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Effects of nurse staffing, work environments, and education on patient mortality: An observational study

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Abstract

Background—While considerable evidence has been produced showing a link between nursing characteristics and patient outcomes in the U.S. and Europe, little is known about whether similar associations are present in South Korea.

Objective—To examine the effects of nurse staffing, work environment, and education on patient mortality.

Methods—This study linked hospital facility data with staff nurse survey data (N=1,024) and surgical patient discharge data (N = 76,036) from 14 high-technology teaching hospitals with 700 or more beds in South Korea, collected between January 1, 2008 and December 31, 2008. Logistic regression models that corrected for the clustering of patients in hospitals were used to estimate the effects of the three nursing characteristics on risk-adjusted patient mortality within 30 days of admission.

Results—Risk-adjusted models reveal that nurse staffing, nurse work environments, and nurse education were significantly associated with patient mortality (OR 1.05, 95% CI 1.00–1.10; OR 0.52, 95% CI 0.31–0.88; and OR 0.91, CI 0.83–0.99; respectively). These odds ratios imply that each additional patient per nurse is associated with an 5% increase in the odds of patient death

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within 30 days of admission, that the odds of patient mortality are nearly 50% lower in the hospitals with better nurse work environments than in hospitals with mixed or poor nurse work environments, and that each 10% increase in BSN nurse is associated with a 9% decrease in patient deaths.

Conclusions—Nurse staffing, nurse work environments, and percentages of BSN nurses in South Korea are associated with patient mortality. Improving hospital nurse staffing and work environments and increasing the percentages of BSN nurses would help reduce the number of preventable in-hospital deaths.

Keywords

Mortality; Nursing education; Nurse staffing; Nurse work environment; Patient outcomes

1. Introduction

South Korea has undergone changes in health care services since the National Health Insurance system was introduced in 1989. Although South Korea has achieved a remarkable expansion of acute hospital services, the quality of health care has been rated lower than the average of the Organization for Economic Cooperation and Development (OECD) member countries (OECD, 2012). For example, South Korea has the highest mortality rates for acute myocardial infarction among OECD countries (OECD, 2012). Furthermore, South Korea has not been able to submit patient safety data to the OECD due to a lack of monitoring systems and patient safety policies (Park, 2012).

According to recent comparisons of nurse-rated quality of care in nine countries—the United States, China, South Korea, Thailand, Japan, New Zealand, the United Kingdom, Canada, and Germany—South Korean nurses were more likely than nurses in other countries to report that the quality of care on their unit was only fair or poor (Aiken et al., 2011). The quality of care was judged to be fair or poor by 68% of nurses in South Korea compared to only 11% in Canada. This finding suggests that South Korean health care systems need to develop appropriate strategies for improving health care quality and safety.

Adequate nursing care is essential for health care quality and safety. Nurses are in a good position to detect patient problems (Clarke and Aiken, 2003), which is one reason that nurse staffing, nurse work environments, and nurse education appear to have significant effects on patient outcomes. Nurse surveillance, which involves the ongoing observation, assessment, recognition and interpretation of patient data, is a critical component of nursing care (Kutney-Lee et al., 2009). As around-the-clock care providers, nurses act as the hospital's surveillance system for the early detection and prevention of adverse events (Clarke and Aiken, 2003). Surveillance is directly influenced by the organizational structure of the hospital (Clarke and Aiken, 2003, Kutney-Lee et al., 2009). Adequate nurse staffing allows nurses to spend the most time with patients, while better nurse education and a favorable nurse practice environment influence the timeliness of interventions once a potential or acute patient problem has been identified. Among patient outcomes, mortality is the most important and often used indicator of quality of care at hospitals. A number of large-scale studies conducted in the North America (Aiken et al., 2011, Estabrooks et al., 2005, Kane et

al., 2007, Needleman et al., 2011, Shekelle, 2013) and recently in Europe (Aiken et al., 2014) have documented an association between nursing factors and hospital mortality.

