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Association of nurse staffing grade and 30-day mortality in intensive care units among cardiovascular disease patients

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Abstract

After the implementation of a policy differentiating inpatient nursing fees, no study is found in the nursing literature for intensive care unit (ICU) patients admitted with cardiovascular (CV) disease exclusively in Korea. This study investigates the relationship between ICU nurse staffing and 30-day mortality using large representative claim database.

National Health Insurance Service-Senior (NHIS-Senior) claim database from 2002 to 2013, which was released by the Korean National Health Insurance Service (KNHIS), was used in this study. We included CV disease inpatients as a primary diagnostic code (I20-I25) who had their ICU utilization records from differentiating inpatient nursing fees code, resulting in 17,081 subjects

After adjusting for confounders, the hazard ratio (HR) for 30-day mortality after discharge (HR: 1.177; *P*: .018) and in-hospital 30-day mortality (HR: 1.145; *P*: .058) were higher in general hospital (GH) than in tertiary hospital (TH). In GH setting, HR for 30-day mortality after discharge (HR: 1.499; *P*: .010) and in-hospital 30-day mortality (HR: 1.377; *P*: .042) were higher in grade 7 to 9 than grade 1 to 2, but not in TH setting.

This study shows that ICU nurse staffing related to improved mortality risk in GHs. Therefore, adequate nurse staffing to provide safe and high-quality care can be ensured by continuous monitoring and evaluation of nurse staffing.

Abbreviations: CCI = charlson comorbidity index, CV = cardiovascular, GH = general hospital, HR = hazard ratio, ICU = intensive care unit, KNHIS = Korean National Health Insurance Service, TH = tertiary hospital.

Keywords: aging, care, mortality, nurse staffing

Key Points

- Significant relationship between nurse staffing grade and mortality in general hospital.
- General hospitals have a relatively lower need to improve nurse staffing than tertiary hospitals.
- Nurse staffing grade in tertiary hospital was not significantly associated with possibilities of dying.

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1. Introduction

Admission to the intensive care unit (ICU) has been known as a risk factor for increased morbidity and mortality outcomes [1], especially in those with cardiovascular (CV) disease.[2] Although ICU for the severely ill patients is associated with specialized clinical team with access to the most technologically sophisticated equipment to provide close nursing surveillance and life-sustaining interventions,[3] advances in technology are just tools to support health care staff in closely monitoring and properly treating patients who are critically ill.[4] Nurses of skilled health care staffs in hospitals are crucial to providing good-quality care services, providing patients with holistic care 24-hour a day.[5]

A recent systematic review suggests that better nurse staffing is associated with improved patient outcomes.[6] Although some researchers express skepticism about its sensitivity to nursing care quality,[7] mortality of those patients is often used as an important indicator for hospital quality.[8] Although research evidence has increased concerning the relationship between bed-to-nurse ratio and patient outcomes in Korea,[9] hospital administrators tend to reduce nurse staffing to decrease hospital costs and maximize efficiency of operation.

Several countries regulate minimum requirements of nurse staffing or offer financial incentives for guaranteed nursing care quality.[10] In 1999, the Korean government implemented a new incentive policy for nurse staffing, namely differentiating inpatient nursing fees by nurse staffing levels to financially incentivize hospitals to improve nurse staffing and the quality of nursing care services.[11–13] At first, there were 6 grades of nurse staffing levels based on the nurse-to-bed ratio only for general care units of all types of hospital, which extended to 7 grades of nurse staffing levels in general hospitals (GHs) in 2007 and 9 grades in 2008 (see Supplemental Digital Content which demonstrates the differentiating nursing fees and code according to staffing level, http://links.lww.com/MD/C564).[11,14]

After the implementation of the policy, differentiating inpatient nursing fees, a few studies have been published on the effects of the policy on nurse staffing in Korea.[11,15–18] However, no study is found in the nursing literature for ICU patients admitted with CV disease exclusively and thus, we examine the relationship between ICU nurse staffing and patient mortality using large representative claim database.

