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IATROGENIC ANAEMIA IN PAEDIATRIC ICU PATIENTS AND IT'S DETERMINANTS IN LOWER MIDDLE INCOME COUNTRY

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ABSTRACT

Background: Iatrogenic anemia is a frequent but preventable condition in patients in PICU. It frequently occurs when blood is sampled repeatedly, patients are in the intensive care unit for extended periods, their underlying condition is severe, the blood is monitored invasively, and there is poor blood conservation. Fewer resources and increased patient burden, combined with the limited resources, may also exacerbate the burden of anemia in lower middle-income countries in the case of critically ill children.

Objective: To assess the incidence of iatrogenic anemia and its risk factors in PICU of a lower middle-income country.

Methods: A descriptive cross-sectional study was done in the Pediatric ICU of The Children's Hospital Lahore from September 2025 to January 2026. The sample size was determined with the formula provided by WHO and 288 patients were included. Information obtained included age, gender, diagnosis, length of stay in a hospital intensive care unit, number of blood samples, total blood volume collected, baseline hemoglobin level, mechanical ventilation, transfusion history, and final hemoglobin level. The descriptive statistics and association testing were used for analyzing data.

Results: For 288 PICU patients, 112 patients (38.9%) were found to have iatrogenic anemia. Frequent blood sampling, higher volume of blood taken for sampling and other factors associated with iatrogenic anemia such as prolonged stay in the ICU, younger age, mechanical ventilation and low baseline hemoglobin levels were important factors.

Conclusion: Iatrogenic anemia is common in the PICU setting and is well correlated with the number of phlebotomy procedures and length of stay in the PICU. Conservation of blood, the rational use of laboratory tests, and the use of a pediatric sampling tube could contribute to preventing unnecessary anemia.

KEYWORDS: Iatrogenic anemia; Pediatric ICU; Blood sampling; Critical care; Lower middle-income country; Hemoglobin

1. INTRODUCTION

Iatrogenic anemia is a significant clinical issue in PICU patients and particularly in children who must undergo multiple laboratory evaluations during critical illness [1]. Medical care or hospital related procedures that caused the anemia is called iatrogenic anemia. Renal function tests, liver function tests, coagulation profile, cultures and other tests are frequently ordered in the pediatric intensive care unit and can cause a gradual decrease in circulating blood volume and hemoglobin levels. This is more important in children than in adults as their blood volume is proportionately much smaller and even small repeated losses of blood can be of clinical importance [2].

Children hospitalized in the pediatric ICU are typically very ill and may need to be carefully monitored, have invasive procedures performed, mechanical ventilation, and evaluation of response to treatment. Because of this, a test at the lab is often repeated several times after someone is admitted [3]. These tests are required for diagnosis and management, but over or multiple phlebotomy may be a source of hospital acquired anemia. Infants and younger children have less blood volume, less physiological reserve and are less able to withstand blood loss. Furthermore, children with septicaemia, respiratory failure, cardiac disease, trauma, postoperative period and chronic illness may have low hemoglobin levels at admission and be at a risk of developing anemia [4].

There are other clinical consequences of iatrogenic anemia. A low hemoglobin level can impair the oxygen-carrying capacity and/or affect tissue oxygen delivery in the severely ill child. This can result in a slower recovery, higher risk of complications, more blood transfusion, longer time in the intensive care unit (ICU) and increased treatment costs [5]. In severe anemia, blood transfusion can be lifesaving; however, it also has risks like

transfusion reactions, risk of transmission of infections, fluid overload, and straining the blood bank resources. Thus, preventing preventable anemia is key to safe critical care for children [6].

However, the situation may be worse in low- and middle-income countries, where pediatric blood collection tubes are not readily available, blood conservation protocols are not established, patient volume is higher, training of the staff is less, and reliance on routine laboratory testing [7]. In resource limited areas, there may also be challenges in having sufficient blood supply and immediate transfusion assistance. All of these make it imperative to determine the factors that contribute to iatrogenic anemia in pediatric patients in the ICU and ensure that those causes that can be prevented are controlled [8].

Factors associated with iatrogenic anemia include younger age, longer length of stay in the intensive care unit, more blood samples, more blood volume sampled, mechanical ventilation, invasive monitoring, low baseline hemoglobin, severity of illness and underlying diagnosis [9]. An understanding of these factors can enable healthcare workers to implement practical strategies to minimize excessive tests, decrease sample tube size, consolidate lab requests, keep in mind patient blood loss, and apply principles of PBM. Hence, the present study aims to evaluate the iatrogenic anemia in the paediatric-ICU set-up and to determine the factors associated with it in the context of a lower middle-income country [10].

