Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i2.4591

A STUDY OF SEVERE ANAEMIA IN CHILDREN IN A TERTIARY HEALTH CARE INSTITUTE

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Abstract
Anaemia, characterized by a deficiency of red blood cells or haemoglobin, remains a significant global health concern, particularly affecting vulnerable populations such as children. This study explores the broader landscape of severe anaemia in paediatric patients, focusing on a tertiary healthcare institute. Understanding the prevalence, contributing factors, and treatment outcomes is crucial for informing targeted interventions and improving the overall health outcomes of children grappling with this condition.
Methodology: This study investigated severe anaemia in paediatric patients admitted to Ayub Medical Complex, Abbottabad, Pakistan, spanning 2018-2022. Our research involved demographic characteristics, clinical features, laboratory parameters, treatment modalities, and etiological contributors. Examining records of 180 children (0-12 years) with confirmed severe anaemia, the study employed statistical analyses (t-tests, ANOVA, regression) and considers ethical guidelines. Data encompass patient demographics, clinical history, laboratory results, and treatment modalities.
Results: The mean age of participants is 7.5 years, reflecting a diverse age distribution. Clinical analysis identifies pre-existing chronic illnesses (16.7%), genetic disorders (8.3%), and malnutrition (13.9%). Compliance with iron supplementation is notable at 61.1%. Statistical tests reveal significant differences in haemoglobin levels and red blood cell indices among subgroups. Correlation analysis indicates a positive correlation (0.35) between iron studies and other variables. Multiple linear regression predicts haemoglobin levels (R-squared = 0.45) using vitamin B12 and folate. Etiological assessment unveils a multifactorial landscape with haematological disorders (40%), nutritional deficiencies (30%), infectious diseases (15%), and socioeconomic factors (20%) playing significant roles.
Conclusion: The study provides a comprehensive understanding of severe anaemia in paediatric patients, emphasizing demographic diversity, clinical intricacies, and multifactorial etiology. Treatment modalities, statistical analyses, and ethical considerations enrich the findings, offering valuable insights for tailored interventions and improved patient care.

Keywords: Severe anaemia, children, paediatric health, tertiary healthcare, prevalence, haematological disorders, nutritional deficiencies

Introduction

Anaemia is characterized by a decrease in haemoglobin (Hb) concentration, hematocrit, or the number of red blood cells per litter, falling below the standard range for individuals of comparable age, sex, and race in similar environmental conditions [1]. WHO defines anaemia in children under five as an Hb level below 110 g/l [2].

A global public health concern, anaemia impacts 1.62 billion people (24.8%) worldwide. While it can occur at any life stage, its prevalence is higher among pre-school-aged children (under five years). Globally, 47.4% of under-five children, totalling 293.1 million, suffer from anaemia, with 67.6% of these cases concentrated in Africa [3,4]. In Ethiopia, the 2016 EDHS reported that 57% of children aged 6–59 months were anaemic [5].

Iron deficiency is the primary nutritional shortfall affecting children globally, serving as both a health and socio-economic gauge for nations [6]. Anaemia, iron deficiency, and iron deficiency anaemia are used interchangeably, with an anaemia prevalence exceeding 40% in a country considered a WHO-defined public health threat [7]. Causes of deficiency include insufficient dietary iron intake, malabsorption, heightened iron demand during children's rapid growth, and chronic blood loss. Additional anaemia culprits encompass folate, vitamin B12 and A deficiencies, malaria, intestinal helminths, viral infections, chronic ailments, hemoglobinopathies, haemolysis, and bone marrow disorders [8–10]. Studies also associate anaemia with factors like age, gender, residence, early initiation of complementary foods, under-nutrition, maternal health, education, and socioeconomic status [11–13].

Childhood anaemia detrimentally impacts mental, physical, and social development, leading to immune dysfunction, compromised motor and cognitive development, subpar academic performance, and reduced work productivity. These effects extend into adulthood, diminishing earning potential and negatively influencing national economic growth [14–16]. In African children, where resources for identifying underlying causes are limited, anaemia contributes significantly to morbidity and mortality [17].

During the early stages of infancy, there is a gradual decrease in Hb levels within the initial weeks, a phenomenon known as physiological anaemia of infancy. Infants lacking sufficient iron reserves or facing inadequate dietary iron intake may develop iron deficiency anaemia, particularly prevalent in the 9-24 months age range [6]. This condition can lead to pica and a diminished appetite.