2. Methods

2.1. Study design and data source

Study data were obtained from National Health Insurance Service-Senior (NHIS-Senior) claim database from 2002 to 2013 which was released by the Korean National Health Insurance Service (KNHIS).[19] The initial NHIS-Senior cohort data was comprised of 558,147 participants. Approximately 10% of the 60 years and above elderly population in 2002 was analyzed, using a stratified random sampling method, excluding non-citizens and special purpose employees with an unidentifiable income level. The baseline cohort members were followed for 11 years until 2013 unless the beneficiaries were disqualified due to death or emigration. Detailed methods for establishing and ensuring the representativeness of NHIS-Senior cohort were published on the KNHIS website (https://nhiss.nhis.or.kr/bd/ay/bdaya001iv.do).[19] For the analysis we included CV disease inpatients as a primary diagnostic code (I20-I25) in the International Classification of Diseases, 10th revision (ICD-10) who had their ICU utilization records from differentiating inpatient nursing fees code, resulting in 17,081 subjects. This study does not need ethical approval because it is not a study using human derivatives, and all subjects are encrypted and cannot be identified.

2.2. Independent variable

The nurse staffing grades were based on the nurse-to-bed ratio. The highest nurse staffing grade was grade 1 (beds/nurse ratio < 0.5), with the lowest nurse staffing grade being grade 9 (beds/nurse ratio ≥2.0). Level of nurse staffing was categorized into 4 groups in each year: grade 1 to 2, grade 3 to 4, grade 5 to 6, and grade 7 to 9.

3. Dependent variable

3.1. All-cause mortality

Thirty-day mortality after discharge was determined by death certificates and discharge diagnosis was determined at the time of discharge by calculating the admission date and length of stay. In-hospital 30-day mortality was determined by mortality date after admission date.

3.2. Control variables

The present analyses included age, sex, income, type of insurance, region, primary diagnosis, route of admission, Charlson Comorbidity Index (CCI), organization type, number of doctors, and hospital technology as control factors; all of the covariates were categorical except for age, and number of doctors. Sex was grouped into male and female. Based on the premiums of the National Health Insurance, which reflects household income in our database, all the people were divided into 10 quintiles and we were further categorized into 3 groups: low (≤3), middle (4–7), or high (8–10). Region was categorized into metropolitan (Seoul), urban (Daejeon, Daegu, Busan, Incheon, Kwangju, or Ulsan), and rural (otherwise). Primary diagnosis of CV disease was categorized into 5 groups: angina pectoris (I20), acute myocardial infarction (I21), subsequent myocardial infarction (I22), certain current complications following acute myocardial infarction (I23), other acute ischemic heart diseases (I24), and chronic ischemic heart disease (I25). Route of admission was categorized into emergency and outpatient, and CCI was grouped as scores of 0, 1, 2, and over 3. Organization type of hospital was categorized into 3 groups: public, corporate, and private. Based on our previous research ,[20] as a proxy to sophisticated equipment, hospital technology was investigated. Using SAS Rank function, hospital technology was categorized into 3 groups.

3.3. Statistical analysis

Chi-square test, log-rank test, analysis of variance (ANOVA), and Cox proportional hazards models were used to investigate the association between nurse staffing and mortality. For all analyses, the criterion for statistical significance was $P \leq .05$, 2-tailed. All analyses were conducted using the SAS statistical software package, version 9.4 (SAS Institute Inc., Cary, NC).

4. Results

4.1. General characteristics of CV disease ICU patients

Table 1 shows the general characteristics for 30-day mortality after discharge and in-hospital 30-day mortality, respectively. Of 17,081 patients with CV disease, 8428 patients (49.3%) used ICU in tertiary hospital (TH) and 8653 patients (50.7%) used in GH. Of the patients admitted to low hospital technology, 14.2% died within 30 days after discharge and 12.9% died within 30 days, respectively (Table 1, Fig. 1). In addition, the prevalence of 30-day mortality after discharge and in-hospital 30-day mortality was 10.3% and 9.3%, respectively (Table 1). Of those admitted to TH, the prevalence of 30-day mortality after discharge and in-hospital 30-day mortality was 8.5% and 7.7%, respectively. Of those admitted to GH, the prevalence of 30-day mortality after discharge and in-hospital 30-day mortality was 12.1% and 10.9%, respectively (Table 2).

4.2. Adjusted effect of nurse staffing level on mortality by hospital type

After adjusting for all of these confounders, the hazard ratio (HR) for 30-day mortality after discharge (HR: 1.177; *P*: .018) and in-hospital 30-day mortality (HR: 1.145; *P*: .058) in GH were higher than TH (Table 3).