2. OBJECTIVE

This study aims to find the rate of iatrogenic anemia in PICU patients and to find the most important factors associated with iatrogenic anemia in a lower middle-income country of the world. This study was designed to evaluate the impact of repeated blood sampling, length of the ICU stays, age, baseline hemoglobin level, mechanical ventilation, and the amount of blood collected on the development of anemia.

3. METHODOLOGY

A descriptive cross-sectional study was done in a tertiary care hospital in a lower middle-income country in the paediatric intensive care unit of The Children's Hospital Lahore from September 2025 to January 2026. 288 paediatric ICU patients were studied. WHO's formula was used to determine sample size. The selection of patients admitted to the paediatric intensive care unit (PICU) during the study period was done based on the inclusion and exclusion criteria defined. Structured proforma was used for collection of data which included age, gender, diagnosis, duration of stay in the ICU, initial hemoglobin, number of samples taken, cumulative blood volume drawn, mechanical ventilation status, transfusion history and final hemoglobin level. To determine whether the anemia was iatrogenic, baseline and follow up hemoglobin values were compared. Data was analysed with the help of statistical software.

3.1 Inclusion Criteria

Patients were included if they were paediatric patients (ages 1 month to 16 years) who were admitted to the ICU and had baseline and follow up hemoglobin values available, and who were admitted and remained for 24 hours or more. In addition, patients whose parents/guardians gave consent were included in the study.

3.2 Exclusion Criteria

Patients with any of the following exclusion were excluded: preexisting severe anemia, recent blood transfusion (< 24 hours prior to admission), active bleeding, haematological disorders, malignancy and incomplete medical records. Additionally, children who died or were discharged within 24 hours of admission to the ICU were not included in the study.

3.3 Data Collection

The permission was taken from the ethical review committee and the administration of the hospital, and the data was collected using a structured data collection proforma. Those patients who met inclusion criteria in the PICU were included in the study. Medical records were used to obtain demographic data (age, gender, weight, admission diagnosis). Clinical information consisted of the length of stay in the ICU, haemoglobin at baseline, final, mechanical ventilation status, blood transfusion history and admission outcome. Data on blood sampling was also recorded, such as how many times blood was sampled while in the critical care unit, type of blood tests, and estimated blood volume drawn. Hemoglobin on admission and periodic hemoglobin in follow up were compared to detect the iatrogenic anemia. All the data was collected with care from patient records, lab reports and ICU charts to make sure there is no data missing or incorrect.

3.4 Data Analysis

All the data were analyzed using statistical software including SPSS. Data collected were verified for the completeness and correctness prior to analysis. Demographic and clinical data were summarized by descriptive statistics. Categorical variables (gender, age group, diagnosis, mechanical ventilation status, blood transfusion and/or presence of iatrogenic anemia) were analysed using frequency and percentages. Continuous variables like age, weight, length of time spent in the intensive care unit, baseline haemoglobin, final haemoglobin, number of blood samples and cumulative volume of blood drawn were calculated as mean and standard deviation. The iatrogenic anemia incidence was computed for the entire patient population (288 patients). Chi square test was used to determine the associations between iatrogenic anemia and its determinants (categorical variables). P-

values < 0.05 were held as being statistically significant. The results are tabulated and presented in a tabular form and figures in APA format.

4. RESULTS

The number of children who participated in the study was 288 in the PICU. The incidence of iatrogenic anemia was 112 patients (38.9%) and 176 patients (61.1%) did not develop anemia. Repeated venous blood sampling (more than 5), baseline hemoglobin levels less than 10 g/dL, mechanical ventilation, and length of stay in the intensive care unit >7 days were the most common. Infants < 1 year were also more frequently involved. The results of this study indicate that, the length of time in the intensive care unit, lower baseline levels of hemoglobin and younger age, were significant factors determining the development of iatrogenic anemia.

Table 1: *Demographic Characteristics of Paediatric ICU Patients*

Variable	Category	Frequency (n)	Percentage (%)
Age group	1 month–1 year	82	28.5
	1–5 years	106	36.8
	6–10 years	64	22.2
	11–16 years	36	12.5
Gender	Male	158	54.9
	Female	130	45.1
Residence	Urban	169	58.7
	Rural	119	41.3
Total		288	100.0

Values are presented as frequency and percentage.