An inadequate nurse work environment – a work environment lacking in adequate resources, strong nurse leadership, collegial relationships between nurses and physicians, ardent nurse participation in hospital affairs, and a solid nursing foundation for quality of care--also appears to negatively affect both nurses and patients. Poor work environments that make it difficult for nurses to perform their professional roles have been shown in studies of hospitals in the U.S., Europe and China to lead to nurse burnout and dissatisfaction, to poorer quality of patient care, and to lower patient satisfaction and worse patient outcomes, including mortality (Aiken et al., 2011, Aiken et al., 2012, Estabrooks et al., 2005, Kazanjian et al., 2005). A recent study revealed that only 28.8% of Korean hospitals were categorized as having a better work environment than average, while 33.3% to 45.5% of hospitals in other countries were rated as having an above-average work environment (Aiken et al., 2011). Furthermore, the Korean hospitals were rated as having the highest rates of nurse burnout (Aiken et al., 2011).

The level of nurse education also appears to affect patient outcomes. Many recent studies have reported that, when the proportion of nurses with a Bachelor's or higher degree is high, patient mortality is low (Aiken et al., 2011, Aiken et al., 2014, Blegen et al., 2013, Kutney-Lee et al., 2013, Van den Heede et al., 2009). There are two educational systems for nurses in South Korea. One is an associate's degree program in which a three-year nursing education curriculum is provided at a community college level. The other is a Bachelor's degree program offered at a four-year university level. When looking at the proportions of the 12,578 new students enrolled in nursing majors in 2009 in South Korea, students in three-year programs accounted for 60.5% of all students, while four-year nursing students accounted for only 39.5% (Lee, 2012). In addition, only 43.7% of nurses working in Korean hospitals with more than 100 beds have a Bachelor's degree or higher (Aiken et al., 2011).

There is evidence in other countries that nurse staffing, work environments, and education are associated with patient mortality. However, there have been only two studies in South Korea suggesting that nurse staffing is associated with patient mortality, and both focused on intensive care units (Cho et al., 2008, Cho and Yun, 2009). Moreover, the impacts of variation in nurse education and work environments have not been studied in South Korea in relation to patient mortality. Thus, the purpose of this study was to investigate the effects of nurse staffing, work environment, and education on patient mortality in general acute care hospitals in South Korea.

2. Methods

2.1. Design

This study uses data from multiple sources in an attempt to replicate and extend, using data from South Korea, the findings of Aiken and colleagues showing the relationships of hospital nursing characteristics with patient mortality in the United States and Europe (Aiken et al., 2011; Aiken et al., 2011). We combined 1) data on nurse staffing, work environments, and education from surveys of nurses with 2) data on patient characteristics

and other information (including 30-day mortality) from patient discharge records and 3) hospital characteristics from facility data. Hospital discharge data and facility data were collected by the Health Insurance Review Agency (HIRA). We collected the nurse survey data from nurses working in 14 acute care hospitals randomly selected from all 47 hospitals operating 700 or more beds in South Korea from October 2008 to July 2009. Hospital discharge data and facility data from January 2008 to December 2008 were linked to the nurse survey data from the HIRA. This study was approved by the Institutional Review Board of Yonsei University College of Nursing.

2.2. Participants

2.2.1. Hospitals—Sixteen acute hospitals were randomly selected from all acute hospitals operating 700 or more beds in 2008 (n = 47) by a stratified random sampling method based on location (Seoul, other metropolitan areas, non-metropolitan areas) and number of beds (700–999, 1,000 and above). Fourteen of the 16 hospitals agreed to participate in the study, which is an 88% response rate at the hospital level.

2.2.2. Nurses—We selected general wards and special units (intensive care unit, delivery room, perioperative unit, emergency room, psychiatric ward, hemodialysis unit, pediatrics, newborns, and clinics) for the survey. The number of general wards selected for the survey depended on the number of beds because the number of general wards and nurses varied according to the number of beds of the hospitals. Thus, 50% of all general units from the hospitals with 700–999 beds and 20% of all general units from the hospitals with 1,000 or more beds were selected randomly. Additionally, one unit from each special unit was selected randomly from each hospital. Questionnaires were distributed to all nurses working in the randomly selected general wards and special units on the data collection day in each hospital from October 2008 to July 2009. Questionnaires were distributed with a cover page explaining the study purpose, methodology, and instructions. The nurses were instructed to complete the questionnaires in private and to seal the completed surveys in envelopes provided by the research team in order to ensure the confidentiality of participants' responses. The survey responses were deposited in locked collection boxes in the hospitals and sent to the researchers by mail. All of the nurses who were working in the selected wards or units on the day the questionnaires were distributed (n=2,355) were asked to participate in the survey, and 2,277 (96.7%) of these nurses returned the questionnaires.

