Egyptian Pediatric Association Gazette

RESEARCH Open Access

Prevalence and types of anemia in infancy, Egypt: cross-sectional study

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Abstract

Background Infant anemia has a significant impact on physical and cognitive development, not only in infancy but also throughout their life.

Objective The study aimed to estimate the prevalence, types, and risk factors of anemia in infancy.

Patients and Methods A cross-sectional study was conducted on 498 infants aged 6-23 months who attended five primary healthcare centers in Kafr-el Sheikh governorate, Egypt, for vaccination and follow-up.

Results The prevalence of anemia among the study infants was 44%, with the highest in those aged 6-12 months. Maternal anemia in pregnancy, low birth weight infant, and lack of adherence to iron supplementation were the significant risk factors for anemia.

Conclusion Infant anemia in Egypt resembles a complicated multifactorial severe health issue with a long-run burden. Health policy interventions such as early screening at 6 months old, more adherence to iron supplements for infants, maternal nutrition education, family planning, and birth spacing between siblings should be accessed to overcome and manage this health problem.

Keywords Anemia, Infant, Development, Iron, Nutrition, Maternal

Background

Infancy represents the visible part of the "golden 1000 days" in our lives, which begins at conception to the 2nd birthday. This period has a great effect on mental, physical, and social development in infants, and the quality of social care, healthcare, and nutrition during this time can determine whether they will thrive or struggle in the future.

Although the human brain continues to develop and change throughout life, the most rapid period of brain growth and highest plasticity are in the last trimester of pregnancy and the first two years of life.

While the brain requires all essential nutrients for growth, certain nutrients such as protein, polyunsaturated fatty acids, iron, zinc, copper, iodine, and vitamins A, B6, and B12 are particularly crucial. Among these nutrients, iron stands out as an example of the

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necessity of sufficient nutrition during specific periods of brain growth to ensure the full realization of developmental potential [1].

Anemia is a condition that results from a deficiency of red blood cells or hemoglobin in the blood, resulting in paleness and fatigue. While anemia can result from a variety of causes, including genetic, infectious, or chronic diseases, *malnutrition* is the most common factor. Unfortunately, the consequences of anemia can persist throughout our lives, particularly for anemic children, who often experience language delays compared to non-anemic children [2].

The burden of anemia is particularly prevalent in developing countries, such as Egypt, where it represents a significant challenge. According to UNICEF, anemia in children under five in Egypt had an overall prevalence of 27.2% in 2014 that increased to 43% in 2022 [3]. This prevalence is particularly high among infants, and ranges from 34.5 to 49.2%, indicating a pressing need for targeted interventions to address the root causes of anemia and minimize its long-term effects [4].

Iron deficiency anemia stands out as the most significant type of anemia affecting infants, as compared to other types such as thalassemia, congenital hypoplastic anemia, and transient erythroblastopenia of childhood. The long-term consequences of iron deficiency anemia on infant development are especially concerning. Studies have found that infants with iron deficiency anemia typically score lower in cognitive, motor, social, emotional, and neurophysiologic development than infants in the comparison group. This suggests the importance of identifying and addressing iron deficiency anemia early in infancy to prevent adverse developmental outcomes [5].

Iron deficiency anemia can also have implications for the efficacy of routine childhood vaccinations. Studies have shown that infants with iron deficiency anemia at the time of vaccination may have a reduced response to diphtheria, pertussis, and pneumococcal vaccines.

This highlights the importance of identifying and addressing anemia in infants to ensure optimal vaccine response and overall health outcomes [6].

However, despite its significance, the prevalence of anemia in infancy is not fully understood, and the variation in its different types remains unclear [7]. Estimates of anemia prevalence in infants have varied in previous studies, indicating a need for further research to clarify the extent, nature, and risk factors of this issue. Such information can inform the development of effective strategies for preventing and managing anemia in infants, which could have potential benefits for overall health and well-being.

