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# Outcomes and Associated Factors of Blood and Blood Component Transfusion in the Pediatric Department at St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia: A Cross-Sectional Study

**Zelalem Dagnachew[1]*, Mamude Dinkeye[2], Tadele Hailu[2], Yihalem Abebe[1], Yemisrach Tamir[1], Yemisrach Taddese[1], Abraraw Admasu[1] and Biniyam Mekonnen[1]**

[1]*Department of Pediatrics and Child Health, Debre Birhan University, Ethiopia*

[2]*Department of Pediatric Hematology and Oncology, St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia*

***Corresponding Author:** Zelalem Dagnachew, Department of Pediatrics and Child Health, Debre Birhan University, Ethiopia.

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## Abstract

**Background:** Blood transfusion is a life-saving intervention; however, its outcomes depend critically on the type of blood component used, clinical indication, and healthcare setting. In low-income countries, whole blood continues to predominate despite evidence favoring component therapy. Pediatric transfusion outcomes in Ethiopian hospital settings are poorly documented.

**Objective:** To assess the immediate clinical and laboratory outcomes of blood and blood component transfusions and their associated factors among pediatric patients (0 - 14 years) admitted to St. Paul's Hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia.

**Methods:** A hospital-based descriptive cross-sectional prospective study was conducted between September 1 and November 30, 2023. All pediatric patients who received any blood or blood component transfusion during the study period with complete records were enrolled using purposive sampling. Data were extracted from blood bank logbooks and patient charts using a structured, pre-tested, WHO guideline-based questionnaire. Clinical improvement was assessed at approximately 6 hours post-transfusion. Bivariate and multivariate binary logistic regression analyses were performed; a p-value <0.05 was considered statistically significant.

**Results:** A total of 262 transfusion episodes were administered to 194 patients (transfusion ratio 1.4 per patient). The median patient age was 3 years; 55.7% were male. Packed red blood cells (PRBC) constituted the most frequently transfused component (40.8%), followed by platelets (24.0%) and whole blood (17.9%). Severe sepsis was the leading underlying diagnosis (29.4%). The mean post-transfusion hemoglobin increase was 2.75 g/dL. Overall, 142 patients (73.2%) achieved clinical improvement. Whole blood-only recipients had the lowest improvement rate (36.0%). On multivariate analysis, PRBC transfusion was independently associated with approximately five times greater odds of clinical improvement compared with whole blood (AOR = 4.95; 95% CI: 2.09 - 11.74; p < 0.001). Patients transfused in the Pediatric Intensive Care Unit (PICU) were six times more likely to improve than those transfused in the pediatric emergency setting (AOR = 6.78; 95% CI: 1.77 - 25.95; p = 0.005). No transfusion reactions were recorded during the study period.

**Conclusion:** PRBC transfusion is significantly associated with better clinical outcomes compared to whole blood in pediatric patients. The continued use of whole blood in Ethiopian healthcare settings warrants urgent policy attention. Strategies to increase component therapy availability and expand ICU-level care infrastructure are recommended.

***Keywords:*** *Blood Transfusion; Blood Components; Packed Red Blood Cells; Pediatric; Transfusion Outcomes; Ethiopia; SPHMMC*

## Introduction

Blood transfusion is a critical therapeutic intervention that can be life-saving across a broad spectrum of clinical conditions including severe anemia, coagulopathy, thrombocytopenia, and acute hemorrhagic shock. The World Health Organization (WHO) classifies blood and blood products as essential medicines, underscoring their indispensable role in modern clinical practice [1]. When administered correctly and to the appropriate indication, transfusion is expected to raise hemoglobin concentration, restore hemodynamic stability, and prevent organ failure - without causing harm through transfusion-associated adverse events or infections [3].

The global burden of transfusion-dependent illness follows a striking geographic gradient. In high-income countries, transfusions are predominantly administered to elderly patients (> 60 years), accounting for up to 76% of all transfusions. In stark contrast, in low-income countries up to 54% of all transfusions are given to children under 5 years of age, primarily for the management of severe anemia [5]. In East and West African studies, children receive between 45 - 60% of all blood transfusions, and up to 30% of pediatric admissions are for the treatment of severe anemia [1].

