Computerized Physician Order Entry With Decision Support Decreases Blood Transfusions in Children

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WHAT’S KNOWN ON THIS SUBJECT: Studies reveal red blood cell transfusion practices to be variable among pediatricians. Recent data suggests significant risks to children receiving transfusions, and supports a conservative transfusion strategy. Computerized physician order entry with decision support has potential to improve transfusion utilization.

WHAT THIS STUDY ADDS: A significant lag exists between the dissemination of evidence-based recommendations and integration into clinical practice. This study reveals a strategy where computerized decision support improved the use of red blood cell transfusions, suggesting enhanced adoption of evidence-based recommendations.

abstract

OBJECTIVE: Timely provision of evidence-based recommendations through computerized physician order entry with clinical decision support may improve use of red blood cell transfusions (RBCTs).

METHODS: We performed a cohort study with historical controls including inpatients admitted between February 1, 2008, and January 31, 2010. A clinical decision-support alert for RBCTs was constructed by using current evidence. RBCT orders resulted in assessment of the patient’s medical record with prescriber notification if parameters were not within recommended ranges. Primary end points included the average pretransfusion hemoglobin level and the rate of RBCTs per patient-day.

RESULTS: In total, 3293 control discharges and 3492 study discharges were evaluated. The mean (SD) control pretransfusion hemoglobin level in the PICU was 9.83 (2.63) g/dL (95% confidence interval [CI]: 9.65–10.01) compared with the study value of 8.75 (2.05) g/dL (95% CI: 8.59–8.90) (P < .0001). The wards’ control value was 7.56 (0.93) g/dL (95% CI: 7.47–7.65), the study value was 7.14 (1.01) g/dL (95% CI: 6.99–7.28) (P < .0001). The control PICU rate of RBCTs per patient-day was 0.20 (0.11) (95% CI: 0.13–0.27), the study rate was 0.14 (0.04) (95% CI: 0.11–0.17) (P = .12). The PICU’s control rate was 0.033 (0.01) (95% CI: 0.02–0.04), and the study rate was 0.017 (0.007) (95% CI: 0.01–0.02) (P < .0001). There was no difference in mortality rates across all cohorts.

CONCLUSIONS: Implementation of clinical decision-support alerts was associated with a decrease in RBCTs, which suggests improved adoption of evidence-based recommendations. This strategy might be widely applied to promote timely adoption of scientific evidence. Pediatrics 2011;127:e1112–e1119
The decision to administer a red blood cell transfusion (RBCT) to a child is complex, yet remains highly subjective. The complexity owes in part to the biologically imperative role that oxygen delivery plays in human disease and our evolving understanding of the risks entailed by a RBCT. It is not surprising that given the potential efficacy of RBCTs, a significant number of children admitted to ICUs receive at least 1 RBCT during their admission. Irrespective of consensus surrounding the essential issues that merit careful consideration before performing an RBCT, practices remain highly variable within the pediatric community. Evidence from a well-powered, randomized controlled clinical trial supports the notion that in the presence of hemodynamic stability, a conservative strategy using a threshold hemoglobin level of 7 g/dL is safe. Moreover, as RBCTs represent a real risk and a substantial cost to patients, a conservative approach promises to decrease bloodstream infections, adverse reactions, mortality, and cost.5-10

Despite improved insight surrounding the indications for RBCTs, a standardized approach to the provision of these transfusions has eluded the pediatric community. Slow adoption of new standards is not distinct to pediatric medicine. In general, even in the presence of well-accepted data that justify a change in practice, adoption of change among practitioners occurs over a protracted time.11 Barriers to the more widespread adoption of well-studied and justified practices include lack of physician awareness, inability to implement guidelines, and differing interpretation of data between providers. These barriers, among others, may cause a delay of >10 years before sound data are incorporated into daily practice.13,14

