IRON DEFICIENCY ANEMIA: PREVALENCE AND ASSOCIATED FACTORS AMONGST ADOLESCENT FEMALES

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Abstract - This study investigates the prevalence of Iron Deficiency Anemia (IDA) among a population of adolescent females at Alqabas Secondary school in Khartoum, Sudan. The study also explores the association between the possession of IDA and a number of socio-economic and biological factors. The analysis was based on a random sample of 150 participants whose measurements of Complete Blood Check (CBC), blood film, serum iron, serum ferritin and total iron binding capacity were obtained to examine the anemia profile. Statistical methods such as mean, proportions, Chi square test of association and correlation analysis were performed on the collected data to estimate the prevalence of IDA and investigate the association in question. The main findings indicate that the overall prevalence of IDA is estimated by 29.5%, but the disease appears to be more prevalent in younger girls as compared with their older counterparts. In addition, the results show that having IDA is mostly associated with: family income, age, father's education, whether parents are separated, habits of eating mud and weekly consumption of meet.

I. INTRODUCTION

Anemia is a cosmopolitan public health problem affecting both developing and developed countries with major consequences for human health as well as social and economic development.(2) It is also the most common cause of deaths. Severe anemia accounts for 20.3% of the deaths in the world. In addition, the risk of dying from haemorrhage and infection is five to ten times greateramong anemic persons as compared to non-anemic persons. Anemia is more likely to occur during preschool age when growth is rapid, and while quick loss of iron is progressing.(7)This is defined as a reduction in the hemoglobin concentration of the blood below normal. Although normal values can vary between laboratories, typical values would be less than 11.5 g/dl especially in females.(6) Iron deficiency (ID) is the most common cause of anemia in every country of the world. ID is defined as a condition in which there are no mobilizable iron stores and in which signs of a compromised supply of iron to tissues, including the erythron, are noted. Some of the literature indicates that the more severe stages of iron deficiency are associated with anemia.(10) Additionally, ID is the most important cause of a microcytic hypochromic anemia, in which the two red cell indices: Mean Corpuscular Colume (MCV) and Mean Corpuscular Haemoglobin (MCH), are reduced and the blood film shows small (microcytic) and pale (hypochromic) red cells.(4) Thus, Iron Deficiency Anemia (IDA) has been a hot topic in public health research. IDA is a decrease in the total hemoglobin levels caused by a lack of sufficient iron. IDA does not develop immediately; instead, a person progresses through stages of ID. This begins with iron depletion, in which the amount of iron in the body is reduced but the amount of iron in the red blood cells remains constant. If iron depletion is not corrected, it progresses to ID, lastly leading to IDA.(6) Shortage of iron occurs, often, due to blood loss, poor diet, or an inability to absorb adequate iron from daily food. Other risk factors, also, include undertaking kidney dialysis treatment. This may be because blood is lost during dialysis, but it is also because the kidneys may no longer be able to make enough of erythropoietin, a hormone needed to make red blood cells.(7)

For adolescents, IDA may constitute the major type of anemia. This is particularly the case for adolescent females. Quickened development, hormonal changes, malnutrition and starting of menstrual periods are major causes during this period. Increased nutritional needs at this stage relate to the fact that adolescents gain up to 50% of the weight, more than 20% of their adult height, and 50% of their adult skeletal mass.(5) The period of adolescence is a period of intense growth. It is second (in terms of quick growth), only to infancy. Thus, identical to infancy, overall nutrient needs are high in order to backup optimum growth and development. The body needs more iron when it is growing rapidly and when frequent blood loss occurs (e.g.through menstruation). Thus, adolescent girls are at especiallyhigh risk of developing ID. This is particularly true for some adolescent girls who experience heavy blood loss during menstruation. Prevention of iron deficiency is fundamental to avoid IDA, as iron deficiency, similar to other micronutrient deficiencies, is generally not superficially visible, although it may already be negatively affecting fundamental physiological processes.(11)

