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Screening for Iron Deficiency Anemia in Children Living at South Sinai

Gamal Abdel Naser Hasan Yamamah
Professor and Head
Pediatrics Department, National Research Centre
Egypt

Nehal Salah Hasan
National Research Centre
Egypt

Asmaa Mahmoud Mohammed
National Research Centre
Egypt

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Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr
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Screening for Iron Deficiency Anemia in Children Living at South Sinai

Gamal Abdel Naser Hasan Yamamah

Nehal Salah Hasan

Asmaa Mahmoud Mohammed

Abstract

South Sinai is an Egyptian governorate lying in Sinai Peninsula at hyper arid zone. It's unique being desert with distant areas and different ethnic origin of inhabitants. Anemia is one of the most important nutritional deficiencies affecting various social and socioeconomic strata. It's more common in developing countries with children and adolescents being at a significantly higher risk for the condition.

Aim: To assess prevalence of iron deficiency anemia in South Sinai children and evaluate reliability of pin prick testing in anemia screening.

Subjects and methods: A descriptive cross sectional study was conducted for children attending schools and nurseries living at 6 districts in South Sinai through multistage random sampling. 1,828 children of both genders were selected. Their mean age was 10.6±3.1 years. Data about age, gender, ethnic origin and consanguinity were collected. Weight and height were measured. Hemoglobin was assessed through pinprick blood sample using standard technique. Complete Blood Count was done for 349 children. In last stage 100 children were selected to measure serum ferritin and transferrin.

Results: Pinprick screening of 1,828 children showed that 37.7% of children had mild to moderate degrees of anemia. There was significant difference between examined districts ($p<0.0001$). Anemia was less prevalent among children aging 10-<15 years, in children with history of parental consanguinity and in children with Bedouin origin ($p<0.01$). Gender had no effect on anemia rates. Severe anemia was present only in 3 children, they were thalassemic. Blood counting confirmed pinprick results and showed that 61.5% of anemic had microcytic hypochromic RBCs. Median serum ferritin was below normal (12.5µg/dl). Depleted iron stores were present in 53% of examined children. Depletion was more in females ($p<0.05$).

Conclusion: Iron deficiency anemia is a health problem among South Sinai children. Screening program is needed. Pinprick hemoglobin testing is simple, cheap and satisfactory.

Key words: Iron deficiency (ID), Anemia, Hemoglobin (Hb), Children

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Introduction

South Sinai is an arid area located at north east region of Egypt. Populations have environmental, climatic, social and ethnic specifications that are markedly different from other areas in Nile valley (Abdelkader 2005). Political and military events lead to lack of health surveys. To our knowledge no comprehensive medical study was mediated for South Sinai children

The World Health Organization estimates that around two billion individuals worldwide, i.e. over 30% of the world's population, are anemic, highlighting the importance of anemia as a public health issue in both developing and developed nations (WHO 2011). In developed countries, 4.3 to 20% of the population, depending on age and gender are affected by iron deficiency anemia, while in developing countries these figures range from 30 to 48% (CDC 2002).

Anemia is one of the most important nutritional deficiencies affecting various social and socioeconomic strata. It is more common in developing countries, with children and adolescents being at a significantly higher risk for the condition (De Andrade Cairo et al. 2014). Anemia remains the most prevalent nutritional disorder among women and children in the Middle East and North Africa region (Austin et al. 2011)

Iron deficiency is the most common nutritional deficiency and is a major cause of morbidity and mortality that is responsible for the majority of cases of anemia (Agudelo et al. 2003).

The prevalence of iron deficiency is not known for most countries due to the high cost of the biochemical tests required to precisely define an individual's iron status. Due to this, the prevalence of anemia is commonly used as an indirect indicator for iron deficiency, based on the assumption that about 50% of all cases of anemia are iron deficient (Lee et al. 2014).