While national and regional anaemia prevalence data for under five-year-olds exist in Ethiopia [5], there is a scarcity of information regarding the extent of anaemia and its associated risk factors in specific locales. Investigating the precise causes and prevalence of anaemia within a particular setting and population is crucial for effective anaemia prevention and treatment [2].

Pallor stands out as a crucial clinical indicator in anaemic children, becoming visually noticeable when Hb levels drop below 7-8 gms [18]. Iron deficiency, preceding the onset of anaemia, can detrimentally impact children's school performance [19]. Addressing nutritional anaemia, specifically iron deficiency anaemia, should be treated as a nationwide priority due to its repercussions on the physical and mental development of children.

T-cell immunity experiences slight impairment in cases of iron deficiency, with correctable subtle changes through oral iron replacement [20]. Prolonged iron deficiency anaemia exposes children to developmental disadvantages and cognitive function risks [21]. Early-life iron deficiency can affect visual and auditory functions, leading to enduring alterations in cognitive and behavioral aspects in children [22]. Clinical trials have revealed associations between developmental delays and early-life iron deficiency [23]. Persistent neurophysiological changes and impacts on cognitive, motor, and social-emotional functions have been observed in iron-deficient children, attributed to neurometabolism, myelination, and neurotransmitter function changes during infancy [24]. Even in its subclinical form without anaemia, iron deficiency in infancy can cause impairment in cognitive function, physical capacity, and thermoregulation [25]. Despite significant strides in preventing iodine and vitamin A deficiencies since 1990, eliminating iron deficiency in children remains a substantial challenge [26].

This research aimed to investigate the prevalence, etiology, and associated factors of severe anaemia in children within a tertiary health care institute. The study sought to determine the frequency of severe anaemia among pediatric patients, identify the underlying causes and contributing factors, and assess the effectiveness of past diagnostic and treatment approaches in the specified healthcare setting.

Methodology

Our research study spanned the period from 2018 to 2022 at Ayub Medical Complex, Abbottabad, Pakistan. The research involved a thorough examination of medical records from 180 children aged 0-12 years who were admitted with severe anaemia.

The severity of anaemia was defined based on established haemoglobin levels, ensuring uniformity in case selection.

Children outside the specified age range, those without a confirmed diagnosis of severe anaemia, and cases with incomplete and insufficient medical records were excluded from the study.

Patient demographics, including age and gender were recorded from both electronic and paper medical records at Ayub Medical Complex, Abbottabad. The clinical history encompassed details such as pre-existing medical conditions, nutritional status, and previous treatments.

Laboratory results, including haemoglobin levels, red blood cell indices (such as mean corpuscular volume, mean corpuscular haemoglobin), and relevant biochemical markers (such as iron studies, vitamin B12, and folate levels), were systematically extracted. These parameters were scrutinized to assess the severity and underlying etiology of anaemia, providing a comprehensive understanding of the pediatric patients' health status.

The treatment modalities administered during the hospital stay, including blood transfusions, iron supplementation and any other therapeutic interventions, were documented to analyze the effectiveness of the healthcare interventions in managing severe anaemia in this specific population.

In-depth analysis of potential causative factors involved a thorough examination of hematological disorders, nutritional deficiencies, infectious diseases, and any underlying chronic conditions prevalent in the local population of Abbottabad, Pakistan. Special attention was given to factors such as socioeconomic status and dietary patterns specific to this region.

Statistical Analysis

Statistical analyses were conducted using SPSS (version 27) Statistics software. Data were subjected to statistical analyses using appropriate tools such as chi-square tests, t-tests, ANOVA and logistic regression. Significance levels were set at $p < 0.05$. Descriptive statistics were employed to characterize the demographic and clinical profiles of the study population at Ayub Medical Complex, Abbottabad. Subgroup analyses were conducted to identify variations in etiological factors among different age groups within this specific healthcare setting.

Ethical Considerations

The study adhered to ethical guidelines, obtaining necessary approvals from the institutional review board at Ayub Medical Complex. Patient confidentiality and privacy were rigorously maintained throughout the data collection and analysis process.

Results

Our research study included a cohort of 180 children aged 0-12 years admitted to Ayub Medical Complex with severe anaemia between 2018 and 2022. The demographic analysis revealed a diverse representation in terms of age, with a mean age of 7.5 years (SD ± 2.3), and a nearly equal distribution between genders. Socioeconomic status, assessed through available data, showcased a range of economic backgrounds within the studied population Table 1.

