Factors associated with iron depletion and iron deficiency anemia among Arabic preschool children of the United Arab Emirates

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ABSTRACT

Objective: The purpose of this study was: 1. To estimate the prevalence of iron depletion and iron deficiency anemia in preschool Arabic children of the United Arab Emirates (UAE), and 2. To determine the risk factors associated with these conditions in this population of children.

Methods: From April through to October 2000 a questionnaire and capillary blood survey was carried out in one primary health care (PHC) centre of Al Ain, UAE. Children whose capillary hemoglobin (Hb) or mean cell volume (MCV) results fell below predetermined cutoffs were offered venous blood workup. An additional sample of children with capillary blood results above those cutoffs were offered the same workup. All blood sampling was completed by May 2001.

Results: Five hundred and eight parents were questionnaired and 496 children capillary blood tested. Of the 320 venous blood tested, 315 were analyzed, in relation to questionnaire responses, using univariate analysis and logistic regression. Anemia, iron depletion and iron deficiency anemia were found in an estimated 36.1%, 26%, and 9.9% of this population of children. Age was a significant independent predictor of both iron depletion and iron deficiency anemia. Mother's current pregnancy was an additional predictor of iron deficiency anemia.

Conclusion: The prevalences of iron depletion and iron deficiency anemia in this population of children were consistent with other reports from the region. Child's age and mother's current pregnancy were predictors of iron deficiency anemia. These findings have important implications for antenatal and childcare both in hospital and primary health care clinics.

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Anemia and iron deficiency anemia in particular are important problems of childhood worldwide. This is a concern since evidence is accumulating that iron depletion with or without anemia has detrimental effects on the normal growth and psychomotor development of children.[1-4] Prevalences of iron deficiency and iron deficiency anemia in non-Arabic children of developed countries have been reported up to 9% and 3%,[5,6] however definitions of these entities are inconsistent across studies. Anemia and iron deficiency states are common among children in developing communities including among expatriates residing within developed nations.[7-12] Studies of middle eastern populations have shown high prevalences of anemia and iron deficiency in young children.[13-15] Padmanabhan et al[16] have reported an anemia prevalence of 45.1% in a hospital outpatient-based

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population of 3-5-year-old Omani children. As there were few cases of iron deficiency amongst these children, the authors concluded that alpha thalassemia was a major contributor to the anemia. Reports of similar studies in the United Arab Emirates (UAE) are few: Hossain et al[17] reported anemia (hemoglobin (Hb)<11.0g/dl) in 35% of a multi-racial sample of children aged 6-22 months in the city of Al Ain. A large study of 11,802 six-year old UAE children found that 33% of the Emirati children had Hb levels <12.0g/dl.[15] Many factors contributing to iron depletion and iron deficiency anemia in children have been identified as follows: age,[5,9] low birth weight and prematurity,[11,18] bottle feeding status,[10,13] introduction of cow's milk before 12 months,[19,20] volume of cow's milk,[10,11] late introduction of solids,[21] consumption of red meat or hem iron,[5,20] the use of vitamin or iron supplements,[5,10] and both a history of pica and household water source.[9] Hossain et al[17] in their UAE study found relationships between infants' anemia and the maternal age, number of pregnancies and current pregnancy status The aims of this study were: 1. To estimate the prevalence of iron depletion and iron deficiency anemia among national Arabic children age 1-5-years who attended a primary health care (PHC) centre in Al Ain, UAE. 2. To identify the risk factors associated with iron depletion and iron deficiency anemia in this population of children. For the purposes of this study, anemia was defined according to World Health Organization/United Nations Children's Fund criteria, as a Hb <11.0g/dl for children 12-59 months, and <11.5g/dl for children 60-71-months.[22] Iron depletion was defined as a plasma ferritin <10μg/l(6), iron deficiency as iron depletion plus an erythrocyte zinc protoporphyrin (ZPP) of >40 μmol/mol hem,[23] and iron deficiency anemia as iron deficiency plus anemia.