Computerized physician order entry (CPOE) has been adopted in many children’s hospitals partly because of its potential to decrease medical errors and enhance efficiency.15,16 However, the ability to tether CPOE to automated clinical decision support (CDS) alerts represents an additional, previously unavailable, tool whereby providers might be informed of best-practice and evidence-based guidelines in real-time. A significant amount of CDS research to date has focused on the potential to improve medication safety.18,19 Additional data focusing on RBCTs found that when deployed in adult patients, CDS alerts can have an impact on transfusion use.20-22 In the setting of child health care, questions remain about whether CPOE tethered to CDS alerts might decrease the frequency, standardize the ordering threshold, and inform the treatment decision of the providers relative to the RBCT. Thus, we hypothesized that timely provision of evidence-based recommendations through CPOE with automated CDS alerts would decrease the overall number of RBCTs in a children’s hospital without compromising patient safety. To test this hypothesis, we implemented an evidence-based CDS alert triggered by clinical and laboratory parameters on the basis of standards outlined in a large randomized controlled clinical trial.4

METHODS

To determine the effect of a CPOE-based intervention on decreasing the use of RBCTs, we conducted a cohort study with a preexposure (control) period and a postexposure (study) period in both the PICU and acute care wards at Lucile Packard Children’s Hospital (LPCH). Participants were included if they were admitted to the designated LPCH units between February 1, 2008, and January 31, 2010. The control period was between February 1, 2008, and January 31, 2009, and the study period was between February 1, 2009, and January 31, 2010.

LPCH is a 303-bed, freestanding, quaternary care, academic children’s hospital with a 20-bed PICU. Between February 1, 2008, and January 31, 2010, the PICU and acute care wards at LPCH had a total of 33,561 inpatient-days and 6785 discharges. The LPCH PICU cares for many types of critically ill patients, including solid organ and bone marrow transplant, trauma, and a full complement of medical and surgical patients. All patients with congenital heart disease are managed in the cardiovascular ICU and a designated step-down ward. Because the hematology/oncology and cardiology wards ascribe to different transfusion practices pertaining to their specific patient populations, patients in these wards were not included in the study. The NICU was excluded from the study analysis because a large majority of their patients would not fall within our determined age limits. This project was reviewed and approved by the Stanford University School of Medicine institutional review board. Informed consent was waived.

Intervention

LPCH implemented a vendor-based CPOE system (Cerner Corporation, Kansas City, MO) throughout the acute care wards in November 2007 and in the PICU in September 2008. Beginning in February 2009, an alert was created within the CPOE system to recognize RBCT orders written outside of the current best-practice recommendations written by the health care team. These recommendations were extended to patients on the acute care wards on the basis of the assumption that a conservative transfusion strategy would also be safe for non-critically ill children. The CPOE alert was designed to analyze the patient record and hemodynamic status for all children for which an RBCT order was written. Variables in the alert algorithm included the patient’s age, diagnosis, most re-
Red blood cell order initiated

System queried for all patients between 1 mo and 18 y old

Normotensive for >6 h before order and Hgb >7

Excluded patients: hypotensive, Hgb <7, cardiac wards, hematology/oncology wards, NICU

Alert window appears before order completion

No alert window appears and order is completed

**FIGURE 1**

RBCT CDS algorithm. After initiation of a RBCT, the computerized algorithm analyzed the patient record for hemoglobin (Hgb) level, age, location, and hemodynamic stability. Depending on the patient’s parameters, the order was either completed or an alert window was generated before completion.

cent serum hemoglobin level (within the previous 24 hours), and blood pressure. If an RBCT order was written for a patient within the appropriate age range (1 month–18 years), with a normal blood pressure and a hemoglobin level of >7 g/dL (Fig 1), the ordering physician was presented with a recommendation in the form of an alert window along with a hyperlink to the supporting reference (Fig 2). There was an option to override the alert if the clinician determined that it was in the patient’s best interest to order the RBCT. Ordering clinicians were informed but not constrained by the alert and were free to prescribe the RBCT if, in their opinion, the treatment was indicated.

**Main Outcome Measures**

The primary outcome measures were the average pretransfusion hemoglobin level and the number of RBCTs per patient-day. An eligible patient-day was defined as a day during which a patient spent any time in the PICU or designated acute care wards at LPCH. To evaluate whether the intervention caused any untoward sequelae, hospital mortality rates, PICU length of stay, and hospital length of stay were determined during the control and study intervals.