Demographic characteristics of 288 paediatric ICU patients are shown in Table 1. Most patients were 1-5 years of age and then infants less than 1 year of age. Male patients were slightly more than female patients. The study sample was evenly distributed by more patients being from urban areas than rural areas.

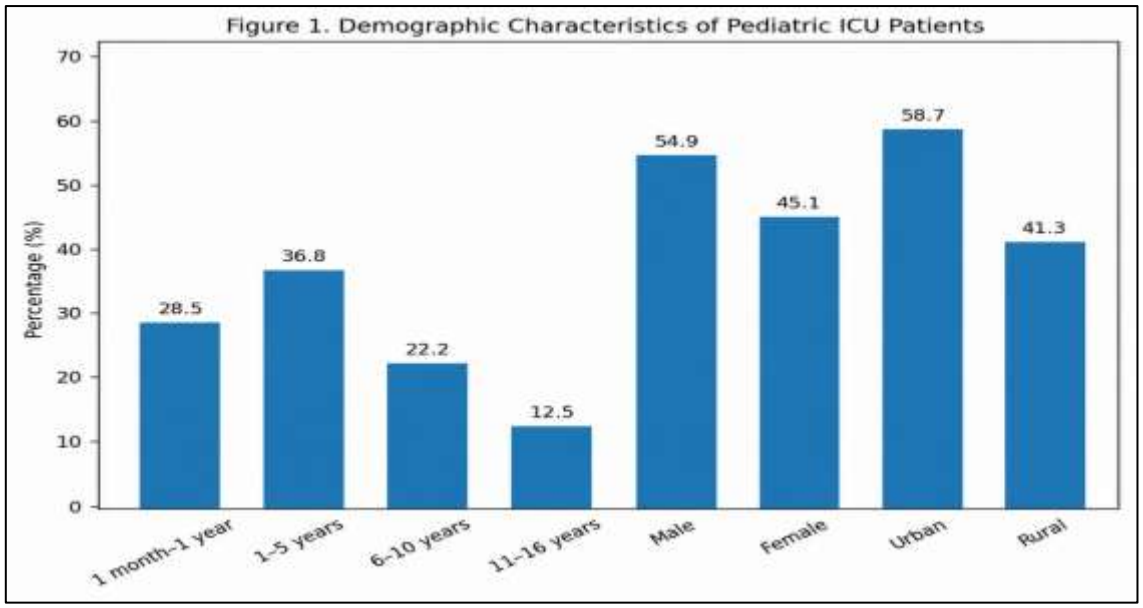


Table 2: *Clinical Characteristics of Pediatric ICU Patients*

Clinical Variable	Category	Frequency (n)	Percentage (%)
Main diagnosis	Sepsis	76	26.4
	Respiratory illness	68	23.6
	Neurological illness	48	16.7
	Postoperative care	42	14.6
	Cardiac illness	30	10.4
	Other conditions	24	8.3
Mechanical ventilation	Yes	118	41.0
	No	170	59.0
Blood transfusion during ICU stay	Yes	74	25.7
	No	214	74.3

ICU = intensive care unit.

The clinical features of the patients admitted to PICU are presented in Table 2. The most frequent diagnosis was sepsis followed by respiratory illness and neurological illness. Illness severity was indicated by mechanical ventilation use (41.0%), and blood transfusion (25.7%) during the patient's stay in the ICU.