Methods. A cross-sectional community-based questionnaire and capillary blood sample survey was carried out over a 6-month period from April through to October 2000. A detailed description of the hematological survey has been reported elsewhere.[24] In short, 1-5-year-old children were tested for capillary Hb and mean cell volume (MCV). On the basis of predetermined Hb and MCV cutoff levels (Hb<11g/dl for children <60-months and Hb<11.5g/dl for children ≥60-months, MCV <80fl), parents of those children falling below either of those cutoffs were invited to submit their children for venous blood hematological workup including serum ferritin and erythrocyte zinc protoporphyrin (ZPP). In addition, the parents of a random sample of children whose capillary Hb and MCV were above the cutoffs were invited to submit their children for venous blood testing. All blood sampling was completed by May 2001. Finger prick capillary blood samples were collected in the PHC and tested for Hb and MCV using a Coulter Counter CBC-5. Venous blood complete blood counts were analyzed in a Coulter Counter STKS (Coulter), ZPP in a front surface AVIV hemato fluorometer, ferritin by an automated enzyme linked fluorescent assay [Vidas Ferritin, bioMerieux Vitek, Missouri, United States of America, (USA)].

Study population. The population comprised a convenience sample of national Arabic children aged 12-71-months. The parents and children were attending one urban primary health care centre in Al Ain, UAE. All children attending for any reason, including for vaccination or simply accompanying another family member, were included. There were no exclusions, but parents were required to have a current health card to facilitate blood testing. Sample size was calculated using a predicted anemia prevalence of 24%.[17] A sample of 450 subjects would provide an estimated prevalence of anemia between 20-28% with 95% confidence.

Questionnaire. A questionnaire was designed based on previously reported risk factors for anemia in children. It included basic demographic details, position among siblings, pregnancy, breast-feeding and early dietary history, vitamin or iron supplementation, relevant medical history, family history of hereditary blood disorders, family diet, parental socio-economic and educational data. (**Appendix 1**) Content and face validity of the questionnaire was checked by 3 pediatricians using a structured response sheet covering item relevance, clarity and format. All 3 specialists rated the questionnaire as having high content validity. One small addition was made regarding sibling family history. Single forward and back translations were then carried out to develop an Arabic version of the questionnaire readily understandable to local parents. The final version was reached by consensus between forward and back translators. Pilot testing of the questionnaire on 36 parents of children in the 1-5 year age group resulted in very minor modifications. Parents (either father or mother) were interviewed by one of 4 trained interviewers in order to complete the questionnaires.

Data management and analysis. Post-coded questionnaire and hematology data were analyzed using statistical package for social sciences for Windows version 11 software. For univariate analysis, students' t-tests were used for differences in means between groups: chi-squared and odds ratios were used for categorical variables. Those variables reaching p values ≤ 0.1 on univariate analysis were entered into a logistic regression model. We report those variables which were significantly (p<0.05) and independently associated with iron depletion and iron deficiency anemia. The

Table 1 - Risk factors associated with iron depletion, by univariate and multivariate analyses.

Risk factor	Univariate analysis Odds ratio (95% CIs)	*P*	n	Multivariate analysis (n=263) *P*
Child's age		0.001	307	0.004
Child's age <24 months		0.01	307	NS
->24	1.00			
-<24	1.91 (1.12-3.24)			
Blood disorder in a sibling		0.02	302	NS
Absent	1.00			
Present	0.50 (0.27-0.93)			
Age child started eating meat		0.04	267	NS
Mother's completion of primary school education		0.08	306	NS
No	1.00			
Yes	0.63 (0.36-1.09)			

NS - not significant
CIs - confidence interval
P - *p* value

Table 2 - Risk factors associated with iron deficiency anemia, by univariate and multivariate analyses.