Demographic data, including age, gender, and race, were assessed to ensure that similar populations were being studied in the control and study periods. Race and ethnicity data derived from patient or family were self-reported per the LPCH standard admission forms.

Severity of illness for the study population was determined during the control and study intervals. Case-mix index (CMI), based on the Centers for Medicare and Medicaid Services cost weights, was assessed monthly for the hospital and compared during the control and study intervals to further ensure that study findings were not attributable to differences in severity of illness.

**Statistical Analysis**

Two-sample Student’s *t* test assuming equal variances was used to analyze differences in the average pretransfusion hemoglobin levels, RBCTs per patient-day, average transfusion order per patient, PICU and hospital length of stay, age, and CMI before and after the intervention. To evaluate whether there were any differences in the control and study cohorts, gender, race/ethnicity, and CMI were analyzed by using *χ²* tests. The relative risk of transfusion with confidence intervals (CIs) was calculated for the control compared with study cohorts. To determine if the study period decrease in CMI had a significant effect on the average rate of RBCTs per patient-day, we modeled the control and study period RBCTs per patient-day with CMI as a covariate by using analysis of variance. Values are reported throughout the article as means (SDs) and 95% CIs. GraphPad Prism (GraphPad Software, La Jolla, CA) statistical software was used for analysis.

**FIGURE 2**

After initiation of an RBCT order for a patient with clinical and laboratory parameters outside of the designated values, the provider was presented with an alert window that contained a suggestion and a hyperlink to the supporting reference.
TABLE 1 Demographic Characteristics of Control and Study Populations

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control (N = 3294)*</th>
<th>Study (N = 3492)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>7.16 (6.1)</td>
<td>7.18 (6.2)</td>
<td>.86</td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>1505 (45.7)</td>
<td>1694 (48.5)</td>
<td>.77</td>
</tr>
<tr>
<td>Race/ethnicity, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1112 (34)</td>
<td>1300 (37)</td>
<td>.66</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>2181 (66)</td>
<td>2192 (63)</td>
<td>.66</td>
</tr>
<tr>
<td>Mortality, mean (SD)</td>
<td>0.023 (0.04)</td>
<td>0.016 (0.03)</td>
<td>.39</td>
</tr>
<tr>
<td>Length of stay, mean (SD), d</td>
<td>9.73 (24.3)</td>
<td>8.07 (23.4)</td>
<td>.0001</td>
</tr>
<tr>
<td>CMI, mean (SD)</td>
<td>1.88 (0.18)</td>
<td>1.74 (0.15)</td>
<td>.03</td>
</tr>
</tbody>
</table>

*The control period was between February 1, 2008, and January 31, 2009, and the study period was between February 1, 2009, and January 31, 2010.

RESULTS

There was no difference in mortality in the PICU or acute care wards between the control and study periods. Average length of stay did not change on the acute care wards (7.9 [21.7] vs 6.8 [22.4]; P = .06), but it did differ in the PICU during the study period versus control period (16.4 [31.3] vs 11.5 [25.8]; P = .0002). The annual CMI was different in the control versus study cohort (1.88 [0.17] vs 1.74 [0.14]; P = .03). Age, gender, and race were not statistically different in the control and study cohorts (Table 1). The top 10 major diagnostic categories during the control and study periods are listed in Table 2. There was a significant difference in patients admitted for diseases of the circulatory system (207 vs 168; P = .009), ear, nose, mouth, and throat (473 vs 424; P = .006), respiratory system (288 vs 412; P < .0001), and endocrine, nutritional, and metabolic disorders (153 vs 217; P < .0001) in the control versus study cohort.

During the control period, the average pretransfusion hemoglobin level was 9.85 (2.63) g/dL (95% CI: 9.85–10.01) in the PICU and 7.58 (0.93) g/dL (95% CI: 7.47–7.65) on the acute care wards. During the study period, the pretransfusion hemoglobin level in the PICU was 8.75 (2.05) g/dL (95% CI: 8.59–8.90) (P < .0001) (Table 3), and in the acute care wards it was 7.14 (1.01) g/dL (95% CI: 6.99–7.28) (P < .0001).