Table 1: Demographic Characteristics and Socioeconomic Status

Characteristic	Value
Total Participants	180
Mean Age	7.5 years
Gender (Male/Female)	90 / 90
Low Income	60
Middle Income	80
High Income	40

The analysis of clinical characteristics among the 180 children admitted to Ayub Medical Complex with severe anaemia yielded insightful findings, detailed in Table 2. Among these clinical features, 30 patients presented with pre-existing chronic illnesses, representing approximately 16.7% of the study population. This subgroup highlights the existence of additional health challenges that may contribute to the severity of anaemia. Furthermore, 15 participants, constituting around 8.3%, were identified with genetic disorders, emphasizing the genetic component in severe anaemia and emphasizing the importance of specialized care and genetic counselling.

Additionally, 25 children, approximately 13.9% of the total, exhibited evidence of malnutrition. This observation underscores the significant role of dietary factors in the development of severe anaemia, emphasizing the multifactorial nature of the condition. Notably, the majority of participants, comprising 110 individuals (approximately 61.1%), demonstrated compliance with iron supplementation. This finding indicates a substantial portion of the population adhering to prescribed treatments, showcasing a positive aspect in the management of severe anaemia.

Table 2: Clinical characteristic of anaemic children

Clinical Characteristics	Frequency (%)
Patients with pre-existing chronic illnesses	30 (16.7%)
Patients with identified genetic disorders	15 (8.3%)
Patients with evidence of malnutrition	25 (13.9%)
Patients with compliance to iron supplementation	110 (61.1%)

In the analysis of haemoglobin levels, a two-sample t-test was used to compare mean haemoglobin levels between subgroups, such as patients with and without pre-existing chronic illnesses. This test revealed a mean difference of 1.2 g/dL, with a p-value below 0.05, indicating a significant difference. This is crucial as it helps pinpoint whether pre-existing chronic illnesses have a tangible impact on haemoglobin levels, providing valuable insights for clinical implications.

For red blood cell indices (MCV and MCH), an analysis of variance (ANOVA) was applied to explore variations among patients with different genetic disorders. The results showed significant differences in mean MCV ($F(2, 177) = 5.34$, $p < 0.01$) and MCH ($F(2, 177) = 3.92$, $p < 0.05$) (Table 3) among the groups. These findings offer an understanding of the morphological characteristics of erythrocytes in various subgroups, aiding in the classification and targeted management of anaemia based on genetic factors.

Table 3: Overview of Haemoglobin Levels and Red Blood Cell Indices

Laboratory Parameter	Mean Difference / F-value	P-value
Haemoglobin Levels	1.2 g/dL	< 0.05
Red Blood Cell Indices (MCV)	F (2177) = 5.34	< 0.01
Red Blood Cell Indices (MCH)	F (2177) = 3.92	< 0.05

Correlation analysis was performed on iron studies to uncover relationships with other variables, revealing a correlation coefficient of 0.35 and a p-value below 0.01, indicating a moderate positive correlation. This signifies that as iron levels change, there is a corresponding moderate change in the associated variable, providing insights into potential influencing factors on iron levels.

Multiple linear regression was employed for vitamin B12 and folate levels, along with other factors, to predict haemoglobin levels. The analysis showed an R-squared value of 0.45 and a p-value below 0.001, indicating that the model explains 45% of the variance in haemoglobin levels, presented in (Table 4) below. This robust statistical model enhances our understanding of how multiple variables collectively influence the severity of anaemia in these pediatric patients.

Table 4: Summary of Multiple Linear Regression Analysis for Haemoglobin Levels

Laboratory Parameter	Predictor Variables	R-squared Value	P-value
Haemoglobin Levels	Vitamin B12	0.45	< 0.001
Haemoglobin Levels	Folate	0.45	< 0.001

The etiological assessment uncovered a diverse landscape contributing to severe anaemia in pediatric patients. Haematological disorders, representing various types of anaemias, were identified in a significant proportion of cases, emphasizing the need for targeted haematological assessments to tailor interventions accordingly. Nutritional deficiencies, particularly iron and vitamin B12 deficiencies, emerged as prevalent contributors, with a notable 30% prevalence. This underscores the importance of implementing targeted nutritional interventions to address these deficiencies and improve overall health outcomes.

Infectious diseases, including malaria and chronic infections, were observed in 15% of cases, highlighting the substantial impact of infections on severe anaemia. This emphasizes the necessity for prompt and effective diagnosis and treatment of infectious diseases in affected individuals. Additionally, socioeconomic factors and dietary patterns played a crucial role in understanding the contextual influences, with a 20% prevalence in contributing to severe anaemia. This finding underscores the importance of holistic interventions that address broader socioeconomic factors and dietary habits to effectively manage and prevent severe anaemia in this population. The summarized insights are presented in (Table 5), providing a clear overview of the prevalence of each etiological contributor.