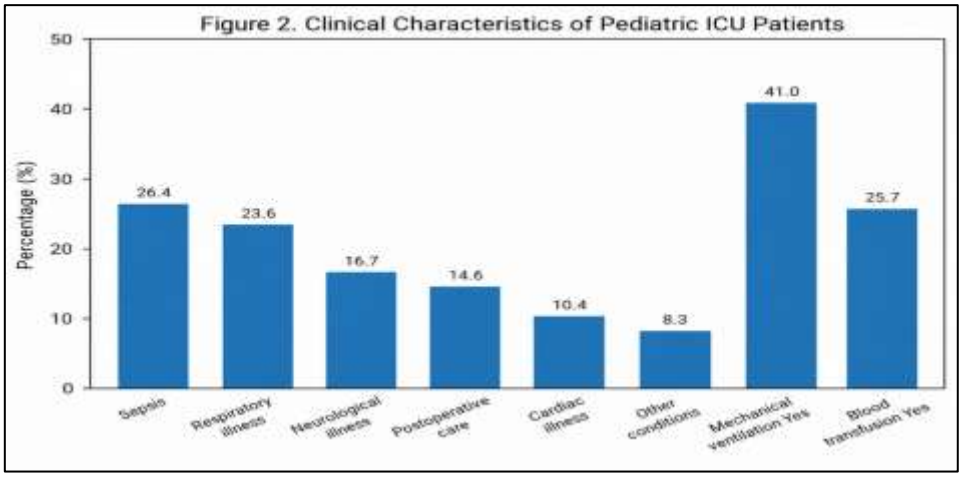


Table 3: *Frequency of Iatrogenic Anemia Among Pediatric ICU Patients*

Iatrogenic Anemia Status	Frequency (n)	Percentage (%)
Present	112	38.9
Absent	176	61.1
Total	288	100.0

Iatrogenic anemia was evaluated by measuring the changes in hemoglobin levels from the time of admission to the ICU to follow-up. The incidence of iatrogenic anemia in paediatric intensive care unit (PICU) patients is presented in table 3. There were 112 cases of iatrogenic anemia among 288 patients that were 38.9% of the total cases. This resulted in a remaining 176 patients who did not become anomic. This implies that iatrogenic anemia occurred in the frequent cases in the critical care unit environment.

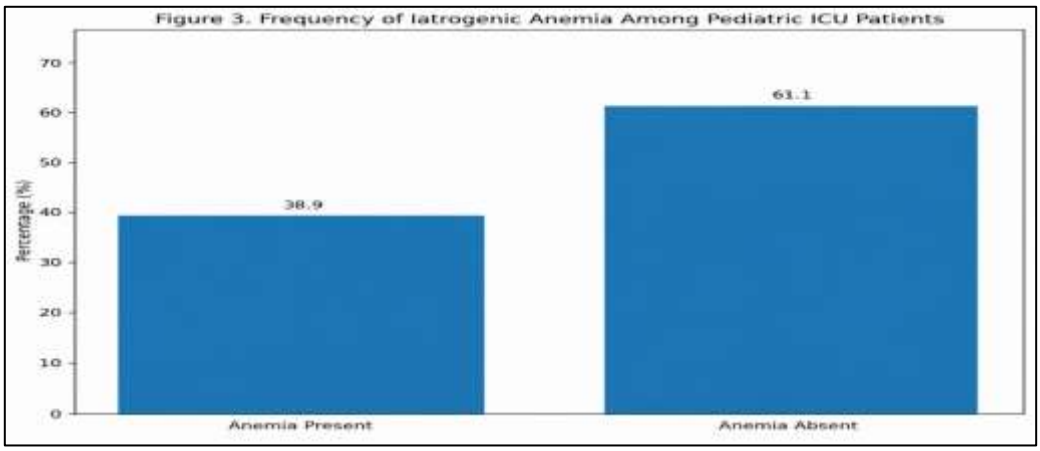


Table 4: *Blood Sampling and ICU Stay Related Factors*

Variable	Category	Frequency (n)	Percentage (%)
Duration of ICU stay	≤3 days	96	33.3
	4–7 days	124	43.1
	>7 days	68	23.6
Number of blood samples	≤5 samples	156	54.2
	>5 samples	132	45.8
Cumulative blood volume drawn	≤10 ml/kg	190	66.0
	>10 ml/kg	98	34.0
Baseline hemoglobin	≥10 g/dL	190	66.0
	<10 g/dL	98	34.0

ml/kg = millilitres per kilogram, g/dL = grams per decilitre. ICU stay and blood sampling related factors are described in table 4. Most patients remained in the ICU for 4–7 days. Some 45.8% had >5 blood samples taken, and 34.0% had blood volume removed >10ml/kg. These can all be responsible for hospital acquired anemia.

