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In Hospitals With More Nurses Who Have Baccalaureate Degrees, Better Outcomes For Patients After Cardiac Arrest

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Abstract

In 2010, prompted by compelling evidence that demonstrated better patient outcomes in hospitals with higher percentages of nurses with a bachelor of science in nursing (BSN), the Institute of Medicine recommended that 80 percent of the nurse workforce be qualified at that level or higher by 2020. Using data from the American Heart Association's Get With the Guidelines–Resuscitation registry (for 2013–18), RN4CAST-US hospital nurse surveys (2015–16), and the American Hospital Association (2015), we found that each 10-percentage-point increase in the

hospital share of nurses with a BSN was associated with 24 percent greater odds of surviving to discharge with good cerebral performance among patients who experienced in-hospital cardiac arrest. Lower patient-to-nurse ratios on general medical and surgical units were also associated with significantly greater odds of surviving with good cerebral performance. These findings contribute to the growing body of evidence that supports policies to increase access to baccalaureate-level education and improve hospital nurse staffing.

Nearly 200,000 patients experience in-hospital cardiac arrest each year in the United States.¹ Many of the one in five patients who survive experience permanent neurologic deficits related to cerebral ischemia or reperfusion injury.² An estimated 28 percent of survivors of in-hospital cardiac arrest have neurologic impairment, which results in reduced quality of life, high hospital costs and readmission rates, and increased mortality risk in the year following the arrest.^{3–5} Importantly, the odds of similar patients surviving cardiac arrest with good cerebral performance vary widely across hospitals.^{3,6–9}

Nurses are the most numerous health professionals at the hospital bedside around the clock and the most frequent first responders to cardiac arrest. A timely response to cardiac arrest requires nurses to identify and respond early to deterioration in patients' conditions. Previous studies have found that lower patient-to-nurse ratios are associated with higher odds of survival after in-hospital cardiac arrest.^{10–12} However, no studies have evaluated the association between nurses' educational qualifications and cardiac arrest outcomes, and no studies have evaluated the extent to which hospital resources, including nurses, are associated with neurologic outcomes among survivors.

A growing body of evidence demonstrates better outcomes for patients in hospitals with a higher proportion of nurses with a bachelor of science in nursing (BSN), including lower odds of mortality and failure to rescue.^{13–18} Within hospitals, increases over time in the proportion of nurses with a BSN are associated with reductions in mortality and improvements in quality of care and patient safety.^{18,19} Compelling evidence prompted the Institute of Medicine in 2010 to recommend that the nurse workforce achieve a composition of at least 80 percent with a BSN or higher qualification by 2020.²⁰ We evaluated the relationship between hospital nurse educational level (that is, the percentage of nurses in the hospital with at least a BSN), nurse staffing, and survival with good cerebral performance after cardiac arrest. We hypothesized that in hospitals with higher proportions of nurses with baccalaureate-level education and lower patient-to-nurse ratios, patients who experienced cardiac arrest would have greater odds of surviving with good cerebral performance, even after patient and other hospital characteristics were accounted for.

Study Data And Methods

We conducted a cross-sectional study using linked data from three sources: patient data for 2013–18 from the American Heart Association's Get With the Guidelines–Resuscitation (GWTG-R) registry, the 2015–16 RN4CAST-US survey, and the American Hospital Association (AHA) 2015 Annual Survey.

The analytic sample for this study included thirty-six hospitals in California, Florida, New Jersey, or Pennsylvania that were represented in the RN4CAST-US survey, responded to the AHA survey, and participated in the GWTG-R clinical registry in the period 2013–18 (sample inclusion/exclusion criteria are listed in online appendix exhibit A-1).²¹ Hospital-level measures of nurse education and staffing were derived from the RN4CAST-US survey and linked to hospital data from the AHA survey and patient-level clinical data from GWTG-R. The merged data file included individual patient and event characteristics, hospital characteristics, and hospital-level nursing characteristics.