Methods

Aim, Design and Setting of the study

The study aimed to investigate the prevalence of anemia among infants aged 6-23 months who attended primary healthcare centers for follow-up and vaccination in Kafr El-Sheikh Governorate during the study period, and who met the inclusion and exclusion criteria.

The present research is a cross-sectional study conducted on infants who attended primary healthcare centers in Kafr El-Sheikh Governorate from August 2022 to February 2023. The primary healthcare centers involved in the study were located in both urban and rural areas. Specifically, Kafr El-Sheikh primary healthcare center (36 infants), Desouk primary healthcare center (217 infants), and El-Reyad primary healthcare center (35 infants) represented urban centers, whereas El-Hamraa primary healthcare center (93 infants) and Aryamun primary healthcare center (117 infants) represented rural centers.

Study population

Study sample

The study sample consisted of infants within the specified age range who attended primary healthcare centers and met the inclusion and exclusion criteria. In Egypt, primary healthcare centers are the main providers of compulsory vaccination. However, other levels of healthcare, including private institutions share in the provision of infant and childhood vaccination.

Sample size and sampling technique

The sample size was calculated using Epi-info software statistical package version 7, considering various parameters such as a 95% confidence level, 97% study power, α error of 5%, and an expected prevalence of anemia among infants aged 6-23 months of 42% [4]. The calculated sample size was 460, and a 10% nonresponse rate was added, resulting in a final sample size of 506. Convenience sampling was used during the study period to include all eligible infants.

Inclusion criteria

The inclusion criteria for the study required infants to be between 6-23 months of age, attending primary health care centers for vaccination and growth follow-up in Kafr El-Sheikh Governorate, and whose mothers consented to participate in the study.

Exclusion criteria

The exclusion criteria for this study included infants with confirmed hematological, immunodeficiency,

malignancy, metabolic, genetic, or neurological disease to exclude anemia of chronic disease as a confounder.

Study tools

In this study, data was collected using a semi-structured questionnaire administered through personal interviews with mothers who participated in the study. The questionnaire covered various infant characteristics, including name, sex, age, residence, birth weight, birth height, order of infant in the family, as well as weight, and height at the time of the study. It also included questions related to exclusive breastfeeding during the first four months and iron supplementation after six months.

Furthermore, the questionnaire inquired about chronic diseases affecting infants, including genetic, metabolic, neurological, malignant, hematological, or immunological diseases. Maternal characteristics, such as name, age, any chronic diseases or illnesses during pregnancy, and whether the mother had anemia during pregnancy, were also included in the questionnaire.

In addition, a blood sample for complete blood count (CBC) was collected from each infant using a sterile, single-use disposable syringe.

Anemia was defined as a reduction in red blood cell (RBC) mass or blood hemoglobin (HGB) concentration [8], according to the World Health Organization's classification of anemia for this age group [9]. Mild anemia was defined as an HGB concentration of 10 to 10.9 mg/dL, moderate anemia as 7 to 9.9 mg/dL, and severe anemia as less than 7 mg/dL.

The type of anemia was classified for this age group using mean corpuscular volume (MCV), with the lower limit being 73 fl and the upper limit being 85 fl. Anemia with MCV within the normal range was classified as normocytic, below this range as microcytic, and above this range as macrocytic anemia [8].

Infants with microcytic anemia were further tested for serum ferritin (normal range: 7-142 ng/mL) [10],, and total iron binding capacity (normal range: 255-450 µg/dL) [11]. If the results of these tests were normal, HGB electrophoresis was performed to exclude thalassemia [12].

Data collection

For data collection, a Microsoft EXCEL spreadsheet was utilized, which was subsequently revised, cleaned, and analyzed utilizing the Statistical Package for Social Science (SPSS version 23).

Data analysis

The statistical analysis was performed using the SPSS software version 23, with a significance level set at $P < 0.05$. Descriptive statistics were conducted and presented as percentages and frequencies for categorical variables, while the mean and standard deviation were used for continuous variables. Pearson Chi-square test was used to examine the relationship between infant anemia and risk factors, which were categorized as binary or ordinal variables. Additionally, multivariate logistic regression was employed to assess the association between risk factors and infant anemia while controlling for confounding variables.

