BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020271
Article Type:	Research
Date Submitted by the Author:	29-Oct-2017
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	iron deficiency, feeding, infants, Qatar

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WORD COUNT

4661 words

Abstract

Objectives To estimate the magnitude of anemia, iron deficiency (ID), iron deficiency anemia (IDA) and to explore epidemiological features of ID and feeding practices among infants aged 12 months in Qatar.
Setting Well baby clinics in 14 randomly selected primary health care centers covering all geographical areas on the national level.
Participants Three hundred and six (163 male and 143 female) infants of all nationalities were enrolled. Mothers were asked to complete a predesigned interview questionnaire and infants were blood tested against anemia, ID and IDA.
Outcome measures Cutoff point used to diagnose anemia was Hb <11.1g/dl, and to diagnose ID, serum ferritin (SF) <6 ug/l with normal C-reactive protein.
Results Prevalence of anemia was 23.5%, ID was 9.2% and IDA was 7.8%. ID was more prevalent among non-Qatari infants compared to Qatari (10.9% *vs.* 1.7%, p=0.029), more prevalent among infants born to housewives and to families of low income (p=0.00). In regard to feeding practice; ID was higher in infants who continued breastfeeding till the age of one year and among those never took infant formula milk (p=0.00). Mothers received infant feeding counseling had less ID occurrence among their infants compared to their counterparts who did not receive such counseling (4.2% *vs.* 13.4%, p=0.005).
Conclusion: Although ID and IDA among infants in Qatar are less prevalent compared with many developing countries, still further efforts should be spent to be compared with the developed. Efforts should target the revealed epidemiological features with special emphasis on infant feeding and infant feeding counselling to mothers.

Key words: Iron, Anemia, Prevalence, feeding, 12 months infants, Qatar

Strengths and limitations of this Study

- The first population-based study about ID and IDA among infants in Qatar.
- Covering a critical age of infancy (12 months) where feeding and weaning practices can influence the health and wellbeing of the child.
- Being a cross-sectional study where temporality cannot be demonstrated.
- Possibility of recall bias may undermine the results.
- Difference in the applied diagnostic criteria and laboratory cutoff values in identification of anemia, ID and IDA across different studies; limits the ability of a precise comparison.

Introduction

Newborns, infants and young children are vulnerable to anemia especially iron deficiency anemia, which represents a public health problem with defined impacts on the health of communities especially in developing countries.[1] Accumulated evidence suggests that early infant feeding practices play a major role in the prevalence of iron deficiency (ID) and iron deficiency anemia

What is already known on this subject?
Iron deficiency and the resultant anemia are common in children by the age of one year especially in developing countries. Both conditions are related to a group of epidemiological features, many of them are modifiable including feeding practices during the first year.
What does this study add?
First study to explore prevalence and determinants of iron deficiency among children aged 12 months in the State of Qatar.

(IDA).[2,3] Anemia early in life, with or without iron depletion, is known to seriously affect children's general health and immunity, retarding their growth and development by causing multiple disorders and abnormalities in different body systems.[3-5]

Anemia is a condition in which the number of red blood cells or their oxygen-carrying capacity decreased until insufficient level to meet physiologic needs, which vary by age, sex and altitude. In different words anemia is a hemoglobin (Hb) concentration 2 standard deviation (SD) below the mean Hb concentration for a normal population of the same gender and age range.[3,6] IDA is a preventable and a treatable condition, therefore, early diagnosis represents the cornerstone in protection from its adverse consequences, together with combat of its contributing factors.

Globally, ID is the most common and widespread nutritional disorder. It can affect all age groups particularly children in the developing countries where its prevalence can be up to 50% among 12 months aged infants in some countries, it is the only nutrient deficiency which is also significantly prevalent in industrialized countries. IDA is a leading cause of mortality and morbidity among infants worldwide, with some of its manifestations possibly irreversible.[7-14] In a systematic review done in 2012 to evaluate micronutrient deficiencies and food fortification in the Middle East; ID represented one of the three commonest micronutrients deficiencies in the region in addition to iodine and vitamin A.[15] According to the World Health Organization (WHO) in 2013; 63% of children under-5 in the Eastern Mediterranean Region had IDA. In some studies; anaemia among preschool children showed similar high rates.[16]

Regarding the sources and bioavailability of iron, the transfer of iron from the mother to fetus occurs mainly during the third trimester of pregnancy and is stored mainly in the liver and bone marrow. Thus, the amount of iron present at birth depends on the gestational age and the weight of the baby.[17] Full term Infants usually have sufficient iron stores until 4 to 6 months of age. During the first months of life, human milk (which contains 0.2–0.3 mg/L of iron) does not provide enough iron to meet the demands of the rapid growth and erythropoiesis; therefore, iron stores are mobilized to meet the iron requirements of the infant mostly around the age of 4-6 months. This resulted in iron stores being generally depleted by the age of 6 months, yet from 4 to 12 months after birth the infant's blood volume doubles. Thus, at this age, dietary sources of iron become critical to keep up with this rapid rate of growth and red blood cells synthesis.[18-22]

Studies have shown that children below two years have an increased nutritional requirements because of their growth spurt, which often leads to a negative nutrient balance.[3,11,50] In general, prolonged exclusive breastfeeding (more than 6 months) causes decrease in dietary iron intake and may lead to iron depletion.[18,23] Male *et al.* in 2001 indicated that feeding with iron-fortified formula was the main factor positively influencing iron status among 12 months infants, as well as, positive association with consumption of cereals and iron supplements.[24] Inadequate complementary feeding practices represent an important risk factor for IDA. These are characterized by consumption of foods with low amounts of bio-available iron or foods with inhibitors to iron absorption, and these practices often extend up to the age of 2years.[18,25]

Infant feeding counseling offered to mothers and other caregivers on how to gradually increase consistency, quantity and frequency of foods; assist in prevention of micronutrient deficiency.[26,27] Preterm babies, as well as, those born small for gestational age, are particularly vulnerable to ID in their

first months of life.[2,28,29] Infants Delivered by cesarean section are more likely to get ID, as their delivery was associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood.[30]

Prevention and control strategies against IDA are mainly depending on the time of diagnosis and start of treatment.[7] The WHO has developed a "Global Strategy for Infant and Young Child Feeding" in order to prevent the development of micronutrient deficiencies including ID and IDA.[26] Many studies indicated that incidence of IDA has significantly decreased over time due to promotion of breastfeeding, improvement of overall nutritional status and use of iron-fortified baby foods.[31,32]

Qatar is a small Arab league State, located in the mid-west bank of the Arabian Gulf, with oil and gas as the main source of wealth, making it the country with number one per capita income worldwide. Most of the population is formed of foreign expats and their families, up to more than 80%. In Qatar, Primary Health Care Corporation (PHCC) is the main provider of primary services through its 23 centers on the national scale. Although Well Baby Clinic (WBC) services at these centers include routine screening for anemia at the age of 12 months during MMR vaccination visit, but not against ID or IDA.[8] Previous studies in Qatar have focused on the extent of anemia but not specifically on ID or IDA in this age group. This study investigated the prevalence and correlates of ID and IDA among infants aged 12 months, as well as, their feeding practices among all nationalities residing in the state. Recruiting participants from WBCs at the PHCC centers is nationally representative, since the utilization of services for periodic health appraisal and scheduled vaccination at 12 month of age is as high as 100%.

Methods

A cross sectional study was conducted at WBCs in PHCC centers, these clinics provide comprehensive evidence-based services to all under-5 children. Out of the 23 PHCC centers on the national scale, 14 were randomly selected. Infants in the WBC appointment system who attended the selected centers seeking WBC services for the 12 months visit and met the eligibility criteria have been included in the study sample. Mothers of all participating infants signed an informed consent.

Eligibility criteria: Males and females, Qatari and non-Qatari infants, attending the WBCs during the 12 months visit. All participants later proved to suffer sickle cell anemia or thalassemia were excluded.

Sample size calculation and sampling technique: As local information about ID is scarce, the latest known prevalence of ID in the nearest regional country (The United Arab Emirates) has been used (prevalence of 26%).[29] The level of confidence used was 95% and 5% error rate**.** The estimated sample size based was 350 after rounding. Systematic random sampling technique was used to recruit study participants. Sampling frame of the current study utilized the daily appointment list in WBCs. The study took place in the period between September 2014 and May 2015.

Study variables: Dependent variables were *Iron deficiency (ID)* defined as Serum Ferritin (SF) below normal reference range (6-24 ug/L) in absence of high C-Reactive Protein (CRP).[3,33] *Iron deficiency anemia (IDA)* defined by combination of three elements; Hb <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).[3,6,33,34] Independent variables included socio-demographic characteristics of infants and their parents, birth history of the participant, history of maternal pregnancies, breastfeeding, intake of infant formula milk, frequency of consumption of different food groups, iron supplementation, infant feeding counseling to mothers, as well as, body mass index (BMI) calculation.

Data collection tools: Interviewer administered questionnaire developed by the research team, anthropometric measurements of participants to calculate BMI and data abstraction sheet used for data collection of laboratory results. Blood samples were collected routinely by WBCs from 12 months aged infants as per their protocol to check for anemia, further laboratory studies utilizing these samples for the current study were done in hematology labs of Hamad Medical Corporation (HMC), the main secondary care provider in Qatar.

Data analysis: Data entry and analysis utilized the Statistical Package for Social Sciences IBM-SPSS© version 20. Descriptive analysis was done, e.g. *frequency distribution tables, proportions, mean and standard deviation,* in addition to analytical statistics, e.g. *Chi-square test / fisher exact probability test* used to assess differences between two or more proportions and the *Student t tes*t was used to compare continuous variables. An *Alpha* (*p*) value of ≤ 0.05 was used as the cut-off level of significance.

Quality control measures: The questionnaire was pre-tested utilizing a convenient sample of 20 infants; their data was later omitted prior to analysis. Content and face validity were established by extensive literature review, consultation of community medicine academic faculty and expert in the fields of hematology and pediatrics. The main researchers did all data entry and review. Standardized methods of blood collection and automated measures for blood analysis used to ensure reliability of the study results.

Ethical considerations: Approvals were obtained prior to fieldwork from ethical review boards of PHCC and HMC. Permission of PHCC center directors was granted, as well as, the participating mothers. Privacy and confidentiality of participant's data was assured. Mothers were invited to participate voluntarily and can withdraw at any time.

Results

Final study sample actually enrolled was three hundred and six (n=306) giving response rate of 87.4%. **Figure (1)** demonstrates the prevalence of the dependent variables.

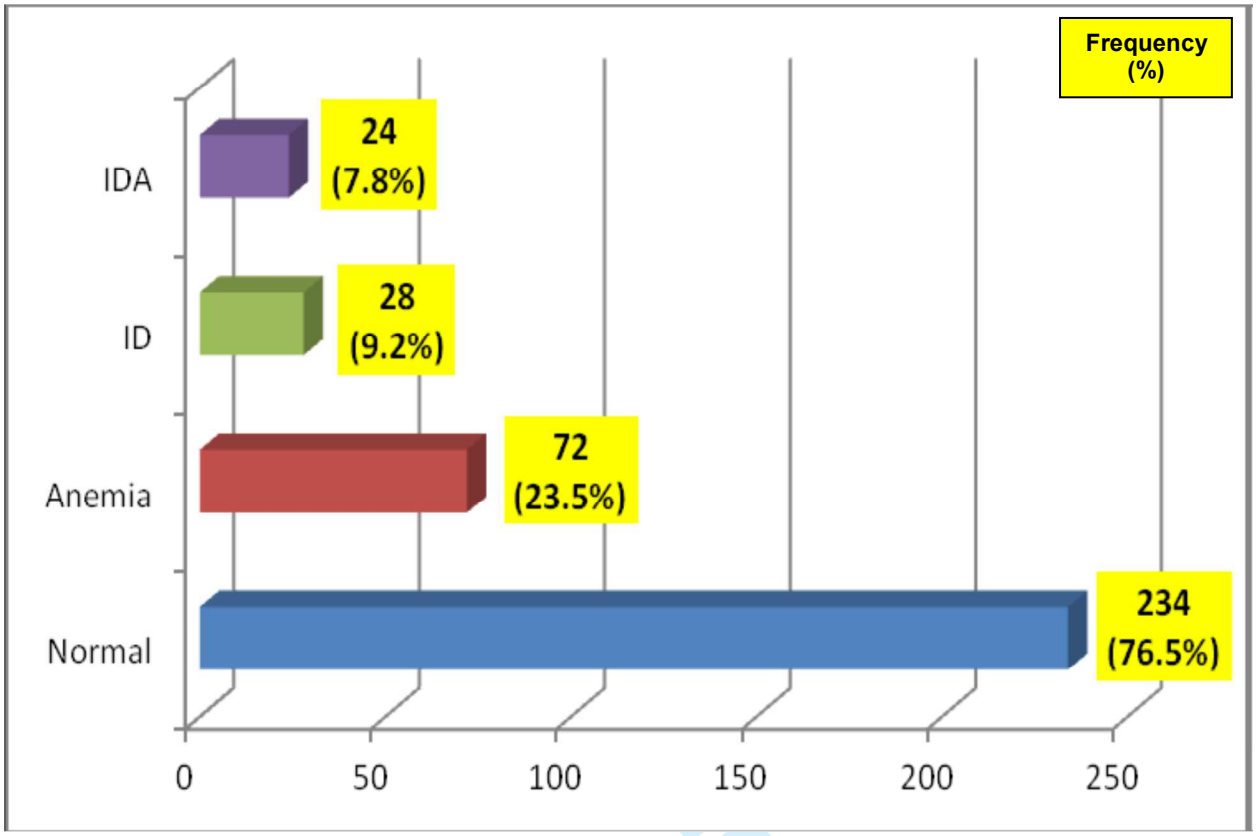

Figure (1): Distribution of study infants according to their anemia, iron deficiency and iron deficiency anemia status, well-baby clinics at primary health care centers, Qatar, n=306

As seen in **Table (1)**, when we assessed the relation between ID and background characteristics of the participated infants, it was found that ID is more common in males but the relation was not statistically significant. This study indicated a statistically significant higher prevalence of ID among Non-Qatari infants compared to their Qatari counterparts.

Table (1): Relation between ID among the study infants and their background characteristics, well-baby clinics at primary health care centers, Qatar, n=306

Characteristic	No ID (%)	ID (%)	Total	X^2	*p* value
Gender					
Male	146 (89.6)	17 (10.4)	163	0.686	0.265
Female	132 (92.3)	11 (7.7)	143		
Nationality					
Qatari	57 (98.3)	1 (1.7)	58	4.748	**0.029***
Non Qatari	221 (89.1)	27 (10.9)	248		
Gestational age					
Pre-term (< 37 weeks)	23 (88.5)	3 (11.5)	26	0.195	0.433
Full-term (≥ 37 weeks)	255 (91.1)	25 (8.9)	280		

Birth weight					
Low (< 2500 grams)	18 (90)	2 (10.0)	20	0.019	0.565
Normal (≥ 2500 grams)	260 (90.9)	26 (9.1)	286		
Mode of child delivery					
Normal	183 (91.5)	17 (8.5)	200	0.294	0.364
Caesarean section	95 (89.6)	11 (10.4)	106		
Twins, triple or multiple birth					
No	270 (90.6)	28 (9.4)	298	0.827	0.460
Yes, twins	8 (100)	0 (0)	8		

*p< 0.05

Regarding the background characteristics of parents, the relation of ID with mother's employment status and the family income were statistically significant, as seen in **Table (2)**.

Table (2): Relation between ID among study infants and their parents background characteristics, well-baby clinics at primary health care centers, Qatar, n=306

Characteristic	No ID (%)	ID (%)	Total	X^2	p value
Mother's age					
≤ 25 years	55 (88.7)	7 (11.3)	62		
26 – 35 years	182 (91.9)	16 (8.1)	198	0.778	0.678
More than 35 years	41 (89.1)	5 (10.9)	46		
Number of mother's pregnancy (including miscarriage)					
< 4	187 (91.2)	18 (8.8)	205	0.102	0.749
> 4	91 (90.1)	10 (9.9)	101		
Mother's education level					
Illiterate	6 (75.0)	2 (25.0)	8		
Up to secondary school	91 (93.8)	6 (6.2)	97	3.598	0.165
University educated and above	181 (90.0)	20 (10.0)	201		
Father's education level					
Up to secondary school	93 (93.0)	7 (7.0)	100	0.826	0.246
University educated and above	185 (89.8)	21 (10.2)	206		
Mother's employment status					
Housewife	186 (87.3)	27 (12.7)	213	10.480	**0.000***
Working job	92 (98.9)	1 (1.1)	93		
Father's occupation					
Manual worker	31 (91.2)	3 (8.8)	34		
Clerk/administrative	85 (87.6)	12 (12.4)	97	1.904	0.593
Professional	118 (92.9)	9 (7.1)	127		
Others	44 (91.7)	4 (8.3)	48		
Total number of children in the family					
1	81 (94.2)	5 (5.8)	86		
2-3	134 (90.5)	14 (9.5)	148	2.140	0.343
More than 3	63 (87.5)	9 (12.5)	72		
Family income in Qatari Riyals (QR)					
Up to10000 QR	107 (82.9)	22 (17.1)	129		
10001-20000 QR	99 (95.2)	5 (4.8)	104	17.369	**0.000***
More than 20000 QR	72 (98.6)	1 (1.4)	73		

*p< 0.05

Table (3) shows several statistically significant relations when we studied the association between ID in infants and their feeding practice and iron supplementation.