Iron deficiency anemia is the most common nutritional deficiency worldwide. It can cause reduced work capacity in adults and impact motor and mental development in children and adolescents. Iron deficiency anemia may affect visual and auditory functioning and is weakly associated with poor cognitive development in children (Killip et al. 2010)

Aim of Work

We aimed to assess the prevalence of iron deficiency anemia among South Sinai children and detect possible risk factors. We also aimed to evaluate the pin prick test for hemoglobin as a reliable screening test.

Subjects and Methods

Study design: A descriptive cross sectional study was conducted on sample of children.

Sampling and sample size: A multistage stratified random sampling technique was used to select a sample of children attending governmental schools and nurseries in 6 districts including cities and surrounding Bedouin settlements in South Sinai governorate. Selection of children was mediated to represent social, environmental and ethnic variations in South Sinai.

The representative sample size was calculated using the automated method that depends on the population size, desired confidence level and confidence interval (Dawson-Saunders and Trapp 1994). The formula used was:

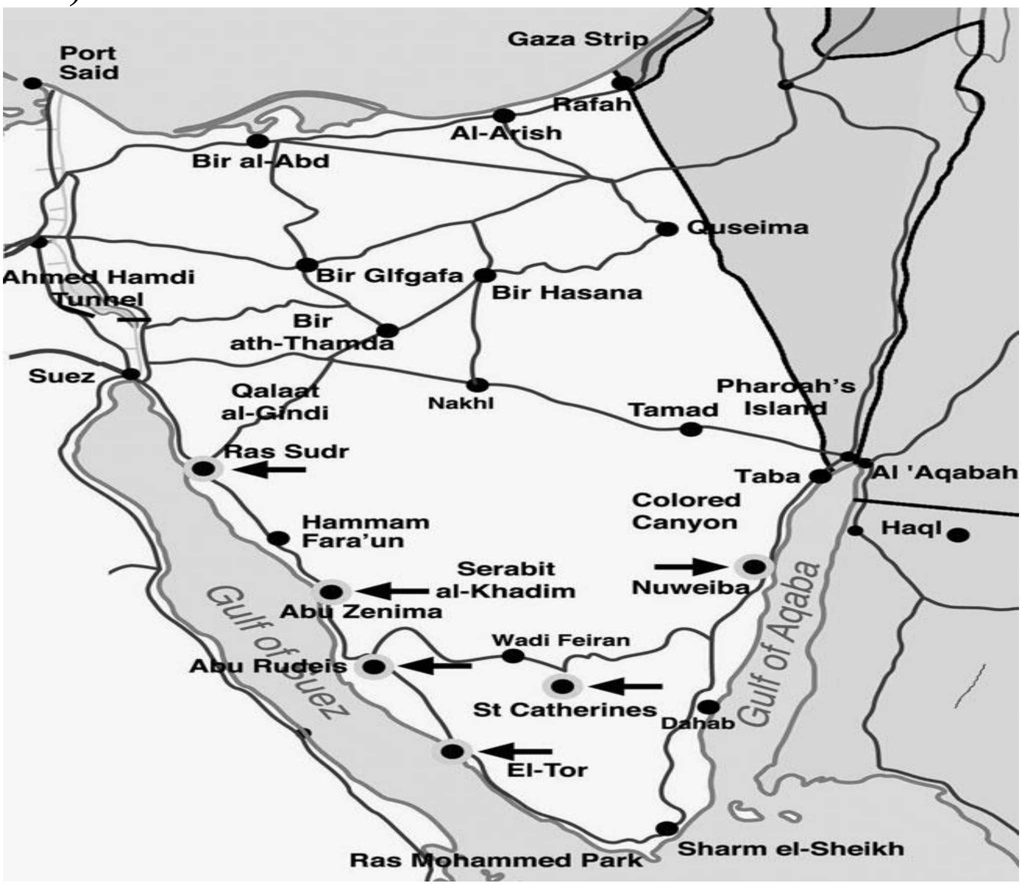
$$\text{Sample Size} = \frac{(Z^2) * (P) * (1-P)}{C^2}$$

Where:
Z=Z value (standard value 1.96 for 95% confidence level).
P=percentage picking a choice, expressed as decimal (0.5 used for sample size needed).
C=confidence interval, expressed as decimal (2.2 in this study).