Component blood therapy - the separation of whole blood into packed red blood cells (PRBC), platelets, and fresh frozen plasma (FFP) - is now the global standard of care. This approach allows targeted treatment of specific deficits while minimizing unnecessary exposure to donor blood. However, whole blood transfusion remains prevalent in many low- and middle-income countries, including Ethiopia, due to resource constraints and limited blood bank infrastructure [2,6,7]. Whole blood is less effective in correcting anemia, carries a greater risk of volume overload, and is associated with worse clinical outcomes in transfused children [6].

Evidence from systematic reviews and randomized controlled trials supports restrictive rather than liberal hemoglobin thresholds for red blood cell transfusion in both neonates and older children, as well as restrictive platelet transfusion policies [4]. In Ethiopian clinical practice, transfusion services face significant challenges including reliance on family and replacement donors, resource limitations, and lack of a formalized national blood strategy [7].

Prior Ethiopian studies demonstrate that whole blood remains the predominant transfusion product and is associated with worse clinical outcomes in adult populations [2,11]. A 2018 study conducted at SPHMMC identified significant inappropriate utilization of blood products in the pediatric setting [8]. Crucially, however, there are no published studies from Ethiopia specifically examining clinical and laboratory outcomes of blood and blood component transfusion in the pediatric population.

This study addresses that evidence gap. Its findings have direct implications for clinical practice, resource allocation, and national blood transfusion policy development in Ethiopia and other low-income settings with similar challenges.

## Methods

### Study design and setting

A hospital-based descriptive cross-sectional prospective study was conducted at the Pediatric Department of St. Paul's Hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia, from September 1 to November 30, 2023. SPHMMC is a federal teaching hospital established in 1968 and governed under the Federal Ministry of Health. It provides tertiary and specialty care with over 700 inpatient beds, serving patients referred from across Ethiopia, and sees approximately 1,200 emergency and outpatient clients daily.

### Study population and sampling

All pediatric patients aged 0 - 14 years admitted to any ward of the pediatric department (Pediatric Emergency, General Pediatric Ward, Pediatric ICU [PICU], Neonatal ICU [NICU], Pediatric Hemato-Oncology [PHO] Ward, and Pediatric Surgical Ward) who received any form of blood or blood component transfusion during the study period were eligible. Purposive (non-random) total sampling was used,

enrolling all eligible patients with complete records. Neonates receiving exchange transfusion and patients with incomplete records were excluded.

### Data collection

Data were collected using a structured, pre-tested questionnaire developed in accordance with WHO pediatric blood transfusion guidelines [4]. Two questionnaire versions were prepared: one for children ≥4 months and one for neonates/infants <4 months, reflecting age-specific WHO hemoglobin thresholds for transfusion. Trained nurses working in the pediatric department extracted data from blood bank logbooks and patient charts. Variables collected included demographics, transfusion unit, indication, type and volume of blood product, duration of transfusion, pre- and post-transfusion hematological parameters (hemoglobin and platelet count), and clinical outcomes. The principal investigator reviewed all forms for completeness and accuracy.

### Outcome definitions

Clinical improvement was defined as documented improvement in vital signs (blood pressure, pulse rate, respiratory rate, $SpO_2$) and clinical signs (pallor, respiratory distress, bleeding tendency) assessed approximately 6 hours after completion of transfusion, as recorded in the patient chart by the attending clinician. For platelet and FFP recipients, improvement was defined as the absence of active bleeding following transfusion. Laboratory improvement was defined as the expected rise in hemoglobin for the volume and type of product transfused (target: approximately 2.7 g/dL increase for PRBC 10 mL/kg or whole blood 20 mL/kg).

### Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics version 26. Descriptive statistics (frequencies, percentages, means, standard deviations) were computed for all variables. Bivariate logistic regression was performed to identify candidate variables associated with clinical improvement ($p < 0.25$). Variables achieving significance were then entered into a multivariate binary logistic regression model. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) are reported; statistical significance was defined as $p < 0.05$.

## Ethical considerations

Ethical clearance was obtained from the Institutional Review Board of SPHMMC prior to study initiation. Patient confidentiality was maintained by assigning unique codes in place of identifying information. As the study relied on retrospective chart review and prospective observation without direct patient intervention, individual informed consent was waived per institutional protocol.

## Results

### Study population and demographic characteristics

Of 290 transfusion episodes recorded in the blood bank during the study period, 262 (90.3%) had complete documentation and were analyzed, representing 194 unique patients. The transfusion-to-patient ratio was 1.4. The majority of patients were male (n = 108, 55.7%). The median age was 3 years. Neonates (< 1 month) comprised the largest age subgroup (n = 50, 25.8%), followed equally by the 1-month-to-1-year (infants) group and both the under-5 and 5 - 10 years age groups (n = 49 each, 25.3% each). Patients aged above 10 years represented 7.2% of the cohort. The majority of transfusions were administered during daytime hours (n = 122, 62.9%) versus nighttime/duty hours (n = 72, 37.1%). Demographic characteristics are summarized in table 1.