Table (3): Relation between ID among the studied infants and their feeding practice, well-baby clinics at primary health care centers, Qatar

Characteristic	No ID (%)	ID (%)	Total	X^2	*p* value
Exclusive breastfeeding for 6 months					
Yes	51 (81.0)	12 (19.0)	63	7.915	**0.007***
No	208 (92.9)	16 (7.1)	224		
Frequency of breastfeeding					
All or almost all feeds	142 (86.1)	23 (13.9)	165		
About half of all feeds	76 (93.8)	5 (6.2)	81	8.893	**0.012***
Few feeds since was born	41 (100.0)	0 (0)	41		
Continuation of breastfeeding at one year					
Yes	115 (82.7)	24 (17.3)	139	17.268	**0.000***
No	144 (97.3)	4 (2.7)	148		
Breastfeeding intake within the last 24 hours					
Yes	112 (82.4)	24 (17.6)	136	18.281	**0.000***
No	147 (97.4)	4 (2.6)	151		
Ever take infant formula milk (n= 306)					
Yes	225 (95.3)	11 (4.7)	236	25.011	**0.000***
Never	53 (75.7)	17 (24.3)	70		
Age at introducing of any solid, semi-solid or soft food (n= 306)					
Less than 6 months	72 (91.1)	7 (8.9)	79	0.011	0.917
6 months or more	206 (90.7)	21(9.3)	227		
Ever take iron supplementation (n= 306)					
Yes	27 (96.4)	1 (3.6)	28	1.154	0.283
No	251 (90.3)	27 (9.7)	278		

*$p < 0.05$

The differences in mean frequency of consumption for different groups of food is seen in **Table (4)**, where infants suffered ID consumed less plants rich in iron, and the difference was statistically significant. The difference was not significant when studying animal sources of iron and overall score of food frequency.

Table (4): Relation between ID among the studied infants and their food frequency score, well-baby clinics at primary health care centers, Qatar, n=306

Food item	Mean ± SD		*Student's t test*	*p* value
	No ID	ID		
Overall score	21.2 ± 3.9	19.89 ± 4.0	1.64	0.12
Animal Source of iron	7.9 ± 2.3	7.9 ± 2.2	0.02	0.98
Plant source of iron	13.2 ± 2.8	11.9 ± 2.7	2.26	**0.03***

*$p < 0.05$

When the relation between ID and infant feeding counseling to the mothers was assessed, it found that there is a significant relation between receiving counseling and ID occurrence, as the prevalence of ID was higher among infants to mothers didn't receive feeding counseling compared to infants of mothers received such counseling (13.4 against 4.2%) respectively, with (χ^2= 7.731 and ***p*= 0.005**).

According to the BMI for age based on z-score, ID prevalence was variable among different BMI groups. It was as high as (16.7%) among wasted/severely wasted infants, and as low as (5.6%) among the overweight/obese group of infants. These relations were insignificant statistically (χ^2= 1.007 and p= 0.799).

Discussion

This is the first population-based descriptive epidemiological study to estimate the prevalence and associated factors of ID and IDA in infants in Qatar. The current study revealed that the prevalence of anemia, iron deficiency and iron deficiency anemia among infants was 23.5%, 9.2% and 7.8% respectively, which is much lower than the published global prevalence. [35]

Comparing the prevalence rate of anemia in the current study with the figures published in other countries of the Eastern Mediterranean Region (EMR), shows that many of these countries suffer even higher burden, WHO report, 2013 showed also no improvement in the overall anaemia situation among the pre-schooler where 63% of children under the age of 5 years had iron deficiency anaemia. [16, 36]

The prevalence of anemia, ID and IDA in our study was also lower than in the United Arab Emirates, Kuwait and Saudi Arabia [29, 37, 38]. A study conducted in Raparin teaching hospital for children in Erbil - Iraq, 2007, among infants aged (12 - 24) months, showed that the prevalence of iron deficiency

ranged between 51.9% and 48.1% respectively. It also showed that about 53% and 30 % of participants had anemia and iron deficiency anemia respectively. [39] These high prevalence rates seen compared to the current work might be attributed to a lower cut-off level used for diagnosis or the possibility of improvement in the figures , if there is recent studies in the aforementioned countries. In addition , Qatar has implemented a well-developed comprehensive well baby program at primary health care centers. In a research done in Ain Shams University Children's Hospital, Egypt in 2011, studying three hundred poor Egyptian infants, anemia diagnosed in 66% of the participants aged between 6 and 24 months, and among them, 43% had iron deficiency anemia [40], this high prevalence rate may be referred to the selection of a high-risk group to be studied. Similar results were seen in Kassala, Eastern Sudan where up to 86% of young children less than three years of age living were diagnosed with iron deficiency anemia.[41]

On the other hand , the prevalence of anemia, iron deficiency and iron deficiency anemia detected in the present study is still behind compared to many developed countries. Male C *et al*, 2001 showed that the prevalence of anemia, ID and IDA was 9.4% ,7.2% and 2.3% respectively. [24] The difference in prevalence compared to the current study may be attributed to the cut-off point of SF, the eligibility criteria and/or the disease determinants between the two populations. In a study from the Republic of Estonia performed between July 2002 to March 2005 and included 171 infants aged 9 to 12 months, showed the prevalence of ID and IDA was 14.0% and 9.4, % respectively they utilized a cutoff value for Hb of <10.5 g/dl and for serum ferritin of <12 µg/L. [28]

In relation to the potential determinants of ID in the current study, there was no statistically significant difference between boys and girls , this is consistent with Vendt *et al*,2007.[28] However , a study from Iran; among the 33 cases diagnosed having iron deficiency anemia, 26 children (78.8%) were males and the prevalence of iron deficiency anemia was statistically significant among boys rather than in girls (p = 0.015).[42] One more study from Iran conducted over 201 infants and showed that the prevalence of iron deficiency anemia was 61.5% among male infants. The researchers used a multiple logistic regression model and revealed that male gender was the most important iron deficiency risk factor they could found in their study (OR = 3.3; 95% CI 1.7-6.3; and $p < 0.001$).[43]

The current study indicated a higher prevalence of iron deficiency among non-Qatari infants compared to their Qatari counterparts and was statistically significant. This difference could be attributed to the possible difference in economic, social and/or nutritional attributes. Iron deficiency was more common among those infants born preterm compared to the full term born infants, but it did not reach the level of statistical significance. This finding is similar to results from other studies form Canada where prematurity and intra-uterine growth retardation are risk factors for iron deficiency and iron deficiency anemia as they cause low hepatic and bone marrow iron stores at birth.[18] A clinical report from the American Academy of Pediatrics acknowledged that the deficit of total body iron in preterm infants increases with decreasing gestational age. It is worsened by the rapid postnatal growth that many infants experience and by frequent phlebotomies without adequate blood replacement; finally, all these are risk factors for iron deficiency. [3]

A low birth weight infant showed more possibility of having iron deficiency compared to those born with normal weight. This finding was similar to a study in Estonia where the mean birth weight among the iron deficient group was significantly lower than in the control group. [28]

Regarding the infant's mode of delivery in this study, those infants born through caesarean section showed more iron deficiency rather than those born through normal delivery. This result was consistent with the result of a systematic review and meta-analysis study, which indicated that caesarean section compared with vaginal delivery is associated with a reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood. This in turn indicates that neonates delivered by caesarean section might be more likely to develop iron deficiency anemia later in infancy compared to their normally delivered counterparts.[30]

In the current study, iron deficiency was more common among infants born to younger mothers aged 25 years old or less (11.3%) compared to 8.1% among infants of mothers aged 26 - 35 years and 10.9% for infants of mothers aged more than 35 years. Similarly an exploratory descriptive study conducted in Egypt over 400 healthy children aged 12 to 24 month, revealed that iron deficiency was more prevalent among infants of mothers aged 20-29 years old (67.2%) compared to infants of mothers aged more than 30 years (22.4%) and to infants of mothers aged less than 20 years old (10.4%).[44] and the explanation may be related to the lack of the infant feeding experience of young mothers. Iron deficiency was more common among infants born to illiterate mothers compared to infants born to mothers with university education or above, but the relation was not statistically significant. On the same trend, the relation with parental education was also insignificant. This result is going with the findings of a study indicated a statistically significant difference found between iron deficiency anemia among children below the age of two years regarding the level of father and mother education, as the highest percentage (32.1%) of anemia cases were belonging to infants of illiterate mothers (X^2=21.775 and p = 0.0001).[44]

On the other hand, educational level of the mother did not have an effect on the iron status of her infant in a study from Iran. [42] In the current study, iron deficiency was more prevalent among infants born to housewife mothers compared to those born to working mothers, and the relation was statistically significant. This result is consistent with the results of a study conducted in Alexandria, Egypt, where 88.4% of infants born to non-working mothers had iron deficiency anemia, compared to only 15.4% of infants born to working mothers.[44] This finding could be explained by possible higher education and knowledge among working mothers compared to housewives, and thus better feeding practices and/or that working mothers rely more on bottle feeding (rich in iron) and have limited frequency and time for breastfeeding compared to their housewife counterparts.

Prevalence of iron deficiency anemia among infants belong to families having more than three children was higher compared to those infants born to families having 2-3 children and to families only having one child and this is similar to a study from Iraq where low serum iron was more prevalent among families had 4 children or more compared to families had less than 4 children.[39] However , a study conducted in Iran , 2007; there was no significant difference between iron deficiency anemia prevalence and the total number of children in the infant's family (P > 0.05).[42]

In the current study, the relation between iron deficiency among the studied infants and (history of exclusive breastfeeding for six months, frequency of breastfeeding, continued breastfeeding at one year and intake of breast milk within 24 hours prior to the interview) were statistically significant ,in the same trend, a study from Estonia indicated that infants who were exclusively breastfed until the age of 6 months had significantly lower Hb and ferritin levels than infants who were exclusive breastfed only until

the age of 3 months.[28] A study from Iran revealed a prevalence of iron deficiency anemia of 27% in infants exclusively breastfed up to 6 months, 16.7% in infants fed with formula milk and 100% in infants fed with cow's milk (p=0.033).[42] The figures goes with what is known about iron content in these types of milk, being highest in formula milk and poor in both breast milk and fresh cow's milk. A Canadian study indicated that prolonged exclusive breastfeeding decreases the intake of dietary iron which in turn leads to iron deficiency. This goes with the well documented fact that growing infants beyond the age of 6 months cannot fully saturate their needs for iron by continuation on exclusive breast milk. [18-22] In a study conducted in South Korea on 87 healthy full-term infants, it showed that at 6 months of age; the incidences of iron deficiency and iron deficiency anemia in breast fed only were 33% and 30%, respectively, significantly higher than formula fed (8% and 5%, respectively) and breast fed with iron supplementation (7% and 5%, respectively). At 12 months of age, the incidences of iron deficiency and iron deficiency anemia in breast fed were 64% and 50%, respectively, again significantly higher than the other groups. [23] The establisher reason is the beneficiary influence of the iron fortifying formula milks on the infants' stores of iron as demonstrated in many studies. [18,45]

In current study, iron deficiency was more prevalent among infants started solid, semi-solid or soft food at age of 6 months or later compared to whom started before the age of 6 months. This corresponds with the results of the Estonia study, where infants fed with solid food before 6 months had statistically higher Hb values than infants whom the solid food was introduced after 6 months of life (11.8 g/dl *vs.* 11.4 g/dl) (P<0.05).[28] Similar findings were demonstrated in many other studies.[25,45] Also in this study, iron deficiency cases were more common among infants with high consumption of food items containing iron of plant sources compared to food items containing iron of animal sources, and this relation was statistically significant. This finding supported by the results of a study conducted in Qatar, where iron deficiency was more common among pregnant women with high consumption of food items containing iron of plant sources (t *test*= 0.2 and p= 0.834) compared to food items containing iron of animal sources (t *test*= 1.6 and p= 0.100). They related the relation to the less bio-available iron in food items of plant origin compared to animal origin. [46]

Regarding iron supplementation, our findings are similar with previous studies, where iron deficiency was less among infants had history of iron supplementation. These infants also had higher Hb concentration and higher MCV. [3] A study conducted on 126 infants divided into 3 groups; 86 cases received iron supplementation irregularly, 27 cases regularly and 13 cases never received iron. Iron deficiency anemia in the first group was 26.7%, in the second group was 3.7% and in the third group was up to 69.2% and the difference between iron deficiency anemia and iron supplementation was statistically significant (p< 0.001).[42] Another study reported significantly lower ferritin concentrations in 6-month-old infants who were exclusively breastfed than in infants who were breastfed and took iron supplementation. [18]

In this study, a significant relation found between receiving infant feeding counseling and prevalence of iron deficiency. A study from the US revealed that iron deficiency prevalence decreased among African American children aged 1-3 years old, from 16% to 6% between years 1976 and 2002. This marked decline has been attributed to implementation of the (Women, Infants and Children Program) which targeted by counseling specific groups of mothers and families, and this led to improvement in infant feeding practices to prevent iron deficiency.[44]

In the present study, iron deficiency prevalence was more common (9.9%) among infants born to mothers with history of having four pregnancies or more, compared to (8.8%) in infants born to mothers with less than four pregnancies (including miscarriage) and the difference was statistically insignificant. The relation may be attributed to the possible depletion of mother's body stores of iron, especially with multiple tightly close pregnancies, as demonstrated in different reports.[18,42] In the current study, iron deficiency prevalence was variable among different infant's BMI groups. These relations were statistically insignificant.

On the other hand; a study conducted in the US indicated that overweight children (1-3 years old) had triple the odds of iron deficiency prevalence compared with normal weight or underweight children, as from the period of 1976 to 2002; iron deficiency prevalence remained consistently high for overweight children at 20% to 24%. [47] A second study from the US showed that iron deficiency prevalence was 20% among those with overweight, 8% for those at risk for overweight, and 7% for normal-weight toddlers (1-3 years old).[48] The possible explanation to this contradiction with the results seen in the two US studies is that; anemia, iron deficiency and iron deficiency anemia is mostly related to the imbalance between iron needs and dietary sources of iron, rather than the relation with the caloric content of infant's nutrition. In addition to the small number of participated infants among wasted and severely wasted group in current study.

Conclusion

Although iron deficiency and iron deficiency anemia among infants in the State of Qatar are less prevalent compared to several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anemia in this study was 23.5%, of iron deficiency was 9.2% and of iron deficiency anemia was 7.8%. Iron deficiency was significantly associated with infants who were non-Qatari, had a non-employed mother, belonged to a family with low total monthly income, exclusively breastfed for 6 months, breastfed more frequently, continued breastfeeding at the age of one year, breastfed within the last 24 hours prior to the interview, never took infant formula milk, frequently consumed plant sources of dietary iron and had a mother that did not receive infant feeding counseling.

Recommendations

Integration of mass iron deficiency and iron deficiency anemia screening prior to 12 months visit to allow for early intervention in addition to proper counseling regarding and breast feeding and proper weaning practice.

Acknowledgments

We are extremely grateful to all the mothers who took part in this study, the staff of the well-baby clinics, data collectors and Dr. Rajvir Singh for his invaluable statistical assistance, support and guidance.

Ethical approval

Appropriate approvals obtained from the Arab Board of Medical Specialization, Institutional Review Board of Hamad Medical Corporation and the Primary Health Care Corporation Research Committee.

Funding

The funding of this study is received from the Research Center at Hamad Medical Corporation, state of Qatar.

Patient consent

Obtained.

Competing interest

None declared.

Data sharing statement

No additional data are available.

Contribution to authorship

AJZ, NAS and SAK designed the study and wrote the primary proposal. AJZ and SAK managed data collection and fieldwork. SRO and AJZ did literature review, data analysis, results interpretation and wrote the discussion. AJZ, SRO and NAS drafted and revised the manuscript. AJZ finalized and submitted the manuscript.