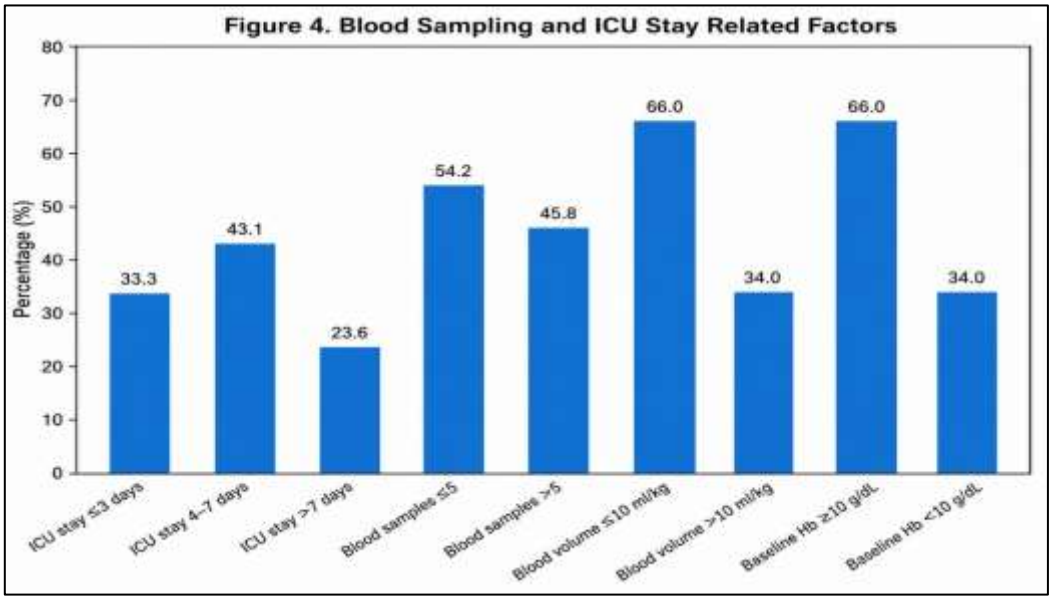
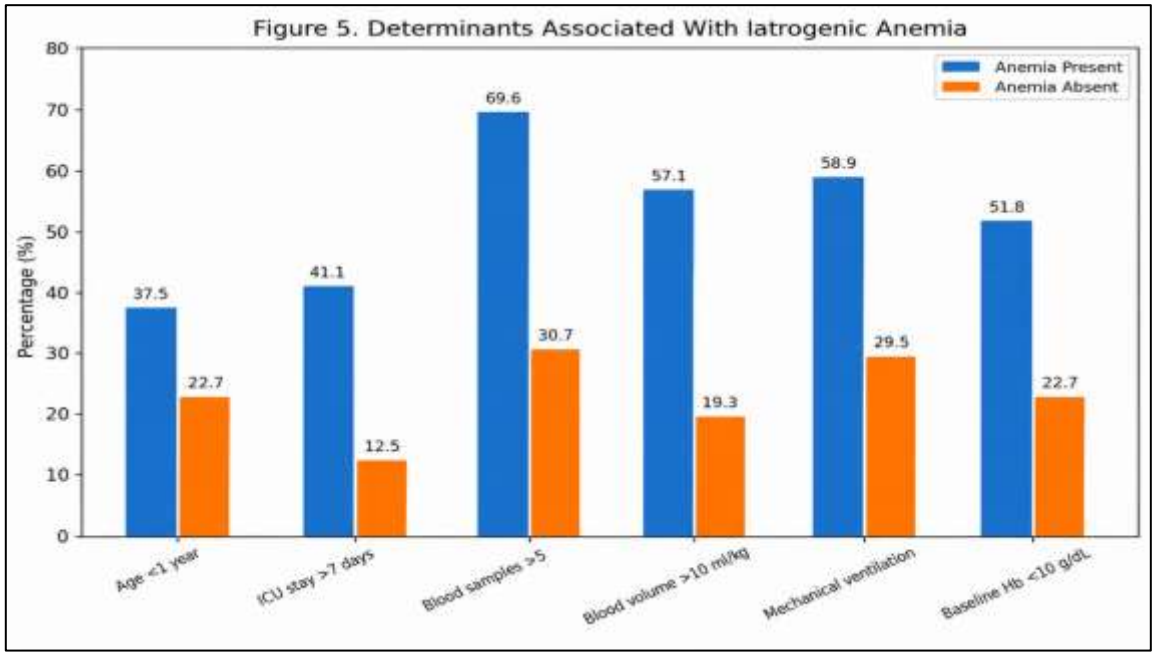