Patient and Public involvement

Patient and public involvement was present from the outset through consultation with healthcare providers and parents to understand the extent, possible causes, and solutions of infant anemia. The research questions and outcome measures were informed by the community's priorities, experiences, and preferences. Patients and the public were involved in the study's design through an easy-to-understand questionnaire. The informed consent process was culturally appropriate and fostered open communication between researchers and participant representatives, who were informed of the intervention and time required to participate in the research before consenting to participate. The study findings, particularly nutrition modifications for pregnant females and weaned infants, will be disseminated through community meetings, public forums, and social media platforms, with participant representatives and the public playing an active role in sharing the results.

Results

This study aimed to determine the prevalence and associated factors of anemia in infants aged 6 to 23 months attending primary healthcare centers in Kafr El-Sheikh Governorate, Egypt. The study included 498 infants with a male-to-female ratio of 53.8%. The sample size was reduced from 506 to 498 due to the exclusion of 8 participants, whose blood samples for CBC were coagulated, before any data analysis. Of the total sample, 285 (57.2%) infants were aged 6 to 12 months, while 213 (42.8%) were above 12 months. The prevalence of anemia was found to be 44%, with a higher prevalence among infants aged 6 to 12 months (49.8%) compared to those above 12 months (36.2%). Iron deficiency anemia was the most frequent type of anemia, comprising 96% of cases. Normocytic anemia represented 3% of cases, while thalassemia accounted for only 1%. In terms of severity, the majority of cases were classified as mild at 65%, followed by moderate at 34%, and only 1% were categorized as severe.

Of the study sample, 13.9% of infants had low birth weight. In terms of birth order, the majority of infants were first or second in birth order (69.2%), followed by third or fourth (27.2%), with only (3.6%) being above that.

The study showed that (62.7%) of infants received exclusive breastfeeding in the first four months, while only 21.1% received iron supplementation after the age of six months. Maternal age was classified as below 20 years (4.2%), between 20 and 30 years (71.5%), and above 30 years (24.3%). Maternal anemia during pregnancy was observed in (43%) of cases.

A significant difference was observed between anemia and lack of iron supplementation after six months of age, P value (0.042). Infants who received iron supplementation had a lower prevalence of anemia (35.2%) compared to those who did not (46.3%). Anemia was more prevalent among infants aged 6 to 12 months (49.8%) than those over 12 months (36.2%), P value (0.002). Low birth weight infants had a higher prevalence of anemia (55.1%) than normal birth weight infants (42.1%), P value (0.043).

Furthermore, a significant difference was found between the prevalence of anemia in infants who exclusively breastfed in the first four months (47.4%) compared to those who had a bottle or mixed feeding during this period (38.2%), P value (0.044).

Additionally, a significant difference was found in infants of mothers who had anemia during pregnancy, with a prevalence of (49.5%) compared to (39.8%) in non-anemic mothers, P value (0.030). A detailed univariate analysis of maternal and infant factors with infant anemia is shown in Table 1

Table 1 A detailed univariate analysis of maternal and infant factors with infant anemia

Variable	Anemic (n= 219/498)		P-value
	No./group	% to its group	
1-Infant gender:			
Male:	**116/268**	**43.3**	**0.74**
Female:	**103/230**	**44.8**	
2-Age in months:			
6-12 months	**142/285**	**49.8**	**0.002**
> 12 months	**77/213**	**36.2**	
3-Birth Weight:			
Normal	**180/429**	**42.1**	**0.04**
Low birth weight	**38/69**	**55.1**	
4-Exclusive breastfeeding in the first 4 months			
Yes	**148/312**	**47.4**	**0.04**
No	**71/186**	**38.2**	
5-Iron supplementation			
Yes	**37/105**	**35.2**	**0.04**
No	**182/393**	**46.3**	
6- Infant order in the family			
First & second	**152/344**	**44.2**	**0.16**
Third & fourth	**62/135**	**45.9**	
7-Mother age :			
Less than 20 years	**9/21**	**42.9**	**0.14**
20-30 years	**166/356**	**46.6**	
>30 years	**44/121**	**36.4**	
8-Maternal anemia during pregnancy			
Yes	**106/214**	**49.5**	**0.03**
No	**113/284**	**39.8**	