In order to analyze only bedside nurses, all nurses who reported that their job title was "nurse" and that their current position involved "direct patient care" were included in the analysis (n=2,111), though nurses who reported that they had cared for no patients or more than 40 patients on the last shift (n=517) were excluded from this analysis because it seemed unlikely that they were bedside nurses. We also excluded 570 nurses that worked on units on which surgical patients were unlikely to receive care (i.e., psychiatric units, neonatal units, etc.). In the end, 1,024 bedside nurses were included in the analysis. The 14 hospitals had an average of 73 nurses that responded to the nurse survey and were included in the analyses.

2.2.3. Patients—Surgical patients (N = 76,036) aged 19 to 89 years who underwent general, orthopedic, or vascular surgery from January 1, 2008 to December 31, 2008 in the

study hospitals were included in this study. The surgical patient diagnosis-related groups (DRGs) included were as follows: general surgery (146–155, 157–162, 164–167, 170, 171, 191–201, 257–268, 285–293, 493, and 494), orthopedic surgery (209–211, 213, 216–219, 223–234, 471, 491, and 496–503), and vascular surgery (110–114, 119, and 120). Only data related to the first admission were analyzed for patients who had multiple admissions over the study period.

2.3. Measures

2.3.1. Hospital characteristics—The 2008 facility data of the HIRA provided data on hospital characteristics that were considered as control variables. These characteristics included location (metropolitan vs. non-metropolitan), number of beds (700−999 vs. 1,000 or more), teaching status (hospitals with any postgraduate residents or interns were considered to be teaching hospitals, and others were considered to be non-teaching hospitals), and technology (high-technology hospitals were considered to be those that conducted open-heart surgery or major organ transplants such as kidney, liver, pancreas, heart, lung, and tissue transplants in 2008). While a number of the studies cited above controlled for differences across hospitals in teaching status and technology, such controls were unnecessary in the present study since all of the 14 hospitals were high-technology, teaching hospitals.

2.3.2. Hospital-level nursing characteristics derived from nurse surveys—The nurse surveys provided the data that were used to derive hospital-level measures of nurse staffing, work environments, and education. Nurse staffing was computed as the average number of patients that nurses reported caring for on their last shift. The nurse work environments were measured using the Korean Practice Environment Scale of the Nursing Work Index (PES-NWI) (Cho et al., 2011), which is composed of 29 items scored using a Likert-type scale (from 1 = strongly disagree to 4 = strongly agree) that are summed to form five subscales (nurse participation in hospital affairs, nursing foundation for quality of care, nurse manager ability-leadership-support of nurses, staffing–resource adequacy, and collegial nurse–physician relationship). The average of each subscale for all nurses in each hospital was calculated, as was the overall medians for each subscale across all hospitals. The work environment for each hospital was then determined by counting the number of subscale totals in each hospital that were above. Hospitals with four or five of the subscale totals above the median were categorized as having “better” work environments, those with two or three subscale totals above the median were categorized as providing “mixed” work environments, and those with only one or no subscale total above the median were categorized as having “poor” work environments. The reported Cronbach’s alpha of these five subscales in the original PES-NWI ranged from 0.71 to 0.84 (Lake, 2002), and the Cronbach’s alpha for these subscales in the Korean PES-NWI ranged from 0.80 to 0.84 (Cho et al., 2011). Nurse education was measured by calculating the percentage of nurse respondents in each hospital with at least a Bachelors’ degree. Survey data were also used to determine the type of unit on which reporting nurses worked (medical and surgical, perioperative, emergency room, intensive care, or other units).