Table 4 showed adjusted effect between nurse staffing level and 30-day mortality according to hospital type (e.g., TH and GH). After adjusting for all confounders in TH, HR in both 30-day mortality after discharge and in-hospital 30-day mortality were not statistically significant, but in GH setting, HR for 30-day mortality after discharge (HR: 1.499; *P*: .010) and in-hospital 30-day mortality (HR: 1.377; *P*: .042) were higher in grade 7 to 9 than grade 1 to 2. In addition, hospital technology, which is considered to be an important indicator of mortality of hospital

Table 1

General characteristics of participants.

			30-day mortality after discharge					In-hospital 30-day mortality				
	Total		No		Yes			No		Yes		
	N	%	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
Age	17,081	100.0	73.5	6.5	77.9	7.3	<.0001	73.5	6.5	78.0	7.4	<.0001
Number of doctors	17,081	100.0	339.5	305.0	266.5	247.8	<.0001	338.8	304.8	264.6	244.3	<.0001
			No	%	N	%		No	%	N	%	
Hospital type							<.0001					<.0001
Tertiary hospital (TH)	8428	49.3	7713	91.5	715	8.5		7780	92.3	648	7.7	
General hospital (GH)	8653	50.7	7603	87.9	1050	12.1		7712	89.1	941	10.9	
CCI							.064					.067
0	6752	39.5	6012	89.0	740	11.0		6081	90.1	671	9.9	
1	3934	23.0	3520	89.5	414	10.5		3568	90.7	366	9.3	
2	2593	15.2	2342	90.3	251	9.7		2361	91.1	232	9.0	
≥3	3802	22.3	3442	90.5	360	9.5		3482	91.6	320	8.4	
Sex							.001					.001
Male	8697	50.9	7868	90.5	829	9.5		7954	91.5	743	8.5	
Female	8384	49.1	7448	88.8	936	11.2		7538	89.9	846	10.1	
Income							.056					.098
Low	4450	26.1	3960	89.0	490	11.0		4013	90.2	437	9.8	
Middle	4378	25.6	3909	89.3	469	10.7		3953	90.3	425	9.7	
High	8253	48.3	7447	90.2	806	9.8		7526	91.2	727	8.8	
Type of insurance							.601					.401
Community insurance	5606	32.8	5045	90.0	561	10.0		5107	91.1	499	8.9	
Workplace insurance	10,033	58.7	8983	89.5	1050	10.5		9075	90.5	958	9.6	
Medical Aid	1442	8.4	1288	89.3	154	10.7		1310	90.9	132	9.2	
Region							.167					.071
Metropolitan	3582	21.0	3232	90.2	350	9.8		3274	91.4	308	8.6	
Urban	3725	21.8	3312	88.9	413	11.1		3347	89.9	378	10.2	
Rural	9774	57.2	8772	89.8	1002	10.3		8871	90.8	903	9.2	
Primary diagnosis							<.0001					<.0001
Angina pectoris	6604	38.7	6400	96.9	204	3.1		6427	97.3	177	2.7	
Acute myocardial infarction	7778	45.5	6428	82.6	1350	17.4		6548	84.2	1230	15.8	
Subsequent myocardial infarction	45	0.3	38	84.4	7	15.6		38	84.4	7	15.6	
Certain current complications following acute myocardial infarction	24	0.1	16	66.7	8	33.3		17	70.8	7	29.2	
Other acute ischemic heart diseases	90	0.5	76	84.4	14	15.6		77	85.6	13	14.4	
Chronic ischemic heart disease	2540	14.9	2358	92.8	182	7.2		2385	93.9	155	6.1	
Route of admission							<.0001					<.0001
Emergency	9253	54.2	8058	87.1	1195	12.9		8163	88.2	1090	11.8	
Outpatient	7828	45.8	7258	92.7	570	7.3		7329	93.6	499	6.4	
Organization type							<.0001					<.0001
Public	263	1.5	202	76.8	61	23.2		206	78.3	57	21.7	
Corporate	16,290	95.4	14,672	90.1	1618	9.9		14,836	91.1	1454	8.9	
Private	528	3.1	442	83.7	86	16.3		450	85.2	78	14.8	
Hospital technology							<.0001					<.0001
Low	6036	35.3	5180	85.8	856	14.2		5260	87.1	776	12.9	
Middle	6118	35.8	5598	91.5	520	8.5		5657	92.5	461	7.5	
High	4927	28.8	4538	92.1	389	7.9		4575	92.9	352	7.1	
Total	17,081	100.0	15,316	89.7	1,765	10.3		15,492	90.7	1589	9.3	

CCI = Charlson Comorbidity Index, SD = standard deviation.