II. RELEVANT FINDINGS

Several studies pointed to an increase incidence of IDA among adolescent females.For example, a cross sectional study was carried out in Tehran among 295 female university students who were chosen randomly to investigate the prevalence of ID and IDA showed that the prevalence was 40.9% for ID and

3.8% for IDA.[9]Also, a cross-sectional study conducted in Palestine on the second semester of the academic year 2005 to investigate the prevalence of IDA in school children aged 6 to 18 years, showed that the prevalence of IDA among females was 30.5%.[6]In addition, in Southern India a study was conducted on 314 adolescent females showed that among the 45.2% of anemic adolescent girls 40.1% had mild anemia, 54.92% had moderate anemia and 4.92% had severe anemia. Similarly, among 230 female adolescent school girls in Kenya, it was found that 65.6% had mild anemia, 27.9% had moderate anemia and 6.5% were severely anemic.[3]In the Middle East, a cross sectional study was carried out in Jeddah, Kingdom of Saudi Arabia.Among 310 adolescent female students whose ages ranged between 18 and 23 years,the results showed that 25.9% of the participants had deficient iron store and 23.9% had IDA.[1]

However, in Sudan, there seems to be a lack of research (with respect to IDA) that targets adolescent females. Most of the studies conducted on this area are eithertarget the entire age range or are conducted on pregnant women. As a result, reliable estimates of the prevalence of IDA among adolescent females may not be available in. Also, the literature on IDA may provide a theoretical framework for the factors that lead to acquiring the disease, but empirical evidence in for adolescent femalesare yet to be obtained to lay out the foundation for more development in the public health sector and the health system in general. Thus, the current study is set out to investigate the prevalence of IDA among adolescent females and to identify the associated factorsfrom a large set of biological and socio-economic factors. The study is conducted on adolescent females at Alqabas secondary school- Sudan. Specifically, the investigation aims at achieving, at least, three objectives. These are:

- To measure the prevalence of iron deficiency (ID) and iron deficiency anemia (IDA) among adolescent females.
- To estimate and compare the prevalence of IDA for the ages 16, 17, 18 and 19 separately.
- To explore the association and correlation between the possession of IDA and a set of selected socio-economic and biological factors.

III. METHODOLOGY

This research is a descriptive analytical study which was based on a cross-sectional survey at Alqabaas Secondary School in Khartoum.

3.1 The sample

Since the population units are somewhat homogeneous, a simple random sample was appropriate for the purpose of this study. A list of all female students was obtained from the school registrar, and was treated as a sampling frame. The required sample was then selected from the sampling frame, and the selected girls were contacted directly for data collection.The sample sizewas estimated according to the following formula

$$n = \frac{p(1-p)(1.96)^2}{E^2}$$

Where

n≡ the required sample size; p≡ an estimate of the proportion of females with IDA in the population. Since this proportion is unknown, we used a value of p=0.5, as p(1-p) is maximized when p=0.5, so this will ensure the largest possible sample size, and hence the required estimate of the prevalence of IDA will be sufficiently precise; and E≡ the maximum margin of error that can be tolerated in the desired estimate of the prevalence of IDA.

Accordingly, we proposed that E= 0.08 as a reasonable margin of error to tolerate for the proportion of p=0.5 (i.e. an estimate of 50% would be accurate to within plus or minus 8% with 95% certainty). Thus, the estimated sample size is

$$n = \frac{0.5(1-0.5)(1.96)^2}{(0.08)^2} = 150 \text{participants}$$

3.2 The Data

There are two types of data that were collected for this research. These are: socio-economic and biological data. Socio-economic data: were collected through a questionnaire form. The questionnaire contains a number of questions about demographic data, medical history, nutrition information and physical abilities. These factors were collected to test their association with the possession of IDA. Biological data: diagnosis of IDA is easy. The disease is characterized by reduced serum ferritin level, reduced serum iron level, increased serum iron-binding capacity. Thus, Complete Blood Count (CBC), blood film, serum ferritin (as a gold standard), serum iron and Total Iron Binding Capacity (TIBC) should were taken. By relying on these, identifying IDA was straightforward process.

