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

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ABSTRACT

Objectives To estimate the magnitude of anaemia, iron deficiency (ID), iron deficiency anaemia (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 healthcare centres 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 anaemia, ID and IDA.

Outcome measures Cut-off point used to diagnose anaemia was haemoglobin <11.1 g/dL, and to diagnose ID, serum ferritin <6 ug/L with normal C reactive protein.

Results Prevalence of anaemia was 23.5%, ID was 9.2% and IDA was 7.8%. ID was more prevalent among non-Qatari infants compared with Qatari (10.9% vs1.7%, p=0.029), more prevalent among infants born to housewives and to families of low income (p≤0.05). With regard to feeding practice, ID was higher in infants who continued breastfeeding until the age of 1 year and among those who never took infant formula milk (p≤0.05). Mothers who received infant feeding counselling had less ID occurrence among their infants compared with their counterparts who did not receive such counselling (4.2%vs13.4%, 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 contextualised and should target the key epidemiological features with special emphasis on infant feeding and infant feeding counselling to mothers.

INTRODUCTION

Infants and young children are vulnerable to anaemia especially iron deficiency anaemia (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] Anaemia 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]

Anaemia may be defined as haemoglobin (Hb) concentration 2 SD below the mean Hb concentration for a normal population of the same gender and age range. ID, the the most common cause of anaemia, is characterised 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 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% has 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 most common micronutrient deficiencies in the region in addition to iodine and vitamin A.[15] According to WHO, in 2013 63% of children under 5 years in the Eastern Mediterranean region (EMR) had IDA and in some studies, anaemia 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 4–6 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 mobilised 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 months 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 lead to a negative nutrient balance.[2] In general, prolonged exclusive breast feeding (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 characterised by consumption of foods with low amounts of bioavailable iron or foods with inhibitors to iron absorption. Such practices often extend up to the age of 2 years.[18 25]

Infant feeding counselling 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 caesarean section are more likely to get ID, as their delivery is associated with reduced placental transfusion and poor iron-related haematological 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 breast feeding, 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 healthcare (PHC) centres include routine screening of infants for anaemia during their measles, mumps and rubilla (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 anaemia 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 extent of the problem in the state of Qatar.

METHODS

A cross-sectional study was conducted at WBCs in Primary Health Care Corporation (PHCC) centres. 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 centres across Qatar operating at time of the study, 14 were providing the WBC service. Infants in the WBC appointment system who attended the selected centres 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 visit were eligible. Participants diagnosed with sickle cell anaemia or thalassaemia 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% was added bringing to 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 show 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 serum ferritin (SF) below normal reference range (6–24 ug/L) in the absence of high C reactive protein (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 500I 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 using human ferritin agglutination with latex particles coated with antiferritin antibodies. The precipitate is determined turbidimetrically at 570/800 nm.

Independent (exposure) variables included sociodemographic characteristics of infants and their parents, birth history of the participant, history of maternal pregnancies, breast feeding, intake of infant formula milk, iron supplementation, infant feeding counselling 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 one to three times/month, 3 for one to six 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 a thorough discussion and assessment by experts in the fields of paediatric haematology 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 (WBCs) for all infants aged 12 months as per their protocol to check for anaemia. Additional laboratory studies for ID detection using these samples were managed in the haematology laboratory of Qatar's

secondary healthcare provider, the Hamad Medical Corporation (HMC).

To avoid measurement bias, all investigations were conducted in accredited laboratories which apply the Qatari 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 V.20) was used for data entry and analysis. Descriptive analysis was undertaken (*frequency distribution tables, proportions, mean and SD),* in addition to analytical statistics (χ^2 *test and Fisher's exact probability test*) to assess differences between two or more proportions and the *Student's t-test* was used to compare continuous variables. An α (*p*) value of ≤0.05 was used as the cut-off level of significance.

Quality control measures

The questionnaire was pretested using a convenient sample of 20 infants. Their data were 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 haematology and paediatrics. In order to prevent any missing data, authors had checked the completeness of data required within each questionnaire and the questionnaires were given serial numbers to allow identification of any missing data during data entry. The main researchers did all data entry and review. Standardised 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 were excluded from further analysis.

Ethical considerations

Permission was also obtained from PHCC centre 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 for possible inconvenience resulting from extra blood withdrawal. Privacy and confidentiality of participants' data was assured. Mothers were invited to participate voluntarily and were 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 anaemia 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
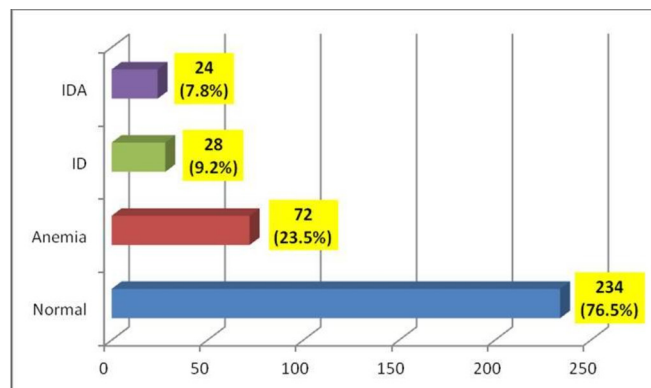
Figure 1 Among the 306 infants 12 months of age and lesser than 13 months, 72 (23.5%) had anaemia which was defined as haemoglobin <11.1 g/dL (normal reference range is 11.1–14.1 g/dL), 28 (9.2%) had iron deficiency (ID) which was defined as serum ferritin (SF) below normal reference range (6–24 ug/L) in absence of high C reactive protein (CRP), and 24 (7.8%) had iron deficiency anaemia (IDA) which was defined by a combination of three elements: haemoglobin <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).

