Most of the hospitals (n = 70, 57.9%) were categorized as major adherence for the ICUs nurse staffing level. The nurse staffing level was categorized as adherence in 41 (33.9%) ICUs and 14 (11.6%) general wards, and as violation in 10 (8.3%) ICUs and 36 (76.0%) general wards. There were 15 (12.4%) hospitals with nurse staffing levels in general wards categorized as major violation.

The overall patient and hospital characteristics among cardiac-arrest patients as well as according to survival status are presented in Table 3. Overall, those aged 60–85 years constituted the majority of the sample (57.1%), followed by those aged 40–59 years (35.6%) and 20–39 years (7.3%). Most of the patients underwent a percutaneous cardiovascular procedure (75.9%), followed by major craniotomy (13.0%), other craniotomy (6.4), and craniotomy for trauma (4.6%). Almost half (45.8%) of the patients had no complication or comorbidity, and 75.9% patients were admitted via the ER. Most of the patients were treated in tertiary hospitals (56.4%), followed by general hospitals (42.5%) and hospitals (1.1%). Most of the patients were treated in hospitals owned by education foundations (52.8%), followed by medical foundations (30.5%) and public (16.7%). Most of the patients had been treated in hospitals with large numbers of physicians (61.7%) and residents (67.9%).

The survival rate after cardiac arrest was higher in younger patients, women, those undergoing a cardiovascular procedure, those with a lower disease severity status, those admitted via an outpatient path, and those treated in tertiary hospitals and in hospitals with higher physician, resident, and nurse staffing levels.

The variation in patient survival according to the nurse staffing status is presented in Table 4. In the multivariate model, the likelihood of survival was approximately twofold higher for patients aged 40–59 years than for those aged 60–85 years [odds ratio (OR) = 2.78, 95% confidence interval (CI) = 2.08–3.71]. Patients receiving all types of craniotomy treatment were less likely to survive than were those receiving a cardiovascular procedure. Patients without complications were more likely to survive than those with complications (OR = 3.43, 95% CI = 1.42–3.66). The survival rate was 45% lower for patients admitted via the ER than for those admitted as outpatients (95% CI = 0.34–0.87).

The likelihood of survival in the ICUs was higher for patients in hospitals with major adherence nurse staffing than in those with adherence nurse staffing (OR = 1.53, 95% CI = 1.13–2.07), while it did not differ significantly between hospitals with violation nurse staffing and with adherence nurse staffing. The likelihood of survival in general wards was lower in hospitals with violation (OR = 0.50, 95% CI = 0.26–0.93) or major violation (OR = 0.45, 95% CI = 0.21–0.97) nurse staffing than in hospitals with adherence nurse staffing.

The relationships between nurse staffing level and survival after cardiac arrest were investigated according to hospital type while controlling for patient characteristics (age, sex, type of operation, disease severity status, and hospitalization path) and hospital characteristics (type, ownership, physician staffing level, and resident staffing level). The results are presented in Table 5. The survival rate after cardiac arrest in the ICUs did not differ between patients in general hospitals and hospitals, while in the general wards of hospitals and general hospitals it was lower for major violation nurse staffing than for adherence nurse staffing (OR = 0.42, 95% CI = 0.21–0.84).

Patients who were cared for in tertiary hospitals with major adherence ICUs nurse staffing were 2.35-fold more likely to survive than those in tertiary hospitals with adherence nurse staffing (95% CI = 1.27–4.36). The patient survival rate after cardiac arrest did not differ significantly between violation nurse staffing and adherence nurse staffing in general wards in tertiary hospitals.

Table 3
Patient and hospital characteristics among cardiac-arrest patients who died or survived (n = 1696).