### Transfusion patterns

Across 262 transfusion episodes, PRBC was the most frequently used component (n = 107, 40.8%), followed by platelets (n = 63, 24.0%), fresh frozen plasma (FFP) (n = 45, 17.1%), and whole blood (n = 47, 17.9%). By patient rather than episode, PRBC monotherapy was the most common treatment strategy (n = 72, 37.1%), followed by PRBC combined with platelets (n = 20, 10.3%), and whole blood

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Time of Transfusion | Daytime | 122 | 62.9 |
| | Nighttime/Duty Hours | 72 | 37.1 |
| Sex | Male | 108 | 55.7 |
| | Female | 86 | 44.3 |
| Age Group | Neonate (< 1 month) | 50 | 25.8 |
| | Infant (< 1 year) | 32 | 16.5 |
| | Under 5 years | 49 | 25.3 |
| | 5-10 years | 49 | 25.3 |
| | Above 10 years | 14 | 7.2 |

***Table 1:*** *Demographic characteristics of transfused pediatric patients, SPHMMC, September-November 2023 (N = 194).*

monotherapy (n = 25, 12.9%) and platelet monotherapy (n = 25, 12.9%) equally. Eleven patients (5.6%) received more than two blood components. Regarding the requesting unit, PICU generated the highest volume of requests (n = 49, 25.3%), followed by NICU (n = 45, 23.2%), PHO ward (n = 37, 19.1%), pediatric emergency (n = 34, 17.5%), and general pediatric ward (n = 26, 13.4%). Transfusion patterns are detailed in table 2.

| Component (per patient) | n | % | Transfusion Episodes | n | % |
|---|---|---|---|---|---|
| Whole blood only | 25 | 12.9 | Whole blood | 47 | 17.9 |
| PRBC only | 72 | 37.1 | PRBC | 107 | 40.8 |
| Platelets only | 25 | 12.9 | Platelets | 63 | 24.0 |
| FFP only | 21 | 10.8 | FFP | 45 | 17.1 |
| Whole blood + PRBC | 2 | 1.0 | Total episodes | 262 | 100.0 |
| Whole blood + Platelets | 4 | 2.1 | | | |
| Whole blood + FFP | 8 | 4.1 | | | |
| PRBC + Platelets | 20 | 10.3 | | | |
| PRBC + FFP | 3 | 1.5 | | | |
| Platelets + FFP | 3 | 1.5 | | | |
| ≥3 components | 11 | 5.7 | | | |
| Total | 194 | 100.0 | | | |

***Table 2:*** *Type and pattern of blood and blood components transfused, SPHMMC, September-November 2023.*

## Clinical diagnoses

The most common underlying diagnosis in transfused patients was severe sepsis (n = 57, 29.4%), followed by hematologic malignancy (n = 34, 17.5%), pancytopenia of various etiologies (n = 19, 9.8%), hemolytic anemia including hemolytic disease of the newborn, autoimmune hemolytic anemia, and hemolytic uremic syndrome (n = 16, 8.2%), severe acute malnutrition (n = 13, 6.7%), hemorrhagic shock/blood loss (n = 13, 6.7%), solid tumors (n = 9, 4.6%), anemia of prematurity (n = 8, 4.1%), and immune thrombocytopenic purpura (n = 5, 2.6%) (Table 3).

| Diagnosis | Frequency (n) | Percentage (%) |
|---|---|---|
| Severe sepsis | 57 | 29.4 |
| Hematologic malignancy | 34 | 17.5 |
| Pancytopenia (various etiologies) | 19 | 9.8 |
| Hemolytic anemia (HDN, AIHA, HUS) | 16 | 8.2 |
| Severe acute malnutrition | 13 | 6.7 |
| Hemorrhagic shock/blood loss | 13 | 6.7 |
| Solid tumors | 9 | 4.6 |
| Anemia of prematurity | 8 | 4.1 |
| Immune thrombocytopenic purpura (ITP) | 5 | 2.6 |
| Other | 20 | 10.3 |