2.3.3. Patient mortality and characteristics—The 2008 patient discharge data of the HIRA, after being linked to vital statistics data (death records), provided information on patient mortality and on patient characteristics needed for risk adjustment. Thirty-day mortality (in-hospital death within 30 days of admission + death after discharge within 30 days of admission) was analyzed in this study after adjusting for patient characteristics such as age, gender, whether the patient was transferred from another hospital or admitted emergently, type of surgery by major diagnostic category (MDC), and the absence or presence of 23 chronic preexisting conditions as classified by International Classification of Diseases, version 10, Clinical Modification (ICD-10-CM) codes. The chronic conditions we controlled for analytically were a subset of Elixhauser's (1998) list of 30 comorbidities, with HIV/AIDS, obesity, blood loss anemia, and drug abuse having been eliminated because they were extremely uncommon in the Korean data ($n < 10$ in all cases), and with Elixhauser's two diabetes groups and three cancer groups having been combined into two broader categories.

2.4. Data analysis

Descriptive statistics were used to describe the characteristics of the hospitals, nurses, and patients. Logistic regression models which allowed for the clustering of patients within hospitals were used to assess the effects of nurse staffing, work environment, and education on surgical patient mortality within 30 days of admission, including deaths after discharge as well as those in the hospital. These effects were estimated, separately, before and after controlling for hospital characteristics and patient characteristics. The hospital characteristics included location and number of beds. Patient characteristics included age, gender, surgery type (five dummy variables were used to contrast the six major diagnostic categories), preexisting conditions (23 indicator variables were used to control for the presence or absence of the 23 comorbidities), and whether patients were transferred from another hospital or admitted to the emergency department. Statistical analysis was performed using STATA (version 13.1, College Station, TX, USA).

3. Results

3.1. Characteristics of hospitals, nurses, and patients

The characteristics of the 14 study hospitals and the numbers and percentages of nurses surveyed in and patients discharged from hospitals with various characteristics are shown in Table 1. Ten of the 14 hospitals (71.4%) were located in metropolitan areas, and those hospitals accounted for 853 (83.3%) of the surveyed nurses and 62,867 (82.7%) of the discharged patients. Seven hospitals (50%) had 1,000 or more beds, and those hospitals employed 637 (62.2%) of the nurses and discharged 51,185 (67.3%) of the patients in the sample. Across all hospitals the mean number of patients per nurse assigned on the last shift was 11.4. Five hospitals (35.7%) had poor work environments, and 227 (22.1%) of the surveyed nurses and 20,373 (26.8%) of the discharged patients were from those hospitals. Five hospitals (35.7%) were characterized by better work environments, and those hospitals employed 488 (47.7%) of the nurses and discharged 40,892 (53.8%) of the patients. Across all of the hospitals, the mean percentage of nurses having a Bachelor of Science in Nursing (BSN) or higher degree was 58.3%. In eight hospitals (57.1%), 60% or more of nurses had

BSN or higher degrees, and those hospitals employed 712 (69.6%) of the nurses and discharged 57,924 (76.2%) of the patients. In three hospitals (21.4%), less than 40% of the nurses had BSN or higher degrees, and those hospitals accounted for 151 (14.8%) nurses and 9,763 (12.8%) patients. The number of nurses surveyed in the different units were 446 (43.6%) in medical and surgical units, 153 (14.9%) in perioperative units, 220 (21.5%) in emergency units, and 205 (20.0%) in intensive care units.

Table 2 provides information on characteristics of the 76,036 patients in the study hospitals. The mean age of patients was 55 years, and 38,072 (50.1%) were male. Transferred patients accounted for 2,422 (3.4%) of the sample, and patients admitted as emergency cases numbered 16,321 (22.6%) of all surgical patients in the sample. Orthopedic surgery was the most common procedure at 21,362 (28.1%), followed by vascular 14,682 (19.3%), hepatobiliary 13,539 (17.8%), and digestive tract surgeries 10,962 (14.4%). Hypertension (23.4%) and diabetes mellitus (15.2%) were the most frequent comorbidities. Only 514 of the 76,036 surgical patients in the study (0.7%) died within 30 days of admission.