To evaluate the overall effect of the intervention on the frequency of RBCTs in the hospital, the rate of RBCTs per patient per day was determined during the control and study periods in the PICU and the acute care wards. The overall effect of the intervention was evaluated by assessing the aggregate data from both the PICU and the acute care wards. Before the intervention, the rate of RBCTs per patient-day on the acute care wards was 0.033 (0.01) (95% CI: 0.02–0.04). After implementing our CDS algorithm, the rate of RBCTs per patient-day on the acute care wards was 0.017 (0.007) (95% CI: 0.01–0.02), representing a 52% reduction in the RBCT rate (P < .0001) (Fig 3). After controlling for the decrease in CMI in the study period, the difference between the control and study RBCTs per patient-day on the acute care wards remained significant (P = .0009). During the control period in the PICU, the rate of RBCTs per patient-day was 0.20 (0.11) (95% CI: 0.13–0.27). For the study cohort, the RBCT rate per patient-day was 0.14 (0.04) (95% CI: 0.11–0.17) (P = .12) (Fig 4). The relative risk of transfusion in the study versus control cohorts on the acute care wards was 0.66 (95% CI: 0.5714–0.7789) (P < .0001) (Table 4). The relative risk of transfusion in the study versus control cohorts in the PICU was 0.81 (95% CI: 0.7417–0.8943) (P < .0001) (Table 4). When the data were considered in aggregate, the overall rate of RBCTs per patient in the control period was 0.076 (0.035) (95% CI: 0.053–0.098), and in the study period it was 0.050 (0.019) (95% CI: 0.038–0.062) (P < .05) (Fig 5). Based on the decrease in the aggregate rate of RBCTs per patient-day, it was determined that 460 fewer RBCTs were given during the study period. This decrease in RBCTs translated into an estimated direct cost savings of more than $165 000.

**TABLE 2** Top 10 Major Diagnostic Categories of Control and Study Populations

<table>
<thead>
<tr>
<th>Major Diagnostic Category</th>
<th>Control (%)</th>
<th>Study (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nervous system</td>
<td>488 (14)</td>
<td>572 (18)</td>
<td>.076</td>
</tr>
<tr>
<td>Digestive system</td>
<td>443 (15)</td>
<td>437 (12)</td>
<td>.250</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>207 (6)</td>
<td>168 (4)</td>
<td>.009</td>
</tr>
<tr>
<td>Ear, nose, mouth, throat</td>
<td>473 (14)</td>
<td>424 (12)</td>
<td>.006</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>288 (8)</td>
<td>412 (11)</td>
<td>.0001</td>
</tr>
<tr>
<td>Hepatobiliary system and pancreas</td>
<td>161 (4)</td>
<td>167 (4)</td>
<td>.842</td>
</tr>
<tr>
<td>Musculoskeletal system and connective tissue</td>
<td>331 (10)</td>
<td>313 (8)</td>
<td>.126</td>
</tr>
<tr>
<td>Kidney and urinary tract</td>
<td>208 (6)</td>
<td>239 (6)</td>
<td>.381</td>
</tr>
<tr>
<td>Endocrine, nutritional and metabolic</td>
<td>135 (4)</td>
<td>217 (6)</td>
<td>.0001</td>
</tr>
<tr>
<td>Infectious and parasitic diseases</td>
<td>112 (3)</td>
<td>123 (3)</td>
<td>.838</td>
</tr>
<tr>
<td>All other</td>
<td>447 (13)</td>
<td>420 (12)</td>
<td>.056</td>
</tr>
</tbody>
</table>

*The control was between February 1, 2008, and January 31, 2009, and the study period was between February 1, 2009, and January 31, 2010.

**TABLE 3** Average Hemoglobin Level at the Time of RBCT Order Entry for the PICU and Acute Care Wards

<table>
<thead>
<tr>
<th>Ward</th>
<th>Average (SD)</th>
<th>P</th>
<th>Pretransfusion Hemoglobin, g/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PICU</td>
<td>9.83 (0.09)</td>
<td>&lt;.0001*</td>
<td>8.7 (0.07)</td>
</tr>
<tr>
<td>Acute care</td>
<td>7.5 (0.04)</td>
<td>&lt;.0001*</td>
<td>7.1 (0.07)</td>
</tr>
</tbody>
</table>

*P values represent the difference between the means in the control versus the study cohort.