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BMJ Open

Iron deficiency, its epidemiological features and feeding practices among infants aged 12 months in Qatar, a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020271.R1
Article Type:	Research
Date Submitted by the Author:	15-Dec-2017
Complete List of Authors:	Zainel, A.Jaleel; Primary Health Care Corporation, Clinical Affairs Osman, Sherif ; Alexandria University High Institute of Public Health; Primary Health Care Corporation, Family and Community Medicine Al-Kohji, Sadriya; Primary Health Care Corporation, Service Development Selim, Nagah; Cairo University, Public Health and Preventive Medicine; Primary Health Care Corporation, Family and Community Medicine
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	iron deficiency, feeding, infants, Qatar

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WORD COUNT

4878 words

Abstract

Objectives To estimate the magnitude of anemia, iron deficiency (ID), iron deficiency anemia (IDA)and to explore epidemiological features of ID and feeding practices among infants aged 12 months in Qatar.

Setting Well baby clinics in 14 randomly selected primary health care centers coveringall geographical areas on the national level.

ParticipantsThree hundred and six (163 male and 143 female) infants of all nationalities were enrolled.Mothers were asked to complete apredesignedinterview questionnaire and infants were blood testedfor anemia, ID and IDA.

Outcome measures Cutoff point used to diagnose anemiawas Hb <11.1g/dl, andto diagnose ID,serum ferritin (SF) <6 ug/l with normal C-reactive protein.

Results Prevalence of anemia was 23.5%, ID was 9.2% and IDA was 7.8%. ID was more prevalent among non-Qatari infants compared to Qatari (10.9% *vs.* 1.7%, p=0.029), more prevalent among infants born to housewives and to families of low income ($p \leq 0.05$). In regard to feeding practice; ID was higher in infants who continued breastfeeding till the age of one year and among those never took infant formula milk ($p \leq 0.05$). Mothers received infant feeding counseling had less ID occurrence among their infants compared to their counterparts who did not receive such counseling (4.2% *vs.* 13.4%, p=0.005).

Conclusion: Although ID and IDA among infants in Qatar are less prevalent compared with many developing countries, still further efforts should be spent to be compared with the developed. Efforts should target the revealed epidemiological features with special emphasis on infant feeding and infant feeding counselling to mothers.

Key words:Iron, Anemia, Prevalence, feeding, 12 months infants, Qatar

Strengths and limitations of this Study

- The first population-based study about ID and IDA among infants in Qatar.
- Coveringa critical age of infancy (12 months) where feeding and weaning practices can influence the health and wellbeing of the child.
- Being a cross-sectional studywheretemporality cannot be demonstrated.
- A prospective study design would have overcome potential recall bias; however, it was not feasible to undertake one at the time due to shortage of resources.
- Difference in the applied diagnostic criteria and laboratory cutoff values in identification of anemia, ID and IDA across different studies; limits the ability of a precise comparison.

Introduction

Newborns, infants and young children are vulnerable to anemia especially iron deficiency anemia (IDA), which represents a public health problem with defined impacts on the health of communities.[1] Published evidence suggests that early infant feeding practices play a major role in the prevalence of iron deficiency (ID) and IDA.[2,3] Anemia early in life, with or without iron depletion, is known to seriously affect children's general health and immunity, retarding their growth and development by causing multiple disorders and abnormalities in different body systems.[3-5]

Anemia is a condition in which the number of red blood cells or their oxygen-carrying capacity decreased until insufficient level to meet physiologic needs, which vary by age, sex and altitude. In

different words anemia is a hemoglobin (Hb) concentration 2 standard deviation (SD) below the mean Hb concentration for a normal population of the same gender and age range.[3,6]IDA is a preventable and a treatable condition, therefore, early diagnosis represents the cornerstone in protection from its adverse consequences, together with combat of its contributing factors.

Globally, ID is the most common and widespread nutritional disorder. It can affect all age groups particularly children in the developing countries where its prevalence can be up to 50% among infants aged 12 months in some countries. It is the only nutrient deficiency which is also significantly prevalent in developed countries. IDA is a leading cause of mortality and morbidity among infants worldwide, with some of its manifestations possibly irreversible.[7-14] In a systematic review done in 2012 to evaluate micronutrient deficiencies and food fortification in the Middle East, ID represented one of the three commonest micronutrients deficiencies in the region in addition to iodine and vitamin A.[15] According to the World Health Organization (WHO) in 2013; 63% of children under-5 in the Eastern Mediterranean Region had IDA. In some studies; anaemia among preschool children showed similar high rates.[16]

In terms of sources and bioavailability of iron, its transfer from the mother to fetus occurs mainly during the third trimester of pregnancy and is stored mainly in the liver and bone marrow. Thus, the amount of iron present at birth depends on the gestational age and the weight of the baby.[17] Full term infants usually have sufficient iron stores until 4 to 6 months of age. During the first months of life, human milk (which contains 0.2–0.3 mg/L of iron) does not provide enough iron to meet the demands of the rapid growth and erythropoiesis; therefore, iron stores are mobilized to meet the iron requirements of the infant mostly around the age of 4-6 months. This results in iron stores being generally depleted by the age of 6 months, yet from 4 to 12 months after birth the infant's blood volume doubles. Thus, at this age, dietary sources of iron become critical to keep up with this rapid rate of growth and red blood cells synthesis.[18-22]

Studies have shown that children below two years have increased nutritional requirements because of their growth spurt, which often leads to a negative nutrient balance.[2] In general, prolonged exclusive breastfeeding (more than 6 months) causes decrease in dietary iron intake and may lead to iron depletion.[18,23] Male *et al.* in 2001 indicated that feeding with iron-fortified formula was the main factor positively influencing iron status among infants up to the age of 12 months, as well as, positive association with consumption of cereals and iron supplements.[24] Inadequate complementary feeding practices represent an important risk factor for IDA. These are characterized by consumption of foods with low amounts of bio-available iron or foods with inhibitors to iron absorption, and these practices often extend up to the age of 2years.[18,25]

Infant feeding counseling offered to mothers and other caregivers on how to gradually increase consistency and quantity of foods assists in prevention of micronutrient deficiency.[26,27] Preterm babies, as well as, those born small for gestational age, are particularly vulnerable to ID in their first months of life.[2,28,29] Infants delivered by cesarean section are more likely to get ID, as their delivery is associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood.[30]

Prevention and control strategies against IDA are mainly depend on the time of diagnosis and start of treatment.[7] The WHO has developed a "Global Strategy for Infant and Young Child Feeding" in order to prevent the development of micronutrient deficiencies including ID and IDA.[26] Many studies

indicated that incidence of IDA has significantly decreased over time due to promotion of breastfeeding, improvement of overall nutritional status and use of iron-fortified baby foods.[31,32]

Qatar is a small Arab league state, located on the northeastern coast of the Arabian Peninsula, with oil and gas as the main source of wealth, making a country with the highest per capita income in the world. Up to 80 % of its population consists of foreign expatriates and their families.The Primary Health Care Corporation (PHCC) is the nation's main provider of primary services with 23 health centerscurrently operating across Qatar. Well Baby Clinic (WBC) services provided at the health centers include routine screening of infants for anemia during their MMR vaccination visit at 12 months of age, however, routine screening for ID or IDA is not undertaken.[8] Previous studies in Qatar have focused on the extent of anemia but not specifically on ID or IDA in this age group. This study investigatesthe prevalence of ID and IDA and the correlates of ID among infants at 12 monthsof age, as well as, their feeding practices retrieved frommothers of all nationalities residing in the state. Based on the 12 months vaccination coverage rates calculated by the PHCC in Qatar and confirmed by its head of child health section, vaccination coverage rates is over 97% at this age, therefore participants recruited are considered a representative sample of the national population. The service is completely free of charge to all nationalities.The current study provides a much needed first snapshot of the extend of problem in the State of Qatar.

Methods

A cross sectional study was conducted at WBCsin PHCC centers. These clinics provide comprehensive evidence-based services to all children under the age of 5 years. Of the 21 PHCC centers across Qatar operating at time of the study, 14 were providing the WBC service. Infants in the WBC appointment system who attended the selected centers seeking WBC services for the 12 month visit and met the eligibility were included in the study sample. Mothers of all participating infants signed an informed consent form.

Eligibility criteria: Male and female infants completed 12 months of age (but less than 13 months) and of all nationalities (Qatari and non-Qatari) attendingWBCs at theirroutine 12 month's visit were eligible. Participants diagnosed with sickle cell anemia or thalassemia were excluded.

Sample size calculation and sampling technique: As ID prevalence in Qatar was not available; the latest published prevalence of ID in the nearest regional country (The United Arab Emirates) of 26 % was used to calculate the sample size.[29] It was estimated that a sample size of 292 is required for the study. To compensate for possible non-responders, an additional 20% were added bringing a total of 350 after rounding. A 95% confidence level and 5% error rate were used for the calculation**.** A systematic random sampling technique was used to recruit study participants. The sampling frame utilized the daily appointment list in WBCs, where the first participant of the day was selected randomly from the list and the following candidates were recruited systematically. The study took place in the period between September 2014 and May 2015.

Study variables: The study included dependent and independent variables. Dependent included'Iron deficiency (ID), defined as Serum Ferritin (SF) below normal reference range (6-24 ug/L) in absence of high C-Reactive Protein (CRP).[3,33], and 'Iron deficiency anemia (IDA)' defined by combination of three elements - Hb <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence

of high CRP (reference level is normally less than 5 mg/L).[3,6,33,34]Independent variables included socio-demographic characteristics of infants and their parents, birth history of the participant, history of maternal pregnancies, breastfeeding, intake of infant formula milk, frequency of consumption of different food groups, iron supplementation, infant feeding counseling to mothers, as well as, body mass index (BMI) calculation.

Data collection tools: The research team developed an interview-administered questionnaireafter extensive literature review to establish content and face validity, followed by thorough discussion and assessment by experts in the fields of pediatric hematology and community medicine. A pilot was undertaken over 20 participants, conveniently sampled, to establish and confirm its suitability. Necessary adjustments were made accordingly. Anthropometric measurements of participants were acquired in order to calculate BMI. Laboratory results of participants were retrievedfrom their electronic medical record using a data extraction sheet. Venous blood samples are collected routinely by well baby clinics for all 12 months aged infants as per their protocol to check for anemia.Additional laboratory studies for ID detection utilizing these samples were managed in hematology laboratory ofthe Qatar's secondary health care provider; Hamad Medical Corporation (HMC).

Data analysis: Statistical Package for Social Sciences IBM-SPSS© version 20 was used for data entry and analysis. Descriptive analysis was undertaken (*frequency distribution tables, proportions, mean and standard deviation),* in addition to analytical statistics (*Chi-square test and fisher exact probability test*) were used to assess differences between two or more proportions and the *Student t tes*t was used to compare continuous variables. An *Alpha* (*p*) value of ≤ 0.05 was used as the cut-off level of significance.

Quality control measures:The questionnaire was pre-tested using a convenient sample of 20 infants. Their data was omitted prior to analysis. Content and face validity were established using extensive literature review and consultation with academic experts in community medicine and experts in the fields of hematology and pediatrics. The main researchers did all data entry and review. Standardized methods of blood collection and automated measures for blood analysis were used to ensure reliability of the study results.

Ethical considerations:Ethical approvals were obtained prior to fieldwork from PHCC and HMC ethical review boards. Permission was also obtained from PHCC center directors, as well as, mothers of infants identified for the study. Privacy and confidentiality of participant's data was assured. Mothers were invited to participate voluntarily and allowed to withdraw at any time during the study.

Results

Of the calculated and approached 350 participants identified for the study, laboratory data was available for 306 of them giving a response rate of 87.4%, but still over the figure required by calculation (i.e. 292). **Figure (1)** demonstrates the prevalence of the dependent variables.

As shown in **Table (1)**, when the relation between ID and background characteristics of the infants were assessed, it was found that ID is more common in males.However the relationship was not

statistically significant. The study found a statistically significant higher prevalence of ID among Non-Qatari infants compared to their Qatari counterparts.

Table (1): Relation between IDand infants' background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Gender					
Male	146 (89.6)	17 (10.4)	163	0.686	0.265
Female	132 (92.3)	11 (7.7)	143		
Nationality					
Qatari	57 (98.3)	1 (1.7)	58	4.748	**0.029**
Non Qatari	221 (89.1)	27 (10.9)	248		
Gestational age					
Pre-term (< 37 weeks)	23 (88.5)	3 (11.5)	26	0.195	0.433
Full-term (≥ 37 weeks)	255 (91.1)	25 (8.9)	280		
Birth weight					
Low (< 2500 grams)	18 (90)	2 (10.0)	20	0.019	0.565
Normal (≥ 2500 grams)	260 (90.9)	26 (9.1)	286		
Mode of child delivery					
Normal	183 (91.5)	17 (8.5)	200	0.294	0.364
Caesarean section	95 (89.6)	11 (10.4)	106		
Twins, triple or multiple birth					
No	270 (90.6)	28 (9.4)	298	0.827	0.460
Yes, twins	8 (100)	0 (0)	8		

In terms of background characteristics of parents, the relation of ID with mother's employment status and the family income were found to be statistically significant, as shown in **Table (2)**.

Table (2): Relation between ID and infantsparents background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Mother's age					
≤ 25 years	55 (88.7)	7 (11.3)	62		
26 – 35 years	182 (91.9)	16 (8.1)	198	0.778	0.678
More than 35 years	41 (89.1)	5 (10.9)	46		
Number of mother's pregnancy (including miscarriage)					
< 4	187 (91.2)	18 (8.8)	205	0.102	0.749
> 4	91 (90.1)	10 (9.9)	101		
Mother's education level					
Illiterate	6 (75.0)	2 (25.0)	8		
Up to secondary school	91 (93.8)	6 (6.2)	97	3.598	0.165
University educated and above	181 (90.0)	20 (10.0)	201		
Father's education level					
Up to secondary school	93 (93.0)	7 (7.0)	100	0.826	0.246
University educated and above	185 (89.8)	21 (10.2)	206		
Mother's employment status					
Housewife	186 (87.3)	27 (12.7)	213	10.480	**≤ 0.05**
Working job	92 (98.9)	1 (1.1)	93		

Father's occupation					
Manual worker	31 (91.2)	3 (8.8)	34		
Clerk/administrative	85 (87.6)	12 (12.4)	97	1.904	0.593
Professional	118 (92.9)	9 (7.1)	127		
Others	44 (91.7)	4 (8.3)	48		
Total number of children in the family					
1	81 (94.2)	5 (5.8)	86		
2-3	134 (90.5)	14 (9.5)	148	2.140	0.343
More than 3	63 (87.5)	9 (12.5)	72		
Family income in Qatari Riyals (QR)					
Up to10000 QR	107 (82.9)	22 (17.1)	129		
10001-20000 QR	99 (95.2)	5 (4.8)	104	17.369	**≤ 0.05**
More than 20000 QR	72 (98.6)	1 (1.4)	73		

Table (3) shows several statistically significant relations between ID in infants and their feeding practice and iron supplementation.

Table (3): Relation between ID and feeding practice

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Exclusive breastfeeding for 6 months					
Yes	51 (81.0)	12 (19.0)	63	7.915	**0.007**
No	208 (92.9)	16 (7.1)	224		
Frequency of breastfeeding					
All or almost all feeds	142 (86.1)	23 (13.9)	165		
About half of all feeds	76 (93.8)	5 (6.2)	81	8.893	**0.012**
Few feeds since was born	41 (100.0)	0 (0)	41		
Continuation of breastfeeding at one year					
Yes	115 (82.7)	24 (17.3)	139	17.268	**≤ 0.05**
No	144 (97.3)	4 (2.7)	148		
Breastfeeding intake within the last 24 hours					
Yes	112 (82.4)	24 (17.6)	136	18.281	**≤ 0.05**
No	147 (97.4)	4 (2.6)	151		
Ever take infant formula milk (n= 306)					
Yes	225 (95.3)	11 (4.7)	236	25.011	**≤ 0.05**
Never	53 (75.7)	17 (24.3)	70		
Age at introducing of any solid, semi-solid or soft food (n= 306)					
Less than 6 months	72 (91.1)	7 (8.9)	79	0.011	0.917
6 months or more	206 (90.7)	21(9.3)	227		
Ever take iron supplementation (n= 306)					
Yes	27 (96.4)	1 (3.6)	28	1.154	0.283
No	251 (90.3)	27 (9.7)	278		

The differences in mean frequency of consumption for different groups of food is shown in **Table (4)**, where infants diagnosed with ID consumed less plants rich in iron, and the difference was statistically significant. However, the difference was not significant for animal sources of iron and the overall score of food frequency.

Table (4): Relation between ID and food frequency score

Food item	Mean ± SD		*Student's t test*	*p* value
	No ID	ID		
Overall score	21.2 ± 3.9	19.89 ± 4.0	1.64	0.12
Animal Source of iron	7.9 ± 2.3	7.9 ± 2.2	0.02	0.98
Plant source of iron	13.2 ± 2.8	11.9 ± 2.7	2.26	**0.03**

When the relation between ID and infant feeding counseling for mothers was assessed, it found that there is a significant relationship between receiving counseling and ID occurrence, as the prevalence of ID was higher among infants to mothers didn't receive feeding counseling compared to infants of mothers received such counseling (13.4 against 4.2%) respectively, with (χ^2= 7.731 and ***p*= 0.005**).