in ICU, was associated with 1.330 times higher mortality (HR in in-hospital 30-day mortality: 1.328; *P*: .002) in hospital with low technology than high technology

5. Discussion

This study shows the differences that exist in grade of ICU nurse staffing with 30-day mortality among CV disease inpatients in Korea. An important finding of this study was that there was a more significant relationship between nurse staffing grade and mortality at GH rather than TH. In Korea, GHs are institutions that have a minimum of 100 inpatient beds and provide physician specialist services in major areas (e.g., internal medicine, surgery, and pediatrics) and THs indicate GHs that are approved to provide most types of advanced medical care and treat severely ill patients. So, GHs have a relatively lower need to improve nurse staffing than THs because they may be delivering care to patients with less critical conditions than those in THs. In contrast, nurse staffing grade in TH was not significantly associated with possibilities of dying. THs play a role as specialized care providers in Korea. Patients who require more intensive care tend to be admitted to THs following an easily obtainable referral from a primary care physician, where they can receive specialized high-quality care.[21] Therefore, it is possible that there are higher

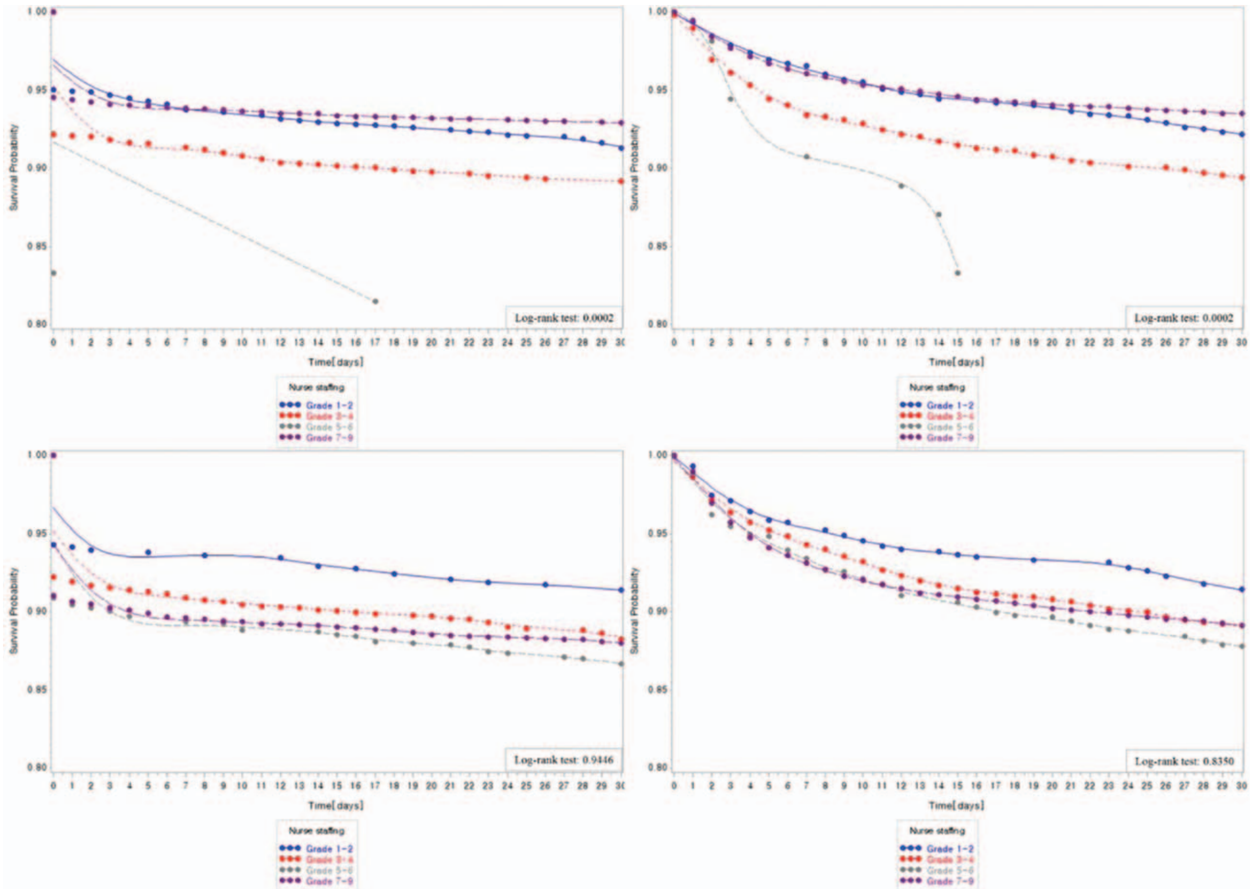

Figure 1. Thirty-day mortality after discharge (left) and in-hospital 30-day mortality (right) for tertiary (upper) and general (lower).

proportion of patients with greater severity of illnesses such as CV disease for the delivery of intensive and sophisticated care for patients in THs. Thus, this result suggests that mortality risk of THs that had highly intensive and complex medical technology in ICU may be more affected by advanced medical technology rather than nursing personnel.