Multivariate logistic regression analysis was done for all significant factors to identify and rank significant predictors of anemia while controlling for confounding variables. It was found that infant age 6-12 months, low birth weight infants, and maternal anemia during pregnancy were the most significant risk factors for anemia in those infants as shown in Table 2

Discussion

In this study, the prevalence of anemia was found to be 44% among the studied group, with a higher prevalence in infants aged between 6-12 months (49.8%). This can be attributed to the depletion of iron stores and the introduction of complementary foods lacking in essential macro and micronutrients. The prevalence was similar to that reported in a previous study conducted in 2014 [13, 14], which found a prevalence of 49.2% in infants between 9-11 months and 41.4% in those aged 12-17 months. According to the World Health Organization (WHO) classification, this prevalence of anemia in our study, which was found to be 44%, represents a severe public health issue [15].

Iron deficiency anemia was found to be the predominant type (96%), followed by normocytic anemia (3%). This has serious impacts on the physical and cognitive development of infants and may have potential long-term effects.

Our study further revealed that iron supplementation had a protective effect against infant anemia; however, only 21.1% of the infants in the study received iron supplements. This finding underscores the concerning issue of low adherence to iron supplementation, even though it is a cost-effective and simple method for preventing and treating anemia in infants and toddlers. Therefore, educating families about the importance of iron supplementation is crucial to achieving greater adherence and preventing iron deficiency anemia [16, 17].

Consistent with previous studies, our findings demonstrated that low birth weight infants had a higher prevalence of anemia compared to normal birth weight infants, which is attributed to early onset iron deficiency anemia caused by limited iron stores. Consequently, iron supplementation should commence at two months of age in low birth-weight infants [18].

Our study found that exclusive breastfeeding in the first four months was associated with a higher prevalence of anemia compared to bottle or mixed feeding during this period. This is surprising as exclusive breastfeeding is recommended as the best source of nutrition for infants in the first four months of life. However, this outcome

Table 2 Multivariate logistic regression for risk factors of anemia in the study infants

VVariable	OR	95% C.I.		P-value
		Lower	Upper	
1- **Maternal anemia during pregnancy**	**0.68**	**0.47**	**0.98**	**0.04**
2- **Exclusive breastfeeding in the first four months**	**0.73**	**0.50**	**1.06**	**0.1**
3- **Iron supplementation**	**1.53**	**0.97**	**2.41**	**.07**
4- **Infants aged between 6-12 months**	**1.72**	**1.19**	**2.49**	**.004**
5- **Low birth weight**	**0.54**	**0.32**	**0.91**	**.02**

can be explained by the possibility that infants who exclusively breastfeed may not be receiving sufficient iron after weaning to meet their nutritional requirements. Thus, iron supplementation or incorporating iron-rich foods in their diet is necessary.

In contrast to a previous study that reported an association between infant anemia and the order of the infant in the family, our study did not find any significant association between the two [19]. However, consistent with previous research, our study revealed a significant association between anemia in mothers during pregnancy and a higher prevalence of anemia in infants [20]. This outcome can be attributed to a decrease in iron stores in the infant during pregnancy and a lack of maternal knowledge about the balanced nutritional requirements for the infant after weaning.

Additionally, we investigated the association between maternal age and infant anemia. Our findings revealed that maternal age below 20 years and between 20-30 years was associated with a higher likelihood of infant anemia compared to mothers above 30 years old. Socioeconomic status was compared as urban and rural residence but no significant difference was found, we did not collect information about income in detail as we considered this could be a source of information bias.