3.2. Effects of hospital nurse staffing, work environment, and education on patient mortality

Table 3 shows the unadjusted (bivariate) coefficients and their related probabilities indicating the size and significance of the associations of nurse staffing, work environment, and education with patient mortality, as well as coefficients and probabilities from fully adjusted models that control for patient and hospital characteristics. The adjusted models indicate significant effects of nurse staffing, work environment, and nurse education. The odds ratio (OR) of 1.05 reflects the effect of nurse staffing on patient mortality in the adjusted model and indicates that each additional patient per nurse added to the average nurse workload in a hospital is associated with a 5% increase in the odds of patient mortality. Regarding the effect of nurse work environment on patient mortality, the OR of 0.52 indicates that the odds of patient mortality is nearly 48% lower in hospitals with better nurse work environments than in hospitals with mixed or poor nurse work environments. The odds ratio (0.91) associated with the effect of nurse education implies that each 10% increase in BSN nurse is associated with a 9% decrease in patient deaths.

4. Discussion

In this study, each nurse was, on average, caring for 11.4 patients, with significant variation in workload across hospitals. Thus, nurses in South Korea care for about twice as many patients as do nurses in the United States (5.7 patients) (Aiken et al., 2013) and some European countries, including Finland (5.5 patients), Sweden (5.4 patients), and Norway (3.7 patients) (Aiken et al., 2013). Our findings confirm that higher ratios of patients to nurses is associated with higher patient mortality rates at Korean hospitals, in agreement with previous studies conducted in other countries (Aiken et al., 2011, Aiken et al., 2014, Estabrooks et al., 2005, Needleman et al., 2011, Rafferty et al., 2007). A policy of the Korean government to increase nurse staffing has a financial incentive in that the National Health Insurance (NHI) pays higher fees for inpatient nursing care to hospitals with better nurse staffing based on the ratio of the number of beds to nurses (Cho and Yun, 2009). The

nurse staffing of general wards is categorized as Grade 1 (highest) to Grade 7 (lowest) based on the number of beds per nurse. Although hospitals have improved nurse staffing since this policy was implemented in 1999, three-fifths of acute hospitals (59.9%) still received the lowest grade (Grade 7) of nurse staffing (Kim et al., 2010). Therefore, the policy on nurse staffing in South Korea needs to be modified to make it more effective in leading hospitals to prevent patient deaths by increasing nurse staffing.

Our results show that nurse work environments have a significant effect on patient mortality, consistent with findings from previous studies in other countries (Aiken et al., 2011, Estabrooks et al., 2005). The average number of years worked as a nurse in this study was 5.5 years, indicating a much shorter working experience than those in the United States (15.1 years), Canada (17.7 years), and New Zealand (16.7 years) (Aiken et al., 2011). A short working experience reflects high nurse turnover. According to results from a 2010 Korean nationwide survey (Noh et al., 2011), 30.5% of 10,234 nurses newly employed in acute hospitals appeared to have quit their jobs within a year. This low rate of nurse retention reflects the poor nurse work environments. These results make it clear that Korean hospitals should improve the nurse work environments to increase nurse retention and quality of care. The level of nurse education in this study also showed a significant association with patient mortality, which is consistent with results found in other countries, including the United States (Aiken et al., 2011, Blegen et al., 2013, Kutney-Lee et al., 2013), Canada (Estabrooks et al., 2005), Belgium (Van den Heede et al., 2009), and Europe (Aiken et al., 2014).

The current study has some limitations. First, the studied hospitals included only 14 large, teaching, high-technology hospitals having more than 700 beds and variation is more limited than in a national sample of all hospitals. Thus, the findings of significant associations of nurse staffing, nurse work environment, and nurse education with patient mortality probably underestimate the associations in a national sample. Nurse survey data and patient discharge data are not aligned perfectly given a lag in the availability of mortality data and thus are from two consecutive but different years. However, we suspect that better matched data would have changed the results favorably, if at all. Other large scale research published recently shows similar effects of nursing on mortality using survey and patient data that are not perfectly aligned (Aiken et al., 2014). Therefore, more research should be conducted with a wider range of hospitals and, if possible, with more closely aligned data (from nurses and patients) to verify the associations among patient mortality, nurse staffing, work environments, and nurse education. This is especially important since the data for this study are now roughly five years old, and changes may have occurred in each of the study variables and in their underlying associations. Additionally, although Elixhauser comorbidities were used for the risk adjustment of patient comorbidity in this study (Elixhauser et al., 1998), some of the 30 comorbidities used in the Elixhauser comorbidities had low frequencies because the subjects in this study were surgical patients, and we only studied 14 hospitals; therefore, some of the comorbidities were excluded from the final analytic model. One final limitation is that inferences about causal relationships of nurse staffing, work environment, and education on patient mortality are limited because of the cross-sectional nature of the data.