The UK Department of Health and Intensive Care Society has proposed a minimum standard of a nurse-to-patient ratio of 1:1 for ICU patients.[22,23] The state of Victoria, Australia, has implemented a minimum ratio of 1 nurse to 1 unconscious patient or 2 to 4 highly dependent patients.[24] However, in Korea, this policy did not include adequate levels of nurse staffing, such as the mandated minimum nurse-to-patient ratios. Although there is a regulation regarding nurse staffing in hospital, approximately 50% of hospitals do not comply with the regulation, largely because there are no penalties for noncompliance.[25] Moreover, it does not consider the occupancy rate and does not reflect the number of direct nursing hours. Therefore, policymakers should

Table 2

General characteristics of participants by tertiary hospital (TH) and general hospital (GH).

	Total		30-day mortality after discharge					In-hospital 30-day mortality				
			No		Yes			No		Yes		
	N	%	N	%	N	%	*P* value	N	%	N	%	*P* value
Level of nurse staffing in TH							<.0001					<.0001
Grade 1–2	1762	20.9	1603	91.0	159	9.0		1624	92.2	138	7.8	
Grade 3–4	1729	20.5	1535	88.8	194	11.2		1546	89.4	183	10.6	
Grade 5–6	54	0.6	43	79.6	11	20.4		45	83.3	9	16.7	
Grade 7–9	4883	57.9	4532	92.8	351	7.2		4565	93.5	318	6.5	
Total	8428	100.0	7713	91.5	715	8.5		7780	92.3	648	7.7	
Level of nurse staffing in GH							.092					.181
Grade 1–2	584	6.8	530	90.8	54	9.3		534	91.4	50	8.6	
Grade 3–4	2047	23.7	1797	87.8	250	12.2		1824	89.1	223	10.9	
Grade 5–6	927	10.7	801	86.4	126	13.6		814	87.8	113	12.2	
Grade 7–9	5095	58.9	4475	87.8	620	12.2		4540	89.1	555	10.9	
Total	8653	100.0	7603	87.9	1050	12.1		7712	89.1	941	10.9	

Table 3

Adjusted effect of hospital type on mortality.

	30-day mortality after discharge			In-hospital 30-day mortality		
	HR	SE	*P* value	HR	SE	*P* value
Age	1.067	0.003	<.0001	1.069	0.004	<.0001
Number of doctors	1.000	0.000	.107	1.000	0.000	.046
Hospital type						
Tertiary hospital (TH)	1.000			1.000		
General hospital (GH)	1.177	0.069	.018	1.145	0.071	.058
CCI						
0	0.954	0.066	.475	0.991	0.069	.894
1	0.978	0.073	.764	0.982	0.077	.810
2	0.957	0.083	.597	1.006	0.086	.944
≥3	1.000			1.000		
Sex						
Male	1.038	0.050	.460	1.026	0.052	.626
Female	1.000			1.000		
Income						
Low	1.043	0.069	.538	1.073	0.072	.326
Middle	1.078	0.060	.210	1.107	0.062	.103
High	1.000			1.000		
Type of insurance						
Community insurance	1.208	0.104	.069	1.282	0.110	.023
Workplace insurance	1.278	0.106	.020	1.412	0.111	.002
Medical Aid	1.000			1.000		
Region						
Metropolitan	1.168	0.065	.017	1.162	0.068	.029
Urban	1.090	0.060	.151	1.126	0.062	.056
Rural	1.000			1.000		
Primary diagnosis						
Angina pectoris	0.421	0.104	<.0001	0.441	0.111	<.0001
Acute myocardial infarction	2.044	0.082	<.0001	2.243	0.088	<.0001
Subsequent myocardial infarction	1.513	0.388	.286	1.778	0.389	.139
Certain current complications following acute myocardial infarction	6.342	0.363	<.0001	6.859	0.388	<.0001
Other acute ischemic heart diseases	1.375	0.280	.255	1.476	0.291	.181
Chronic ischemic heart disease	1.000			1.000		
Route of admission						
Emergency	1.105	0.055	.068	1.133	0.057	.030
Outpatient	1.000			1.000		
Organization type						
Public	1.506	0.170	.016	1.608	0.176	.007
Corporate	0.948	0.117	.652	0.932	0.122	.567
Private	1.000			1.000		
Hospital technology						
Low	1.427	0.066	<.0001	1.426	0.068	<.0001
Middle	1.073	0.069	.308	1.066	0.072	.370
High	1.000			1.000		