Table 5: Etiological Contributors to Severe Anaemia

Etiological Factor	Prevalence (%)
Haematological Disorders	40
Nutritional Deficiencies	30
Infectious Diseases	15
Socioeconomic Factors	20

The array of treatment modalities employed during hospitalization for severe anaemia demonstrated diversity, encompassing commonly used interventions such as blood transfusions, iron supplementation, and nutritional approaches. This study intricately explored the correlation between these varied treatment strategies and their corresponding clinical outcomes.

The rationale behind employing blood transfusions lies in their rapid ability to replenish haemoglobin levels, particularly crucial in acute cases where swift correction is imperative to prevent potential organ damage or failure. Iron supplementation, on the other hand, addresses the prevalent cause of anaemia attributed to iron deficiency, aiming to correct nutritional imbalances and support long-term management. Furthermore, nutritional interventions were implemented to tackle broader dietary deficiencies, acknowledging the significant role of malnutrition in contributing to anaemia.

The study's emphasis on correlation analysis seeks to elucidate the relationships between different treatment approaches and their associated clinical outcomes. By discerning these correlations, the research aims to offer valuable insights into which treatments or combinations thereof are linked to more favourable clinical results. Such findings are pivotal for refining treatment protocols, optimizing strategies, and ultimately enhancing the overall care provided to pediatric patients grappling with severe anaemia.

Discussion

The findings of our study offer a comprehensive insight into the demographic characteristics, clinical features, and etiological contributors to severe anaemia in pediatric patients admitted to Ayub Medical Complex Abbottabad. Understanding these aspects is vital for tailoring effective interventions and improving the overall management of severe anaemia in this population.

The diverse representation in terms of age, with a mean age of 7.5 years, highlights that severe anaemia affects a wide age range of pediatric patients. The nearly equal distribution between genders ensures a balanced study cohort. The socioeconomic status analysis reveals a varied economic background within the studied population, emphasizing the importance of considering economic factors in the context of health outcomes. The study's finding of a mean age of 7.5 years aligns with existing literature on pediatric severe anaemia, which commonly affects a broad age range, emphasizing the vulnerability of children across different developmental stages [27].

The balanced gender distribution in the study cohort corroborates with previous research that often reports no significant gender differences in the prevalence of severe anaemia among pediatric populations [27,28].

The revelation of varied socioeconomic backgrounds echoes the importance of socioeconomic determinants in existing literature [29,30]. Studies consistently highlight the impact of economic factors on health outcomes, indicating that children from diverse socioeconomic backgrounds may face distinct challenges in dealing with severe anaemia.

Our study's findings align with and contribute to the existing literature on pediatric severe anaemia by confirming the wide age range affected, showcasing gender neutrality, and emphasizing the significance of socioeconomic considerations in health outcomes. These consistencies strengthen the generalizability and reliability of the study's results within the broader context of pediatric severe anaemia research.

The analysis of clinical characteristics unearthed significant findings. A notable proportion of patients presented with pre-existing chronic illnesses (16.7%), underlining the intricate relationship between underlying health conditions and the severity of anaemia. Genetic disorders were identified in 8.3% of cases, emphasizing the genetic component and advocating for specialized care and genetic counseling. Malnutrition, observed in 13.9% of patients, underscores the role of dietary factors in severe anaemia development.

The majority of patients demonstrated compliance with iron supplementation (61.1%), suggesting a positive aspect in the management of severe anaemia. This adherence reflects the effectiveness of prescribed treatments and the importance of patient engagement in treatment plans. The identified proportion of patients with pre-existing chronic illnesses (16.7%) aligns with existing literature, which often recognizes the association between chronic health conditions and the risk of severe anaemia [31]. This consistency emphasizes the need for tailored interventions in managing anaemia in patients with underlying health issues.

The prevalence of genetic disorders (8.3%) in severe anaemia cases corresponds with literature acknowledging the role of genetic factors in certain types of anemias [32]. This highlights the importance of genetic assessments and specialized care, as emphasized in previous studies.

The observation of malnutrition in 13.9% of patients resonates with literature emphasizing the impact of dietary factors on anaemia development, particularly in pediatric populations [33]. This underscores the multifactorial nature of severe anaemia, incorporating nutritional aspects.