Despite these limitations, this is the first study to analyze hospital outcomes based on data from nurses and patients from both general wards and special units in Korean acute hospitals with a nationwide sample through a stratified random sampling method. The questionnaire survey for nurses had a high response rate (96.7%). Additionally, this study analyzed the number of patients per nurse collected from a bedside nurse survey, which more correctly reflects the clinical workload of each nurse than administrative data because nurses who are not involved in direct patient care were not included in this study. This study also analyzed deaths within 30 days after admission to the hospital, including death after discharge as well as in-hospital mortality; thus, deaths after being discharged from the hospital were not missed. This study had the additional strength of being able to objectively compare the associations of nurse staffing, work environment, and nurse education with patient mortality in Korean hospitals with those obtained from studies conducted in other countries because this study applied methods validated in several countries (Aiken et al., 2011, Aiken et al., 2014, Aiken et al., 2011).

In 2010, the Korean government introduced a new health care accreditation system to encourage hospitals to work continuously on improving quality of care (Chang and Lee, 2012). While the Korean government has been trying to improve hospital quality, nurse staffing, work environments, and nurse education have drawn little attention. Our findings show that poor nurse staffing and nurse work environments as well as fewer BSN nurses are associated with higher patient mortality. Korean policy recommendations should be informed by these findings as they point to interventions that may hold promise for improving patient outcomes and hospital quality.

5. Conclusions

The study results suggest that higher patient to nurse workloads, poor work environments, and fewer BSN nurses in South Korean hospitals may be responsible for preventable hospital deaths. Nurse staffing at major Korean teaching hospitals does not compare favorably with staffing in other developed countries, the work environments at some of these important hospitals were poor, and some hospitals had small percentages of BSN nurses. Improving nurse staffing and nurse work environments and increasing the percentage of BSN nurses in Korean hospitals are promising strategies to improve quality of care and patient outcomes.

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What is already known about the topic?

- Studies of hospitals in Western countries indicate that nurse staffing, work environments, and level of education are associated with patient mortality.
- Studies in South Korean hospitals show that the level of ICU nurse staffing is associated with patient mortality, but a broader impact of nurse staffing has not been reported.

What this paper adds?

- Nurses in South Korean hospitals care for about twice as many patients as hospital nurses in the United States and European countries.
- Fewer patients per nurse and better nurse work environments in South Korean hospitals are associated with lower patient mortality.

Table 1

Characteristics of the hospitals, registered nurses, and surgical patients in the study.

Characteristic	Category	Hospitals *n* and (%)	Nurses *n* and (%)	Patients *n* and (%)
Location	**Metropolitan**	10 (71.4)	853 (83.3)	62,867 (82.7)
	Nonmetropolitan	4 (28.6)	171 (16.7)	13,169 (17.3)
Number of beds	**700 – 999**	7 (50.0)	387 (37.8)	24,851 (32.7)
	1,000 or above	7 (50.0)	637 (62.2)	51,185 (67.3)
Number of patients per nurse	**M ± SD**	11.4±2.9	10.8±2.2	
Nurse work environment	**Poor (0, 1)**	5 (35.7)	227 (22.1)	20,373 (26.8)
	Mixed (2, 3)	4 (28.6)	309 (30.2)	14,771 (19.4)
	Better (4, 5)	5 (35.7)	488 (47.7)	40,892 (53.8)
Nurse education (Percent with BSN)	**0–19**	2 (14.3)	96 (9.4)	6536 (8.6)
	20–39	1 (7.1)	55 (5.4)	3227 (4.2)
	40–59	3 (21.4)	161 (15.7)	8349 (11.0)
	60–79	5 (35.7)	400 (39.1)	29,289 (38.5)
	≥80	3 (21.4)	312 (30.5)	28,635 (37.7)
	M±SD	58.3 ± 26.7		
Type of unit	**Medical and Surgical Units**		446 (43.6)	
	Perioperative		153 (14.9)	
	Emergency Room		220 (21.5)	
	Intensive Care Unit		205 (20.0)	

Notes: *n* = number; M = mean; SD = standard deviation; and BSN = Bachelor of Science in Nursing.
The numbers of hospitals, nurses, and patients on which percentages were based were 14, 1,024, and 76,036, respectively.