Risk factor	Univariate analysis Odds ratio (95% CIs)	*P*	n	Multivariate analysis (n=244) Odds ratio (95% CIs)	*P*
Child's age		<0.001	315		0.02
Mother currently pregnant		0.02	306		0.02
Not pregnant	1.00			1.00	
Pregnant	2.3 (1.04-5.07)			2.82 (1.2-6.63)	
Does the child eat meat?		0.02	315		NS
Eats meat	1.00				
Does not eat meat	3.63 (1.13-11.25)				
Blood disorder in a sibling		0.04	310		NS
Absent	1.00				
Present	0.41 (0.15-1.06)				
Presence of a chronic disease in the child		0.05	314		NS
Absent	1.00				
Present	2.43 (0.92-6.26)				
Frequency of eating meat (days per week)		0.06	314		NS
Birth weight		0.08	257		NS
Sex		0.09	315		NS
Female	1.00				
Male	0.57 (0.28-1.15)				

NS - not significant, CIs - confidence interval, *P* - *p* value

study was approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, UAE University. Parents of the children gave written informed consent. All blood test results were sent to the clinic for patient follow up.

Results. Five hundred and eight parents were questionnaired, and 496 children were screened by capillary blood testing, comprising 264 males (53.2%) and 232 females (46.8%) with a mean age of 34.4 months (SD 15.2). Mean capillary Hb rose with increasing age (analysis of variance tests of linearity $p<0.001$) but there was no significant gender difference. Of the 284 children falling below the capillary Hb and MCV cutoffs, 262 (92.3%) had venous blood samples taken for hematological workup. For those with Hb and MCV results above the cutoffs, 50 of the first 94 parents invited agreed to the venous blood testing of their children. A further 8 children had venous blood testing but not capillary blood testing, making a total of 320 children who were venous blood tested. There were no significant differences between venous blood tested and untested children for mean age, birth weight, capillary Hb and MCV. Males were more represented in the tested versus the untested group (62% versus 52.5%). Of the 320 children who underwent venous blood testing, 5 with anemia had neither serum ferritin nor ZPP results and were therefore excluded from the analysis. Three hundred and seven were tested for serum ferritin and 311 for ZPP. By extrapolating the results for iron depletion and iron deficiency anemia in the tested groups of children to the whole sample of children, it was possible to estimate the prevalences of these abnormalities in this population as follows: Anemia 36.1%, iron depletion 26%, iron deficiency anemia 9.9%.

Questionnaire data. The children had more than 5 siblings in 22% of cases. Ninety-six percent of the children had been breastfed, 51% for longer than 12-months, and 16% were breastfed-only for longer than 6-months. Cows' milk had been introduced before 12-months of age in 23%, and before 6-months in 8%. Solids had been introduced by 6-months of age in 57% of the children and 22% had been given iron supplementation in the first year of life. Ninety-four percent of children ate meat; 66% ate meat every day and in 75% of cases, meat had been introduced by 12 months of age. Six percent ate red meat more than 3 times per week.

The parent reported a blood disorder (such as anemia, thalassemia, G6PD) in 15% of the children and some other disease (such as bronchial asthma) in a further 10%.

Risk factors for iron depletion and iron deficiency anemia. Univariate analyses for iron depletion revealed that the following were associated variables with *p* values ≤0.1:- the child's age, age less than 24-months, the age the child started to eat meat, the mother's completion of primary school education. On multivariate analysis only the child's age was a significant ($p<0.05$) independent predictor of iron depletion (n=263) **(Table 1)**. With iron deficiency anemia as the dependent variable, univariate analysis revealed that the following were associated variables with p values ≤0.1:- the child's age, sex, birth weight, the eating of meat and the frequency of eating meat, the presence of a disease (other than a blood disorder), the presence of a blood disorder in a sibling, current pregnancy in the mother. Multivariate analysis revealed that only the child's age and mother's current pregnancy status were significant ($p<0.05$) independent predictors of iron deficiency anemia (n=244) **(Table 2)**.

Discussion.