According to the BMI for age based on z-score, ID prevalence was variable among different BMI groups. [35,36] It was as high as (16.7%) among wasted/severely wasted infants, (9.7%) among infants at risk of overweight, (9.4%) among infants with normal BMI and as low as (5.6%) among the overweight/obese group of infants. These relationships were not statistically significant (χ^2= 1.007 and *p*= 0.799).

Discussion

This is the first population-based descriptive epidemiological study to estimate the prevalence and associated factors of ID and IDA in infants in Qatar. This study found the prevalence of anemia, iron deficiency and iron deficiency anemia among infants was 23.5%, 9.2% and 7.8% respectively, which is much lower than the published global prevalence. [37]

Comparing the prevalence rate of anemia from this study with the figures published for other countries of the Eastern Mediterranean Region (EMR) shows that many of them have an even higher burden of disease. The WHO report, 2013 showed also no improvement in the overall anaemia situation among the pre-schooler where 63% of children under the age of 5 years had iron deficiency anaemia. [16, 38]

The prevalence of anemia, ID and IDA in our study was also lower than in the United Arab Emirates, Kuwait and Saudi Arabia [29, 39, 40]. A study conducted in Raparin teaching hospital for children in

Erbil - Iraq, 2007, among infants aged (12 - 24) months, showed that the prevalence of iron deficiency ranged between 51.9% and 48.1%. It also showed that about 53% and 30 % of participants had anemia and iron deficiency anemia respectively. [41]

In addition, Qatar has implemented a well-developed and comprehensive well baby program at primary health care centers. In a study undertaken in 2011 at Ain Shams University Children's Hospital (Egypt) which included three hundred poor Egyptian infants, anemia was diagnosed in 66% of the participants aged between 6 and 24 months, and among them, 43% had iron deficiency anemia [42]. This high prevalence rate may be referred to the selection of a high-risk group for the study. Similar results were also seen in Kassala (Eastern Sudan) where up to 86% of young children less than three years of age living were diagnosed with iron deficiency anemia.[43]

On the other hand, the prevalence of anemia, iron deficiency and iron deficiency anemia found in this study is still lower compared to many developed countries. Male C *et al*, 2001 showed that the prevalence of anemia, ID and IDA was 9.4% , 7.2% and 2.3% respectively. [24] The difference in prevalence compared to this study may be attributed to the cut-off point of SF, the eligibility criteria and/or the disease determinants between the two populations. In a study from the Republic of Estonia undertaken between July 2002 to March 2005 and included 171 infants aged 9 to 12 months, the prevalence of ID and IDA was found to be 14.0% and 9.4, % respectively. The study utilized a cutoff value for Hb of <10.5 g/dl and for serum ferritin of <12 µg/L. [28]

In relation to the potential determinants of ID in this study, there was no statistically significant difference between male and female participants. This is consistent with Vendt *et al*,2007.[28] However , in a study from Iran, of the 33 cases diagnosed with iron deficiency anemia, 26 children (78.8%) were males and the prevalence of iron deficiency anemia was statistically significant among male infants compared with girl infants ($p = 0.015$).[44]. Another study from Iran which included 201 infants showed that the prevalence of iron deficiency anemia was 61.5% among male infants. The researchers used a multiple logistic regression model and reported that male gender was the most important iron deficiency risk factor they found in their study (OR = 3.3; 95% CI 1.7-6.3; and $p < 0.001$).[45]

This study found a statistically significant higher prevalence of iron deficiency among non-Qatari infants compared to their Qatari counterparts. This difference can be attributed to the possible difference in economic, social and/or nutritional attributes. Iron deficiency was more common among those infants born preterm compared to infants born full term. However, this result is not statistically significant. This finding is similar to results from other studies form Canada where prematurity and intra-uterine growth retardation are risk factors for iron deficiency and iron deficiency anemia as they cause low hepatic and bone marrow iron stores at birth.[18] A clinical report from the American Academy of Pediatrics acknowledged that the deficit of total body iron in preterm infants increases with decreasing gestational age. It is worsened by the rapid postnatal growth that many infants experience and by frequent phlebotomies without adequate blood replacement. All these are risk factors for iron deficiency. [3]

Infants with low birth weight showed more possibility of having iron deficiency compared to those born with normal weight. This finding was similar to a study conducted in Estonia where the mean birth weight among the iron deficient group was significantly lower than that in the control group. [28]

As for the infant's mode of delivery in this study, those infants born through caesarean section showed higher iron deficiency rather than those born through normal delivery. This result was consistent with the result of a systematic review and meta-analysis study which indicated that caesarean section compared with vaginal delivery is associated with a reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood. This in turn indicates that neonates delivered by caesarean section might be more likely to develop iron deficiency anemia later in infancy compared to their normally delivered counterparts.[30]

In this study, iron deficiency was more common among infants born to younger mothers aged 25 years old or less (11.3%) compared to 8.1% among infants of mothers aged 26 - 35 years and 10.9% for infants of mothers aged more than 35 years. Similarly an exploratory descriptive study conducted in Egypt with 400 healthy children aged 12 to 24 month reported that iron deficiency was more prevalent among infants of mothers aged 20-29 years old (67.2%) compared with infants of mothers aged more than 30 years (22.4%) and infants of mothers aged less than 20 years old (10.4%).[46]. An explanation for this may be related to the lack of infant feeding experience of young mothers. Iron deficiency was more common among infants born to illiterate mothers compared to infants born to mothers with university education or above, however the findings were not statistically significant. On the same trend, the relationship with parental education was also not statistically significant. This result is in line with the findings of a study which found a statistically significant difference between iron deficiency anemia among children below the age of two years and the level of father and mother education. The study reported that the highest percentage (32.1%) of anemia cases were belonging to infants of illiterate mothers (X^2=21.775 and p = 0.0001).[46]

On the other hand, a study from Iran reported that educational level of the mother did not have an effect on the iron status of infants. [44]In this study, iron deficiency was more prevalent among infants born to mothers who were housewives compared to those born to working mothers, and the relationship was statistically significant. This result is consistent with the results of a study conducted in Alexandria, Egypt, where 88.4% of infants born to non-working mothers had iron deficiency anemia, compared to only 15.4% of infants born to working mothers.[46] This finding could be explained by possible higher education and knowledge among working mothers compared to housewives, and thus better feeding practices and/or that working mothers rely more on bottle feeding (rich in iron) and have limited frequency and time for breastfeeding compared to their housewife counterparts.

Prevalence of iron deficiency anemia among infants belonging to families with more than three children was higher compared to those infants born to families with 2-3 children and to families with only one child. This result is similar to results from a study which was undertaken in Iraq where low serum iron was more prevalent among families which had 4 children or more compared to families that had less than 4 children.[41] However, a study conducted in Iran in 2007report no significant difference between iron deficiency anemia prevalence and the total number of children in the infant's family (P > 0.05).[44]

In this study, the relationship between iron deficiency among the infants studied and history of exclusive breastfeeding for six months, frequency of breastfeeding, continued breastfeeding at one year and intake of breast milk within 24 hours prior to the interview were statistically significant, These findings are in line with a study from Estonia which reported that infants who were exclusively breastfed

until the age of 6 months had significantly lower Hb and ferritin levels than infants who were exclusive breastfed only until the age of 3 months.[28] A study from Iran reported a prevalence of iron deficiency anemia of 27% in infants exclusively breastfed up to 6 months, 16.7% in infants fed with formula milk and 100% in infants fed with cow's milk (p=0.033).[44] The figures goes with what is known about iron content in these types of milk with it being high in formula milk and low in both breast milk and fresh cow's milk. A Canadian study indicated that prolonged exclusive breastfeeding decreases the intake of dietary iron which in turn leads to iron deficiency. This goes with the well documented fact that growing infants beyond the age of 6 months cannot fully saturate their needs for iron by continuation on exclusive breast milk. [18-22] In a study conducted in South Korea on 87 healthy full-term infants, it showed that at 6 months of age; the incidences of iron deficiency and iron deficiency anemia in breast fed only were 33% and 30%, respectively, significantly higher than formula fed (8% and 5%, respectively) and breast fed with iron supplementation (7% and 5%, respectively). At 12 months of age, the incidences of iron deficiency and iron deficiency anemia in breast fed were 64% and 50%, respectively, again significantly higher than the other groups. [23] The established reason is the beneficiary influence of the iron fortifying formula milks on the infants' stores of iron as demonstrated in many studies. [18,47]

In the current study, mothers were asked about frequency of consumption of different food items rich in iron, which was used to calculate the food frequency score derived from a previous study conduted in Qatar.[48] Based on their responses, a score was constructed for each consumed food item. A score of 1 for no previous consumption, 2 for 1-3 times/month, 3 for 1-6 times/week and 4 for daily consumption was assigned. Food items of animal origin were summed, as well as those of plant origin and the mean $\pm$ SD was calculated for participants either with or without ID. Findings showed that infants suffered ID consumed less plants rich in iron compared to their counterparts without ID, and the difference was statistically significant (t test= 2.26 and p= 0.03). The difference was not significant statistically when studying the animal sources of iron and the overall score of food frequency. This finding supported by the results of the above mentioned Qatari study, where iron deficiency was more common among pregnant women with high consumption of food items containing iron of plant sources (t *test*= 0.2 and p= 0.834) compared to food items containing iron of animal sources (t *test*= 1.6 and p= 0.100). They relate this to less bio-available iron in food items of plant origin compared to animal origin.

In this study, iron deficiency was more prevalent among infants who started solid, semi-solid or soft food at age of 6 months or later compared to those who started before the age of 6 months. This corresponds with the results of the Estonian study, where infants fed with solid food before 6 months had statistically higher Hb values than infants who were introduced to solid food after 6 months of life (11.8 g/dl *vs*. 11.4 g/dl) (P<0.05).[28] Similar findings were demonstrated in many other studies.[25,47]

Regarding iron supplementation, our findings are similar with previous studies, where iron deficiency was less among infants who had history of iron supplementation. These infants also had higher Hb concentration and higher MCV. [3]A study conducted on 126 infants divided into 3 groups, where 86 cases received iron supplementation irregularly, 27 cases regularly and 13 cases never received iron. IDA in the first group was 26.7%, in the second group was 3.7% and in the third group was up to 69.2%. The difference between iron deficiency anemia and iron supplementation was statistically significant (p< 0.001).[44]Another study reported significantly lower ferritin concentrations in 6-month-old infants who were exclusively breastfed than in infants who were breastfed and took iron supplementation. [18]

In this study, a significant relationship was found between mothers receiving infant feeding counseling and prevalence of iron deficiency. A study from the US reported that iron deficiency prevalence decreased among African American children aged 1-3 years old, from 16% to 6% between years 1976 and 2002. This marked decline was attributed to implementation of the Women, Infants and Children Program which targeted specific groups of mothers and families with counseling, and this led to improvement in infant feeding practices to prevent iron deficiency.[46]

In the present study, iron deficiency prevalence was more common (9.9%) among infants born to mothers with history of having four pregnancies or more, compared to (8.8%) in infants born to mothers with less than four pregnancies (including miscarriage) and the difference was statistically insignificant. The relationship may be attributed to the possible depletion of the mother's body stores of iron, especially with multiple tightly close pregnancies, as demonstrated in different reports.[18,44] In this study, iron deficiency prevalence was variable among different infant's BMI groups. These relations were statistically insignificant.

On the other hand, a study conducted in the US indicated that overweight children (1-3 years old) had triple the odds of iron deficiency prevalence compared with normal weight or underweight children, as from the period of 1976 to 2002; iron deficiency prevalence remained consistently high for overweight children at 20% to 24%. [49] A second study from the US showed that iron deficiency prevalence was 20% among those with overweight, 8% for those at risk for overweight, and 7% for normal-weight toddlers (1-3 years old).[50] The possible explanation to this contradiction with the results seen in the two US studies is that, anemia, iron deficiency and iron deficiency anemia is mostly related to the imbalance between iron needs and dietary sources of iron, rather than the relation with the caloric content of infant's nutrition. In addition to the small number of participated infants among wasted and severely wasted group in this study.

Conclusion

Although iron deficiency and iron deficiency anemia among infants in the State of Qatar are less prevalent compared to several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anemia in this study was 23.5%, of iron deficiency was 9.2% and of iron deficiency anemia was 7.8%. Iron deficiency was significantly associated with infants who were non-Qatari, had a non-employed mother, belonged to a family with low total monthly income, exclusively breastfed for 6 months, breastfed more frequently, continued breastfeeding at the age of one year, breastfed within the last 24 hours prior to the interview, never took infant formula milk, frequently consumed plant sources of dietary iron and had a mother that did not receive infant feeding counseling.

Although iron deficiency and iron deficiency anemia among infants in the State of Qatar are less prevalent compared to several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anemia in this study was 23.5%, of iron deficiency was 9.2% and of iron deficiency anemia was 7.8%. Iron deficiency was significantly associated with infants who were non-Qatari, had a unemployed mother, belonged to a family with low

total monthly income, exclusively breastfed for 6 months, breastfed more frequently, continued breastfeeding at the age of one year, breastfed within the last 24 hours prior to the interview, never took infant formula milk, frequently consumed plant sources of dietary iron and had a mother that did not receive infant feeding counseling.

The study fill gaps in knowledge necessary to plan public health interventions at national as well as regional level in the Gulf Cooperation Council (GCC) countries.

Recommendations

Integration of mass iron deficiency and iron deficiency anemia screening prior to 12 months visit to allow for early intervention in addition to proper counseling regarding and breast feeding and proper weaning practice.

Acknowledgments

We are extremely grateful to all the mothers who took part in this study, the staff of the well-baby clinics, data collectors and Dr. Rajvir Singh for his invaluable statistical assistance, support and guidance.

Ethical approval

Appropriate approvals obtained from the Arab Board of Medical Specialization, Institutional Review Board of Hamad Medical Corporation and the Primary Health Care Corporation Research Committee.

Funding

The funding of this study is received from the Research Center at Hamad Medical Corporation, state of Qatar.

Patient consent

Mothers of participants were consented in written after appropriate description of the study aim and value.

Competing interest

None declared.

Figure legends

Figure (1): Among the three hundred and six infants of completed 12 months of age and lesser than 13 months; 72 (23.5%) had anemia which defined as hemoglobin <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), 28 (9.2%) had iron deficiency (ID) which defined as Serum Ferritin (SF) below normal reference range (6-24 ug/L) in absence of high C-Reactive Protein (CRP), and 24 (7.8%) had iron deficiency anemia (IDA) which defined by combination of three elements - hemoglobin <11.1 g/dl

(normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).

Data sharing statement

No additional data are available.

Contribution to authorship

AJZ, NASand SAK designed the study and wrote the primary proposal.AJZ and SAK managed data collection and fieldwork.SROand AJZ did literature review, data analysis,results interpretation and wrote the discussion.AJZ, SROand NAS drafted and revised the manuscript. AJZ finalized and submittedthe manuscript.

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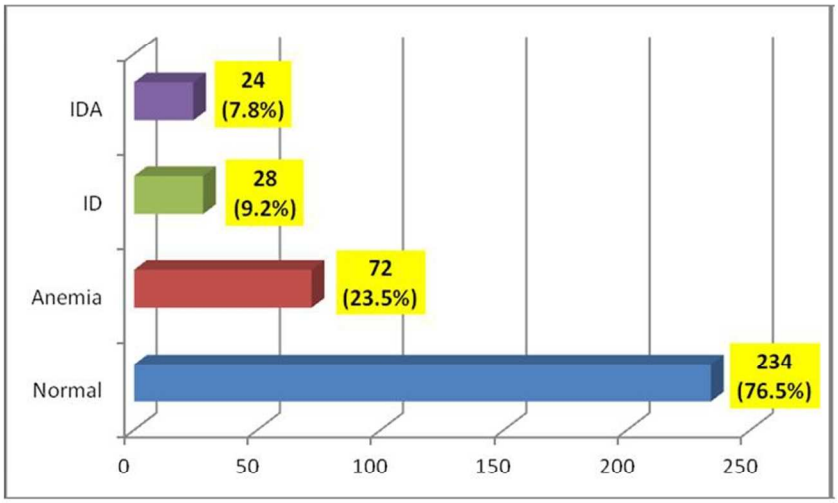

Figure (1): Distribution of study infants according to their anemia, iron deficiency and iron deficiency anemia status

81x60mm (300 x 300 DPI)

STROBE Statement checklist

Item	Item number	Status	Page number
Title and abstract	1	Included	1, 2
Introduction			
Background/rationale	2	Included	2, 3, 4
Objectives	3	Included	4
Methods			
Study design	4	Included	4
Setting	5	Included	4
Participants	6	Included	4
Variables	7	Included	4, 5
Data sources/ measurement	8	Included	5
Bias	9	Included	2
Study size	10	Included	4
Quantitative variables	11	Included	4
Statistical methods	12	Included	5
Results			
Participants	13	Included	5 - 9
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Interpretation	20	Included	13
Generalizability	21	Included	13
Other information			
Funding	22	Included	14

BMJ Open

Iron deficiency, its epidemiological features and feeding practices among infants aged 12 months in Qatar, a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020271.R2
Article Type:	Research
Date Submitted by the Author:	08-Feb-2018
Complete List of Authors:	Zainel, A.Jaleel; Primary Health Care Corporation, Clinical Affairs Osman, Sherif ; Alexandria University High Institute of Public Health; Primary Health Care Corporation, Family and Community Medicine Al-Kohji, Sadriya; Primary Health Care Corporation, Service Development Selim, Nagah; Cairo University, Public Health and Preventive Medicine; Primary Health Care Corporation, Family and Community Medicine
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	iron deficiency, feeding, infants, Qatar

Iron deficiency, its epidemiological features and feeding practices among infants aged 12 months in Qatar, a cross-sectional study

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WORD COUNT

4699 words

Abstract

Objectives To estimate the magnitude of anemia, iron deficiency (ID), iron deficiency anemia (IDA) and to explore epidemiological features of ID and feeding practices among infants aged 12 months in Qatar.