		Died (n = 737) n (%)	Survived (n = 959) n (%)	Total (n = 1696) n (%)	χ^2	p
Age, years	20–39	45 (36.3)	79 (63.7)	124 (7.3)	39.456	<.001
	40–59	208 (34.4)	396 (65.6)	604 (35.6)		
	60–85	484 (50.0)	484 (50.0)	968 (57.1)		
Sex	Female	456 (38.5)	729 (61.5)	1185 (69.9)	39.603	< .001
	Male	281 (55.0)	230 (45.0)	511 (30.1)		
Type of operation	Major craniotomy	194 (87.8)	27 (12.2)	221 (13.0)	410.586	< .001
	Other craniotomy	95 (87.2)	14 (12.8)	109 (6.4)		
	Craniotomy for trauma	65 (83.3)	13 (16.7)	78 (4.6)		
	Percutaneous cardiovascular procedure	383 (29.7)	905 (70.3)	1288 (75.9)		
Disease severity status	No complication or comorbidity	210 (27.1)	100 (72.9)	776 (45.8)	183.305	< .001
	Minor complication or comorbidity	312 (51.2)	311 (48.8)	609 (35.9)		
	Moderate complication or comorbidity	215 (69.1)	588 (30.9)	311 (18.3)		
Hospitalization path	Outpatient	99 (24.2)	310 (75.8)	409 (24.1)	81.281	< .001
	Emergency room	638 (49.6)	649 (50.4)	1287 (75.9)		
Hospital type	Hospital	16 (84.2)	3 (15.8)	19 (1.1)	25.834	< .001
	General hospital	346 (48.0)	375 (52.0)	721 (42.5)		
	Tertiary hospital	375 (39.2)	581 (60.8)	956 (56.4)		
Hospital ownership	Medical corporation	238 (46.0)	279 (54.0)	517 (30.5)	5.107	0.078
	Education foundation	366 (40.9)	529 (59.1)	895 (52.8)		
	Public	133 (46.3)	151 (53.2)	284 (16.7)		
Physician staffing level	Under 18	316 (48.7)	333 (51.3)	649 (38.3)	11.726	<0.001
	18 and higher	421 (40.2)	626 (59.8)	1047 (61.7)		
Resident staffing level	Under 16	261 (47.9)	284 (52.1)	545 (32.1)	6.428	0.011
	16 and higher	476 (41.4)	675 (58.6)	1151 (67.9)		
ICU nurse staffing level	Major adherence	500 (39.8)	757 (60.2)	1257 (74.1)	29.089	< .001
	Adherence	202 (55.7)	161 (44.4)	363 (21.4)		
	Violation	35 (46.1)	41 (54.0)	76 (4.5)		
General ward nurse staffing level	Adherence	108 (26.9)	294 (73.1)	402 (23.7)	66.923	< .001
	Violation	567 (47.5)	308 (52.5)	1194 (70.4)		
	Major violation	62 (62.0)	38 (38.0)	100 (5.9)		

Table 4
Patient survival according to nurse staffing level ($n = 1696$).

Variable		OR	95% CI	Z	Prob. > |Z|
Univariate model					
ICU nurse staffing level	Major adherence	1.41	1.07–1.87	2.43	0.015
	Adherence	1.00			
	Violation	1.76	0.89–3.45	1.63	0.103
General ward nurse staffing level	Adherence	1.00			
	Violation	0.43	0.19–0.97	−2.02	0.043
	Major violation	0.26	0.09–0.74	−2.53	0.011
Adjusted model					
Age, years	20–39	3.60	2.46–5.28	6.58	< .001
	40–59	2.78	2.08–3.71	6.94	< .001
	60–85	1.00			
Sex (ref. = female)	Male	1.25	0.93–1.69	1.49	0.137
Type of operation	Major craniotomy	0.06	0.03–0.09	−11.65	< .001
	Other craniotomy	0.07	0.03–0.13	−7.64	< .001
	Craniotomy for trauma	0.11	0.05–0.22	−6.08	< .001
	Percutaneous cardiovascular procedure	1.00			
Disease severity status	No complication or comorbidity	3.43	1.42–3.66	3.64	< .001
	Minor complication or comorbidity	1.35	0.88–1.95	1.35	0.177
	Moderate complication or comorbidity	1.00			
Hospitalization path (ref. = outpatient)	Emergency room	0.55	0.34–0.87	−2.57	0.010
Hospital type	Hospital	0.66	0.17-2.55	−0.60	0.548
	General hospital	1.33	0.95–1.86	1.68	0.092
	Tertiary hospital	1.00			
Hospital ownership	Medical corporation	1.29	0.88–1.90	1.30	0.195
	Education foundation	0.95	0.66–1.38	−0.25	0.805
	Public	1.00			
Physician staffing level (ref. = under 18)	18 and higher	0.77	0.55–1.09	−1.45	0.147
Resident staffing level (ref. = under 16)	16 and higher	1.23	0.90–1.67	1.30	0.194
ICU nurse staffing level	Major adherence	1.53	1.13–2.07	2.75	0.006.
	Adherence	1.00			
	Violation	0.90	0.62–1.30	−0.58	0.563
General ward nurse staffing level	Adherence	1.00			
	Violation	0.50	0.26–0.93	−2.18	0.029
	Major violation	0.45	0.21–0.97	−2.04	0.042