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 were available for 306 of them giving a response rate of 87.4%, but still over the figure required by calculation for statistical relevance (ie, 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 boys. However the relationship was not statistically significant. There was a statistically significant higher prevalence of ID among Non-Qatari infants compared with their Qatari counterparts.

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

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.

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

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

Characteristic	No ID(%)	ID(%)	Total	χ^2	P values
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					
Preterm (<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		

Table 2 Relation between iron deficiency (ID) and infants' parents' background characteristics

Characteristic	No ID(%)	ID(%)	Total	χ^2	P values
Mother's age					
≤25 years	55 (88.7)	7 (11.3)	62	0.778	0.678
26 –35 years	182 (91.9)	16 (8.1)	198		
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	1.904	0.593
Clerk/administrative	85 (87.6)	12 (12.4)	97		
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	2.140	0.343
2–3	134 (90.5)	14 (9.5)	148		
More than 3	63 (87.5)	9 (12.5)	72		
Family income in Qatari riyals (QRs)					
Up to10 000 QRs	107 (82.9)	22 (17.1)	129	17.369	≤**0.05**
10 001–20 000 QRs	99 (95.2)	5 (4.8)	104		
More than 20 000 QRs	72 (98.6)	1 (1.4)	73		

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 anaemia, 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/caregiver feeding practices retrospectively is prone to recall bias. Other potential limitations include the use of single rather than combined indicators of anaemia (ie, Hb) and SF and CRP for IDA. Other measurements of anaemia might have included zinc protoporphyrin and ID could also be confirmed by microscopy (microcytic, hypochromic cells) and measurement of total iron binding capacity. Such measurements might help to reduce the potential for underestimating or overestimating prevalence of anaemia, ID and IDA. Differences in the applied diagnostic criteria and laboratory cut-off values in identification of anaemia, ID and IDA across different studies also limit the ability of a precise comparison.

Table 3 Relation between iron deficiency (ID) and feeding practice

Characteristic	No ID(%)	ID(%)	Total	χ^2	P values
Exclusive breast feeding 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 breast feeding					
All or almost all feeds	142 (86.1)	23 (13.9)	165	8.893	**0.012**
About half of all feeds	76 (93.8)	5 (6.2)	81		
Few feeds since birth	41 (100.0)	0 (0)	41		
Continuation of breast feeding at 1 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 introduction of any solid, semisolid 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		

Comparing these findings with figures published for other EMR countries, it appears that many of them have an even higher burden of disease. The WHO report (2013) also showed no improvement in the overall anaemia situation among preschoolers where 63% of children under the age of 5 years had IDA.[16 38] The prevalence of anaemia, 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, in 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 anaemia and IDA, respectively.[41]

Qatar has implemented a well-developed and comprehensive well baby programme at PHC centres. In a study undertaken in 2011 at Ain Shams University Children's Hospital in Egypt which included 300 poor Egyptian infants, anaemia was diagnosed in 66% of the participants aged between 6 months 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 3 years of age were diagnosed with IDA.[43]

On the other hand, the prevalence of anaemia, ID and IDA found in this study is still high compared with many

Table 4 Relation between iron deficiency (ID) and food frequency score

Food item	Mean±SD		Student's t-test	P values
	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**

studies have reported prevalence rates of IDA of 27% in infants exclusively breastyfed 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 breast feeding has been suggested to decrease the intake of dietary iron, which in turn leads to ID especially in growing infants beyond the age of 6 months when the needs for iron may not be adequately met by continuation of exclusive breast feeding.[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 breastfed 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 infants were 64% and 50%, respectively, again significantly higher than the other groups.[23] The established reason is the beneficial 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 with 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 the previously mentioned Qatari study in which ID was more common among pregnant women with high consumption of food items containing iron from plant sources (t-$test$=0.2 and p=0.834) compared with food items containing iron from animal sources (t-$test$=1.6 and p=0.100). They related this to less bioavailable iron of plant origin compared with animal origin in food items.

Our finding of higher prevalence of ID among infants who started solid, semisolid or soft food at the age of 6 months or later compared with 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 was supported by a study where infants with iron supplementation had higher Hb concentration and higher mean corpuscular volume (MCV).[3] In another study conducted on 126 infants divided into three 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 breast fed compared with infants who were breast fed and took iron supplementation.[18]

We found a significant relationship between maternal infant feeding counselling and prevalence of ID. In a previous US study, ID prevalence decreased from 16% to 6% between the years 1976 and 2002 among African-American children aged 1–3 years. This marked decline was attributed to implementation of the Women, Infants and Children programme which targeted specific groups of mothers and families with counselling, 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 with 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]

ID prevalence was variable among different infant BMI groups. These relations were statistically insignificant. On the other hand, a study conducted in the USA indicated that overweight children (1–3 years old) had three times 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 USA showed that ID prevalence was 20% among 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, anaemia, 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 breast feeding in low-income families.

CONCLUSION

Although ID and IDA among infants in the state of Qatar are less prevalent compared with several developing countries including those in the EMR, they are still relatively higher than rates seen in the developed ones. The prevalence of anaemia 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 unemployed or belonged to a family with low total monthly income. Infants exclusively breast fed for 6 months, breast fed more frequently, and those who continued breast feeding at the age of 1 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 counselling 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 levels 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 GCC region countries, which share a similar structure, culture, behaviour and sociodemographic characteristics.

Integration of mass ID and IDA screening prior to the 12-month visit to allow for early intervention in addition to proper counselling regarding breast feeding and proper weaning practice is also recommended.

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