

# National Benchmarks for Proportions of Patients Receiving Blood Transfusions During Pediatric and Congenital Heart Surgery: An Analysis of the STS Congenital Heart Surgery Database



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**Background.** To determine national benchmarks and assess variability across centers, The Society of Thoracic Surgeons Congenital Heart Surgery Database was analyzed to document proportions of patients receiving intraoperative transfusion of packed red blood cells (PRBC) during open heart surgery.

**Methods.** Index cardiopulmonary bypass operations reported in The Society of Thoracic Surgeons Congenital Heart Surgery Database (2014 to 2015) were potentially eligible for inclusion. Data from centers with more than 15% missing data for PRBC transfusion were excluded, as were individual records missing information about PRBC transfusion. The distribution of center-level PRBC transfusion rates in various clinically relevant groups was estimated by fitting a two-level logistic mixed model.

**Results.** The study population included 22,874 index cardiopulmonary bypass operations in 81 centers. Center-level intraoperative PRBC transfusion rates stratified by age group, weight, STAT Mortality Category, and lowest core temperature were documented. For younger patients

and patients undergoing higher-complexity operations, median center PRBC transfusion rates consistently approached 100%, with narrow interquartile ranges indicating little center variability. Center PRBC transfusion rates declined with increasing patient age, but with greater variability (wider interquartile ranges) across centers. Intraoperative PRBC transfusion was uncommon (median center transfusion rates <30%) in older patients (teenagers and adults) undergoing lower-complexity (STAT Mortality Category <3) operations.

**Conclusions.** Most centers transfuse PRBCs routinely in higher-risk, younger, and smaller patients, with little variability across centers. For lower-risk operations in older and larger patients, centers are more likely to forgo intraoperative transfusions. This analysis provides national benchmarks for center-level PRBC transfusion rates during pediatric and congenital heart surgery.

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Strategies to limit transfusion of blood during cardiac surgery continue to evolve, as do thresholds for blood transfusion [1–4]. Although the effect of restrictive

transfusion protocols versus liberal transfusion protocols in children has been studied [5, 6], limited data are available regarding nationwide variation in pediatric and congenital heart surgery transfusion practice. One study used administrative data to examine national trends and variability in blood utilization in pediatric cardiac surgery [7]; however, nationwide variation in the practice of transfusion for pediatric and congenital heart surgery has not been assessed with clinical data. Strategies to capture information about the use of blood during pediatric and

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congenital heart surgery have been developed jointly through the collaboration of The Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database (CHSD) Task Force and the Congenital Cardiac Anesthesia Society, and these data elements have been incorporated into the STS CHSD. Using the STS CHSD, we analyzed proportions of patients receiving intraoperative transfusion of packed red blood cells (PRBC) during open heart surgery to determine national benchmarks of rates of transfusion during pediatric and congenital cardiac surgery and to assess variability across centers.

## Patients and Methods

### Data Source

The STS CHSD was used for this study. STS CHSD is an audited comprehensive database of patients who have undergone congenital and pediatric cardiac surgical operations at centers in the United States and Canada. STS CHSD is a voluntary registry of preoperative, operative, and outcomes data for all patients undergoing congenital and pediatric cardiovascular operations at participating centers. STS CHSD usually uses the following four age groupings: neonates (0 to 30 days), infants (31 days to 1 year), children (>1 year to <18 years), and adults (≥18 years); however, for this analysis, we used the following six age groupings: neonates (0 to 30 days), infants (31 days to 1 year), toddlers (>1 year to <4 years), children (≥4 years to <13 years), teens (≥13 years to <18 years), and adults (≥18 years). All data in this analysis comes from the STS CHSD, and no data were included from the STS Adult Cardiac Surgery Database.

The Report of the 2010 STS Congenital Heart Surgery Practice and Manpower Survey, undertaken by the STS Workforce on Congenital Heart Surgery, estimated that 125 hospitals in the United States of America and 8 hospitals in Canada perform pediatric and congenital heart surgery [8]. The report of the 2015 STS Congenital Heart Surgery Practice Survey includes a similar estimation of the number of centers performing congenital and pediatric heart surgery in North America [9]. In 2017 the STS CHSD included data from 118 North American CHSD participants representing 125 hospitals performing congenital heart surgery in North America, 122 of the 125 hospitals (97.62% penetration by hospital) in the United States and 3 of the 8 centers in Canada.

Coding for this database is accomplished by clinicians and support staff using the International Pediatric and Congenital Cardiac Code [10, 11] and is entered into the contemporary version of the STS CHSD data collection form [12]. The definitions of all terms and codes from the STS CHSD used in this report have been standardized and published [12]. Evaluation of data quality in the STS CHSD includes intrinsic verification of data (eg, identification and correction of values that are missing/out of range and inconsistencies across fields), along with a formal process of audits at approximately 10% of all

participating centers each year conducted by a panel of independent quality-assurance personnel and pediatric cardiac surgeons [13, 14].

### Accounting for Case Mix

Due to the large number of different types of pediatric and congenital cardiac operations (ie, more than 200 individual procedure types, most often performed in various combinations), it is useful to stratify individual operations into groups or categories that are relatively homogeneous with respect to complexity or risk. This methodology is referred to as risk stratification and has been used in STS CHSD since 2002.

Since 2010, STS has used the empirically based STS — European Association for Cardio-Thoracic Surgery Congenital Heart Surgery (STAT) Mortality Categories for risk stratification. The STAT Mortality Categories [15, 16] are a tool for stratification that is based on the procedure-specific estimate of the risk of discharge mortality, which was developed from an analysis of 77,294 operations entered into the European Association for Cardio-Thoracic Surgery Congenital Heart Surgery Database (33,360 operations) and the STS CHSD (43,934 operations). Procedure-specific mortality rate estimates were calculated using a Bayesian model that was adjusted for small denominators. Operations were sorted by increasing risk and grouped into five STAT Mortality Categories that were designed to be optimal with respect to minimizing variation within categories and maximizing variation between categories. STAT Category 1 is associated with the lowest risk for mortality and STAT Category 5 is associated with the highest risk for mortality.

### Study Population

Intraoperative blood use across centers was assessed for all patients in STS CHSD who underwent an index cardiovascular operation with cardiopulmonary bypass (CPB) from January 1, 2014, to December 31, 2015 ( $n = 36,771$  operations from 113 centers). Operations missing “CPB time” were excluded, as were individual records of operations with missing information about PRBC transfusion and centers with more than 15% missing data for intraoperative blood use ( $n = 13,897$  operations from 32 centers). The final study population therefore included 22,874 index cardiac operations with CPB from 81 centers.

Intraoperative PRBC transfusion was defined as intraoperative administration of PRBCs, or CPB blood prime, or both. Each center’s rate of transfusion of PRBCs was calculated as the percentage of operations in a particular category with intraoperative PRBC transfusion(s). Transfusions of other blood products, and PRBC transfusions administered during the hospitalization but prior to entering the operating room for the index operation or after completion of the index operation, are not included in the calculation of this rate of intraoperative transfusion of PRBCs.

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