OR, odds ratio; CI, confidence interval.

Table 5
Patient survival according to nurse staffing level and hospital type ($n = 1696$).

Variable		OR	95%CI	Z	Prob. > |Z|
Hospitals and general hospitals					
ICU nurse staffing level	Major adherence	1.38	0.96–1.99	1.75	0.080
	Adherence	1.00			
	Violation	0.81	0.54–1.22	−1.01	0.312
General ward nurse staffing level	Adherence	1.00			
	Violation	0.58	0.32–1.04	−1.83	0.067
	Major violation	0.42	0.21–0.84	−2.46	0.014
Tertiary hospitals					
ICU nurse staffing level	Major adherence	2.35	1.27–4.36	2.72	0.007
	Adherence	1.00			
General ward nurse staffing level	Violation	0.53	0.24–1.16	−1.59	0.111
	Adherence	1.00			

The model was adjusted while controlling for patient age, sex, type of operation, disease severity status, and hospitalization path, as well as hospital ownership, physician staffing level, and resident staffing level.

4. Discussion

The present analysis of administrative data has revealed an association between the nurse staffing level and survival after cardiac arrest among perioperative patients in Korea. This study is the first attempt at finding a relationship between nurse staffing level as quantified based on the legally required standard and PCA survival, with a relationship between the nurse staffing level and the risk of cardiac arrest being revealed (Kane et al., 2007).

A few studies in other countries have provided evidence of an association between the nurse staffing level and patient survival after cardiac arrest. One of these studies used a large national registry to investigate the association between the cardiac-arrest survival rate and hospital characteristics, and found that hospitals with lower nurse-to-bed ratios were better at both preventing and treating in-hospital cardiac arrest (Chen et al., 2013). Another study found a relationship between the nurse staffing level and the survival of cardiac-arrest patients (McHugh et al., 2016). The defibrillation time was also found to be important to the role of the nurse in performing CPR for cardiac arrest (Rochman, 2012). The most significant findings are that, when controlling for hospital characteristics, both patient characteristics and a higher nurse

staffing level were associated with a higher survival rate, while the physician staffing level did not affect patient survival. The availability of adequate nurse staffing ensures suitable responses to resuscitation events, including the recognition of patients in a critical condition, performing CPR early, and utilizing skilled CPR teams in hospitals when necessary.

It is important to consider how the nurse staffing level is calculated and whether this has been measured adequately (Welton, 2016). Previous studies used the actual nurse-to-bed ratio at the hospital level (Chen et al., 2013) and surveyed the actual patient-to-nurse ratio (McHugh et al., 2016) to investigate the relationship between the nurse staffing level and survival after cardiac arrest. We categorized the nurse staffing level according to adherence with the medical law standard by considering a converted nurse-to-patient ratio derived from the NHI claim data. The status of adherence rather than the actual nurse-to-patient ratios was used to generate findings since this is more appropriate for responding to the primary concern of clinicians and policy-makers—to determine whether the legal adherence status is both effective and safe.