Setting Well baby clinics in 14 randomly selected primary health care centers covering all geographical areas on the national level.

Participants Three hundred and six (163 male and 143 female) infants of all nationalities were enrolled. Mothers were asked to complete a predesigned interview questionnaire and infants were blood tested for anemia, ID and IDA.

Outcome measures Cutoff point used to diagnose anemia was hemoglobin (Hb) <11.1g/dl, and to diagnose ID, serum ferritin (SF) <6 ug/l with normal C-reactive protein (CRP).

Results Prevalence of anemia was 23.5%, ID was 9.2% and IDA was 7.8%. ID was more prevalent among non-Qatari infants compared to Qatari (10.9% *vs.* 1.7%, p=0.029), more prevalent among infants born to housewives and to families of low income ($p \leq 0.05$). With regard to feeding practice, ID was higher in infants who continued breastfeeding until the age of one year and among those who never took infant formula milk ($p \leq 0.05$). Mothers who received infant feeding counseling had less ID occurrence among their infants compared to their counterparts who did not receive such counseling (4.2% *vs.* 13.4%, p=0.005).

Conclusion: Although ID and IDA among infants in Qatar are less prevalent compared with many developing countries, still further efforts are needed for improvement towards more developed countries. Efforts should be contextualized and target the key epidemiological features with special emphasis on infant feeding and infant feeding counselling to mothers.

Key words: Iron, Anemia, Prevalence, feeding, 12 months infants, Qatar

Strengths and limitations of this Study

- The first population-based study about ID and IDA among infants in Qatar.
- Covering a critical age of infancy (12 months) where feeding and weaning practices can influence the health and wellbeing of the child.
- Being a cross-sectional study where temporality cannot be demonstrated.
- A prospective study design would have overcome potential recall bias; however, it was not feasible to undertake one at the time due to shortage of resources.
- Differences in the applied diagnostic criteria and laboratory cutoff values in identification of anemia, ID and IDA across different studies limit the ability of a precise comparison.

Introduction

Infants and young children are vulnerable to anemia especially iron deficiency anemia (IDA), which represents a public health problem with defined impacts on the health of communities.[1] Published evidence suggests that early infant feeding practices play a major role in the prevalence of iron deficiency (ID) and IDA.[2,3] Anemia early in life, with or without iron depletion, is known to seriously affect children's general health and immunity, retarding their growth and development by causing multiple disorders and abnormalities in different body systems.[3-5]

Anemia may be defined as hemoglobin (Hb) concentration 2 standard deviations (SD) below the mean Hb concentration for a normal population of the same gender and age range. ID, the commonest cause of anemia, is characterized by a depletion of iron in various body compartments and / or tissues. IDA is said to exist when ID is severe enough to significantly affect erythropoiesis.[3,6] IDA is a preventable and a treatable condition, therefore, early diagnosis represents the cornerstone in protection from its adverse consequences and combating its contributing factors.

Globally, ID is the most common and widespread nutritional disorder affecting all age groups, particularly children in developing countries where prevalence as high as 50% have been reported among infants aged 12 months in some countries. IDA is a leading cause of mortality and morbidity among infants worldwide and some of its manifestations are possibly irreversible.[7-14] In a systematic review done in 2012 to evaluate micronutrient deficiencies and food fortification in the Middle East, ID represented one of the three commonest micronutrient deficiencies in the region in addition to iodine and vitamin A.[15] According to the World Health Organization (WHO) in 2013, 63% of children under-5 in the Eastern Mediterranean Region (EMR) had IDA and in some studies, anemia among preschool children showed similarly high rates.[16]

Iron transfer from mother to fetus occurs mainly during the third trimester of pregnancy and is stored mainly in the liver and bone marrow. Thus, the amount of iron present at birth depends on the gestational age and weight of the baby.[17] Full term infants usually have sufficient iron stores until 4 to 6 months of age. During the infantile growth spurt , human milk (which contains 0.2–0.3 mg/L of iron) may not provide enough iron to meet high demands for rapid growth and erythropoiesis. Therefore, existing iron stores are mobilized to meet the iron requirements of the infant mostly around the age of 4-6 months. This may result in stores being generally depleted by the age of 6 months, yet from 4 to 12 months after birth, the infant's blood volume doubles, causing a 'physiologically dilution effect' for red blood cells and Hb. Thus at this age, dietary sources of iron become critical to keep up with the rapid rate of growth and red blood cell synthesis.[18-22]

Studies have shown that increased nutritional requirements during the growth spurt, may often leads to a negative nutrient balance.[2] In general, prolonged exclusive breastfeeding (more than 6 months) predisposes to decreased dietary iron intake and may lead to iron depletion.[18,23] Male *et al.* in 2001 indicated that feeding with iron-fortified formula positively influenced iron status among infants up to the age of 12 months. There was also a positive association with consumption of cereals and iron supplements.[24] Inadequate complementary feeding practices which represent an important risk factor for IDA are characterized by consumption of foods with low amounts of bio-available iron or foods with inhibitors to iron absorption. Such practices often extend up to the age of 2 years.[18,25]

Infant feeding counseling offered to mothers and other caregivers on how to gradually increase consistency and quantity of foods also assists in prevention of micronutrient deficiency.[26,27] Preterm babies, as well as, those born small for gestational age, are particularly vulnerable to ID in their first months of life.[2,28,29] Infants delivered by cesarean section are more likely to get ID, as their delivery is associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood.[30]

Prevention and control strategies against IDA are mainly dependent on the timing of diagnosis and start of treatment.[7] The WHO "Global Strategy for Infant and Young Child Feeding" was developed as

guidance to the prevention of micronutrient deficiencies including ID and IDA.[26] Many studies indicate that incidence of IDA has significantly decreased over time due to promotion of breastfeeding, improvement of overall nutritional status and use of iron-fortified baby foods.[31,32]

In Qatar, Well Baby Clinic (WBC) services provided at the primary health care (PHC) centers include routine screening of infants for anemia during their MMR vaccination visit at 12 months of age but routine screening for ID or IDA is not undertaken.[8] Previous studies in Qatar have focused on the extent of anemia but not specifically on ID or IDA in this age group. This study investigates the prevalence of ID and IDA and the correlates of ID among infants at 12 months of age, as well as infant and child feeding practices among mothers of all nationalities resident in Qatar. The current study provides a much needed first snapshot of the extend of problem in the State of Qatar.

Methods

A cross sectional study was conducted at WBCs in Primary Health Care Corporation (PHCC) centers. These clinics provide comprehensive evidence-based services to all children under the age of 5 years. Of the 21 PHCC centers across Qatar operating at time of the study, 14 were providing the WBC service. Infants in the WBC appointment system who attended the selected centers seeking WBC services for the 12 month visit and met the eligibility were included in the study sample. Mothers of all participating infants signed an informed consent form.

Eligibility criteria: Male and female infants completed 12 months of age (but less than 13 months) and of all nationalities (Qatari and non-Qatari) attending WBCs at their routine 12 month's visit were eligible. Participants diagnosed with sickle cell anemia or thalassemia were excluded.

Sample size calculation and sampling technique: As ID prevalence in Qatar was not available; the latest published prevalence of ID in the nearest regional country (The United Arab Emirates) of 26 % was used to calculate the sample size.[29] It was estimated that a sample size of 292 is required for the study. To compensate for possible non-responders, an additional 20% were added bringing a total of 350 after rounding. A 95% confidence level and 5% error rate were used for the calculation**.** Data from the 12 months vaccination coverage rates calculated by the PHCC in Qatar confirmed by its head of child health section shows a vaccination coverage rate of over 97% at this age, Therefore participants recruited are considered a representative sample of the national population. A systematic random sampling technique was used to recruit study participants. The sampling frame was drawn from the daily appointment list in WBCs. The first participant of the day was selected from the list and subsequent participants were selected randomly. The study took place in the period between September 2014 and May 2015.

Study variables: Dependent (outcome variables) measured included 'ID', defined as SF below normal reference range (6-24 ug/L) in the absence of high CRP.[3,33], and 'IDA' defined by a combination of three elements - Hb <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).[3,6,33,34] Hb was determined using Sysmex 500 I machines to determine the complete blood picture and count. Ferritin was determined using Cobas Integra 400 plus machine. The technique was particle enhanced immunoturbidimetric assay utilizing human ferritin agglutination with latex particles coated with anti-ferritin antibodies. The precipitate is determined turbidimetrically at 570/800 nm.

Independent (exposure) variables included socio-demographic characteristics of infants and their parents, birth history of the participant, history of maternal pregnancies, breastfeeding, intake of infant formula milk, , iron supplementation, infant feeding counseling to mothers, body mass index (BMI) calculation., as well as, frequency of consumption of different food groups. Mothers were interviewed about frequency of infant's consumption of different food items rich in iron. Based on their responses, a food frequency score was calculated for each consumed food item according to the following criteria: A score of 1 for no previous consumption, 2 for 1-3 times/month, 3 for 1-6 times/week and 4 for daily consumption. Food items of animal origin were summed up as well as those of plant origin and the mean (±SD) was calculated for participants either with or without ID.

Data collection tools: The research team developed an interview-administered questionnaire after extensive literature review to establish content and face validity, followed by thorough discussion and assessment by experts in the fields of pediatric hematology and community medicine. A pilot was undertaken over 20 participants, conveniently sampled, to establish and confirm its suitability. Necessary adjustments were made accordingly. Anthropometric measurements of participants were acquired in order to calculate BMI. Laboratory results of participants were retrieved from their electronic medical record using a data extraction sheet. Venous blood samples are collected routinely by well baby clinics for all 12 months aged infants as per their protocol to check for anemia. Additional laboratory studies for ID detection utilizing these samples were managed in hematology laboratory of the Qatar's secondary health care provider; Hamad Medical Corporation (HMC).

Data analysis: Statistical Package for Social Sciences IBM-SPSS© version 20 was used for data entry and analysis. Descriptive analysis was undertaken (*frequency distribution tables, proportions, mean and standard deviation),* in addition to analytical statistics (*Chi-square test and fisher exact probability test*) were used to assess differences between two or more proportions and the *Student t tes*t was used to compare continuous variables. An *Alpha* (*p*) value of ≤ 0.05 was used as the cut-off level of significance.

Quality control measures: The questionnaire was pre-tested using a convenient sample of 20 infants. Their data was omitted prior to analysis. Content and face validity were established using extensive literature review and consultation with academic experts in community medicine and experts in the fields of hematology and pediatrics. The main researchers did all data entry and review. Standardized methods of blood collection and automated measures for blood analysis were used to ensure reliability of the study results.

Ethical considerations: Ethical approvals were obtained prior to fieldwork from PHCC and HMC ethical review boards. Permission was also obtained from PHCC center directors, as well as, mothers of infants identified for the study. The methodology of the study was fully described to the ethical review board to allow possible inconvenience resulting from extra blood withdrawal. Privacy and confidentiality of participant's data was assured. Mothers were invited to participate voluntarily and allowed to withdraw at any time during the study.

Results

Of the total 350 study participants identified, laboratory data was available for 306 of them giving a response rate of 87.4%, but still over the figure required by calculation for statistical relevance (i.e. n=292). **Figure (1)** demonstrates the prevalence of the dependent variables.

As shown in **Table (1)**, when the relation between ID and background characteristics of the infants was assessed, it was found that ID is more common in males. However the relationship was not statistically significant. There was a statistically significant higher prevalence of ID among Non-Qatari infants compared to their Qatari counterparts.

Table (1): Relation between ID and infants' background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Gender					
Male	146 (89.6)	17 (10.4)	163	0.686	0.265
Female	132 (92.3)	11 (7.7)	143		
Nationality					
Qatari	57 (98.3)	1 (1.7)	58	4.748	**0.029**
Non Qatari	221 (89.1)	27 (10.9)	248		
Gestational age					
Pre-term (< 37 weeks)	23 (88.5)	3 (11.5)	26	0.195	0.433
Full-term (≥ 37 weeks)	255 (91.1)	25 (8.9)	280		
Birth weight					
Low (< 2500 grams)	18 (90)	2 (10.0)	20	0.019	0.565
Normal (≥ 2500 grams)	260 (90.9)	26 (9.1)	286		
Mode of child delivery					
Normal	183 (91.5)	17 (8.5)	200	0.294	0.364
Caesarean section	95 (89.6)	11 (10.4)	106		
Twins, triple or multiple birth					
No	270 (90.6)	28 (9.4)	298	0.827	0.460
Yes, twins	8 (100)	0 (0)	8		

In terms of background characteristics of parents, the relation of ID with mother's employment status and the family income were found to be statistically significant, as shown in **Table (2)**.

Table (2): Relation between ID and infants parents background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Mother's age					
≤ 25 years	55 (88.7)	7 (11.3)	62		
26 – 35 years	182 (91.9)	16 (8.1)	198	0.778	0.678
More than 35 years	41 (89.1)	5 (10.9)	46		
Number of mother's pregnancy (including miscarriage)					
< 4	187 (91.2)	18 (8.8)	205	0.102	0.749
> 4	91 (90.1)	10 (9.9)	101		
Mother's education level					
Illiterate	6 (75.0)	2 (25.0)	8	3.598	0.165
Up to secondary school	91 (93.8)	6 (6.2)	97		

University educated and above	181 (90.0)	20 (10.0)	201		
Father's education level					
Up to secondary school	93 (93.0)	7 (7.0)	100	0.826	0.246
University educated and above	185 (89.8)	21 (10.2)	206		
Mother's employment status					
Housewife	186 (87.3)	27 (12.7)	213	10.480	**≤ 0.05**
Working job	92 (98.9)	1 (1.1)	93		
Father's occupation					
Manual worker	31 (91.2)	3 (8.8)	34		
Clerk/administrative	85 (87.6)	12 (12.4)	97	1.904	0.593
Professional	118 (92.9)	9 (7.1)	127		
Others	44 (91.7)	4 (8.3)	48		
Total number of children in the family					
1	81 (94.2)	5 (5.8)	86		
2-3	134 (90.5)	14 (9.5)	148	2.140	0.343
More than 3	63 (87.5)	9 (12.5)	72		
Family income in Qatari Riyals (QR)					
Up to10000 QR	107 (82.9)	22 (17.1)	129		
10001-20000 QR	99 (95.2)	5 (4.8)	104	17.369	**≤ 0.05**
More than 20000 QR	72 (98.6)	1 (1.4)	73		

Table (3) shows several statistically significant relations between ID in infants and their feeding practice and iron supplementation.

Table (3): Relation between ID and feeding practice

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Exclusive breastfeeding for 6 months					
Yes	51 (81.0)	12 (19.0)	63	7.915	**0.007**
No	208 (92.9)	16 (7.1)	224		
Frequency of breastfeeding					
All or almost all feeds	142 (86.1)	23 (13.9)	165		
About half of all feeds	76 (93.8)	5 (6.2)	81	8.893	**0.012**
Few feeds since was born	41 (100.0)	0 (0)	41		
Continuation of breastfeeding at one year					
Yes	115 (82.7)	24 (17.3)	139	17.268	**≤ 0.05**
No	144 (97.3)	4 (2.7)	148		
Breastfeeding intake within the last 24 hours					
Yes	112 (82.4)	24 (17.6)	136	18.281	**≤ 0.05**
No	147 (97.4)	4 (2.6)	151		
Ever take infant formula milk (n= 306)					
Yes	225 (95.3)	11 (4.7)	236	25.011	**≤ 0.05**
Never	53 (75.7)	17 (24.3)	70		
Age at introducing of any solid, semi-solid or soft food (n= 306)					

Less than 6 months	72 (91.1)	7 (8.9)	79	0.011	0.917
6 months or more	206 (90.7)	21(9.3)	227		
Ever take iron supplementation (n= 306)					
Yes	27 (96.4)	1 (3.6)	28	1.154	0.283
No	251 (90.3)	27 (9.7)	278		

The differences in mean frequency of consumption for different groups of food is shown in **Table (4)**, where infants diagnosed with ID consumed less plant foods rich in iron, and the difference was statistically significant. However, the difference was not significant for animal sources of iron and the overall score of food frequency.