***Table 3:*** *Underlying diagnoses of transfused patients, SPHMMC Pediatric Department, September-November 2023.*

## Hematological parameters

Of 194 patients, 147 (75.8%) had both pre- and post-transfusion hemoglobin values documented. Pre-transfusion, severe anemia (Hgb < 7 g/dL) per WHO criteria was present in 64 patients (43.6%), and extreme anemia (Hgb < 5 g/dL) in 17 (11.6%). Liberal transfusion (Hgb > 7 g/dL at the time of transfusion) was applied in 83 patients (56.4%). A statistically significant increase in post-transfusion hemoglobin was observed ($p < 0.01$), with a mean Hgb rise of 2.75 g/dL (SD 1.944) across the cohort. Pre-transfusion hemoglobin below 5 g/dL was present in 11.6% of patients, compared to 1.4% post-transfusion (Table 4). Platelet counts also significantly improved post-transfusion ($p < 0.01$), with a reduction in the proportion with platelet counts below $10 \times 10^9$/L from 35.5% to 21.0%.

Peripheral blood morphology was performed prior to transfusion in only 35 patients (18.0%). The mean duration of transfusion was 3 hours; no transfusions exceeded the recommended 4-hour limit. No transfusion reactions were documented during the study period.

| Parameter | Level | Pre-Transfusion n (%) | Post-Transfusion n (%) | p-value |
|---|---|---|---|---|
| Hemoglobin (n = 147) | < 5 g/dL | 17 (11.6%) | 2 (1.4%) | < 0.01 |
| | 5-7 g/dL | 47 (32.0%) | 16 (10.9%) | |
| | 7.1-10 g/dL | 50 (34.0%) | 69 (46.9%) | |
| | > 10 g/dL | 33 (22.4%) | 60 (40.8%) | |
| Platelet count (n = 62) | $< 10 \times 10^9$/L | 22 (35.5%) | 13 (21.0%) | < 0.01 |
| | $10\text{-}20 \times 10^9$/L | 18 (29.0%) | 21 (33.9%) | |
| | $21\text{-}50 \times 10^9$/L | 14 (22.6%) | 13 (21.0%) | |
| | $51\text{-}100 \times 10^9$/L | 6 (9.7%) | 12 (19.4%) | |
| | $> 100 \times 10^9$/L | 2 (3.2%) | 3 (4.8%) | |

***Table 4:*** *Pre- and post-transfusion hematological parameters, SPHMMC, September-November 2023.*

## Clinical outcomes

Of 194 patients, 142 (73.2%) achieved clinical improvement following transfusion, while 52 (26.8%) did not improve. Among non-improvers, whole blood monotherapy accounted for the largest single-group contribution: 16 of 25 whole blood-only patients (64.0%)

did not improve, representing 30.7% of all clinical non-improvement cases. By contrast, 66 of 72 patients (91.7%) receiving PRBC alone improved clinically. Outcomes stratified by blood product type are presented in table 5.

| Blood Component Type | Improved n (%) | Not Improved n (%) | Total n (%) |
|---|---|---|---|
| Whole blood only | 9 (36.0%) | 16 (64.0%) | 25 (100%) |
| PRBC only | 66 (91.7%) | 6 (8.3%) | 72 (100%) |
| Platelets only | 19 (76.0%) | 6 (24.0%) | 25 (100%) |
| FFP only | 12 (57.1%) | 9 (42.9%) | 21 (100%) |
| Whole blood + PRBC | 1 (50.0%) | 1 (50.0%) | 2 (100%) |
| Whole blood + Platelets | 2 (50.0%) | 2 (50.0%) | 4 (100%) |
| Whole blood + PRBC + Platelets | 2 (66.7%) | 1 (33.3%) | 3 (100%) |
| PRBC + Platelets + FFP | 5 (100%) | 0 (0.0%) | 5 (100%) |
| Total | 142 (73.2%) | 52 (26.8%) | 194 (100%) |

***Table 5:*** *Clinical improvement stratified by type of blood component, SPHMMC, September-November 2023.*

### Factors associated with clinical improvement

In bivariate logistic regression, clinical improvement was significantly associated with sex (p = 0.015), type of blood component (p < 0.001), pediatric unit (p = 0.005), and post-transfusion hematological improvement (p = 0.011). After multivariate adjustment, two factors retained independent significance: type of blood component and pediatric unit.