DATA SOURCES

GET WITH THE GUIDELINES–RESUSCITATION: GWTG-R is a national, prospective quality improvement registry sponsored by the American Heart Association that collects resuscitation data from hospitals nationwide. Participation in the registry is voluntary. In participating hospitals, trained hospital personnel use an online, interactive case report form to record standardized data regarding the medical history, hospital care, and outcomes of consecutive patients for all cardiac arrest patients treated with resuscitation. The registry uses standardized reporting for cardiac arrest to ensure that all patient and outcome variables are collected consistently across hospitals.^{22,23} Cardiac arrest cases are identified by a centralized system that aggregates data from cardiac arrest flow sheets, hospital paging system log reviews, routine code cart checks, pharmacy drug records, and hospital billing for resuscitation medications. The reporting system uses real-time reporting with data checks for accuracy and completeness before submission, with an error rate of 2.4 percent.²⁴ Additional details regarding standardized reporting of in-hospital resuscitation data are provided elsewhere.²⁵

Our study population was limited to cardiac arrest patients on inpatient units. Hospitals with fewer than ten cardiac arrests documented in the period 2013–18 were excluded, as were hospitals with fewer than ten nurse respondents to the RN4CAST survey. Exclusion criteria included patients younger than age eighteen (resuscitation guidelines differ for children), other unit types (emergency departments and procedural areas were excluded because our focus was on inpatient units), and patients with implantable cardioverter-defibrillators (a cardiac arrest primary prevention measure).

In a review of missing data, we discovered that many GWTG-R hospitals were missing a large proportion of discharge neurologic status scores, consistent with previously published studies.^{6,7,26} To minimize missing data, we excluded seventeen hospitals that were missing more than 50 percent of discharge Cerebral Performance Category (CPC) scores. The subsequent missing discharge CPC score rate among the remaining thirty-six hospitals was 1.9 percent. The final analytic sample included 11,123 patients in thirty-six hospitals that had information from all three data sources on patient characteristics, nursing resources, hospital characteristics, and resuscitation outcomes.

RN4CAST-US: Nurse survey data were collected as part of the RN4CAST-US survey that took place in 2015–16 in California, Florida, New Jersey, and Pennsylvania. Hospitals in these states are roughly representative of hospitals nationally, and over 20 percent of US

hospital admissions occur in these four states. Our sampling frame consisted of 231,000 nurses, which represented a 30 percent random sample of nurses in the four states. Surveys were mailed to nurses' home addresses and asked nurses to provide detailed information about nursing resources and the quality and safety of care in their employing hospital, as well as their education level. Nurse surveys were linked to corresponding hospitals, and responses were aggregated at the hospital level and linked to external data sources using unique hospital identifiers.

The response rate for the nurses sampled was 26 percent. This does not reflect substantial non-response bias, as demonstrated by intensive resurveys of 1,400 of the original nonrespondents. Nurse education and nurses' reports of hospital characteristics (for example, work environments and workloads) and their own characteristics (job dissatisfaction and burnout) differed little between respondents and nonrespondents in the study. A full description of the nurse survey methods is provided elsewhere.^{19,27} Among the thirty-six hospitals in our final sample, the average number of nurse respondents providing direct patient care was 44 nurses, with a range from 10 to 129 nurses per hospital.

AMERICAN HOSPITAL ASSOCIATION: We used data from the 2015 AHA Annual Survey, which collects information on organizational structure, facilities and services, and total beds for all hospitals in the US, including non-AHA members.

MEASURES

NURSE EDUCATION: We created an aggregate measure of nurse education at the hospital level by calculating the percentage of nurses with a BSN or higher degree. The predictive validity of this measure of nurse education for studying patient outcomes has been demonstrated.^{13,28,29} The survey asked, "What is your highest level of education completed in nursing?" Each nurse surveyed selected one of the following options: hospital diploma, associate's degree, baccalaureate degree, clinical master's degree, nonclinical master's degree, doctor of nursing practice, and PhD or other doctorate. We then created a binary indicator of whether the respondent had a BSN or higher to aggregate for a hospital-level measure that indicated the percentage of nurses with a BSN or higher.¹³ Although some nursing education programs offer non-BSN baccalaureate degrees with a major in nursing, in the context of this study we defined baccalaureate education as a BSN.