3.3 Statistical methods

A wide range of statistical methods was applied to analyze the data. Descriptive statistical methods such as the mean, standard deviation, proportions and graphics were obtained to describe the main features of the data and estimate the prevalence of ID and IDA. Additionally, analytical statistical methods were also applied. In this regard, association tests and correlation analysis methods such as Chi square test of association and Spearman correlation coefficient were conducted to investigate the relationship between IDA and the collected factors.

IV. ANALYSIS AND RESULTS

The results are presented across two major domains depending on the type of analysis. Namely, we distinguish descriptive results from analytical results.

Before discussing the main results, it is worth mentioning that the responding sample size is 149. That is to say, although we mentioned in the methodology that the required sample size is 150, due to refusal of participation from one sampling unit the size was reduced to 149. However, we do not expect this to have an effect on the precision level of the results since it is just one unit. The results are classified as: Normal, Iron Deficiency (ID) and Iron Deficiency Anemia (IDA). Based on this, an overall classification of anemia status can be obtained by combining participants with normal and ID statuses into a single category "normal" and those with IDA into a separate category "anemic".

4.1 Descriptive results

Looking at figure 1, it can be seen that, overall, the majority of the participants (70.5%) are normal meanwhile 29.5% are anemic.

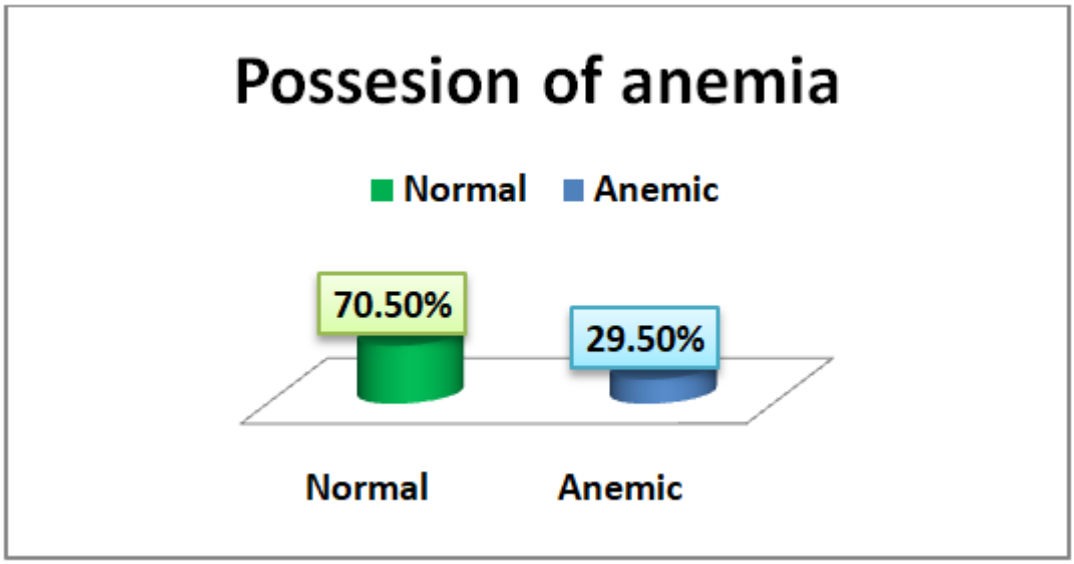


Figure 1: General classification of anemia status in the sample

The previous generic classification can be broken down into more specific classification as shown in figure 2. The figure shows that 71% (41% + 30%) of the participants suffer from iron deficiency, but only 30% of the total participants are actually classified as anemic.