Patients who received PRBC monotherapy were approximately five times more likely to achieve clinical improvement compared to those who received whole blood only (AOR = 4.95; 95% CI: 2.09 - 11.74; p < 0.001). Patients transfused in the PICU had six times greater odds of clinical improvement than those transfused in the pediatric emergency setting (AOR = 6.78; 95% CI: 1.77 - 25.95; p = 0.005). Patients transfused in the NICU showed approximately four times greater improvement odds compared to pediatric emergency (AOR = 4.40; 95% CI: 1.13 - 17.09; p = 0.032). Age, sex, diagnosis, and pre/post-transfusion hemoglobin level were not independently associated with clinical improvement after multivariate adjustment. Full regression results are presented in table 6.

| Variable | Category | Improved n | Not Improved n | COR (95% CI) | AOR (95% CI) | p-value |
|---|---|---|---|---|---|---|
| Age | Neonate (ref) | 26 | 24 | 1 | 1 | -- |
| | Infancy | 15 | 17 | 1.23 (0.51-2.99) | 3.12 (0.30-32.6) | 0.343 |
| | Under 5 years | 26 | 23 | 0.96 (0.44-2.11) | 2.51 (0.23-27.6) | 0.452 |
| | 5-10 years | 25 | 24 | 1.04 (0.47-2.29) | 2.14 (0.20-22.7) | 0.529 |
| | >10 years | 4 | 10 | 2.71 (0.75-9.79) | 3.64 (0.30-44.4) | 0.311 |
| Blood Component | Whole blood (ref) | 9 | 16 | 1 | 1 | -- |
| | PRBC | 66 | 6 | 0.051 (0.016-0.165) | 4.948 (2.086-11.736) | <0.001 |
| | Platelets | 19 | 6 | 0.178 (0.052-0.607) | 1.155 (0.513-2.598) | 0.728 |
| | FFP | 12 | 9 | 0.422 (0.128-1.385) | 0.564 (0.242-1.312) | 0.184 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pediatric Unit | Emergency (ref) | 31 | 3 | 1 | 1 | -- |
| | General Ward | 19 | 7 | 3.807 (0.877-16.5) | 4.060 (0.917-17.98) | 0.065 |
| | PICU | 30 | 19 | 6.544 (1.753-24.4) | 6.784 (1.773-25.948) | 0.005 |
| | NICU | 32 | 13 | 4.198 (1.089-16.2) | 4.400 (1.133-17.093) | 0.032 |
| | PHO Ward | 29 | 8 | 2.851 (0.689-11.8) | 2.985 (0.697-12.786) | 0.141 |

***Table 6:*** *Multivariate logistic regression: Determinants of clinical improvement following blood transfusion, SPHMMC, September-November 2023.*

## Discussion

This prospective cross-sectional study is the first to specifically examine outcomes of blood and blood component transfusion in the Ethiopian pediatric population, filling an important gap in the literature. We analyzed 262 transfusion episodes in 194 pediatric patients across a 3-month period at SPHMMC, a major national referral center. The overall clinical improvement rate was 73.2%, and PRBC transfusion was identified as the strongest independent predictor of clinical benefit, with patients receiving PRBC approximately five times more likely to improve than those receiving whole blood.

The demographic profile of our cohort - with a median age of 3 years and neonates comprising the largest subgroup (25.8%) - is broadly consistent with transfusion epidemiology in sub-Saharan Africa, where children under 5 bear the highest transfusion burden [5,6]. The predominance of PRBC transfusion (40.8% of all episodes) reflects a practice shift at SPHMMC compared to historical patterns at Ethiopian hospitals, where whole blood accounted for 85% of transfusions in one Addis Ababa study conducted in 2010-11 [11] and 55.9-84.7% across wards in a 2021 study at Yekatit-12 Hospital [2]. The increasing adoption of component therapy at SPHMMC is encouraging, though whole blood still represented 17.9% of episodes, indicating room for further improvement.

The mean post-transfusion hemoglobin increase of 2.75 g/dL in our study is consistent with findings from other African pediatric studies: 3.1 g/dL in a Nigerian teaching hospital [3] and 2.9 g/dL in a Gabonese multicenter study [6]. However, the baseline anemia burden in our cohort differed notably from Gabon, where 95.1% met WHO criteria for severe anemia (Hgb < 7 g/dL) compared to 43.6% in our study, likely reflecting the different disease mix - malaria and sickle cell disease predominated in Gabon, while severe sepsis and hematologic malignancy drove anemia in our population.