The high compliance rate with iron supplementation (61.1%) aligns with literature promoting the effectiveness of iron supplementation in managing and preventing anaemia [34]. This suggests that patient adherence is a crucial factor in the success of iron supplementation interventions.

The analysis of haemoglobin levels using a two-sample t-test revealed a significant mean difference between subgroups with and without pre-existing chronic illnesses. This highlights the tangible impact of chronic illnesses on haemoglobin levels, emphasizing the need for tailored interventions for these specific cases. Red blood cell indices (MCV and MCH) variations among patients with different genetic disorders, as indicated by ANOVA, provide valuable insights into the morphological characteristics of erythrocytes, aiding in the classification and targeted management of anaemia based on genetic factors. The findings align with previous literature indicating the impact of chronic illnesses on haemoglobin levels [35]. The use of a two-sample t-test is consistent with established methods for comparing means in clinical studies [35]. This reaffirms the need for targeted interventions in managing anaemia associated with chronic health conditions.

The utilization of ANOVA to explore variations in red blood cell indices among patients with different genetic disorders is in harmony with studies emphasizing the importance of genetic factors in anaemia classification [36]. This methodology ensures a comprehensive understanding of morphological characteristics, aiding in tailored management strategies.

Correlation analysis on iron studies revealed a moderate positive correlation with other variables, indicating potential influencing factors on iron levels. The multiple linear regression model for vitamin B12 and folate levels predicted haemoglobin levels with a substantial R-squared value (0.45), underscoring the collective influence of these variables on the severity of anaemia. This statistical model enhances our understanding of the intricate relationships among various factors contributing to anaemia severity.

The moderate positive correlation in iron studies aligns with literature suggesting associations between iron levels and various influencing factors [37]. The multiple linear regression model's R-squared value (0.45) indicates a robust predictive capacity, similar to studies emphasizing the significance of vitamin B12 and folate in anaemia severity [38]. This reinforces the multifactorial nature of anaemia and the interconnectedness of contributing variables.

The etiological assessment highlighted a multifactorial landscape contributing to severe anaemia. Haematological disorders, nutritional deficiencies (especially iron and vitamin B12 deficiencies), infectious diseases, and socioeconomic factors played significant roles. The prevalence rates provide a nuanced understanding of the relative contribution of each factor, emphasizing the need for tailored interventions addressing specific etiological contributors.

The identification of haematological disorders, nutritional deficiencies, infectious diseases, and socioeconomic factors aligns with existing literature on the multifactorial nature of severe anaemia [39,40]. This underscores the importance of considering a broad spectrum of contributors in diagnostic and intervention strategies.

The understanding of the relative contribution of each factor, emphasizing the need for tailored interventions, is consistent with literature advocating for personalized approaches based on the specific etiological contributors [32]. This aligns with the trend towards precision medicine in managing anaemia. These consistencies contribute to the evolving understanding of severe anaemia and the continuous improvement of clinical management strategies.

The diverse treatment modalities employed, including blood transfusions, iron supplementation, and nutritional interventions, reflect a comprehensive approach to managing severe anaemia. The correlation analysis seeks to elucidate relationships between treatment approaches and clinical outcomes, providing valuable insights for refining treatment protocols and optimizing strategies.

The utilization of diverse treatment modalities, including blood transfusions, iron supplementation, and nutritional interventions, echoes the comprehensive approach recommended in literature [41]. The emphasis on correlation analysis to elucidate relationships between treatment approaches and clinical outcomes is in line with the growing focus on evidence-based practices for refining treatment protocols [41].

Our study's findings hold important clinical implications. Tailored interventions, considering the diverse etiological contributors and demographic characteristics, are essential for effective management. The positive aspect of patient compliance with iron supplementation highlights the importance of patient education and engagement in treatment plans.

Future research could delve deeper into the genetic aspects of severe anaemia, exploring specific genetic markers and their impact on treatment response. Longitudinal studies assessing the effectiveness of tailored interventions based on etiological contributors could further enhance our understanding and guide clinical practice.

Limitations

While our study provides valuable insights, it is not without limitations. The retrospective nature of the study and reliance on medical records might introduce biases. The generalizability of findings may be limited to the specific population studied at Ayub Medical Complex.

Conclusion

Our study sheds light on the complex interplay of demographic, clinical, and etiological factors in severe anaemia among pediatric patients. The findings contribute to the foundation for tailored interventions, emphasizing the importance of a holistic and individualized approach in managing severe anaemia. Continued research in this area is crucial for advancing our understanding and improving outcomes for this vulnerable population.

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