Table (4): Relation between ID and food frequency score

Food item	**Mean ± SD**		***Student's t test***	***p* value**
	No ID	**ID**		
Overall score	21.2 ± 3.9	19.89 ± 4.0	1.64	0.12
Animal Source of iron	7.9 ± 2.3	7.9 ± 2.2	0.02	0.98
Plant source of iron	13.2 ± 2.8	11.9 ± 2.7	2.26	**0.03**

When the relation between ID and infant feeding counseling for mothers was assessed, there was a significant relationship between receiving counseling and ID occurrence, as the prevalence of ID was higher among infants to mothers didn't receive feeding counseling compared to infants of mothers received such counseling (13.4 against 4.2%) respectively, with (χ^2= 7.731 and ***p*= 0.005**).

From the BMI for age based on z-score, ID prevalence was variable among different BMI groups.[35, 36] It was as high as 16.7%among wasted/severely wasted infants, 9.7% among infants at risk of overweight, 9.4% among infants with normal BMI and as low as 5.6% among the overweight/obese group of infants. These relationships were not statistically significant (χ^2= 1.007 and *p*= 0.799).

Discussion

This is the first population-based descriptive epidemiological study to estimate the prevalence and associated factors of ID and IDA in infants in Qatar. We found a prevalence of anemia, ID and IDA among infants of 23.5%, 9.2% and 7.8% respectively, which is much lower than the published global prevalence.[37]

Comparing these findings with figures published for other countries of the EMR, it appears that many of them have an even higher burden of disease. The WHO report, 2013 also showed no improvement in the overall anemia situation among pre-schoolers where 63% of children under the age of 5 years had

IDA.[16, 38] The prevalence of anemia, ID and IDA in our study was also lower than in the United Arab Emirates, Kuwait and Saudi Arabia.[29, 39, 40] A study conducted in Raparin teaching hospital for children in Erbil - Iraq, 2007, among infants aged (12 - 24) months, showed that the prevalence of ID ranged between 51.9% and 48.1%. It also showed that about 53% and 30 % of participants had anemia and IDA respectively.[41]

Qatar has implemented a well-developed and comprehensive well baby program at PHC centers. In a study undertaken in 2011 at Ain Shams University Children's Hospital in Egypt which included three hundred poor Egyptian infants, anemia was diagnosed in 66% of the participants aged between 6 and 24 months, and among them, 43% had IDA.[42] This high prevalence rate may be due to the selection of a high-risk group for the study. Similar results were also seen in Kassala (Eastern Sudan) where up to 86% of young children less than three years of age living were diagnosed with IDA.[43]

On the other hand, the prevalence of anemia, ID and IDA found in this study is still high compared to many developed countries. Male C *et al*, 2001 showed that the prevalence of anemia, ID and IDA was 9.4%, 7.2% and 2.3% respectively.[24] The difference in prevalence compared to this study may be attributed to the cut-off point of SF, the eligibility criteria and/or the disease determinants between the two populations. A study from Estonia undertaken between July 2002 to March 2005 of 171 infants aged 9 to 12 months, found a prevalence of ID and IDA of 14.0% and 9.4, % respectively. The study utilized a cut-off value for Hb of <10.5 g/dl and for serum ferritin of <12 µg/L.[28]

In relation to the potential determinants of ID in this study, gender did not appear to be a factor as there was no statistically significant difference between male and female participants. This is consistent with Vendt *et al*,2007.[28] However , in a study from Iran, of 33 cases diagnosed with IDA, 26 children (78.8%) were males and the prevalence of IDA was statistically significant among male compared with female infants (p = 0.015).[44] Another study of 201 infants in Iran showed a prevalence of IDA of 61.5% among male infants. Employing a multiple logistic regression model, the researchers reported that male gender was the most important ID risk factor in their study (OR = 3.3; 95% CI 1.7-6.3; and $p < 0.001$).[45]

In this study, we found a statistically significant higher prevalence of ID among non-Qatari infants compared to their Qatari counterparts. This difference can be attributed to possible difference in economic, social and/or nutritional attributes. ID was more common among those infants born pre-term compared to infants born full term. However, this result is not statistically significant. In other studies from Canada, prematurity and intra-uterine growth retardation were shown to be risk factors for ID and IDA associated with low hepatic and bone marrow iron stores at birth.[18] A clinical report from the American Academy of Pediatrics indicated that the deficit of total body iron in preterm infants increases with decreasing gestational age, is worsened by the rapid postnatal growth that many infants experience and by frequent phlebotomies without adequate blood replacement. All these are risk factors for ID. [3]

Infants with low birth weight were shown to be more prone to ID compared to those born with normal weight. This finding is similar to a study conducted in Estonia where the mean birth weight among the iron deficient group was significantly lower than that in the control group. [28]

Concerning the infant's mode of delivery in this study, those infants born through caesarean section showed higher risk of iron deficiency than those born through normal delivery. This finding is consistent

with results of a systematic review and meta-analysis which synthesized evidence that compared with vaginal delivery, caesarean section is associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood. This in turn indicates that neonates delivered by caesarean section might be more likely to develop iron deficiency anemia later in infancy compared to their normally delivered counterparts.[30]

In this study, ID was more common among infants born to younger mothers aged 25 years or less (11.3%) compared to among infants of mothers aged 26 - 35 years (8.1%) and for infants of mothers aged more than 35 years (10.9%). Similarly an exploratory descriptive study conducted in Egypt with 400 healthy children aged 12 to 24 months reported that iron deficiency was more prevalent among infants of mothers aged 20-29 years old (67.2%) compared with infants of mothers aged more than 30 years (22.4%) and infants of mothers aged less than 20 years old (10.4%).[46] An explanation for this may be related to the lack of infant feeding experience of young mothers . We found that ID was more common among infants born to illiterate mothers compared to mothers with higher education. However, the findings were not statistically significant. Similarly, the relationship with parental education was not statistically significant. Our findings are similar to a study which showed a statistically significant difference between IDA among children below the age of two years and the level of parental education. In that study, the highest percentage of anemia cases (32.1%) were found in infants of illiterate mothers (X^2=21.775 and p = 0.0001).[46]

On the contrary, a study from Iran reported that educational level of the mother did not have an effect on the iron status of infants. [44] Our study also showed that ID was more prevalent among infants born to mothers who were housewives compared to those born to working mothers, and the relationship was statistically significant. This finding is consistent with the results of a study conducted in Alexandria, Egypt, where 88.4% of infants born to non-working mothers had IDA compared to only 15.4% of those born to working mothers.[46] The difference could be explained by possible higher education and knowledge among working mothers compared to housewives, and thus better feeding practices and/or that working mothers are more reliant on formula feeding and breastfeed less compared to their housewife counterparts.

Prevalence of IDA in infants from families with more than three children was high compared to those infants born to families with 2-3 children and to families with only one child. This corroborates a study undertaken in Iraq where low serum iron was found in children from families which had 4 children or more compared to families that had less than 4 children.[41] However, a study conducted in Iran in 2007 reported no significant difference between IDA prevalence and the total number of children in the infant's family ($P > 0.05$).[44]

The relationship between ID and history of exclusive breastfeeding for six months, frequency of breastfeeding, continued breastfeeding at one year and intake of breast milk within 24 hours prior to the interview were statistically significant in this study. Similar results were found in a study from Estonia in which infants exclusively breastfed until the age of 6 months had significantly lower Hb and ferritin levels compared to those exclusive breastfed only until the age of 3 months.[28] Other studies have reported prevalence rates of IDA of 27% in infants exclusively breastfed up to 6 months, 16.7% in infants fed with formula milk and 100% in infants fed with cow's milk (p=0.033).[44] The figures appear to

reflect the iron content of different types of milk with levels higher in formula milk (fortified with iron) and relatively low in breast milk and fresh cow's milk. Prolonged exclusive breastfeeding has been suggested to decrease the intake of dietary iron, which in turn leads to iron deficiency especially in growing infants beyond the age of 6 months when the needs for iron may not be adequately met by continuation of exclusive breastfeeding.[18-22] In South Korea a study of 87 healthy full-term infants showed that at 6 months of age, the incidences of ID and IDA in breast-fed only infants were 33% and 30%, respectively, significantly higher than formula fed (8% and 5%, respectively) and those breast-fed with iron supplementation (7% and 5%, respectively). At 12 months of age, the incidences of ID and IDA in breastfed were 64% and 50%, respectively, again significantly higher than the other groups. [23] The established reason is the beneficiary influence of the iron fortifying formula milks on the infants' stores of iron as demonstrated in many studies.[18,47]

In the current study, mothers were asked about frequency of consumption of different food items rich in iron, which was used to calculate the food frequency score derived from a previous study conducted in Qatar.[48] The findings showed that infants who suffered ID consumed less plants rich in iron compared to their counterparts without ID, and the difference was statistically significant (t test= 2.26 and p= 0.03). No significant differences were found when studying animal sources of iron and the overall score of food frequency. This finding supports mentioned previous Qatari study in which ID was more common among pregnant women with high consumption of food items containing iron of plant sources (*t test*= 0.2 and *p*= 0.834) compared to food items containing iron of animal sources (*t test*= 1.6 and *p*= 0.100). They related this to less bio-available iron in food items of plant origin compared to animal origin.

Our finding of higher prevalence of ID among infants who started solid, semi-solid or soft food at age of 6 months or later compared to those who started before the age of 6 months is similar to the results of other studies where infants fed with solid food before 6 months had statistically higher Hb values than those who were introduced to solid food after 6 months of life.[25,28,47]

Infants on iron supplementation were less likely to be iron deficient in this study. This finding supported by a study where infants with iron supplementation had higher Hb concentration and higher MCV.[3] In another study conducted on 126 infants divided into 3 groups, where 86 cases received iron supplementation irregularly, 27 cases regularly and 13 cases never received iron, IDA in the first group was 26.7%, 3.7% in the second group and 69.2% in the third group who never received any iron supplementation. The relationship between IDA and no iron supplementation was statistically significant ($p< 0.001$).[44] Similarly, significantly lower ferritin concentrations in 6-month-old infants have been reported in infants who were exclusively breastfed compared to infants who were breastfed and took iron supplementation.[18]

We found a significant relationship between maternal infant feeding counseling and prevalence of ID. In a previous US study, ID prevalence decreased among African American children aged 1-3 years old, from 16% to 6% between years 1976 and 2002. This marked decline was attributed to implementation of the Women, Infants and Children Program which targeted specific groups of mothers and families with counseling, and this led to improvement in infant feeding practices to prevent ID.[46]

Our finding of higher ID prevalence among infants born to mothers with a history of having four pregnancies (9.9%) or more, compared to infants born to mothers with less than four pregnancies (8.8%) may be attributed to the possible depletion of the mother's body stores of iron, especially with multiple tightly close pregnancies,.[18,44]

Iron deficiency prevalence was variable among different infant BMI groups. These relations were statistically insignificant. On the other hand, a study conducted in the US indicated that overweight children (1-3 years old) had triple the odds of ID prevalence compared with normal weight or underweight children and ID prevalence remained consistently high for overweight children at 20% to 24%.[49] A second study from the US showed that ID prevalence was 20% among those with overweight, 8% for those at risk for overweight, and 7% for normal-weight toddlers (1-3 years old).[50] The possible explanation to this contradiction with the results seen in the two US studies is that, anemia, ID and IDA are mostly related to the imbalance between iron needs and dietary sources of iron, rather than the relation with the caloric content of infant's nutrition or body composition. In this study, we had a very small insignificant number of participating infants who were wasted or severely wasted.

Conclusion

Although ID and IDA among infants in the State of Qatar are less prevalent compared to several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anemia in this study was 23.5%, ID was 9.2% and IDA was 7.8%. ID was significantly associated with non-Qatari infants, those whose mothers were un-employed or belonged to a family with low total monthly income. Infants exclusively breastfed for 6 months, breastfed more frequently, and those who continued breastfeeding at the age of one year, or who never took infant formula milk were also at higher risk. Furthermore, those who frequently consumed plant sources of dietary iron and had a mother that did not receive infant feeding counseling were at greater risk of ID and IDA.

We believe that these findings are worth further exploration and that they fill gaps in our current knowledge and can help us to plan public health interventions at national as well as regional level in the Gulf Cooperation Council (GCC) countries.

Recommendations

Integration of mass ID and IDA screening prior to 12 months visit to allow for early intervention in addition to proper counseling regarding breast feeding and proper weaning practice.

Acknowledgments

We are extremely grateful to all the mothers who took part in this study, the staff of the WBCs, data collectors and Dr. Rajvir Singh for his invaluable statistical assistance, support and guidance.

Ethical approval

Appropriate approvals obtained from the Arab Board of Medical Specialization, Institutional Review Board of HMC and the PHCC Research Committee.

Funding

The funding of this study is received from the Research Center at HMC, state of Qatar.

Patient consent

Mothers of participants were consented in written after appropriate description of the study aim and value.

Competing interest

None declared.

Figure legends

Figure (1): Among the three hundred and six infants of completed 12 months of age and lesser than 13 months; 72 (23.5%) had anemia which defined as hemoglobin <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), 28 (9.2%) had iron deficiency (ID) which defined as Serum Ferritin (SF) below normal reference range (6-24 ug/L) in absence of high C-Reactive Protein (CRP), and 24 (7.8%) had iron deficiency anemia (IDA) which defined by combination of three elements - hemoglobin <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).

Data sharing statement

No additional data are available.

Contribution to authorship

AJZ, NAS and SAK designed the study and wrote the primary proposal. AJZ and SAK managed data collection and fieldwork. SRO and AJZ did literature review, data analysis, results interpretation and wrote the discussion. AJZ, SRO and NAS drafted and revised the manuscript. AJZ finalized and submitted the manuscript.

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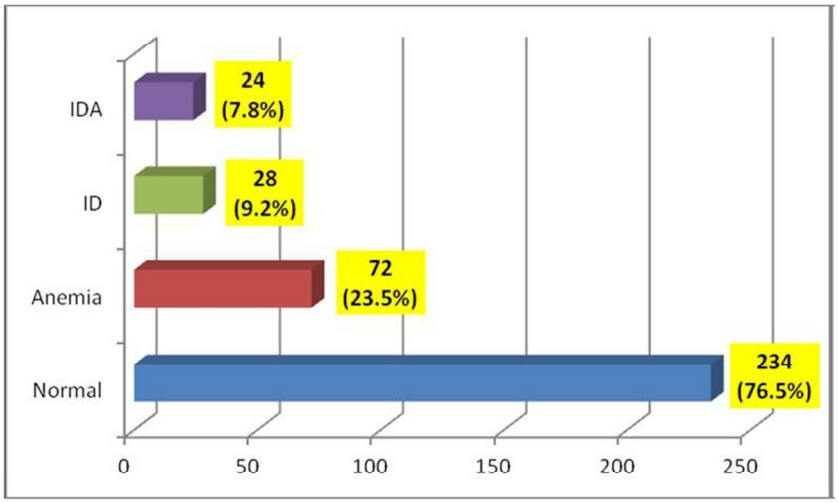

Figure (1): Distribution of study infants according to their anemia, iron deficiency and iron deficiency anemia status

81x60mm (300 x 300 DPI)

STROBE Statement checklist

Item	Item number	Status	Page number
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Limitations	19	Included	2
Interpretation	20	Included	12
Generalizability	21	Included	4, 12
Other information			
Funding	22	Included	12

BMJ Open

Iron deficiency, its epidemiological features and feeding practices among infants aged 12 months in Qatar, a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-020271.R3
Article Type:	Research
Date Submitted by the Author:	08-Mar-2018
Complete List of Authors:	Zainel, A.Jaleel; Primary Health Care Corporation, Clinical Affairs Osman, Sherif ; Alexandria University High Institute of Public Health; Primary Health Care Corporation, Family and Community Medicine Al-Kohji, Sadriya; Primary Health Care Corporation, Service Development Selim, Nagah; Cairo University, Public Health and Preventive Medicine; Primary Health Care Corporation, Family and Community Medicine
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	iron deficiency, feeding, infants, Qatar

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WORD COUNT

5088 words

Abstract

Objectives To estimate the magnitude of anemia, iron deficiency (ID), iron deficiency anemia (IDA) and to explore epidemiological features of ID and feeding practices among infants aged 12 months in Qatar.

Setting Well baby clinics in 14 randomly selected primary health care centers covering all geographical areas on the national level.

Participants Three hundred and six (163 male and 143 female) infants of all nationalities were enrolled. Mothers were asked to complete a predesigned interview questionnaire and infants were blood tested for anemia, ID and IDA.