Regarding maternal education, all were high school and university graduates, so we excluded this factor from the start.

Therefore, young mothers require particular attention to ensure they receive proper education regarding healthy nutrition, particularly foods that are rich in iron, for both themselves and their infants. Maternal health education, prenatal care, family planning, and birth spacing are critical factors that can impact the risk of anemia in infants.

Our cross-sectional study had certain limitations as it cannot establish the sequence of factors that lead to infant anemia. Prematurity, which is an important factor to consider in the context of infant anemia, was not represented or analyzed as none of the study participants was delivered as a premature baby.

Therefore, further prospective studies are required to investigate potential factors that contribute to this condition. These studies may emphasize modifying the national anemia screening program to begin at the age of 6 months for early detection and management, improving maternal nutrition, providing health education, promoting family planning, enhancing adherence to iron supplementation, and ensuring appropriate timing and quality of weaning practices.

By identifying the most significant causes of infant anemia, prioritizing efforts, and integrating interventions, we can effectively address this health issue. Addressing this critical public health concern will require a comprehensive and collaborative approach involving healthcare providers, policymakers, and communities alike.

Conclusion

To conclude, this study highlights a high prevalence of anemia among infants in Egypt and identifies various critical risk factors linked to the condition. The study's outcomes strongly recommend early screening and intervention for anemia commencing at 6 months old, along with focused education for mothers and families regarding healthy nutrition and iron supplementation.

Furthermore, family planning and birth spacing seem to act protectively in decreasing the risk of infant anemia. However, given the complex interplay between these factors and the potential for confounding variables, further research is necessary to fully understand the mechanisms underlying infant anemia and to develop effective, evidence-based interventions for prevention and management.

Abbreviations

CBC	Complete blood count
HGB	Hemoglobin
MCV	Mean corpuscular volume
RBC	Red blood cell
SPSS	The Statistical Package for Social Science
UNICEF	United Nations Children's Emergency Fund
WHO	World Health Organization

Acknowledgments
The authors express their heartfelt gratitude to all the medical staff working in the primary healthcare centers of Kafr El-Sheikh, as well as their colleagues in the primary healthcare department and the directorate of health affairs in Kafr El-Sheikh. They also extend their greetings to their colleagues working in the laboratory department of Kafr El-Sheikh Fever Hospital.

Authors' contributions
M A E participated in the study's conception and drafted the initial manuscript. S A G participated in the study's design, conception and methodology. V A E participated in the study's design, conception and methodology. E M B participated in protocol writing and collection of data. A N E participated in protocol writing and collection of data. A M A contributed to the material preparation and data analysis. T S E contributed to the material preparation and data analysis. H Y E contributed to the material preparation and data analysis. All authors reviewed and provided feedback on earlier versions. All authors have read and approved the final version of the manuscript.

Funding
The authors state that they did not receive any funds, grants, or other support during the preparation of this manuscript.

Availability of Data and Materials
The datasets produced and analyzed in this study are not available for public access due to ethics committee regulations. However, they are available upon request from the corresponding author.

Declarations

Consent to participate
Written informed consent was obtained from the parents.

Ethics approval and consent to participate
The study had been approved by the Ethics Committee of the Ministry of Health and Population, Egypt (Com.No/Dec.No:6-2022/6). Informed consent was obtained from each participant's mother after explaining the purpose, benefits, and potential risks of the study, as well as the right to withdraw at any time without any penalty or loss of benefit. Confidentiality of participants' personal and medical information was strictly maintained by assigning unique codes to each participant's data and storing them in a secure and locked cabinet. The blood samples were collected by trained and licensed medical professionals according to aseptic procedures and without causing any harm or discomfort to the infants. The study followed the principles of the Declaration of Helsinki and the International Conference on Harmonization for Good Clinical Practice.

Consent for publication
Not applicable.

Competing interests
The authors do not have any relevant financial or non-financial interests to report.

Received: 17 October 2023 Accepted: 30 November 2023
Published online: 03 January 2024

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