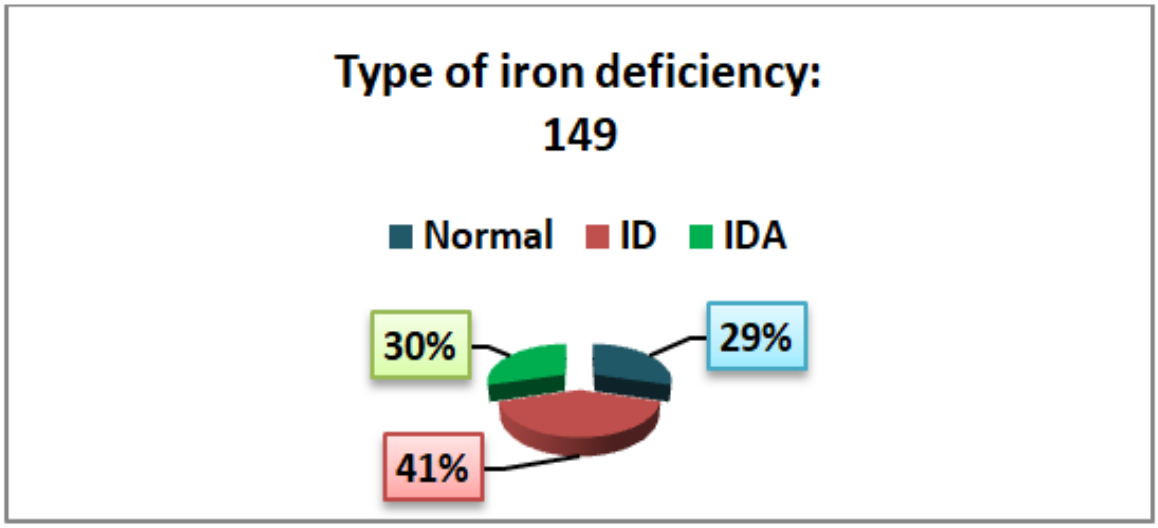


Figure 2: Specific classification of anemia status in the sample

Table 1 shows the mean values and standard deviations of the serum ferritin, serum iron and TIBC separately for normal, ID and IDA participants. By looking at the mean values for serum ferritin, for instance, it can be seen that the value for normal participants (94.41) is the highest and that it is less for those with ID (16.71). As for those with IDA they have the lowest mean value which falls outside of the normal range. A similar pattern can also be noticed with the mean value of serum iron. With regard to the mean value of TIBC, as expected, this is noticeably high for those with IDA.

Table 1:Mean and standard deviations for Hematological and iron measures

Variable	Normal	ID	IDA	Normal range
Serum ferritin				
Mean	94.41	16.72	3.91	(13- 150)ng/ml
Standard deviation	43.977	3.899	1.902	
Serum iron				
Mean	106.75	41.75	32.05	(37- 145)mcg/dl
Standard deviation	46.252	46.252	22.575	
TIBC				
Mean	327.39	412.15	534.64	(250- 425)mcg/dl
Standard deviation	64.351	108.455	145.104	

The prevalence of anemia can be presented in many ways. One of the important ways, especially in this research, may be to calculate the prevalence separately for each single-year age. Table 2 presents the proportion of anemic girls in each single-year age in the sample. It can be seen from the table that the largest proportion of anemic sample members is in the age 16 (60%). This is to say that 60% of those whose age is 16are anemic. However, this proportion declines rapidly with the increase in age indicating that younger adolescents are the most subjected part of the population to this disease. Figure 3 displays the same pattern of frequencies in a graphical representation.