NURSE STAFFING: Each nurse surveyed reported the number of patients and the number of nurses on the unit during their last shift. Nurses also reported the type of unit where they worked, which allowed us to create separate measures of nurse staffing for general (medical-surgical) floors and intensive care units (ICUs) in each hospital. We created aggregate measures of staffing on general floors and in adult ICUs for each hospital by dividing the average number of patients reported by nurses on the unit during their last shift by the average number of nurses on the unit for the same shift. This direct survey measure of staffing included only bedside nurses, and its predictive validity for measuring hospital nurses' workloads to study patient outcomes is well established.^{14,30,31}

HOSPITAL CHARACTERISTICS: We controlled for hospital characteristics using variables obtained from the 2015 AHA hospital survey. Hospital size was categorized by number of beds: 250 or fewer, 251–500, and 501 or more. Teaching status was categorized as none (no residents or fellows), minor (one resident or fellow per four beds), and major (more than one resident or fellow per four beds). We identified high-technology hospitals based on the presence of facilities for open-heart surgery, major organ transplants, or both. These hospital-level variables have been associated with patient mortality and outcomes of cardiac arrest in previous studies.^{30,32,33} We also assessed whether hospitals employed intensivists.

NEUROLOGIC OUTCOMES: Neurologic outcomes were measured based on CPC scores and reported in the GWTG-R registry as one of the following five scores: CPC 1 (good cerebral performance), CPC 2 (moderate cerebral disability), CPC 3 (severe cerebral disability), CPC 4 (coma or vegetative state), or CPC 5 (brain death).^{34,35} *Good cerebral performance* was defined as having a score of CPC 1 at hospital discharge.⁸

STATISTICAL ANALYSIS—To estimate the association between nurse education and staffing and patient survival with good cerebral performance after cardiac arrest, we used logistic regression with generalized estimating equations to account for clustering of patients within hospitals. The primary outcome was a binary variable indicating whether patients did or did not survive to hospital discharge with good cerebral performance. As a secondary outcome, we evaluated survival to discharge without regard to neurologic status.

In our regression models the continuous percentage of nurses with a BSN in each hospital was divided by 10 so that a unit change in BSN represented a 10-percentage-point increase in nurses with a BSN. A unit change in nurse staffing on general floors and in ICUs represented a change of one additional patient per nurse.

Our risk-adjustment model accounted for patient, event, and hospital characteristics. We used the validated risk-adjustment approach developed by Paul Chan and colleagues³⁶ to adjust for patient and event characteristics associated with cardiac arrest outcomes: age, pre-arrest conditions (malignancy, sepsis, hepatic insufficiency, and hypotension), pre-arrest critical care interventions (vasopressors, assisted or mechanical ventilation, and cardiac monitoring), and initial cardiac arrest rhythm. We also adjusted for baseline neurologic impairment, whether the event was witnessed, and whether the event occurred in an ICU, as well as the following hospital characteristics: number of beds, teaching status, technology status, and employment of hospital intensivists. As the vast majority of hospitals in our sample had rapid response teams, this characteristic was not included in the analyses.

To address the potential limitations of using data from slightly different time periods, which may arise from changes in hospital staffing of nurses with a BSN over time, we conducted a sensitivity analysis. We replicated our analyses using a smaller sample of patients who experienced in-hospital cardiac arrest in the period 2015–16, to match more closely with the nurse survey conducted in the same period and AHA hospital data from 2015. The association of nurse education and nurse staffing with cardiac arrest outcomes in this

restricted sample (4,864 patients in thirty hospitals) did not differ appreciably from the results reported here.

To identify potential differences in resuscitation quality metrics that would explain variation in patient outcomes, we evaluated the association between BSN staffing and process measures (including time to compression, time to defibrillation, or time to epinephrine).

All analyses were performed in Stata, version 15.0, using two-sided statistical tests with an α level of 0.05 based on complete case analysis.

LIMITATIONS—This observational study had some limitations. First, the cross-sectional design prevented us from establishing a causal relationship between nurse education, nurse staffing, and cardiac arrest outcomes. Hospitals with higher percentages of nurses with a BSN and lower patient-to-nurse ratios may have additional resources that affect cardiac arrest outcomes. To mitigate the effects of omitted factors on our findings, analyses were adjusted for other hospital organizational characteristics.