In our study, we found the nurse staffing level to be significantly related to survival after PCA. Patients in hospitals violating the legal standard in general wards had a risk of a lower survival rate after PCA, while providing a more-than-adequate nurse staffing level in the ICUs might increase the survival rate.

After performing the same analysis with the subjects categorized according to hospital types, major violations general ward nurse staffing significantly influenced survival after PCA in both hospitals and general hospitals. Our study results suggest that meeting the legal standard for the nurse staffing level is a prerequisite for ensuring the safety of cardiac-arrest patients. It is therefore necessary to strengthen both the supervision and punishment of hospitals that do not comply with the nurse staffing levels specified in the medical law.

There was no case of violation of the ICUs nurse staffing level or major violation of the general ward nurse staffing level in tertiary hospitals. This is because Korean tertiary hospitals are assessed every 3 years, and designation as a tertiary hospital includes fulfilling a minimum requirement for the nurse staffing level: the nurse-to-patient ratio should be lower than 2.3 in general wards and 1.2 in the ICUs (KOIHA (Korea Institute for Healthcare Accreditation) (2018)). This standard exceeds the general ward nurse-to-patient ratio of 2.5 required in the medical law. If hospitals provide more nurses to care for patients, they can receive extra points in the evaluation for tertiary hospital designation (KOIHA (Korea Institute for Healthcare Accreditation) (2018)). It is expected that the nurse staffing level at a tertiary hospital level would be higher than that required according to the medical law. Therefore, policymakers should also be concerned about devising appropriate incentive policies to enhancing adequate nurse staffing level.

Moreover, the survival rate after PCA in tertiary hospitals differed between adherence and major adherence of the ICUs nurse staffing level adherence. This implies that providing an ICUs nurse staffing level better than that required by medical law is beneficial for the patients with PCA in tertiary hospitals. While the nurse staffing level for the ICUs was added in 2008 to the Korean medical law that had been enacted in 1962, this regulation has not been revised to reflect changes in patient disease severity, complexity of medical treatment, and the medical environment. For tertiary hospitals, it is necessary to determine the adequate level of ICUs nurse staffing due to the need to cure and care for patients with a high disease severity.

The general wards nurse staffing level required by the medical law should also be reconsidered. This is because the number of nurses per patient required by the legal standard is lower than that required by other countries, even if considering the differences in the health care environment of other countries. The medical law standard of a nurse-to-patient ratio of 2.5 in general wards at the hospital level can be converted to a shift-nurse-to-patient ratio of 11.9 (Cho et al., 2016). This standard is lower than the law in California for the staffing ratio of registered nurses, which is 5 in medical/surgical departments ("California RN Staffing Ratio Law, 2018). A minimum nurse-to-patient ratio of 4 is recommended in a level-1 acute general medical or surgical wards in a public hospital setting on morning and afternoon shifts in Victoria, Australia ((ANMF (Australian Nursing and Midwifery Federation) Victorian branch (2018)).

The limitations of this study are as follows. First, its cross-sectional design made it impossible to establish the causality of the relationship between the nurse staffing level and the survival of cardiac-arrest patients. Second, we used NHI claim data rather than GWTG-R data. We used information from the NHI claim data and applied the KCPT to create our data set, but the data were nationwide. Despite these limitations, we have elucidated the relationship between the nurse staffing level and cardiac-arrest survival, which is one of the most drastic situations confronted by patients in hospitals.

5. Conclusions

Our findings suggest that compliance with the medical law standard for providing an adequate nurse staffing level can improve the probability of survival after PCA. The medical law standard is important for patient safety, and regulations to enforce its requirements are needed. The legal standards for nurse staffing vary between countries, and so future studies need to confirm the relevance of various patient outcomes according to specific legal standards, because legislation is one of the best strategies for securing adequate nurse staffing levels.

Because the survival rate after PCA varies according to hospital type, it is necessary to develop tailored policies to ensure compliance with the medical law.

Conflict of interest

None to declare.

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