CCI = Charlson Comorbidity Index.

consider several approaches to recommend improving? nurse staffing. Ideally, every hospital, to see how differences in policies and financial performance affect the cost-effectiveness of staffing and its effect on quality of health care, should be monitored.[26,27]

In a variety of healthcare and clinical settings, further research on the workforce is urgently required to guide decisions about safe staffing levels to ensure patient safety, because nurses and doctors may substitute 1 another, so that units that are short of doctors may compensate by hiring more nurses.[28]

A large number of units and patients analyzed in this study, as well as the use of appropriate methods for the structure of the data, are additional strengths of this study. These results will hopefully be developed in future qualitative and quantitative research. Despite access to a large national sample, this study has limitations in terms of interpreting and comparing results with other studies. Major limitation relates to risk adjustment in patient mortality. Although age, gender, income, type of insurance, residential region, primary diagnosis, and comorbidity for risk adjustment were used, we were not able to adjust treatment of ICU variable that may affect risk of mortality because of lack of information. Inaccuracy of risk adjustment may lead to skewed results. Furthermore, because our claim database analyzed do not contain any clinical findings or information about the disease's severity, we were unable to consider all possible covariates associated with risk of mortality. Therefore, our analytic approach was to apply regression models separately to tertiary and GHs because they had groups of patients and disease severity. Inclusion of hospital characteristics (i.e., ownership, hospital technology) should contribute indirectly to reducing variations in disease severity. Additional measures

Table 4

Adjusted effect of nurse staffing on mortality in hospital type.

	Tertiary hospital						General hospital					
	30-day mortality after discharge			In-hospital 30-day mortality			30-day mortality after discharge			In-hospital 30-day mortality		
	HR	SE	*P* value	HR	SE	*P* value	HR	SE	P-value	HR	SE	*P* value
Age	1.069	0.006	<.0001	1.070	0.006	<.0001	1.066	0.004	<.0001	1.069	0.005	<.0001
Number of doctors	1.000	0.000	.492	1.000	0.000	.304	0.999	0.000	0.111	0.999	0.000	.076
Level of nurse staffing in TH												
Grade 1–2	1.000			1.000			1.000			1.000		
Grade 3–4	1.038	0.120	.755	1.127	0.124	.333	1.367	0.159	0.049	1.277	0.160	.126
Grade 5–6	1.382	0.323	.316	1.171	0.358	.658	1.353	0.180	0.093	1.233	0.183	.250
Grade 7–9	0.967	0.106	.752	0.998	0.112	.982	1.499	0.156	0.010	1.377	0.157	.042
CCI												
0	0.943	0.101	.561	0.987	0.106	.905	0.970	0.089	0.732	0.999	0.093	.996
1	0.985	0.110	.892	0.995	0.116	.965	0.996	0.098	0.969	0.990	0.103	.921
2	0.835	0.130	.164	0.891	0.135	.392	1.064	0.109	0.570	1.108	0.114	.367
≥3	1.000			1.000			1.000			1.000		
Sex												
Male	0.978	0.078	.777	0.998	0.081	.984	1.074	0.065	0.273	1.038	0.068	.580
Female	1.000			1.000			1.000			1.000		
Income												
Low	0.935	0.109	.537	0.991	0.112	.939	1.142	0.090	0.140	1.151	0.094	.134
Middle	1.033	0.093	.728	1.054	0.097	.590	1.120	0.079	0.152	1.156	0.082	.076
High	1.000			1.000			1.000			1.000		
Type of insurance												
Community insurance	1.512	0.227	.068	1.349	0.224	.181	1.151	0.121	0.246	1.258	0.129	.076
Workplace insurance	1.543	0.229	.058	1.441	0.225	.105	1.270	0.124	0.054	1.442	0.132	.005
Medical Aid	1.000			1.000			1.000			1.000		
Region												
Metropolitan	1.154	0.096	.136	1.105	0.101	.322	1.228	0.092	0.025	1.258	0.096	.017
Urban	1.156	0.095	.127	1.136	0.098	.192	1.054	0.079	0.510	1.122	0.081	.158
Rural	1.000			1.000			1.000			1.000		
Primary diagnosis												
Angina pectoris	0.407	0.162	<.0001	0.447	0.168	<.0001	0.428	0.140	<.0001	0.442	0.151	<.0001
Acute myocardial infarction	2.118	0.121	<.0001	2.223	0.127	<.0001	2.014	0.115	<.0001	2.285	0.124	<.0001
Subsequent myocardial infarction	0.000	166.518	.952	0.000	181.722	.956	1.782	0.396	0.145	2.180	0.399	.051
Certain current complications following acute myocardial infarction	7.317	0.428	<.0001	9.536	0.431	<.0001	4.605	0.721	0.034	2.602	1.011	.344
Other acute ischemic heart diseases	1.619	0.589	.413	1.180	0.718	.817	1.333	0.323	0.373	1.572	0.326	.166
Chronic ischemic heart disease	1.000			1.000			1.000			1.000		
Route of admission												
Emergency	0.987	0.098	.893	1.030	0.103	.776	1.191	0.068	0.010	1.212	0.071	.007
Outpatient	1.000			1.000			1.000			1.000		
Organization type												
Public	6.252	0.603	.002	8.374	0.605	.000	1.479	0.175	0.025	1.567	0.180	.013
Corporate	1.000			1.000			0.984	0.124	0.897	0.985	0.129	.909
Private	N/A			N/A			1.000			1.000		
Hospital technology												
Low	1.467	0.101	.000	1.486	0.105	.000	1.330	0.090	0.002	1.328	0.094	.002
Middle	1.102	0.096	.312	1.155	0.100	.147	1.051	0.101	0.623	1.010	0.106	.925
High	1.000			1.000			1.000			1.000		