Table 2: Prevalence of anemia across the ages 16, 17, 18 and 19

Age in years	Possession of Anemia		Total	Prevalence
	Anemic	Normal		
16	18	12	30	60%
17	15	28	43	34.88%
18	8	49	57	14.04%
19	3	16	19	15.79%
Total	44	105	149	-

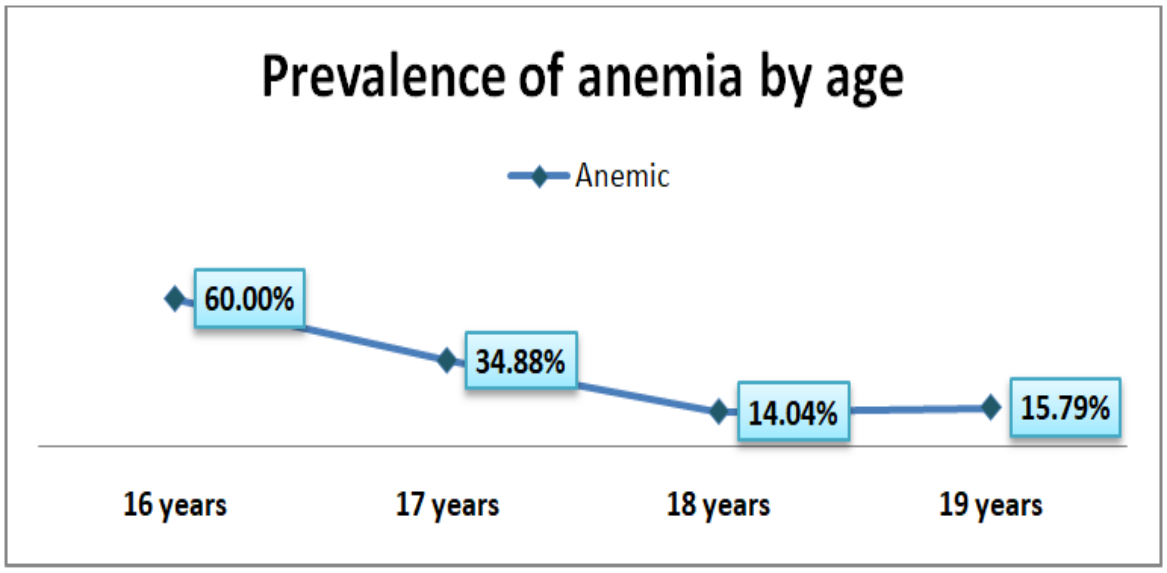


Figure 3: Prevalence of anemia by age

4.2 Analytical results

This part of the analysis is concerned with testing the association and correlation between a number of factors and the possession of IDA.

The methods used here are Chi square test of association and Spearman coefficient of correlation. Table 3 presents the results of a series of Chi square tests between the possession of IDA and a number of factors. The table also includes the value of Spearman correlation coefficient between each factor and the possession of IDA. As can be seen from the table, Chi square test reveals significant association between the possession of IDA and a number of factors. These are: age, father's education, monthly income, parent's separation status, habit of eating mud, consumption of chicken/week and consumption of red meet/week. These results are also confirmed by the correlation analysis.

Overall, it can be noticed that the most correlated factors with IDA are age (-.36), income (-.482), father's education (-.263) and habit of eating mud (.276).

Table 3: Association tests and correlation between IDA and the collected factors

Factor	Chi square	correlation
Age (categorised)	22.277 (.000***)	-.360
History of anemia	0.041 (.840)	-.016
Taking vitamins	0.422 (.516)	-.053
Mother's education	5.011 (.171)	-.090
Father's education	13.110 (.004**)	-.263
Mother's employment status	0.988 (.320)	.081
Social class G.M. income	47.082 (.000***)	.482
Parents separated	5.615 (.018**)	.194
History of malaria	1.722 (.189)	-.108
Eating ice	2.294 (.130)	.124
Eating mud	11.377 (.001***)	.276
Consumption of dairy products/week	4.122 (.249)	.066
Consumption of chicken/week	6.569 (.087*)	.076
Consumption of fish/week	4.086 (.130)	-.061
Consumption of red meat/week	12.816 (.005***)	.223

- The entries in the brackets are the associated p-values. The correlation is Spearman correlation. *, ** and *** indicate significance at levels 0.1, 0.05 and .001 respectively.