Outcome measures Cutoff point used to diagnose anemia was hemoglobin (Hb) <11.1g/dl, and to diagnose ID, serum ferritin (SF) <6 ug/l with normal C-reactive protein (CRP).

Results Prevalence of anemia was 23.5%, ID was 9.2% and IDA was 7.8%. ID was more prevalent among non-Qatari infants compared to Qatari (10.9% *vs.* 1.7%, p=0.029), more prevalent among infants born to housewives and to families of low income ($p \leq 0.05$). With regard to feeding practice, ID was higher in infants who continued breastfeeding until the age of one year and among those who never took infant formula milk ($p \leq 0.05$). Mothers who received infant feeding counseling had less ID occurrence among their infants compared to their counterparts who did not receive such counseling (4.2% *vs.* 13.4%, p=0.005).

Conclusion: Although ID and IDA among infants in Qatar are less prevalent compared with many developing countries, still further efforts are needed for improvement towards more developed countries. Efforts should be contextualized and target the key epidemiological features with special emphasis on infant feeding and infant feeding counselling to mothers.

Key words: Iron, Anemia, Prevalence, feeding, 12 months infants, Qatar

Strengths and limitations of this Study

- The first population-based study about ID and IDA among infants in Qatar.
- Covering a critical age of infancy (12 months) where feeding and weaning practices can influence the health and wellbeing of the child.
- Being a cross-sectional study where temporality cannot be demonstrated.
- A prospective study design would have overcome potential recall bias; however, it was not feasible to undertake one at the time due to shortage of resources.
- Differences in the applied diagnostic criteria and laboratory cutoff values in identification of anemia, ID and IDA across different studies limit the ability of a precise comparison.

Introduction

Infants and young children are vulnerable to anemia especially iron deficiency anemia (IDA), which represents a public health problem with defined impacts on the health of communities.[1] Published evidence suggests that early infant feeding practices play a major role in the prevalence of iron deficiency (ID) and IDA.[2,3] Anemia early in life, with or without iron depletion, is known to seriously affect children's general health and immunity, retarding their growth and development by causing multiple disorders and abnormalities in different body systems.[3-5]

Anemia may be defined as hemoglobin (Hb) concentration 2 standard deviations (SD) below the mean Hb concentration for a normal population of the same gender and age range. ID, the commonest cause of anemia, is characterized by a depletion of iron in various body compartments and / or tissues. IDA is said to exist when ID is severe enough to significantly affect erythropoiesis.[3,6] IDA is a preventable and a treatable condition, therefore, early diagnosis represents the cornerstone in protection from its adverse consequences and combating its contributing factors.

Globally, ID is the most common and widespread nutritional disorder affecting all age groups, particularly children in developing countries where prevalence as high as 50% have been reported among infants aged 12 months in some countries. IDA is a leading cause of mortality and morbidity among infants worldwide and some of its manifestations are possibly irreversible.[7-14] In a systematic review done in 2012 to evaluate micronutrient deficiencies and food fortification in the Middle East, ID represented one of the three commonest micronutrient deficiencies in the region in addition to iodine and vitamin A.[15] According to the World Health Organization (WHO) in 2013, 63% of children under-5 in the Eastern Mediterranean Region (EMR) had IDA and in some studies, anemia among preschool children showed similarly high rates.[16]

Iron transfer from mother to fetus occurs mainly during the third trimester of pregnancy and is stored mainly in the liver and bone marrow. Thus, the amount of iron present at birth depends on the gestational age and weight of the baby.[17] Full term infants usually have sufficient iron stores until 4 to 6 months of age. During the infantile growth spurt , human milk (which contains 0.2–0.3 mg/L of iron) may not provide enough iron to meet high demands for rapid growth and erythropoiesis. Therefore, existing iron stores are mobilized to meet the iron requirements of the infant mostly around the age of 4-6 months. This may result in stores being generally depleted by the age of 6 months, yet from 4 to 12 months after birth, the infant's blood volume doubles, causing a 'physiologically dilution effect' for red blood cells and Hb. Thus at this age, dietary sources of iron become critical to keep up with the rapid rate of growth and red blood cell synthesis.[18-22]

Studies have shown that increased nutritional requirements during the growth spurt, may often leads to a negative nutrient balance.[2] In general, prolonged exclusive breastfeeding (more than 6 months) predisposes to decreased dietary iron intake and may lead to iron depletion.[18,23] Male *et al.* in 2001 indicated that feeding with iron-fortified formula positively influenced iron status among infants up to the age of 12 months. There was also a positive association with consumption of cereals and iron supplements.[24] Inadequate complementary feeding practices which represent an important risk factor for IDA are characterized by consumption of foods with low amounts of bio-available iron or foods with inhibitors to iron absorption. Such practices often extend up to the age of 2 years.[18,25]

Infant feeding counseling offered to mothers and other caregivers on how to gradually increase consistency and quantity of foods also assists in prevention of micronutrient deficiency.[26,27] Preterm babies, as well as, those born small for gestational age, are particularly vulnerable to ID in their first months of life.[2,28,29] Infants delivered by cesarean section are more likely to get ID, as their delivery is associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood.[30]

Prevention and control strategies against IDA are mainly dependent on the timing of diagnosis and start of treatment.[7] The WHO "Global Strategy for Infant and Young Child Feeding" was developed as

guidance to the prevention of micronutrient deficiencies including ID and IDA.[26] Many studies indicate that incidence of IDA has significantly decreased over time due to promotion of breastfeeding, improvement of overall nutritional status and use of iron-fortified baby foods.[31,32]

In Qatar, Well Baby Clinic (WBC) services provided at the primary health care (PHC) centers include routine screening of infants for anemia during their MMR vaccination visit at 12 months of age but routine screening for ID or IDA is not undertaken.[8] Previous studies in Qatar have focused on the extent of anemia but not specifically on ID or IDA in this age group. This study investigates the prevalence of ID and IDA and the correlates of ID among infants at 12 months of age, as well as infant and child feeding practices among mothers of all nationalities resident in Qatar. The current study provides a much needed first snapshot of the extend of problem in the State of Qatar.

Methods

A cross sectional study was conducted at WBCs in Primary Health Care Corporation (PHCC) centers. We recruited 350 infants whose mothers were interviewed using interview-administered questionnaires. The response rate was 87.4% as only 306 infants completed the study by undertaking the necessary laboratory tests. The WBCs provide comprehensive evidence-based services to all children under the age of 5 years. Of the 21 PHCC centers across Qatar operating at time of the study, 14 were providing the WBC service. Infants in the WBC appointment system who attended the selected centers seeking WBC services for the 12 month visit and met the eligibility were included in the study sample. Mothers of all participating infants signed an informed consent form.

Eligibility criteria: Male and female infants completed 12 months of age (but less than 13 months) and of all nationalities (Qatari and non-Qatari) attending WBCs at their routine 12 month's visit were eligible. Participants diagnosed with sickle cell anemia or thalassemia were excluded.

Sample size calculation and sampling technique: As ID prevalence in Qatar was not available; the latest published prevalence of ID in the nearest regional country (The United Arab Emirates) of 26 % was used to calculate the sample size.[29] It was estimated that a sample size of 292 is required for the study. To compensate for possible non-responders, an additional 20% were added bringing a total of 350 after rounding. A 95% confidence level and 5% error rate were used for the calculation**.** Data from the 12 months vaccination coverage rates calculated by the PHCC in Qatar confirmed by its head of child health section shows a vaccination coverage rate of over 97% at this age, Therefore participants recruited are considered a representative sample of the national population. A systematic random sampling technique was used to recruit study participants. The sampling frame was drawn from the daily appointment list in WBCs. The first participant of the day was selected from the list and subsequent participants were selected randomly. The study took place in the period between September 2014 and May 2015.

Study variables: Dependent (outcome variables) measured included 'ID', defined as SF below normal reference range (6-24 ug/L) in the absence of high CRP.[3,33], and 'IDA' defined by a combination of three elements - Hb <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).[3,6,33,34] Hb was determined using Sysmex 500 I machines to determine the complete blood picture and count. Ferritin was determined using Cobas Integra 400 plus machine. The technique was particle enhanced immunoturbidimetric assay utilizing

human ferritin agglutination with latex particles coated with anti-ferritin antibodies. The precipitate is determined turbidimetrically at 570/800 nm.

Independent (exposure) variables included socio-demographic characteristics of infants and their parents, birth history of the participant, history of maternal pregnancies, breastfeeding, intake of infant formula milk, , iron supplementation, infant feeding counseling to mothers, body mass index (BMI) calculation., as well as, frequency of consumption of different food groups. Mothers were interviewed about frequency of infant's consumption of different food items rich in iron. Based on their responses, a food frequency score was calculated for each consumed food item according to the following criteria: A score of 1 for no previous consumption, 2 for 1-3 times/month, 3 for 1-6 times/week and 4 for daily consumption. Food items of animal origin were summed up as well as those of plant origin and the mean (±SD) was calculated for participants either with or without ID.

Data collection tools: The research team developed an interview-administered questionnaire after extensive literature review to establish content and face validity, followed by thorough discussion and assessment by experts in the fields of pediatric hematology and community medicine. A pilot was undertaken over 20 participants, conveniently sampled, to establish and confirm its suitability. Necessary adjustments were made accordingly. Anthropometric measurements of participants were acquired in order to calculate BMI. Laboratory results of participants were retrieved from their electronic medical record using a data extraction sheet. Venous blood samples are collected routinely by well baby clinics for all 12 months aged infants as per their protocol to check for anemia. Additional laboratory studies for ID detection utilizing these samples were managed in hematology laboratory of the Qatar's secondary health care provider; Hamad Medical Corporation (HMC).

To avoid measurement bias, all investigations were conducted in accredited laboratories which apply the Qatar national standards. To overcome selection bias, we strictly applied the exclusion criteria and recruited a representative sample. For consistency, where appropriate all measurements were repeated and the average of concordant readings recorded for the variables of concern. Although we intended to overcome all sources of bias, recall bias cannot be ruled out.

Data analysis: Statistical Package for Social Sciences IBM-SPSS© version 20 was used for data entry and analysis. Descriptive analysis was undertaken (*frequency distribution tables, proportions, mean and standard deviation),* in addition to analytical statistics (*Chi-square test and fisher exact probability test*) were used to assess differences between two or more proportions and the *Student t tes*t was used to compare continuous variables. An *Alpha* (*p*) value of ≤ 0.05 was used as the cut-off level of significance.

Quality control measures: The questionnaire was pre-tested using a convenient sample of 20 infants. Their data was omitted prior to analysis. Content and face validity were established using extensive literature review and consultation with academic experts in community medicine and experts in the fields of hematology and pediatrics. In order to prevent any data missing, authors had checked the completeness of data required within each questionnaire and the questionnaires had given serial numbers to allow identification of any missing data during data entry. The main researchers did all data entry and review. Standardized methods of blood collection and automated measures for blood analysis were used to ensure reliability of the study results. Of the original sample of 350 selected, 44 subjects failed to complete the laboratory tests therefore their data was excluded from further analysis.

Ethical considerations: Ethical approvals were obtained prior to fieldwork from PHCC and HMC ethical review boards. Permission was also obtained from PHCC center directors, as well as, mothers of infants identified for the study. The methodology of the study was fully described to the ethical review board to allow possible inconvenience resulting from extra blood withdrawal. Privacy and confidentiality of participant's data was assured. Mothers were invited to participate voluntarily and allowed to withdraw at any time during the study.

Patient and Public Involvement: The development of the research question and outcome measures were informed by published literature on anemia and ID. Patients' priorities, experience and preferences were not directly gathered nor were they involved in designing the study. Customer care service in PHCC (Hayyak team) supported recruitment of patients for the study. There are no plans to disseminate results to the study participants directly. However, it is intended to share the results with WBCs where the study was conducted. It is likely that study participants will become aware of them when they visit WBCs in the future.

Results

Of the total 350 study participants identified, laboratory data was available for 306 of them giving a response rate of 87.4%, but still over the figure required by calculation for statistical relevance (i.e. n=292). **Figure (1)** demonstrates the prevalence of the dependent variables.

As shown in **Table (1)**, when the relation between ID and background characteristics of the infants was assessed, it was found that ID is more common in males. However the relationship was not statistically significant. There was a statistically significant higher prevalence of ID among Non-Qatari infants compared to their Qatari counterparts.

Table (1): Relation between ID and infants' background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Gender					
Male	146 (89.6)	17 (10.4)	163	0.686	0.265
Female	132 (92.3)	11 (7.7)	143		
Nationality					
Qatari	57 (98.3)	1 (1.7)	58	4.748	**0.029**
Non Qatari	221 (89.1)	27 (10.9)	248		
Gestational age					
Pre-term (< 37 weeks)	23 (88.5)	3 (11.5)	26	0.195	0.433
Full-term (≥ 37 weeks)	255 (91.1)	25 (8.9)	280		
Birth weight					
Low (< 2500 grams)	18 (90)	2 (10.0)	20	0.019	0.565
Normal (≥ 2500 grams)	260 (90.9)	26 (9.1)	286		
Mode of child delivery					
Normal	183 (91.5)	17 (8.5)	200	0.294	0.364
Caesarean section	95 (89.6)	11 (10.4)	106		
Twins, triple or multiple birth					
No	270 (90.6)	28 (9.4)	298	0.827	0.460
Yes, twins	8 (100)	0 (0)	8		

In terms of background characteristics of parents, the relation of ID with mother's employment status and the family income were found to be statistically significant, as shown in **Table (2)**.

Table (2): Relation between ID and infants parents background characteristics

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Mother's age					
≤ 25 years	55 (88.7)	7 (11.3)	62		
26 – 35 years	182 (91.9)	16 (8.1)	198	0.778	0.678
More than 35 years	41 (89.1)	5 (10.9)	46		
Number of mother's pregnancy (including miscarriage)					
< 4	187 (91.2)	18 (8.8)	205	0.102	0.749
> 4	91 (90.1)	10 (9.9)	101		
Mother's education level					
Illiterate	6 (75.0)	2 (25.0)	8		
Up to secondary school	91 (93.8)	6 (6.2)	97	3.598	0.165
University educated and above	181 (90.0)	20 (10.0)	201		
Father's education level					
Up to secondary school	93 (93.0)	7 (7.0)	100	0.826	0.246
University educated and above	185 (89.8)	21 (10.2)	206		
Mother's employment status					
Housewife	186 (87.3)	27 (12.7)	213	10.480	**≤ 0.05**
Working job	92 (98.9)	1 (1.1)	93		
Father's occupation					
Manual worker	31 (91.2)	3 (8.8)	34		
Clerk/administrative	85 (87.6)	12 (12.4)	97	1.904	0.593
Professional	118 (92.9)	9 (7.1)	127		
Others	44 (91.7)	4 (8.3)	48		
Total number of children in the family					
1	81 (94.2)	5 (5.8)	86		
2-3	134 (90.5)	14 (9.5)	148	2.140	0.343
More than 3	63 (87.5)	9 (12.5)	72		
Family income in Qatari Riyals (QR)					
Up to10000 QR	107 (82.9)	22 (17.1)	129		
10001-20000 QR	99 (95.2)	5 (4.8)	104	17.369	**≤ 0.05**
More than 20000 QR	72 (98.6)	1 (1.4)	73		

Table (3) shows several statistically significant relations between ID in infants and their feeding practice and iron supplementation.

Table (3): Relation between ID and feeding practice

Characteristic	No ID (%)	ID (%)	Total	χ^2	*p* value
Exclusive breastfeeding for 6 months					
Yes	51 (81.0)	12 (19.0)	63	7.915	**0.007**
No	208 (92.9)	16 (7.1)	224		

Frequency of breastfeeding					
All or almost all feeds	142 (86.1)	23 (13.9)	165		
About half of all feeds	76 (93.8)	5 (6.2)	81	8.893	**0.012**
Few feeds since was born	41 (100.0)	0 (0)	41		
Continuation of breastfeeding at one year					
Yes	115 (82.7)	24 (17.3)	139	17.268	**≤ 0.05**
No	144 (97.3)	4 (2.7)	148		
Breastfeeding intake within the last 24 hours					
Yes	112 (82.4)	24 (17.6)	136	18.281	**≤ 0.05**
No	147 (97.4)	4 (2.6)	151		
Ever take infant formula milk (n= 306)					
Yes	225 (95.3)	11 (4.7)	236	25.011	**≤ 0.05**
Never	53 (75.7)	17 (24.3)	70		
Age at introducing of any solid, semi-solid or soft food (n= 306)					
Less than 6 months	72 (91.1)	7 (8.9)	79	0.011	0.917
6 months or more	206 (90.7)	21(9.3)	227		
Ever take iron supplementation (n= 306)					
Yes	27 (96.4)	1 (3.6)	28	1.154	0.283
No	251 (90.3)	27 (9.7)	278		

The differences in mean frequency of consumption for different groups of food is shown in **Table (4)**, where infants diagnosed with ID consumed less plant foods rich in iron, and the difference was statistically significant. However, the difference was not significant for animal sources of iron and the overall score of food frequency.