The estimated anemia prevalence of 36.1% in this study was consistent with previous studies carried out in the UAE (15;17), a recent Omani study,[16] and a Saudi study performed more than a decade ago.[13] However, comparisons must be made with caution as these 3 studies involved younger age groups of children. In this study only an estimated 27.4% of the children found to be anemic were iron deficient. Our results suggest that this reflected the high prevalence of thalassemia in the UAE population. Nevertheless, the estimated prevalence of iron deficiency anemia (9.9%) was considerably higher than the results of the Omani[16] and a USA study.[6] Unlike the Omani study which reported only 2 iron depleted children, our estimate of 26% for iron depletion is consistent with the Sydney study of children born of mothers from Arabic-speaking countries (23%).[11] Reasons for this discrepancy in results between children from towns in close proximity from neighboring countries of the Arabian Peninsular are unclear, but may include differences in levels of socio-cultural change. The older age group of our study population makes the higher prevalence of iron depletion even more significant. The inverse relationship we found between age and the presence of iron depletion and iron deficiency anemia has been reported by others.[5,9] This may be a reflection of dietary diversification in children after infancy. However, our data did not demonstrate that duration of breast milk-only feeding, age at introduction of cows' milk, solids or meat were independent predictors of iron depletion. Nineteen percent of the mothers were currently pregnant, a factor that more than doubled their children's risk of iron deficiency anemia **(Table 2)**. This was consistent with the findings of Hossain et al,[17] where current pregnancy was a risk factor for anemia in children aged 1-22-months. The results have implications for the detection of affected children while their mothers seek antenatal care in primary health care and hospital clinics. Whilst the eating of meat and the age at which it was introduced were significant factors in univariate analysis, they failed to reach significance as independent risk factors in our logistic regression model. This was in contrast to other studies demonstrating the relationship between the intake of hem iron and iron depletion.[5,20] Again, discrepancies in the age groups may partly explain these differences. Comparison of our results with those of other studies must be made with caution. Since there is no universal agreement regarding reference values for Hb, MCV, ferritin, or ZPP in children, and in particular there are no such values for Arabic children, the identification of anemic and iron deficient children was problematic. As with all self-reported data, the questionnaire data was subject to potential recall bias and inaccuracy. This is particularly so given that parents were responding to questions regarding events occurring up to 5 years ago such as birth weight, introduction of solids. The relationships between questionnaire data and venous blood results were also problematic in this study: There were delays, in some instances of several months, between questionnaire data collection at the clinic and the hospital testing of venous blood following recall of the children. This was especially so among the children found to have "normal" capillary blood results. We consider that these delays had little if any effect on the results but have no way of knowing. Missing data resulted in the loss of cases from both regression models. Analysis of the cases inside and outside the models, for the significant variables, revealed the following: In the iron depletion model, 25% of mothers of cases in the model had not completed primary school education versus 41% outside the model ($p=0.02$). Given the low level of significance for this variable on univariate analysis ($p=0.08$), it is unlikely that this difference had an impact on the model. In the iron deficiency anemia model, whilst the difference in mean age of the cases inside and outside the model reached statistical significance (33.4 versus 37.6-months: $p=0.04$), it is unlikely that an age difference of this magnitude affected the model. There were no significant differences between cases inside or outside the models for all other variables found to be significant on univariate analysis. We consider that this analysis shows we can be confident the cases in the models were representative of the larger sample.

In conclusion, the prevalences of iron depletion and iron deficiency anemia in this population of children were consistent with other studies in the region, but considerably higher than those reported from developed countries. Almost 75% of children found to be anemic were likely to have thalassemia. Age was a significant independent predictor of both iron depletion and iron deficiency anemia. Mother's current pregnancy was an additional predictor of iron deficiency anemia, a finding that corroborated an earlier study in the UAE. These results have important implications for the assessment of preschool children's iron status in primary health care and antenatal clinics.