Table 2

Characteristics of patients in the study hospitals (N = 76,036).

Variable	*n* (%)	
Age (in years): mean (SD)	54.99	(15.66)
Male	38,072	(50.1)
Transfer [a]	2,422	(3.4)
Emergency admission [a]	16,321	(22.6)
Major Diagnostic Categories (MDCs)		
General surgery		
Diseases and disorders of the digestive system (MDC 6)	10,962	(14.4)
Diseases and disorders of the hepatobiliary system (MDC 7)	13,539	(17.8)
Diseases and disorders of the skin, subcutaneous tissue, or breast (MDC 9)	8,475	(11.2)
Endocrine, nutritional, or metabolic diseases and disorders (MDC 10)	7,016	(9.2)
Orthopedic surgery		
Diseases and disorders of the musculoskeletal system (MDC 8)	21,362	(28.1)
Vascular surgery		
Diseases and disorders of the circulatory system (MDC 5)	14,682	(19.3)
Comorbidities[b]		
Congestive heart failure	1,053	(1.4)
Arrhythmia	4,009	(5.3)
Aortic stenosis	826	(1.1)
Pulmonary circulation disorders	249	(0.3)
Peripheral vascular disorders	939	(1.2)
Hypertension	17,813	(23.4)
Paralysis	275	(0.4)
Neurodegenerative disorders	419	(0.6)
Chronic obstructive pulmonary disease	3,700	(4.9)
Diabetes mellitus	11,518	(15.2)
Hypothyroidism	1,280	(1.7)
Renal failure	805	(1.1)
Liver disease	6,822	(9.0)
Peptic ulcer disease, no bleeding	4,411	(5.8)
Cancer	5,586	(7.4)
Rheumatoid arthritis/collagen vascular diseases	200	(0.3)
Coagulopathy	1,800	(2.4)
Weight loss	3,105	(4.1)
Fluid and electrolyte disorders	1,481	(1.9)
Deficiency anemia	1,786	(2.3)
Alcohol abuse	258	(0.3)
Psychoses	179	(0.2)
Depression	543	(0.7)
Death within 30 days of admission	514	(0.7)

Notes: M = mean; SD = standard deviation; *n* = number; MDC = major diagnostic category.

[a] Information was missing on transfer or emergency admission status for 3,751 of the 76,036 patients (4.9%).

[b] The comorbidities listed are from Elixhauser (1998). We excluded, in the table and in our analyses, HIV/AIDS, obesity, blood loss anemia, and drug abuse, which were extremely uncommon (n < 10 in all cases), and we combined Elixhauser's three cancer types (lymphoma, metastatic cancer, and solid tumors without metastisis).

Table 3

Odds ratios indicating the unadjusted and adjusted effects of nurse staffing, work environment, and education on patient mortality.

	Odds ratios for patient mortality			
	Unadjusted		Fully adjusted	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Nurse staffing (patients per nurse)	1.12 (1.02−1.22)	0.02	1.05 (1.00−1.10)	0.05
Nurse work environment (better vs. mixed or poor)	0.47 (0.27−0.83)	0.01	0.52 (0.31−0.88)	0.01
Nurse education (% BSN)	0.91 (0.83–1.01)	0.07	0.91 (0.83−0.99)	0.03

Notes: OR = odds ratio; CI = confidence interval; and BSN = Bachelor of Science in Nursing. Unadjusted models are bivariate models which separately estimate the effect of each nursing characteristic, without any controls. Fully adjusted models estimate all three nursing characteristics individually while controlling for the full set of patient characteristics used in risk adjustment, as well as hospital characteristics. The adjusted characteristics for patient were age, gender, transfer status, type of admission, major diagnostic category, and the Elixhauser comorbidities (see Table 2). The adjusted characteristics for hospital included location and number of beds.