Table (4): Relation between ID and food frequency score

Food item	Mean ± SD		*Student's t test*	*p* value
	No ID	ID		
Overall score	21.2 ± 3.9	19.89 ± 4.0	1.64	0.12
Animal Source of iron	7.9 ± 2.3	7.9 ± 2.2	0.02	0.98
Plant source of iron	13.2 ± 2.8	11.9 ± 2.7	2.26	**0.03**

When the relation between ID and infant feeding counseling for mothers was assessed, there was a significant relationship between receiving counseling and ID occurrence, as the prevalence of ID was higher among infants to mothers didn't receive feeding counseling compared to infants of mothers received such counseling (13.4 against 4.2%) respectively, with (χ^2= 7.731 and ***p*= 0.005**).

From the BMI for age based on z-score, ID prevalence was variable among different BMI groups.[35, 36] It was as high as 16.7%among wasted/severely wasted infants, 9.7% among infants at risk of overweight, 9.4% among infants with normal BMI and as low as 5.6% among the overweight/obese group of infants. These relationships were not statistically significant (χ^2= 1.007 and p= 0.799).

Discussion

This is the first population-based descriptive epidemiological study to estimate the prevalence and associated factors of ID and IDA in infants in Qatar. We found a prevalence of anemia, ID and IDA among infants of 23.5%, 9.2% and 7.8% respectively, which is much lower than the published global prevalence.[37]

Being a cross-sectional study temporality cannot be assessed. Assessing parental/care-giver feeding practices retrospectively is prone to recall bias. Other potential limitations include the use of single rather than combined indicators of anemia (i.e. Hb) and serum ferritin and CRP for IDA. Other measurements of anemia might have included zinc protoporphyrin and iron deficiency could also be confirmed by microscopy (microcytic, hypochromic cells) and measurement of total iron binding capacity (TIBC). Such measurements might help to reduce the potential for under or overestimating prevalence of anemia, ID and IDA. Differences in the applied diagnostic criteria and laboratory cutoff values in identification of anemia, ID and IDA across different studies also limit the ability of a precise comparison.

Comparing these findings with figures published for other countries of the EMR, it appears that many of them have an even higher burden of disease. The WHO report, 2013 also showed no improvement in the overall anemia situation among pre-schoolers where 63% of children under the age of 5 years had IDA.[16, 38] The prevalence of anemia, ID and IDA in our study was also lower than in the United Arab Emirates, Kuwait and Saudi Arabia.[29, 39, 40] A study conducted in Raparin teaching hospital for children in Erbil - Iraq, 2007, among infants aged (12 - 24) months, showed that the prevalence of ID ranged between 51.9% and 48.1%. It also showed that about 53% and 30 % of participants had anemia and IDA respectively.[41]

Qatar has implemented a well-developed and comprehensive well baby program at PHC centers. In a study undertaken in 2011 at Ain Shams University Children's Hospital in Egypt which included three hundred poor Egyptian infants, anemia was diagnosed in 66% of the participants aged between 6 and 24 months, and among them, 43% had IDA.[42] This high prevalence rate may be due to the selection of a high-risk group for the study. Similar results were also seen in Kassala (Eastern Sudan) where up to 86% of young children less than three years of age living were diagnosed with IDA.[43]

On the other hand, the prevalence of anemia, ID and IDA found in this study is still high compared to many developed countries. Male C *et al*, 2001 showed that the prevalence of anemia, ID and IDA was 9.4%, 7.2% and 2.3% respectively.[24] The difference in prevalence compared to this study may be attributed to the cut-off point of SF, the eligibility criteria and/or the disease determinants between the two populations. A study from Estonia undertaken between July 2002 to March 2005 of 171 infants aged 9 to 12 months, found a prevalence of ID and IDA of 14.0% and 9.4, % respectively. The study utilized a cut-off value for Hb of <10.5 g/dl and for serum ferritin of <12 μg/L.[28]

In relation to the potential determinants of ID in this study, gender did not appear to be a factor as there was no statistically significant difference between male and female participants. This is consistent with Vendt *et al*,2007.[28] However , in a study from Iran, of 33 cases diagnosed with IDA, 26 children (78.8%) were males and the prevalence of IDA was statistically significant among male compared with female infants (p = 0.015).[44] Another study of 201 infants in Iran showed a prevalence of IDA of 61.5% among male infants. Employing a multiple logistic regression model, the researchers reported that male gender was the most important ID risk factor in their study (OR = 3.3; 95% CI 1.7-6.3; and $p < 0.001$).[45]

In this study, we found a statistically significant higher prevalence of ID among non-Qatari infants compared to their Qatari counterparts. This difference can be attributed to possible difference in economic, social and/or nutritional attributes. ID was more common among those infants born pre-term compared to infants born full term. However, this result is not statistically significant. In other studies from Canada, prematurity and intra-uterine growth retardation were shown to be risk factors for ID and IDA associated with low hepatic and bone marrow iron stores at birth.[18] A clinical report from the American Academy of Pediatrics indicated that the deficit of total body iron in preterm infants increases with decreasing gestational age, is worsened by the rapid postnatal growth that many infants experience and by frequent phlebotomies without adequate blood replacement. All these are risk factors for ID. [3]

Infants with low birth weight were shown to be more prone to ID compared to those born with normal weight. This finding is similar to a study conducted in Estonia where the mean birth weight among the iron deficient group was significantly lower than that in the control group. [28]

Concerning the infant's mode of delivery in this study, those infants born through caesarean section showed higher risk of iron deficiency than those born through normal delivery. This finding is consistent with results of a systematic review and meta-analysis which synthesized evidence that compared with vaginal delivery, caesarean section is associated with reduced placental transfusion and poor iron-related hematologic indices in both cord and peripheral blood. This in turn indicates that neonates delivered by caesarean section might be more likely to develop iron deficiency anemia later in infancy compared to their normally delivered counterparts.[30]

In this study, ID was more common among infants born to younger mothers aged 25 years or less (11.3%) compared to among infants of mothers aged 26 - 35 years (8.1%) and for infants of mothers aged more than 35 years (10.9%). Similarly an exploratory descriptive study conducted in Egypt with 400 healthy children aged 12 to 24 months reported that iron deficiency was more prevalent among infants of mothers aged 20-29 years old (67.2%) compared with infants of mothers aged more than 30 years (22.4%) and infants of mothers aged less than 20 years old (10.4%).[46] An explanation for this may be related to the lack of infant feeding experience of young mothers . We found that ID was more common among infants born to illiterate mothers compared to mothers with higher education. However, the findings were not statistically significant. Similarly, the relationship with parental education was not statistically significant. Our findings are similar to a study which showed a statistically significant difference between IDA among children below the age of two years and the level of parental education. In that study, the highest percentage of anemia cases (32.1%) were found in infants of illiterate mothers (X^2=21.775 and p = 0.0001).[46]

On the contrary, a study from Iran reported that educational level of the mother did not have an effect on the iron status of infants. [44] Our study also showed that ID was more prevalent among infants born to mothers who were housewives compared to those born to working mothers, and the relationship was statistically significant. This finding is consistent with the results of a study conducted in Alexandria, Egypt, where 88.4% of infants born to non-working mothers had IDA compared to only 15.4% of those born to working mothers.[46] The difference could be explained by possible higher education and knowledge among working mothers compared to housewives, and thus better feeding practices and/or that working mothers are more reliant on formula feeding and breastfeed less compared to their housewife counterparts.

Prevalence of IDA in infants from families with more than three children was high compared to those infants born to families with 2-3 children and to families with only one child. This corroborates a study undertaken in Iraq where low serum iron was found in children from families which had 4 children or more compared to families that had less than 4 children.[41] However, a study conducted in Iran in 2007 reported no significant difference between IDA prevalence and the total number of children in the infant's family ($P > 0.05$).[44]

The relationship between ID and history of exclusive breastfeeding for six months, frequency of breastfeeding, continued breastfeeding at one year and intake of breast milk within 24 hours prior to the interview were statistically significant in this study. Similar results were found in a study from Estonia in which infants exclusively breastfed until the age of 6 months had significantly lower Hb and ferritin levels compared to those exclusive breastfed only until the age of 3 months.[28] Other studies have reported prevalence rates of IDA of 27% in infants exclusively breastfed up to 6 months, 16.7% in infants fed with formula milk and 100% in infants fed with cow's milk (p=0.033).[44] The figures appear to reflect the iron content of different types of milk with levels higher in formula milk (fortified with iron) and relatively low in breast milk and fresh cow's milk. Prolonged exclusive breastfeeding has been suggested to decrease the intake of dietary iron, which in turn leads to iron deficiency especially in growing infants beyond the age of 6 months when the needs for iron may not be adequately met by continuation of exclusive breastfeeding.[18-22] In South Korea a study of 87 healthy full-term infants showed that at 6 months of age, the incidences of ID and IDA in breast-fed only infants were 33% and 30%, respectively, significantly higher than formula fed (8% and 5%, respectively) and those breast-fed with iron supplementation (7% and 5%, respectively). At 12 months of age, the incidences of ID and IDA in breastfed were 64% and 50%, respectively, again significantly higher than the other groups. [23] The established reason is the beneficiary influence of the iron fortifying formula milks on the infants' stores of iron as demonstrated in many studies.[18,47]

In the current study, mothers were asked about frequency of consumption of different food items rich in iron, which was used to calculate the food frequency score derived from a previous study conducted in Qatar.[48] The findings showed that infants who suffered ID consumed less plants rich in iron compared to their counterparts without ID, and the difference was statistically significant (t test= 2.26 and p= 0.03). No significant differences were found when studying animal sources of iron and the overall score of food frequency. This finding supports mentioned previous Qatari study in which ID was more common among pregnant women with high consumption of food items containing iron of plant sources (t *test*= 0.2 and p=

0.834) compared to food items containing iron of animal sources (*t test*= 1.6 and *p*= 0.100). They related this to less bio-available iron in food items of plant origin compared to animal origin.

Our finding of higher prevalence of ID among infants who started solid, semi-solid or soft food at age of 6 months or later compared to those who started before the age of 6 months is similar to the results of other studies where infants fed with solid food before 6 months had statistically higher Hb values than those who were introduced to solid food after 6 months of life.[25,28,47]

Infants on iron supplementation were less likely to be iron deficient in this study. This finding supported by a study where infants with iron supplementation had higher Hb concentration and higher MCV.[3] In another study conducted on 126 infants divided into 3 groups, where 86 cases received iron supplementation irregularly, 27 cases regularly and 13 cases never received iron, IDA in the first group was 26.7%, 3.7% in the second group and 69.2% in the third group who never received any iron supplementation. The relationship between IDA and no iron supplementation was statistically significant ($p< 0.001$).[44] Similarly, significantly lower ferritin concentrations in 6-month-old infants have been reported in infants who were exclusively breastfed compared to infants who were breastfed and took iron supplementation.[18]

We found a significant relationship between maternal infant feeding counseling and prevalence of ID. In a previous US study, ID prevalence decreased among African American children aged 1-3 years old, from 16% to 6% between years 1976 and 2002. This marked decline was attributed to implementation of the Women, Infants and Children Program which targeted specific groups of mothers and families with counseling, and this led to improvement in infant feeding practices to prevent ID.[46]

Our finding of higher ID prevalence among infants born to mothers with a history of having four pregnancies (9.9%) or more, compared to infants born to mothers with less than four pregnancies (8.8%) may be attributed to the possible depletion of the mother's body stores of iron, especially with multiple tightly close pregnancies,.[18,44]

Iron deficiency prevalence was variable among different infant BMI groups. These relations were statistically insignificant. On the other hand, a study conducted in the US indicated that overweight children (1-3 years old) had triple the odds of ID prevalence compared with normal weight or underweight children and ID prevalence remained consistently high for overweight children at 20% to 24%.[49] A second study from the US showed that ID prevalence was 20% among those with overweight, 8% for those at risk for overweight, and 7% for normal-weight toddlers (1-3 years old).[50] The possible explanation to this contradiction with the results seen in the two US studies is that, anemia, ID and IDA are mostly related to the imbalance between iron needs and dietary sources of iron, rather than the relation with the caloric content of infant's nutrition or body composition. In this study, we had a very small insignificant number of participating infants who were wasted or severely wasted.

To the best of our knowledge, this is the first population-based study about ID and IDA among infants in Qatar covering a critical age of infancy (12 months). As PHCC is the main provider of WBC services in Qatar the findings provide useful baseline data which can be used in future studies including a critical look at the impact of infant feeding practices especially prolonged exclusive breastfeeding in low income families.

Conclusion

Although ID and IDA among infants in the State of Qatar are less prevalent compared to several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anemia in this study was 23.5%, ID was 9.2% and IDA was 7.8%. ID was significantly associated with non-Qatari infants, those whose mothers were un-employed or belonged to a family with low total monthly income. Infants exclusively breastfed for 6 months, breastfed more frequently, and those who continued breastfeeding at the age of one year, or who never took infant formula milk were also at higher risk. Furthermore, those who frequently consumed plant sources of dietary iron and had a mother that did not receive infant feeding counseling were at greater risk of ID and IDA.

We believe that these findings are worth further exploration and that they fill gaps in our current knowledge and can help us to plan public health interventions at national as well as regional level in the Gulf Cooperation Council (GCC) countries.

Recommendations

Longitudinal studies in a larger cohort to confirm these findings would be useful in helping to better understand the extent of the problem in Qatar and other countries of the Gulf Cooperation Council (GCC) region which share a similar structure, culture, behavior and sociodemographic characteristics.

Integration of mass ID and IDA screening prior to 12 months visit to allow for early intervention in addition to proper counseling regarding breast feeding and proper weaning practice is also recpmmended.

Acknowledgments

We are extremely grateful to all the mothers who took part in this study, the staff of the WBCs, customer care service in PHCC (Hayyak team) and data collectors for their support and guidance. We also thank Dr. Rajvir Singh for his invaluable statistical assistance.

Ethical approval

Appropriate approvals obtained from the Arab Board of Medical Specialization, Institutional Review Board of HMC and the PHCC Research Committee.

Funding

The funding of this study is received from the Research Center at HMC, state of Qatar.

Patient consent

Mothers of participants were consented in written after appropriate description of the study aim and value.

Competing interest

None declared.

Figure legends

Figure (1): Among the three hundred and six infants of completed 12 months of age and lesser than 13 months; 72 (23.5%) had anemia which defined as hemoglobin <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), 28 (9.2%) had iron deficiency (ID) which defined as Serum Ferritin (SF) below normal reference range (6-24 ug/L) in absence of high C-Reactive Protein (CRP), and 24 (7.8%) had iron deficiency anemia (IDA) which defined by combination of three elements - hemoglobin <11.1 g/dl (normal reference range is 11.1-14.1 g/dl), low SF (<6 mcg/L) and absence of high CRP (reference level is normally less than 5 mg/L).

Data sharing statement

No additional data are available.

Contribution to authorship

AJZ, NAS and SAK designed the study and wrote the primary proposal. AJZ and SAK managed data collection and fieldwork. SRO and AJZ did literature review, data analysis, results interpretation and wrote the discussion. AJZ, SRO and NAS drafted and revised the manuscript. AJZ finalized and submitted the manuscript.

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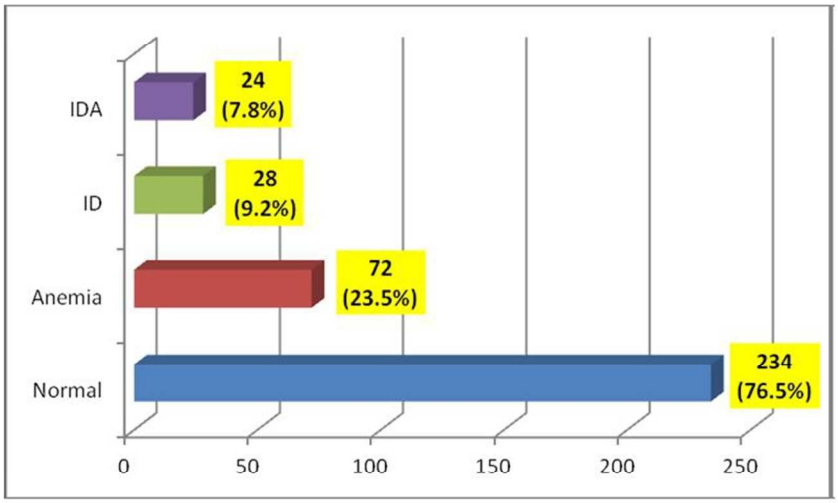

Figure (1): Distribution of study infants according to their anemia, iron deficiency and iron deficiency anemia status

81x60mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2 - 4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4, 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6 - 8
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6 - 8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	NA

		which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	6 - 8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9 - 12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.