The calculated sample size was 1,823 child at 95% confidence level and confidence interval = 2.2.

The study included 1,828 child representing all the 6 areas of South Sinai (El-Tur, Abu Redeis, Abu Zenima, Saint Katherine, Nuweibaa and Ras Sidre) (Figure 1).

Figure 1. *Map of Egypt's Sinai Peninsula (the arrows point to the studied areas)*



Source: http://www.allsinai.info/bilder/maps/sinai04-b.jpg (no copyright indicated).

Study subjects were 889 girls and 939 boys. Their age ranged between 2.7-17.8 years (Mean ±SD = 10.6 ±3.1; Median = 10.3).

Methods:

- Approval of National Research Centre Ethical committee was obtained and explanation about the study was provided for children care givers and school teachers before examination and blood sampling.
- Personal data were collected (birth date to calculate age, gender, residence and ethnic origin).
- Anthropometric measures were recorded (weight and height) using standard techniques and highly sensitive balance and scale (SECCA apparatus). Body Mass Index (BMI) was calculated according to standard equation: BMI = Weight (Kg) / Height (m^2)
- Screening for anemia status:

    - Blood sample was withdrawn from tip of a finger after disinfection through Pinprick, 200 µl of blood was collected in an eppendorf tube. Hemoglobin was estimated to 1,828 subjects by hemoglobin cyanide method and measured in a spectrometer at a wavelength of 540 nm.
    - Four ml of venous blood samples were withdrawn from 349 subjects. Two ml was withdrawn on EDTA containing vacutainer and the other two ml was withdrawn on plain vacutainer.
    - EDTA blood was used for measurement of complete blood count (CBC), while serum was obtained after blood centrifugation and used to measure serum ferritin and transferrin for 100 subjects. Transferrin saturation percent was calculated according to standard equation.

- Complete blood count (CBC) was performed to 349 subjects by Medonic hematology analyzer.
- Serum ferritin was measured by ELISA technique using the kit provided from Immunospec (IMMUNOSPEC CORPORATION 7018 Owensmouth Ave. Suite # 103 Canoga Park, C.A. 91303).
- Serum ferritin was considered below normal according to WHO values (WHO 2011).
- Serum transferrin was measured by ELISA technique using kit provided from Abcam Inc (Cambridge, MA 02139-1517, USA). Trasferrin percent saturation was calculated and values <20 were considered below normal (Transferrin saturation 2010).

WHO Hemoglobin thresholds classification for anemia degrees was applied to our data (WHO 1989).

- Data manipulation and statistical analysis:

- The collected data and the clinical results have been computerized and coded using SPSS version 18.0 soft ware (Statistical Package for Social Science) and statistically analyzed. Quantitative data were expressed as mean values ± standard deviation (SD). Ranges, frequency of distributions were estimated for quantitative variables. Normally distributed data were compared using Student's t-test for 2 groups and ANOVA test for more than 2 groups. On the other hand, non-parametric tests were used for abnormally distributed data. Significance level of 0.05 is used.
- The significance of differences between proportions was tested by the Chi-square test (χ^2). Differences were considered significant with *P* value ≤ 0.05. Logistic regression analysis was performed to predict the presence or absence of outcome based on a set of predictor values. Odds ratios and their 95% CI for significantly associated factors were reported.

Results

Using the WHO classification for anemia degrees according to age and gender (WHO 1989), studied subjects were classified into normal or anemic. Those with anemia were categorized into mild, moderate or severe anemia.

In the present work, the overall prevalence of anemia among studied children (1,828) in all districts under study was 37.9%. Mild anemia accounted 22% and moderate anemia accounted 15.7%.

Only 3 cases had severe anemia, two from El-Tur and one from Redeis. They had history of thalassemia (Table 1).