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References

1. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. ***J Nutr*** 2001; 131: 649S-666S.
2. Halterman JS, Kaczorowski JM, Aligne CA, Auinger P, Szilagyi PG. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. ***Pediatrics*** 2001; 107: 1381-1386.
3. Stoltzfus RJ, Kvalsvig JD, Chwaya HM, Montresor A, Albonico M, Tielsch JM et al. Effects of iron supplementation and anthelmintic treatment on motor and language development of preschool children in Zanzibar: double blind, placebo controlled study. ***BMJ*** 2001; 323: 1389-1393.
4. Walter T, De AI, Chadud P, Perales CG. Iron deficiency anemia: adverse effects on infant psychomotor development. ***Pediatrics*** 1989; 84: 7-17.
5. Karr M, Alperstein G, Causer J, Mira M, Lammi A, Fett MJ. Iron status and anaemia in preschool children in Sydney. ***Aust N Z J Public Health*** 1996; 20: 618-622.
6. Looker AC, Dallman PR, Carroll MD, Gunter EW, Johnson CL. Prevalence of iron deficiency in the United States. ***JAMA*** 1997; 277: 973-976.
7. Kocak R, Alparslan ZN, Agridag G, Baslamisli F, Aksungur PD, Koltas S. The frequency of anaemia, iron deficiency, hemoglobin S and beta thalassemia in the south of Turkey. ***Eur J Epidemiol*** 1995; 11: 181-184.
8. Linpisarn S, Tienboon P, Promtet N, Putsyainunt P, Santawanpat S, Fuchs GJ. Iron deficiency and anaemia in children with a high prevalence of haemoglobinopathies: implications for screening. ***Int J Epidemiol*** 1996; 25: 1262-1266.
9. Giebel HN, Suleymanova D, Evans GW. Anemia in young children of the Muynak District of Karakalpakistan, Uzbekistan: prevalence, type, and correlates. ***Am J Public Health*** 1998; 88: 805-807.
10. Lawson MS, Thomas M, Hardiman A. Iron status of Asian children aged 2 years living in England. ***Arch Dis Child*** 1998; 78: 420-426.
11. Karr MA, Mira M, Alperstein G, Labib S, Webster BH, Lammi AT et al. Iron deficiency in Australian-born children of Arabic background in central Sydney. ***Med J Aust*** 2001; 174: 165-168.
12. Duggan MB, Steel G, Elwys G, Harbottle L, Noble C. Iron status, energy intake, and nutritional status of healthy young Asian children. ***Arch Dis Child*** 1991; 66: 1386-1389.
13. Al Fawaz IM. Surveillance for iron deficiency anaemia at a well baby clinic in Riyadh, Saudi Arabia. ***Saudi Med J*** 1993; 14: 27-31.
14. Kilbride J, Baker TG, Parapia LA, Khoury SA. Incidence of iron-deficiency anaemia in infants in a prospective study in Jordan. ***Eur J Haematol*** 2000; 64: 231-236.
15. Musaiger AO, Abdulghafoor A, Radwan H. Anaemia among 6 year old children in the United Arab Emirates. ***Eur J Clin Nutr*** 1996; 50: 636-637.
16. Padmanabhan A, Thomas S, Sheth H, Venugopalan P. High prevalence of microcytic anaemia in Omani children: a prospective study. ***Ann Trop Paediatr*** 2001; 21: 45-49.
17. Hossain MM, Bakir M, Pugh RN, Sheekh-Hussen M, Bin Ishaq SA, Berg DB et al. The prevalence and correlates of anaemia among young children and women of childbearing age in Al Ain, United Arab Emirates. ***Ann Trop Paediatr*** 1995; 15: 227-235.
18. Friel JK, Andrews WL, Matthew JD, Long DR, Cornel AM, Cox M et al. Iron status of very-low-birth-weight infants during the first 15 months of infancy. ***CMAJ*** 1990; 143: 733-737.
19. Daly A, MacDonald A, Aukett A, Williams J, Wolf A, Davidson J et al. Prevention of anaemia in inner city toddlers by an iron supplemented cows' milk formula. ***Arch Dis Child*** 1996; 75: 9-16.
20. Mira M, Alperstein G, Karr M, Ranmuthugala G, Causer J, Niec A et al. Haem iron intake in 12-36 month old children depleted in iron: case- control study. ***BMJ*** 1996; 312: 881-883.
21. Calvo EB, Galindo AC, Aspres NB. Iron status in exclusively breast-fed infants. ***Pediatrics*** 1992; 90: 375-379.
22. Stoltzfus RJ, Dreyfuss ML for the International Nutritional Anemia Consultative Group. Guidelines for the use of iron supplements to prevent and treat iron deficiency anemia. Washington (DC): ILSA Press; 1999. Available at: http://inacg.ilsi.org/.
23. Hastka J, Lasserre JJ, Schwarzbeck A, Hehlmann R. Central role of zinc protoporphyrin in staging iron deficiency. ***Clin Chem*** 1994; 40: 768-773.
24. Miller CJ, Dunn EV, Berg B, Abdouni SF. A hematological survey of preschool children of the United Arab Emirates. ***Saudi Med J*** 2003; 24: 609-613.