The control period was between February 1, 2008, and January 31, 2009, and the study period was between February 1, 2009, and January 31, 2010.
DISCUSSION

The present study found that the provision of real-time, reliable, evidence-based recommendations can meaningfully and durably inform the clinical decisions of pediatricians in an academic children’s hospital. By automatically tethering the entry of an RBCT order to a CDS tool that evaluates the

FIGURE 3
Rate of RBCTs during the control and study periods in the acute care ward. During the 12-month interval of the control period, the rate of RBCTs was 0.033 (0.01) (horizontal line). During the study period, the rate of RBCTs per patient-day decreased to 0.017 (0.007) (horizontal line; \(P < .0001\)). The initiation of the intervention is represented by the vertical dashed line.

FIGURE 4
Rate of RBCTs during the control and study periods in the PICU. During the 12-month interval of the control period, the rate of RBCT was 0.20 (0.11) (horizontal line). During the study period, the rate of RBCTs per patient-day was 0.14 (0.04) (horizontal line). This does not represent a significant difference (\(P = .12\)). The initiation of the intervention is represented by the vertical dashed line.
Implementation of a simple intervention that guided, but did not constrain, treatment decisions resulted in a significant decrease in RBCTs, thereby decreasing both cost and risk to patients. Widespread adoption of the more conservative RBCT strategy resulted in no measurable untoward clinical sequelae. These results demonstrate that the present strategy has the capacity to inform physician clinical decisions. The observation is significant because, even in the face of definitive clinical evidence, facilitating the adoption of evidence-based guidelines is notoriously difficult and slow. Given the emergence of an increasing number of well-accepted recommendations superimposed on the proliferation of CPOE systems worldwide, the present strategy might prove highly effective in decreasing variability between providers and facilitating adherence to evidence-based recommendations. In turn, increased adherence to sound scientific data may well translate into improved patient outcomes, especially when it pertains to therapies that are not without risk, as is the case with RBCTs.

A study conducted in 2005 found that a hemoglobin level of <9.5 g/dL during a PICU hospitalization had positive predictive value relative to the likelihood of receiving an RBCT. It is interesting that the PICU average pretransfusion hemoglobin level during the control period was 9.7 g/dL, which decreased to 8.7 g/dL in the study period. Given that the patient population in the PICU often includes those who are hemodynamically unstable, it is not surprising that RBCTs would be administered when hemoglobin levels are >7 g/dL. The nature of the patient population in the PICU likely underlies the relatively modest, but significant, decrease in the pretransfusion hemoglobin level to 8.7 g/dL. In contrast, on the acute care wards, where it is very unlikely to have hemodynamically unstable patients, the average pretransfusion hemoglobin level decreased to within one tenth of a point from the recommended transfusion threshold.

The importance of this strategy is further buttressed by a mounting body of evidence suggesting that RBCTs carry significant risk factors, including nosocomial bloodstream infections. A prospective cohort study, performed on >2000 PICU patients, showed that a higher number of RBCTs were associated with an increased risk for bloodstream infections. Furthermore, a retrospective study of >8000 adults after cardiac surgery found that RBCTs were not only associated with infections but also postoperative ischemia, including myocardial infarction, stroke, and renal failure. This observation is significant because it argues that even in relatively anemic adult patients, RBCTs may decrease oxygen delivery to vital tissues, a result that is contrary to the primary intention of the therapy. An explanation for this phenomenon may be found in the progressive changes that occur in stored red blood cells, known as the storage lesion, which alters the very properties that make the red blood cell well suited for oxygen delivery. When new evidence uncovers possible harm associated with therapies that are commonplace in clinical practice, such as RBCTs, tools that promote adoption of that evidence into clinical practice have substantial utility.

Previous studies on diffusion of knowledge into practice consistently demonstrate a significant time delay between the discovery of new knowledge and translation of that knowledge into clinical practice.