Table 1. *Prevalence of Anemia among Screened Children and Effect of Residence*

Anemia status by hemoglobin level (g/dl)	**District**						**Total**
	Tur *f* *(%)*	**Redeis** *f* *(%)*	**Zeneima** *f* *(%)*	**Sidre** *f* *(%)*	**St.Kath** *f* *(%)*	**Nuweibaa** *f* *(%)*	***f*** ***(%)***
Normal	**271 (63.8)**	**146 (64.9)**	**105 (62.5)**	**203 (54.7)**	**187 (76.9)**	**223 (56.3)**	**1135 (62.1)**
Mild anemia	77 (18.1)	44 (19.5)	44 (26.2)	101 (27.2)	38 (15.7)	98 (24.8)	**402 (22.0)**
Mod. anemia	76 (17.9)	33 (14.7)	19 (11.3)	67 (18.1)	18 (7.4)	75 (18.9)	**288 (15.7)**
Severe anemia	1 (0.2)	2 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	**3 (0.2)**
All anemia	**154 (36.2)**	**79 (35.1|)**	**63 (37.5)**	**168 (45.3)**	**56 (23.1)**	**173 (43.7)**	**693 (37.9)**
Total	**425 (100)**	**225 (100)**	**168 (100)**	**371 (100)**	**243 (100)**	**396 (100)**	**1828 (100)**

Note: χ^2= 57, df = 15, P-value < 0.0001*.
Source: Authors' estimations.

Statistically significant difference was observed in prevalence of anemia in different districts (P-value<0.0001) with higher prevalence in Sidre and Nuweibaa (45.3% and 43.7% respectively). Lower values were present in Zeneima (37.5%), El-Tur (36.2), Redeis (35.1%) and St. Kathrene (23.1%) (Table 1).

Age group 10-<15years had the least prevalence of anemia (32.8%). Other studied age groups had anemia ranging between 41.3% and 42.0%. The difference was statistically significant (P<0.0001) (Table 2).

Table 2. *Effect of Age Group on Prevalence of Anemia among Screened Children*

Anemia status by hemoglobin level (g/dl)	Age group (years)								Total	
	<6		6- <10		10- <15		≥15			
	f	*(%)*	*f*	*(%)*	*f*	*(%)*	*f*	*(%)*	*f*	*(%)*
Normal	25	58.1	470	58.7	501	67.2	139	58.0	1135	62.1
Anemia	18	41.9	330	41.3	244	32.8	101	42.0	693	37.9
Total	**43**	**100.0**	**800**	**100.0**	**745**	**100.0**	**240**	**100.0**	**1828**	**100.0**

Note: χ^2= 68.7, df = 9, P-value < 0.0001*.
Source: Authors' estimations.

Among the studied children, 615 had history of positive parental consanguinity and 783 had negative history. Meanwhile, 430 could not give a conclusive history. Children with history of positive consanguinity had less prevalence of anemia (34.6%). On the other hand, those with negative history had higher values (38.4%). The difference between the 2 groups was significant (P=0.008) (Table 3).

853 of the examined children were of Bedouin origin, while 975 were coming from other urban regions of the Nile Valley. Those of Bedouin origin had less prevalence of anemia (35.5%) compared to children of urban origin (40.0%). The difference was statistically significant (P=0.008) (Table 3).

Males were 939 of the studied subjects with anemia prevalence of 39.0%, while females were 889 with anemia prevalence of 36.7%. Males had higher levels of anemia but gender seems to have no statistical difference (P=0.6) (Table 3).