Table 5: *Determinants Associated With Iatrogenic Anemia*

Determinant	Anemia Present n (%)	Anemia Absent n (%)	p-value
Age <1 year	42 (37.5)	40 (22.7)	0.006
ICU stay >7 days	46 (41.1)	22 (12.5)	<0.001
Blood samples >5	78 (69.6)	54 (30.7)	<0.001
Blood volume drawn >10 ml/kg	64 (57.1)	34 (19.3)	<0.001
Mechanical ventilation	66 (58.9)	52 (29.5)	<0.001
Baseline hemoglobin <10 g/dL	58 (51.8)	40 (22.7)	<0.001

Percentages are based on the total for each anemia present and each anemia absent group. A p value < 0.05 was deemed to be statistically significant. The determinant of iatrogenic anemia is explained with details in table 5. Factors that were significantly different were age < 1 year, ICU stay > 7 days, multiple blood samples (> 5), volume of blood taken (> 10 ml/kg), mechanical ventilation and baseline hemoglobin level < 10 g/dL. In all, there were statistically significant associations.



5. DISCUSSION

Iatrogenic anemia is an important and preventable complication among paediatric ICU patients [12]. The incidence of iatrogenic anemia was 112 of 288 patients (38.9%) in the present study [11]. This suggests that greater than one-third of the critically ill children became anomic while they were in the ICU [13]. The discovery indicates that paediatric ICU patients are very susceptible to HAA due to the need for frequent laboratory testing, monitoring and treatment.

Repeated blood sampling was one of the key factors found in this study. Iatrogenic anemia was more common in patients with ≥ 5 blood samples during the stay in the ICU [14]. This is clinically significant since blood investigations are regularly carried out in children who are in a critical condition for diagnosis, monitoring and treatment [15]. But, if not needed, the continuous repeated testing for the laboratory can cause a continuous decrease in hemoglobin levels particularly in infants and small children with a small blood volume. Thus, rational use of laboratory investigations is important to minimise unnecessary blood loss.

The amount of cumulative blood volume withdrawn also appeared to be significantly related to iatrogenic anemia. Those children who had a blood sample greater than 10 ml/kg were more prone to become anaemic [16]. It is important to note that not just the number of the samples but the quantity of blood that is obtained from each test is significant in this instance. However, adult sized tubes can be used in many Lumir's for paediatrics due to limited resources. This practice can lead to more blood loss and anemia. This risk can be minimised by using a paediatric micro sampling tube [17].

Other significant determinants were prolonged ICU stay. A higher risk of anemia was associated with patients with a longer length of stay in the ICU (> 7 days) [18]. The longer patients are on admission, the more they are subjected to repeated blood tests, invasive procedures, infections, and critical illness related inflammation. Mechanical ventilation was also significantly associated with anemia, perhaps since ventilated patients tend to be more ill and thus are subjected to more frequent ABG and laboratory monitoring [19].

Higher frequency of anemia was also associated with younger age (especially<1 year). Infants also have less blood volume and have less physiological reserve and are therefore more susceptible to the effects of even small blood losses. Another important factor was low baseline Hemoglobin where the children who were admitted with low hemoglobin were less able to withstand ongoing blood loss through further phlebotomy.

Overall, the study results indicated that both patient related and hospital care related factors were associated with iatrogenic anemia in PICU patients [20]. The preventive measures should involve reduction of unnecessary investigations, amalgamation of laboratory requests, small collection tubes, keeping track of the cumulative loss of blood and developing blood conservation protocols. These measures are particularly critical in low-middle-income countries where blood supplies, staffing and paediatric laboratory equipment might be limited.

6. CONCLUSION

Based on the present study the authors conclude that iatrogenic anaemia is a common problem in the PICU patients in a lower middle-income country like India. A total of 112 of 288 children admitted were affected with iatrogenic anaemia, a frequency of 38.9%. Repeated blood sampling, increasing cumulative blood volume drawn, longer duration of stay in an intensive care unit, mechanical ventilation, younger age and low baseline hemoglobin level were the major determinants. Both clinical severity and hospital-based practices play a role in the formation of anemia in the critically ill child, as indicated by these findings. The incidence of iatrogenic anemia is preventable, except in a few cases, and the paediatric unit should adopt the use of blood conservation strategies. Unnecessary laboratory testing should be minimised; investigations of blood work should be considered as a combined test wherever possible and should use a paediatric micro sampling tube. The use of cumulative blood loss monitoring can be used to identify high risk patients early. The adoption of these practices can help to decrease anemia, transfusion needs, the length of time that a patient requires intensive unit care and patient safety.

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