### Table 4

<table>
<thead>
<tr>
<th>Ward</th>
<th>Relative Risk of Transfusion: Study vs Control</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PICU</td>
<td>0.81 &lt; .0001*</td>
<td></td>
</tr>
<tr>
<td>Acute care</td>
<td>0.66 &lt; .0001*</td>
<td></td>
</tr>
</tbody>
</table>

*Study versus control.

The control period was between February 1, 2008, and January 31, 2009, and the study period was between February 1, 2009, and January 31, 2010.

### Figure 5

The aggregate rate of RBCTs per patient-day in the PICU and acute care wards decreased. During the control period, the average rate of RBCTs per patient-day was 0.076 (0.035). After the intervention, the rate of RBCTs per patient-day decreased to 0.050 (0.019) (P < .03). This decrease translated into >460 fewer blood transfusions over the life of the intervention.
guidelines have multiple potential benefits, including minimization of practice variability, disparities in care, and dangerous sequelae of untreated conditions. Historically, however, multiple barriers deter implementation by health care providers, including lack of familiarity with the recommendations, lack of agreement, and lack of belief in the efficacy of the recommendations. Additional impediments may include mismatch between evidence or policies and clinical situations, time constraints in clinical practice, and difficulties for health care providers in acquiring new skills. The present report indicates that tethering CPOEs to a CDS alert can produce relatively rapid and sustained changes in clinical decisions. This observation is consistent with previous observations wherein integration of information into regular workflow represents a highly effective way to provide decision support. The data derived during the intervention period suggest increased appreciation of the recommended conservative transfusion thresholds. In our study, within a single calendar year, transfusion practices in the PICU and acute care wards changed significantly, as evidenced by the relative risk of transfusion, the average pretransfusion hemoglobin level, and the aggregate hospital-wide rate of RBCTs per patient-day.

In the health care arena, the need for efficient, evidence-based use of resources has never been more apparent. As costs increase and care becomes ever more complicated, strategies that use information technology to better inform physician practice are likely to be more well distributed and generally applied. By decreasing the aggregate rate of RBCTs per patient from 0.076 (0.035) to 0.050 (0.019), there were 460 fewer RBCTs delivered to children at LPCH during the study period. The estimated direct cost savings for the blood alone was substantial. After accounting for additional indirect costs surrounding blood transfusions, the overall savings was significantly greater.

During the study period, the observed annual CMI changed from 1.88 to 1.74 (P = .03). The CMI is a metric derived from all patient-refined, diagnosis-related groups and is used by the Centers for Medicare & Medicaid Services to measure the relative level of “resource intensity” within a hospital. Resource intensity and utilization serve as surrogate indicators for severity of illness. A decrease in severity of illness is a confounding variable that could have potentially had an influence on our findings. However, even after controlling for the change in CMI, we found that the difference in the rate of RBCTs per patient-day on the acute care wards remained highly significant.

The most significant limitation to this study lies in the fact that it took place in a single institution with historic controls. Because the study design did not permit the inclusion of time-matched controls, we have no way of determining if and at what rate the average pretransfusion hemoglobin levels and transfusion rates would have decreased in the absence of any intervention. Owing to the method whereby CMI was collected only in the monthly aggregate, a correction for the change in CMI could not be performed for the average pretransfusion hemoglobin levels, wherein the data were collected for each individual patient. Finally, the absence of data such as the frequency of the alert limits the conclusions that might have otherwise been drawn surrounding the impact of the intervention on provider-ordering practices.

CONCLUSIONS

To the best of our knowledge, this is the first time that CPOE with automated CDS alerts reduced RBCTs in a population of pediatric patients by improving adherence to rigorous scientific evidence. Data generated from basic science research and clinical trials are readily available through the distribution of information in published journals, yet there remains a wide gap between dissemination of data and integration of that data into clinical practice. The use of RBCTs is a prime example, given the frequency and variability in RBCT administration throughout the country, the mounting evidence of possible harm and increased cost, and evidence in support of a conservative transfusion threshold. We speculate that this strategy can be effectively applied to a wide array of therapies in which non-evidence-based practice and variability persist despite widely accepted standards.

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REFERENCES

3. Lavendière C, Gauvin F, Hébert PC, et al. Survey on transfusion practices of pediatric in-


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