Second, we did not have unit-level information about nurse and patient characteristics. Patient data (collected in the period 2013–18) did not match exactly with nurse survey data (from 2015–16) and AHA hospital data (from 2015). However, as noted above, results did not differ appreciably in a sample of patients whose data were limited to 2015–16.

Third, as reported previously, discharge neurologic status is not documented for all cardiac arrest patients in the GWTG-R registry.^{6,7,26} Excluding hospitals with a high rate of missingness may have introduced bias.

Fourth, we did not find significant associations with resuscitation process measures that would explain the relationship between nurse education, nurse staffing, and patient outcomes. Fifth, the sample of thirty-six hospitals was limited to those that voluntarily participated in GWTG, and the generalizability of these results may be limited by the fact that GWTG hospitals differ in some ways from hospitals nationally. Hospitals that participate in GWTG tend to have a higher proportion of nurses with a BSN, and the lower variation may have led us to underestimate the relationship between nurse education and cardiac arrest outcomes.

Study Results

Exhibit 1 describes characteristics of the hospitals and patient outcomes following cardiac arrest. Overall, the share of nurses with a BSN ranged from 33 percent to 86 percent by hospital, with a mean of 61 percent. The mean staffing ratio on general floors was 4.7 patients per nurse, with a range of 2.8–6.6 patients per nurse. The mean patient age was sixty-five, 57 percent were male, and 20 percent were black (data not shown). Overall, 11.2 percent of patients survived cardiac arrest to discharge with good cerebral performance, 7.1 percent survived to discharge with neurologic disability, and 81.7 percent did not survive to discharge (exhibit 1). The majority of arrests were monitored (89 percent) and witnessed (87 percent), and 70 percent occurred in the ICU. (Appendix exhibit A-2 shows these data and detailed patient and event characteristics.)²¹

Exhibit 2 shows the results of unadjusted (bivariate) and adjusted models that estimated the associations of nurse education and staffing with survival following in-hospital cardiac arrest. Adjusted models reestimated the effects of nurse education and staffing after controlling for patient characteristics, event characteristics, and hospital characteristics, as shown in appendix exhibits A-3 and A-4.²¹ In the adjusted model, each unit (or ten-percentage-point) increase in the hospital share of nurses with a BSN was significantly associated with greater odds of survival with good cerebral performance (odds ratio: 1.24; 95% percent confidence interval: 1.08, 1.42). Because these odds ratios are multiplicative, this implies that the odds of surviving to discharge with good cerebral performance would be greater in hospitals with 70 percent of nurses having a BSN than in hospitals with 40 percent of nurses having a BSN—since the two groups of hospitals would differ by three units (a factor of $1.24 \times 1.24 \times 1.24 = 1.91$, or nearly doubled). Nurse education was not significantly associated with surviving to discharge when neurologic status was not considered. Nurse staffing on general floors, but not ICUs, was associated with both outcomes. Each additional patient per nurse was associated with 17 percent lower odds of surviving to discharge with good cerebral performance (odds ratio: 0.83; 95% CI: 0.70, 0.98) and 16 percent lower odds of surviving to discharge regardless of neurologic status (odds ratio: 0.84; 95% CI: 0.73, 0.97). This implies that the odds of surviving to discharge with good cerebral function and of surviving to discharge regardless of neurologic status would be lower for patients in hospitals whose workloads were six patients per nurse than for patients in hospitals whose workloads were four patients per nurse (a two-unit difference) by factors of $0.83 \times 0.83 = 0.69$ and $0.84 \times 0.84 = 0.71$, respectively, or by roughly 30 percent in each case.

Other factors that predicted surviving to discharge with good cerebral performance included patient age, initial shockable rhythm, no baseline neurologic impairment, absence of pre-arrest conditions (malignancy, sepsis, hepatic insufficiency, and hypotension), no assisted or mechanical ventilation, no vasopressors pre-arrest, and a witnessed arrest (see appendix exhibits A-3 and A-4).²¹ Hospital characteristics other than nurse education and staffing were not significantly associated with patient outcomes.