Table 3. *Effect of Consanguinity, Ethnic Origin and Gender on Anemia Prevalence*

Anemia status by hemoglobin level (g/dl)	History of consanguinity			Ethnic Origin		Gender		Total
	N/A *f* *(%)*	Yes *f* *(%)*	No *f* *(%)*	Urban *f* *(%)*	Bedouin *f* *(%)*	Male *f* *(%)*	Female *f* *(%)*	**Total *f* *(%)***
Normal	251 (58.4)	402 (65.4)	482 (61.6)	585 (60.0)	550 (64.5)	572 (61.0)	563 (63.3)	**1,135 (62.0)**
Anemia	179 (41.6)	213 (34.6)	301 (38.4)	390 (40.0)	303 (35.5)	367 (39.0)	326 (36.7)	**693 (37.9)**
Total	**430 (100)**	**615 (100)**	**783 (100)**	**975 (100)**	**853 (100)**	**939 (100)**	**889 (100)**	**1,828 (100)**
	P-value = 0.008 χ^2 *= 17.3* *df = 6*			*P-value = 0.008* χ^2 *= 7.9* *df = 3*		*P-value = 0.6* χ^2 *= 1.6* *df = 3*		

Source: Authors' estimations.

A trial for detection of anemia risk factors that may contribute to the development of anemia among South Sinai children was mediated. A binomial logistic regression analysis was performed on anemia as an outcome and 13 predictors to predict the factors that may be associated with increased probability of anemia among screened children. All available predictors were involved in the equation (residential location of the city, consanguinity, gender, origin, age, weight, height, stature degree (normal, tall or short), BMI, height for age Z-score, height for age percentile, weight for age Z-score and weight for age percentile.

Only residential location of the city and height for age percentile add significantly to the model prediction of anemia among screened children (OR=2.4, 1.01 respectively) (P-value<0.05). On the other hand, gender, consanguinity, origin, age, weight, BMI, height, height for age Z-score, stature, weight for age Z-score and weight for age percentile of screened children did not add significantly to the model prediction of anemia (P-value>0.05).

Complete blood count (CBC) was done for a subsample of 349 subjects by Medonic hematology analyzer. Table 4 presents values of hemoglobin (g/dl), RBCs count (million/µl), white blood cells count (x 10^3/µl), hematocrit (%), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC) and platelet count (x 10^3/µl) (Table 4).

Table 4. *CBC Parameters of 349 Children According to their Age Groups*

Parameter (mean±SD)	Age group (years)				
	<6	***6- <10***	***10- <15***	***≥15***	***P-value***
Hemoglobin(g/dl)	11.6±0.8	11.6±0.8	12.1±1.1	11.5±1.8	0.002*
RBCs(million/µl)	4.5±0.37	4.6±0.38	4.6±0.4	4.7±0.6	0.2
WBCs(X10^3/ µl)	8.8±3.4	7.7±2.1	6.8±1.8	6.2±1.2	<0.0001*
HCT (%)	36.3±2.5	36.3±0.2	37.8±5.9	37.1±5.6	0.04*
M.C.V (fl)	79.2±3.3	78.6±5	80±8.8	80.2±10	0.3
M.C.H (pg)	26.4±1.4	26.5±4.1	27±2.4	28.1±10	0.3
M.C.H.C (g/dl)	33.6±1.7	33.4±1.3	33.2±1.3	31.8±2	<0.0001*
Platelet (X10^3/ µl)	292±80.7	290.7±67.3	270.8±59.3	247.7±65.2	0.002*

Source: Authors' estimations.

Present data proved that 129 out of 349 were anemic (36.96%). CBC results showed that the mean hemoglobin concentration was 11.8±1.0 g/dl, ranging between 5.2 and 15.0 g/dl. Age group 10-<15 years had values of hemoglobin (12.1 g/dl) and hematocrit (37.8%) higher than other age groups (P<0.002 and P<0.04, respectively) (Table 4). The difference was statistically significant (P=0.002 and P=0.04, respectively). Anemia among Bedouins accounted 31% compared to 40% of urban origin.

Data of CBC was very close and comparable to results obtained by pinprick testing. Age group 10- <15 years has the least prevalence of anemia by both tests.

Among anemic children 61.5% were microcytic hypochromic indicating prolonged iron deficiency. Iron deficiency anemia is well known as microcytic anemia.

