

Critical Care Nursing's Impact on Pediatric Patient Outcomes

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Background. Previous studies have demonstrated the effect of adult nursing skill mix, staffing ratios, and level of education on patient deaths, complication rates, and failure to rescue (FTR). To date, only one known study had examined the effect of nursing experience and education on postoperative pediatric cardiac operations.

Methods. Nursing survey data were linked to The Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database for patients undergoing cardiac operations (2010 to 2011). Logistic regression models were used to estimate associations of nursing education and years of clinical experience with in-hospital mortality rates, complication rates, and FTR. Generalized estimating equations and robust standard error estimates were used to account for within-center correlation of outcomes.

Results. Among 15,463 patients (29 hospitals), the in-hospital mortality rate was 2.8%, postoperative complications occurred in 42.4%, and the FTR rate was 6.4%. After covariate adjustment, pediatric critical care units

with a higher proportion of nurses with a Bachelor of Science degree or higher had lower odds of complication (odds ratio for 10% increase, 0.85; 95% confidence interval, 0.76 to 0.96; $p = 0.009$). Units with a higher proportion of nurses with more than 2 years of experience had lower mortality rates (odds ratio for 10% increase, 0.92; 95% confidence interval, 0.85 to 0.99; $p = 0.025$).

Conclusions. This is the first study to demonstrate that higher levels of nursing education and experience are significantly associated with fewer complications after pediatric cardiac operations and aligns with our previous findings on their association with reduced deaths. These results provide data for pediatric hospital leaders and reinforce the importance of organization-wide mentoring strategies for new nurses and retention strategies for experienced nurses.

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The effect of nursing care on patient outcomes is well established [1–6]. Evidence demonstrating the effect of nursing skill mix, staffing ratios, and level of education on outcomes including patient deaths, complication rates, and failure to rescue (FTR), defined as the probability of death after a complication, has been reported from studies of a variety of adult patient populations [2, 6–17]. These outcomes have been a particular concern for the adult surgical population, citing a multitude of contributing factors, including patient, organizational, and human [10, 18, 19].

During the past decade, we have investigated the effect of pediatric nursing characteristics for children

undergoing congenital heart operations [3, 20–22]. Our initial examinations revealed a limited effect of nursing skill mix and staffing ratios on deaths for congenital heart surgical patients, despite a wide variation in staffing models across children's hospitals nationally [21]. We further documented the variation in pediatric nursing- and unit-based characteristics through development of a national survey of 43 pediatric cardiovascular programs in free-standing children's hospitals in the United States [20]. Linking this survey data to risk-adjusted outcomes for congenital heart surgical patients revealed a significant relationship between education and years of nursing experience and deaths [3]. This first-time finding in pediatric nursing showed that not only was years of nursing experience significantly associated with deaths, the level of nursing experience in a unit's staffing model was also associated with deaths [3].

New knowledge is being generated that relates patient factors to death, complications, resource utilization, and FTR for congenital heart surgical patients [23–30].

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Abbreviations and Acronyms

ACLS	= Advanced Cardiovascular Life Support
ANCC	= American Nurses Credentialing Center
BSN	= Bachelor of Science in Nursing
CCRN	= Certification for Adult, Pediatric and Neonatal Critical Care Nurses
CHSD	= Congenital Heart Surgery Database
CI	= confidence intervals
CPN	= Certified Pediatric Nurse
DNP	= Doctor of Nursing Practice
EACTS	= European Association for Cardiothoracic Surgery
FTR	= failure to rescue
MS	= Master of Science
OR	= odds ratio
PALS	= Pediatric Advanced Life Support
PhD	= Doctor of Philosophy
RNs	= Registered Nurse
STS	= The Society of Thoracic Surgeons

Opportunities remain to further understand the effect of the structure of our health care teams and processes of care for this highly specialized field. Across the country, congenital heart surgical patients consume a disproportionate share of hospital resources due to the critical care services necessary postoperatively. Critical care nursing is a requisite service for these patients. Understanding why patients need educated and experienced registered nurses (RNs) is essential to justify the resources and to understand the implications for staff recruitment and retention. The purpose of this study was to further evaluate the association of pediatric critical care nursing and organizational characteristics with outcomes in a large multicenter cohort of children undergoing cardiac operations.

Material and Methods

Approval for this study was granted by the Boston Children's Hospital Institutional Review Board and The Society of Thoracic Surgeons (STS) National Database Access and Publications Committee to conduct an analysis linking nursing survey data and clinical data from the STS Congenital Heart Surgery (CHS) Database.

Nursing and Organizational Characteristics

DATA SOURCES. Data (2009 to 2010) were collected from 43 pediatric cardiovascular programs among Children's Hospital Association member institutions participating in a nursing survey eliciting information on nine domains of nursing, including RN staffing, nursing education, specialty certification, overall clinical experience, cardiac care experience, indirect resources, processes of care, physical unit characteristics, and organizational characteristics. More detailed survey methodology and summary analyses have been previously described [20].

The nursing and organizational variables examined in this study were years of overall nursing experience, the proportion of RNs with clinical experience of 2 years or less, the proportion of RNs with a Bachelor of Science in Nursing (BSN) degree or higher, the proportion of RNs with Critical Care certification, and American Nurses Credentialing Center Magnet recognition. These four variables had previously been found to be significantly associated with surgical outcomes [3].

The STS-CHSD

Since 1998, the STS-CHSD has collected perioperative, operative, and outcome data on children undergoing cardiac operations in North America. The database currently contains information on more than 300,000 operations from more than 100 United States centers performing pediatric cardiac operations. The Duke Clinical Research Institute serves as the data warehouse for the STS databases.

Linkage of Data Sources

The nursing survey data were linked to the STS-CHSD at the hospital level by matching hospital names and locations. Of the 43 hospitals surveyed, we were able to identify and link the two data sources for 38 hospitals that also participated in the STS database during the study period.

Study Population

We used the clinical data collected in STS-CHSD during 2010 and 2011, the 2-year time span after the survey was completed. Among the 38 linked hospitals, 1 did not submit clinical experience information and was excluded from the study.

From the remaining 37 hospitals, the STS-CHSD collected information on 23,361 index cardiovascular operations (the first operation of the hospital admission) in children and adolescents aged younger than 18 years. We excluded 2,786 operations that were not classifiable by the STS-European Association for Cardiothoracic Surgery (EACTS) risk of death categories [27] or the STS morbidity risk categories [27] and 11 patients who died during operations. In the 20,564 operations that were left, we calculated the proportion of cases with missing STS data for each hospital. Eight hospitals with more than 15% of data missing in one of these STS data sections were excluded: preoperative factors, abnormalities, and complications. This step excluded 5,054 operations. Finally, we excluded operations with missing information for deaths ($n = 12$) and complications ($n = 35$). The final sample consisted of 15,463 operations from 29 hospitals.

Statistical Analysis

We summarized the distributions of nurses by certification, education, and clinical experience as well as by the variation in the number of nurses within categories of these variables across the hospitals. We tabulated the distributions of patient characteristics including age, gender, weight, STS-EACTS mortality categories, STS morbidity categories, number of previous cardiothoracic

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