V. DISCUSSION

Iron deficiency anemia is the most common nutritional deficiency worldwide. The negative consequences of IDA on the cognitive and physical development and education productivity of adolescents are of major concern.

This cross section study was carried out on adolescent females at Alqabas Secondary school in Khartoum-Sudan to estimate the prevalence of IDA and to investigate its association with a number of socio-economic factors.

The prevalence of IDA

The findings in this studyshowed that the overall prevalence of IDA among adolescent females is 29.5%. This estimate does not deviate much from other estimates of the prevalence of IDA on similar age groups. For example, Fatin A-Sages et al[(1)]estimated the prevalence of IDA on a similar population as 24%. However, in contrast to these, a study in a slightly more developed country (Iran) by M Ramziet al reported a low prevalence of anemia (1.7%) among adolescent school girls. [(8)] The findings also showed that some of those who were classified as "normal" also suffer from iron deficiency. From the total population, the percentage of those with ID was estimated as 40%. This result is a little worrying as it shows that the proportion of adolescent females who are at risk to be anemic in the future is high.

With respect to the prevalence of anemia bay age, the results showed that the prevalence of IDA reaches its highest level (60%) at the age of 16, but then this goes down as age increases until it reaches its lowest value at the ages of 17 (14.04) and 18 (15.79%). This pattern shows a negative correlation between the prevalence of IDA and age. In other words, the older these girls are the lower the risk of becoming anemic. This may be explained in different ways. One explanation is that, often, when people get older, they become more aware of the importance of a healthy diet. Thus, they tend to include necessary nutrition in their daily meals which may balances out the levels of iron in their system. Another way to put it is that, in a country like Sudan, younger individuals may not pay attention to the quality of food that they consume every day, if at all. Rather, they often focus on the quantity and the joy that is associated with eating.

The determinants of IDA

The factors that are associated with IDA are well established in the literature. Nonetheless, out of a large set of collected factors, the current study found evidence for a limited number of these. In what follows, we discuss the major factors. Family income: was found to be significantly associated with the possession of IDA. The correlation between these was, however, found to be negative. This means that girls from more well-off families are at a lower risk of becoming anemic. This result is in line with both common sense and most of the literature. It is not odd that a family with higher income levels have more alternatives in terms of daily food.

Age: we have already mentioned the effect of age on the prevalence of anemia. To emphasize, our results here indicated a highly significant association between age and being anemic. Father's education: it might seem a little odd to not find a significant association with the mother's education and the possession of IDA. Instead, the results showed that the father's education is in direct correlation with IDA. However, when looking at the household structure in most parts of Sudan where the father is usually the dominant member of the household (i.e. the one that makes the decisions and provides the family with food) it is all explained. Whether parents

are separated: is also a significant factor. It is not controversial that when parents are separated, most of the time, poor decisions about nutrition, health and even education are made.

Habits of eating mud: is known to be correlated with IDA.[4] Thus, our finding here is in no contradiction with the other literature on the subject.

Consumption of red meat: meat, in general, is a good source of iron. Therefore, one would expect this variable to be significantly associated with the possession of IDA.

In sum, the prevalence of IDA among adolescent females is not worryingly high. However, a large proportion of those who might consider themselves as "normal" might, in fact, be suffering from ID as supported by the results in this study. This, in turn, may increase the prevalence of the disease in the near future if awareness is not raised. Households who have adolescent females should pay more attention to the type of nutrition that is incorporated in daily meals and variety of food should be included. Also, routine checkups should be performed especially on younger girls. This may help identify ID early before it is turned into IDA. Finally, schools may also help decreasing the prevalence of the disease if they dedicate short sessions during the week to advice students on this issue.

Finally,a follow up study may investigate the differences in the prevalence of IDA between adolescent females and adolescent males. This will benefit the estimation of an overall prevalence of IDA for the entire population of adolescents regardless of gender as well as identifying whether or not gender is an associated factor with IDA.

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