Further subsample of 100 subjects were tested for serum ferritin and transferrin levels. Transferrin saturation was then calculated. Median serum ferritin was below 15 in all studied age groups and transferrin saturation was below 20 indicating marked depletion of iron stores in studied children. No age difference was detected (Table 5). Decrease in serum ferritin is one of the earliest signs of iron deficiency. 53% of studied children had iron stores depletion. More depletion was present among females (66.0%) compared to males (41.5%) with significant difference (P=0.014) (Table 6).

Table 5. *Ferritin and Transferrin of 100 Children According to their Age Groups*

Parameter	**Age group (years) n=100**				
	<6 (n=6)	**6- <10 (n=32)**	**10- <15 (n=56)**	**≥15 (n=6)**	**P-value**
Ferritin (µg/l)					
Mean±SD	15.1±8.4	23.9±19.6	21.6±17.7	16.5±9.2	>0.05
Median	13	12.5	13	12	>0.05
Transferrin					
Mean±SD	289±68	279±57	291.7±62	304±53	>0.05
Median	284	280	297	299	>0.05
Transferrin Saturation (%)	12.6	14.8	12.5	11.8	>0.05

Source: Authors' estimations.

Table 6. *Depleted Iron Stores by Age Group and Gender among Screened Children*

Iron stores status by ferritin level (ng/ml**)**	**Age group**				**Gender**		**Total**
	<6y *f (%)*	***6- <10*** *f (%)*	***10- <15*** *f (%)*	***≥15*** *f (%)*	***Male*** *f (%)*	***Female*** *f (%)*	**Total *f* *(%)***
Replete iron stores	3 (50.0)	15 (46.8)	27 (48.2)	2 (33.3)	31 (58.5)	16 (34.0)	**47 (47.0)**
Depleted iron stores	3 (50.0)	17 (53.2)	29 (51.8)	4 (66.7)	22 (41.5)	31 (66.0)	**53 (53.0)**
Total	**6 (100)**	**32 (100)**	**56 (100)**	**6 (100)**	**53 (100)**	**47 (100)**	**100 (100)**
	P-value = 0.9 $\chi^2 = 0.5$, *df = 3*				*P-value = 0.014* $\chi^2 = 5.9$, *df = 1*		

Source: Authors' estimations.

Discussion

Anemia is a term given to a pathological process in which erythrocyte hemoglobin (Hb), hematocrit (Ht) and the concentration of red blood cells per unit of volume are abnormally low compared to the peripheral blood parameters of a reference population. In normal individuals, hematocrit and hemoglobin levels vary in accordance with the phase of development of the individual, and as a function of hormonal stimulation, environmental oxygen pressure, age and gender (Jordão et al. 2009).

The overall prevalence of anemia among studied children (1,828) in all districts under the present study was 37.9%. Mild anemia accounted 22% and moderate anemia accounted 15.7%.

In developed countries, 4.3 to 20% of the population, depending on age and gender, are affected by iron deficiency anemia, while in developing countries these figures range from 30 to 48% (CDC 2002).

A recent Egyptian study on 300 children at Fayoum governorate demonstrated that 64% of the studied children had iron deficiency anemia with 20% mild, 41.7% moderate and 2.3% severe (AL Ghwass et al. 2015).

The prevalence of anemia (defined as hemoglobin concentrations <11g/ dL increased from 37.04% to over 52% among Egyptian children between 12 months and 36 months of age using data from the Egyptian Demographic and Health Surveys between 2000 and 2005 **(**Austin et al. 2012).

In the present work; only residential location of the city and height for age percentile add significantly to the model prediction of anemia among screened children (OR=2.4, 1.01 respectively) (P-value<0.05). This can explain the statistical significant difference observed in prevalence of anemia between different cities (P-value<0.05) with higher prevalence in Sider and Nuweibaa (45.3%) and (43.7%) respectively.