The overall clinical improvement rate of 73.2% falls between that reported at Black Lion Specialized Hospital (81.1%) [11] and Yekatit-12 Hospital (85.2%) [2] in Ethiopia, although both of these studies included adult patients, precluding direct comparison. The substantially lower improvement rate observed in the Gabonese study's unfavorable outcomes (1.8%) reflects a fundamentally different case mix and the very high PRBC utilization rate in that setting [6].

The critical finding of this study is the markedly inferior clinical outcome associated with whole blood transfusion. Only 36% of whole blood-only recipients improved clinically, compared with 91.7% of PRBC recipients. On adjusted analysis, PRBC recipients were approximately five times more likely to achieve clinical improvement (AOR 4.95). This aligns with findings from the Black Lion Hospital audit, where 66.2% of non-improved patients had received whole blood [11], and with evidence from Gabon, where whole blood has been eliminated from hospital practice precisely because of its association with volume overload, lower hematocrit concentration per unit transfused, and adverse outcomes in children [6]. The pathophysiological explanation is straightforward: PRBCs deliver a higher concentration of red cells per volume of infusion, reducing the risk of transfusion-associated circulatory overload (TACO) and minimizing exposure to unnecessary plasma proteins.

An important secondary finding was the significant association between transfusion location and clinical outcome. Patients transfused in the PICU and NICU were approximately six and four times more likely to improve, respectively, compared to those transfused in the pediatric emergency setting. This likely reflects multiple confounders: critical care units may preferentially use PRBC (consistent with the product-outcome relationship), and patients in ICU settings receive more comprehensive multi-organ supportive care including mechanical ventilation, vasopressors, and close hemodynamic monitoring. Disentangling the independent contribution of ICU-level supportive care from product type in determining outcomes requires prospective studies with more granular data.

Liberal transfusion was used in the majority of patients (56.4%, Hgb > 7 g/dL), and while we found no statistically significant difference in outcomes between liberal and restrictive transfusion strategies, this study was underpowered to detect such a difference. Current WHO and international society guidelines strongly endorse restrictive thresholds as both safe and efficacious in stable pediatric patients [4], and our results do not contradict this evidence base.

The finding that peripheral blood morphology was performed in only 18.0% of patients before transfusion is a concern. Peripheral morphology can guide diagnosis, identify transfusion-modifying conditions, and optimize management. This gap suggests a need for systematic pre-transfusion workup protocols.

This study has several limitations. The single-center design and purposive sampling limit generalizability. The 3-months study window may introduce seasonal variation in disease prevalence. Clinical improvement was assessed at a single time point (approximately 6 hours post-transfusion), which may not capture delayed clinical deterioration or late adverse events. Assessment of platelet transfusion outcomes was constrained by irregular platelet availability, which affected adherence to transfusion guidelines. Clinical improvement as defined in this study relies on physician documentation in the chart, introducing potential ascertainment bias. Future multicenter, prospective cohort studies with standardized outcome definitions and longer follow-up are needed.

## Conclusion

In this cohort of Ethiopian pediatric patients, PRBC transfusion was associated with significantly better clinical outcomes than whole blood transfusion, with an approximately five-fold increase in the odds of clinical improvement. The overall clinical improvement rate was 73.2%, with whole blood recipients having the lowest improvement rates (36.0%). Better outcomes in ICU settings likely reflect both preferential use of PRBC and the availability of comprehensive supportive care. These findings provide the first Ethiopian pediatric-specific evidence supporting the global consensus that PRBC should replace whole blood as the standard of care.

Healthcare authorities and hospital administrators should urgently prioritize scale-up of blood component preparation and storage capacity across Ethiopian pediatric facilities. Clinical protocols mandating PRBC over whole blood for pediatric anemia management should be formally established and enforced. Improving pre-transfusion diagnostic workup - including peripheral blood morphology - and expanding ICU-level care infrastructure will be critical to further improving transfusion outcomes in this vulnerable population.

## Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Authors' Contributions

Zelalem Dagnachew conceived the study, designed the data collection tool, supervised data collection, performed statistical analysis, and drafted the manuscript. Mamude Dinkeye and Tadele Hailu supervised the study design and analysis, critically reviewed and revised the manuscript. Yihalem Abebe, Yemisrach Tamir, Yemisrach Taddese, Abraraw Admasu, and Biniyam Mekonnen contributed to data collection, data entry, and manuscript review. All authors read and approved the final manuscript.

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## Conflict of Interest

None declared.

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## Ethical Approval

Obtained from the Institutional Review Board of SPHMMC.

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