At higher levels of staffing of nurses with a BSN, the predicted probability of surviving to discharge with good cerebral performance increased substantially (exhibit 3). However, we observed little variation in resuscitation quality metrics reported by hospitals, and we did not find significant associations between BSN nurse staffing and resuscitation process measures that would explain the relationship between nurse education and patient outcomes. In the majority of cases, hospitals reported meeting guidelines of compressions within one minute (97 percent), defibrillation within two minutes (84 percent), or epinephrine within five minutes (93 percent) within the appropriate patient subgroups, depending on initial rhythm.

Discussion

This study demonstrated that in hospitals with higher proportions of nurses with a BSN and lower patient-to-nurse ratios, patients have greater odds of surviving to discharge with good cerebral performance following in-hospital cardiac arrest. Nursing surveillance is a critical factor in response to cardiac arrest. Professional nurses working in hospitals with more

baccalaureate-trained colleagues and lower nurse workloads may have a greater opportunity to recognize patient deterioration before cardiac arrest, institute life-saving interventions, and assemble an effective team response, thus minimizing the potential for neurologic damage. These findings are consistent with a substantial body of evidence that demonstrates better outcomes for patients in hospitals with higher percentages of nurses with a BSN.^{13–19} Consistent with previous studies, higher patient-to-nurse ratios on general floors were associated with lower odds of survival following in-hospital cardiac arrest,^{11,12} as well as lower odds of surviving to discharge with good cerebral performance.

Having more nurses with a BSN and lower patient-to-nurse ratios does not occur at random: Hospitals with these characteristics likely differ from other hospitals in terms of resources and culture that affect response to cardiac arrest. Investment in human capital, including nursing resources, is a key component of organizational transformation to reduce harm and improve patient outcomes.^{37,38} Retention of highly skilled nurses with a BSN at the bedside is associated with adequate registered nurse (RN) staffing levels and supportive work environments, including nurse engagement in hospital affairs, professional autonomy, and good collaborative relations with physicians. Instead of viewing nursing costs as a financial loss, hospital executives may need to consider the financial implications of preventing adverse outcomes. Cost savings from avoided adverse events and subsequent reductions in hospital days and readmissions may result in greater value for hospitals that invest in increased nurse staffing.³⁹ Similarly, economic evaluation of the Institute of Medicine's 80 percent BSN-trained nurse workforce recommendation supports a strong business case for increasing the proportion of nurses with a BSN, with higher patient "doses" of BSN nursing linked to lower hospital readmissions and shorter lengths-of-stay.^{13,40}

While hospitals are preferentially hiring nurses with a BSN, those nurses are in short supply in some areas of the country because of regional inequities in access to BSN education. In 2017 over half of new RNs entered practice without a bachelor's degree.⁴¹ That year the state of New York passed "BSN in 10" legislation that requires nurses who graduate with an associate's degree or diploma to obtain a BSN within ten years of graduation to retain their RN license.⁴² More innovation is needed in higher education policies, practices, and financing to facilitate greater access to baccalaureate-level education for all RN students.

In summary, our findings suggest that patients in hospitals with higher proportions of nurses with a BSN and lower nurse workloads have greater odds of surviving to discharge with good cerebral performance following in-hospital cardiac arrest. Health care systems that continue to preferentially hire nurses with a BSN and invest in evidence-based nurse staffing may see improvements in hospital performance benchmarking for cardiac outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

A previous version of this article was presented at the AcademyHealth Annual Research Meeting in Seattle, Washington, June 24–26, 2018. All participating institutions were required to comply with local regulatory and