Age group 10-<15years had the least prevalence of anemia (P<0.0001). Children with history of consanguinity and those of Bedouin origin have less prevalence of anemia (P=0.008). Gender has no effect (P=0.6) (Table 3).

In korean study female had more IDA at age 15-54 y, other age groups showed no gender difference (Lee et al. 2014) as our results.

It was found that children from low social class and those of low maternal educational level had a higher risk for IDA than other children in rural areas. Infants with IDA were found to consume foods with low iron content 50% below recommended daily allowance (AL Ghwass et al. 2015).

One of the most important factors determining iron deficiency anemia is inadequate diet, with poor iron, micronutrient and vitamin content, leading to an insufficient intake of nutrients such as iron, folic acid, vitamin A, vitamin B12 and vitamin D. Multiple micronutrient deficiencies are still common worldwide and may be present at any age, hampering both physical and cognitive development (Kurpad 2013**).** In addition to age, gender and physiological state, socioeconomic and nutritional status were also significant risk factors for IDA; low socioeconomic status, underweight, iron- or vitamin C-poor diets were all associated with IDA **(**Lee et al. 2014**).** In South Sinai; iron, vitamin C and vitamin A intakes were below required allowances (Ghanem et al. 2015).

To reach a definitive diagnosis of iron deficiency anemia, in addition to performing a full blood count (hemoglobin, hematocrit, red blood cell count), ferritin and serum iron levels should be measured (Silva et al. 2002).

CBC proved that 129 out of 349 were anemic (36.96%). Age group 10<15 years have hemoglobin and hematocrit values above other age groups ($P<0.002$ and $P<0.04$, respectively). Anemia among Bedouins was 31% compared to 40% of urban origin.

These data are consistent with results of pin prick Hb test that was mediated for 1828 children.

Median serum ferritin in the present work was decreased below 15 and Transferrin saturation was below 20.

In progress of iron deficiency, a sequence of biological and hematological events occur. Serum ferritin (is an indication for iron stores) decreases. It provides a relatively accurate estimate of body iron stores in absence of inflammatory disease. Transferrin percent saturation also decreases (Glader 2007).

Plasma ferritin levels decrease when there is a deficiency of iron that is not complicated by another concomitant disease. This reduction in ferritin occurs early, well before the abnormalities in hemoglobin levels, serum iron levels or in erythrocyte size become apparent (Paiva et al. 2000).

Patients with a serum ferritin concentration less than 25 ng per mL (25 mcg per L) have a very high probability of being iron deficient. The most accurate initial diagnostic test for IDA is the serum ferritin measurement. (Guyatt et al. 1992).

53% of examined children had depleted iron stores. Females had higher rates than males ($P=0.014$). Older children ≥15 years have more depletion but difference was not significant ($P=0.9$).

Data of the present work and literature publications indicate that nutritional iron deficiency is quite prevalent among South Sinai children leading to this high prevalence of anemia (37.9%). Variation in different cities and effect of ethnic origin and consanguinity drives attention to nutritional habits in each city that augment or inhibit the occurrence of anemia.

Conclusions

Prevalence of anemia among South Sinai children proved to be 37.8%. Anemic children were mild to moderate. This value comes within the developing world published data. Yet, this value is high enough to pay attention for such health problem to avoid well known hazard of anemia.

Only residential city was proved to be a contributing risk factor for anemia in South Sinai children. Sidre and Nuweibaa cities should take the priority in proper iron supplementation and health education program. Other factors as age, gender and ethnic origin were not risk factors and did not cause increase in anemia prevalence.

CBC is the most accurate test for anemia evaluation. It measures hemoglobin and hematocrite. It shows the size of RBC (MCV), hemoglobin per RBC (MCH) and MCHC. The present work showed that CBC results are comparable to pinprick testing regarding anemia screening. In addition, pinprick test is simple, cheap and could be done in remote areas.

Nutrition supplementation is provided to school children in South Sinai through biscuits distributed in schools. The value of this meal needs to be evaluated and the program needs updating.

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