CCI = Charlson Comorbidity Index, HR = hazard ratio, TH = tertiary hospital.

that take account of severity of illness are needed for more complete risk adjustment. Second, the rates of nurse turnover at different types of hospitals were not considered in this study. A higher turnover rate will increase the cost of employing nurses, and so further studies considering nurse turnover will be helpful to understand the nurse staffing levels at specific hospitals. Finally, we used an anonymized and auto-generated claim database with *ICD-10* codes, limiting validation of the individual ICD codes. In particular, there is frequent under-reporting of certain medical conditions resulting in incomplete coding.[29,30]

6. Conclusions

The findings of this study show that increased nurse staffing levels related to improved mortality risk in ICU of GHs in Korea. Therefore, adequate nurse staffing to provide safe and high-quality care can be ensured by continuous monitoring and evaluation of nurse staffing. These findings recommend that a strategy need to be developed towards better compliance to conduct future research.

Author contributions

KJH contributed to designing the study and editing the manuscript. JHK collected, analyzed and interpreted the data and writes the manuscript
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References

[1] Tam V, Steven FA, Hillman KM, et al. Using administrative data to develop a nomogram for individualizing risk of unplanned admission to intensive care. Resuscitation 2008;79:241–8.

[2] Bastero-Minon P, Russell JL, Humpl T. Frequency, characteristics, and outcomes of pediatric patients readmitted to the cardiac critical care unit. Intensive Care Med 2012;38:1352–7.

[3] Sandelowski M. Devices and Desires: Gender, Technology and American Nursing. The University of North Carolina Press, , Chapel Hill, London:2000.

[4] West E, Rafferty A-M, Rowan K. Preserving the humanity of care in high-tech environments. Paper Given at the In Sickness and in Health Conference Iceland 2004.

[5] Zulli R, Nicosia F, Borroni B, et al. Increased prevalence of silent myocardial ischaemia and severe ventricular arrhythmias in untreated patients with Alzheimer's disease and mild cognitive impairment without overt coronary artery disease. Clin Neurol Neurosurg 2008;110:791–6.

[6] Lankshear AJ, Sheldon TA, Maynard A. Nurse staffing and healthcare outcomes: a systematic review of the international research evidence. ANS Adv Nurs Sci 2005;28:163–74.

[7] Tong PK. The effects of California minimum nurse staffing laws on nurse labor and patient mortality in skilled nursing facilities. Health Econ 2011;20:802–16.