privacy guidelines and, if required, to secure Institutional Review Board approval. Because the data were used primarily at the local site for quality improvement, sites were granted a waiver of informed consent under the Common Rule. This research was supported by funding from the National Institute of Nursing Research (Grant Nos. R01NR016002 [Matthew McHugh, principal investigator], R01NR014855 [Linda Aiken, principal investigator], and T32NR007104 [Aiken, principal investigator]). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. IQVIA is the data collection coordination center for the American Heart Association/American Stroke Association Get With the Guidelines programs. Hospitals participating in the Get With the Guidelines Resuscitation registry submit clinical information regarding the medical history, hospital care, and outcomes of consecutive patients hospitalized for cardiac arrest using an online, interactive case report form and the Patient Management Tool of IQVIA. The University of Pennsylvania serves as the data analytic center and has an agreement with IQVIA to prepare the data for research purposes. The authors acknowledge the members of the American Heart Association's Get With the Guidelines Adult Research Task Force for reviewing an earlier version of this article: Anne Grossestreuer, Ari Moskowitz, Dana Edelson, Joseph Ornato, Katherine Berg, Mary Ann Peberdy, Matthew Churpek, Michael Kurz, Monique Anderson Starks, Paul Chan, Saket Girotra, Sarah Perman, and Zachary Goldberger.

NOTES

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EXHIBIT 3. Predicted probability of patient survival with good cerebral performance following in-hospital cardiac arrest, by hospital percentage of nurses with a bachelor of science in nursing (BSN)

SOURCE Authors' analysis of data for 2013–18 from the Get With the Guidelines–Resuscitation registry. **NOTES** The vertical axis shows predicted probability of patient survival with good cerebral performance following in-hospital cardiac arrest. Predicted probabilities were adjusted for the patient and hospital characteristics listed in the notes to exhibit 2. Good cerebral performance is defined in the text. The error bars indicate 95% confidence intervals.

EXHIBIT 1**Hospital characteristics and patient outcomes following in-hospital cardiac arrest**

	Number or mean	% or SD
HOSPITAL CHARACTERISTICS		
Percent of nurses with BSN	61	12
General floor patients per nurse	4.7	0.8
ICU patients per nurse	2.7	1.4
Number of beds		
250 or fewer	11	30.6%
251–500	5	13.9
501 or more	20	55.6
Hospital teaching status		
None (no residents or fellows)	12	33.3%
Minor (1 resident or fellow per 4 beds)	10	27.8
Major (more than 1 resident or fellow per 4 beds)	14	38.9
Hospital technology status		
High	29	80.6%
Not high	7	19.4
Hospital intensivists employed		
Yes	29	80.6%
No	7	19.4
State		
California	11	30.6%
Florida	4	11.1
New Jersey	5	13.9
Pennsylvania	16	44.4
PATIENT OUTCOMES		
Survived to discharge with good cerebral performance (CPC 1)	1,244	11.2%
Survived to discharge with neurologic disability (CPC 2–4)	797	7.1
Died in hospital (CPC 5)	9,082	81.7

SOURCE Authors' analysis of data for 2013–18 from the Get With the Guidelines–Resuscitation registry. **NOTES** There were thirty-six hospitals and 11,123 patients in the study. Cerebral Performance Category (CPC) scores and technology status are explained in more detail in the text. SD is standard deviation. BSN is bachelor of science in nursing. ICU is intensive care unit.

EXHIBIT 2

Association of nurse education and staffing levels with patients' odds of survival following in-hospital cardiac arrest at all or with good cerebral performance

	Odds ratio for survival:			
	With good cerebral performance		At all	
	Unadjusted	Adjusted^a	Unadjusted	Adjusted^a
Nurse education	1.16 **	1.24 ***	1.02	1.03
Nurse staffing	0.94	0.83 **	0.97	0.84 **

SOURCE Authors' analysis of data for 2013–18 from the Get With the Guidelines–Resuscitation registry. **NOTES** Nurse education refers to the hospital percentage of nurses with a bachelor of science in nursing. Nurse staffing refers to the average number of general floor patients per nurse.

^aAdjusted for patient and event characteristics (age, pre-arrest conditions [malignancy, sepsis, hepatic insufficiency, and hypotension], pre-arrest critical care interventions [vasopressors, assisted or mechanical ventilation, and cardiac monitoring], initial cardiac arrest rhythm, baseline neurologic impairment, witnessed event, and arrest location in the intensive care unit [ICU]), ICU nurse staffing, and hospital characteristics [number of beds, teaching status, technology status, and employment of hospital intensivists]). The full models are provided in appendix exhibits A-3 and A-4 (see note 21 in text).

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 $p < 0.05$

 $p < 0.01$