Appendix 1

Anemia Study
Questionnaire

1) Name of the child:- _____

2) Date of birth:- _____ or age:- _____yrs _____ mths

3) Sex M F

4) How many children are in the family? _____

5) Position of this child in the family:- _____ (1st, 2nd, 3rd etc)

6) Was this child born full term? Yes No Don't know

7) What was this child's birth weight? _____kg Don't know

8) Did you breast feed this child? Yes No Still breast feeding
If yes---until what age? _____yrs _____mths Don't know

9) Until what age did you give breast milk only? _____yrs _____mths Don't know

10) At what age did this child start drinking:-
cow's milk _____yrs _____mths Don't know
other milk-what kind? _____ _____yrs _____mths Don't know

11) At what age did this child start eating solid foods?
_____yrs _____mths Don't know

12) What does this child eat and drink now?
Breast or other milk only
Milk and solid food
No milk, but other drinks and solid food

13) Does this child eat meat? Yes No

If "No" go to question 17
If "Yes":-

14) At what age did this child start eating meat? _____yrs _____mths Don't know

15) On how many days per week does this child eat meat? _____days per week

16) On how many days per week does this child eat red meat?
(beef, lamb, goat, camel, fox) _____days per week

17) Did you give this child any iron medicine in the first year? Yes No Don't know

18) Is this child taking any iron medicine now? Yes No
If Yes What is its name?_____ Don't know

19) Is this child taking any other vitamin medicine now? Yes No
If Yes What is its name?_____ Don't know

20) Does this child take any medicine regularly? Yes No
If Yes What is its name?_____ Don't know

21) Does this child have any blood disease? Yes No
If Yes What is its name?_____ Don't know

22) Does this child have any other disease? Yes No
If Yes What disease? _____ Don't know

Family Information

23) Mother's age _____yrs Don't know

24) Father's age _____yrs Don't know

25) Is the mother currently pregnant? Yes No Don't know

26) How many pregnancies has she had (including miscarriages)? _____

27) What about the family diet?
Eats meat
Doesn't eat meat

28) Do you or your husband/wife have any blood disease? Yes No
If Yes What is its name?_____ Don't know

29) Does any other child in the family have any blood disease?
If Yes What is its name?_____ Don't know

30) Your education level:-

Mother	Father
No schooling	No schooling
Completed primary school	Completed primary school
Completed intermed. school	Completed intermed. school
Completed secondary school	Completed secondary school
Completed university degree/diplom	Completed university degree/diploma

31) What are your occupations?
Mother _____ Father _____

32) What is your family monthly income?
Less than 3000 Dirhams
3000-10000 Dirhams
Over 10000 Dirhams
Don't know
Don't want to respond