[8] Tourangeau AE, Cranley LA, Jeffs L. Impact of nursing on hospital patient mortality: a focused review and related policy implications. Qual Saf Health Care 2006;15:4–8.

[9] Cho SH, Yun SC. Bed-to-nurse ratios, provision of basic nursing care, and in-hospital and 30-day mortality among acute stroke patients admitted to an intensive care unit: cross-sectional analysis of survey and administrative data. Int J Nurs Stud 2009;46:1092–101.

[10] Buchan J. A certain ratio? The policy implications of minimum staffing ratios in nursing. J Health Serv Res Policy 2005;10:239–44.

[11] Kim Y, Kim J. Impact of a financial incentive policy on Korean nurse staffing. Int Nurs Rev 2015;62:171–9.

[12] Ministry of Health & Welfare. Notification no. 2006-97: Details of revised application standard and methods for medical care benefits and relative value scale. 2006. Available at: http://www.mw.go.kr/front_new/jb/sjb0402vw.jsp?PAR_MENU_ID=03&MENU_ID=030402&BOARD_ID =220&BOARD_FLAG=03&CONT_SEQ=39840&page=1.Accessed June 20, 2014.

[13] Kim MA. Reform of nursing differentiation fee regulation: for the development of hospital nursing. Webzine Daehankanho 2007;46:1–4.

[14] Ministry of Health & Welfare. Notification no. 2007-272: Revision of medical care benefits and relative value scale. 2007. Available at: http://www.mw.go.kr/front_new/jb/sjb0403vw.jsp Accessed June 20, 2014).

[15] Cho SH, June KJ, Kim YM, et al. Changes in hospital nurse staffing after implementing differentiated inpatient nursing fee by staffing grades. J Korean Acad Nurs Adm 2008;14:167–75.

[16] Kim YM, Kim J, June KJ, et al. Changing trend in grade of nursing management fee by hospital characteristics: 2008-2010. J Korean Clin Nurs Res 2010;16:99–109.

[17] Yoon HS, Kim J. Activity-based costing analysis of nursing activities in general hospital wards. J Korean Acad Nurs Adm 2013;19:449–61.

[18] Cho SH, Hwang JH, Kim J. Nurse staffing and patient mortality in intensive care units. Nurs Res 2008;57:322–30.

[19] Lee J, Lee JS, Park SH, et al. Cohort profile: the national health insurance service-national sample cohort (NHIS-NSC), South Korea. Int J Epidemiol 2016;46:e15.

[20] Kim JH, Lee Y, Park EC. Beyond volume: hospital-based healthcare technology as a predictor of mortality for cardiovascular patients in Korea. Medicine (Baltimore) 2016;95:e3917.

[21] Chun CB, Kim SY, Lee JY, et al. Republic of Korea: health system review. Health Syst Transit 2009;11:1–84.

[22] Adomat R, Hewison A. Assessing patient category/dependence systems for determining the nurse/patient ratio in ICU and HDU: a review of approaches. J Nurs Manag 2004;12:299–308.

[23] Beattie J, Calpin-Davies PJ. Workforce dilemmas: a comparison of staffing in a generalist and a specialist intensive care unit. Intensive Crit Care Nurs 1999;15:52–7.

[24] Australian Nursing Federation-Victorian, Branch, Summary of nurse-patient ratio agreement. 2000. Available at:http://www.anfvic.asn.au/news_briefs/news_ratios%20summary.htm. Accessed on February 2, 2007.

[25] Cho S, June KJ, Kim Y, et al. Changes in hospital nurse staffing after implementing differentiated inpatient nursing fees by staffing grades. J Korean Acad Nurs Adm 2008;14:167–75.

[26] Spetz J. Public policy and nurse staffing: what approach is best? J Nurs Adm 2005;35:14–6.

[27] White KM. Policy spotlight: staffing plans and ratios. Nurs Manage 2006;37: 18–22, 4.

[28] Carmel S. Boundaries obscured and boundaries reinforced: incorporation as a strategy of occupational enhancement for intensive care. Sociol Health Illn 2006;28:154–77.

[29] Bhattacharyya T, Iorio R, Healy WL. Rate of and risk factors for acute inpatient mortality after orthopaedic surgery. J Bone Joint Surg Am 2002;84-A:562–72.

[30] Iezzoni LI, Foley SM, Daley J, et al. Comorbidities, complications, and coding bias. Does the number of diagnosis codes matter in predicting in-hospital mortality. JAMA 1992;267:2197–203.