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THE ADEQUACY OF MICRONUTRIENTS FROM COMPLEMENTARY FOOD AMONG INFANTS LESS THAN TWO YEARS IN ALEXANDRIA, EGYPT

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ABSTRACT

Purpose: This paper assesses the dietary intake and adequacy of micronutrients from complementary foods among infants under two years of age.

Design/methods: A cross-sectional study was conducted on 400 healthy infants aged 6–24 months. The studied sample was proportionally allocated and randomly selected from eight primary health care centres in Alexandria. Data about socioeconomic characteristics, medical history, breastfeeding practices, and dietary intake were collected from the mother of each infant. The weight and height (length) of each subject were measured.

Findings: An inadequate intake of all micronutrients was found in a considerable percentage of children. The highest percentage of inadequacy was found among children under 12 months of age with respect to iron and vitamin C, and among children aged 12–24 months with respect to thiamine and calcium. Most infants had fair breast feeding practices (88.3%). The rate of stunting, wasting, underweight for age, overweight and obesity was 37%, 12.8%, 16.7%, 19.5% and 18.1% of infants, respectively.

Social implications: Nutrition education was recommended for mothers about the health and nutrition of their infants and preparation of safe nutritious complementary foods.

Originality/Value: This is the first study done at a sub-national level addressing micronutrient adequacy among infants in Alexandria, Egypt.

Keywords: Micronutrients, dietary intake, adequacy, complementary food

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INTRODUCTION

Adequate nutrition during infancy is essential for lifelong health and wellbeing. Infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health (Butte et al., 2002). Breast milk is deficient in some important nutrients and becomes inadequate for the infant above six months of age. When breast milk is no longer enough to meet the nutritional needs of the infant, foods should be added to the diet of the child. Breast milk adequacy may be altered by the type and amount of offered foods. The transition from exclusive breastfeeding to family foods, referred to as complementary feeding, typically covers the period from 6 to 18–24 months of age and is a very vulnerable period (WHO, 2003; Marriott et al., 2012). There may need to be closer monitoring of the consumed complementary food to avoid possible nutritional deficiencies (Fegan et al., 2016; Vossenaar and Solomons, 2012).

The first two years of a child's life are particularly important. Optimal nutrition during this period lowers morbidity and mortality, reduces the risk of chronic diseases and fosters better development overall (Marriott et al., 2012). There is a large and increasing evidence to indicate that nutrition and health affect children's cognitive, motor, and behavioural development both pre- and post-natal (Grantham-McGregor et al.,1999). In developing countries, millions of young children suffer from nutritional deficiencies and frequent infections. Malnutrition caused by micronutrient deficiency increases a child's vulnerability to communicable diseases by affecting the body's resistance to infections (Rice et al., 2000; Keusch, 2003).

Few children receive nutritionally adequate and safe complementary food. In many countries, only one third of breastfed infants aged 6–23 months meets the criteria of dietary diversity and feeding frequency that are appropriate for their age (Marriott et al., 2012). Cereals or starchy roots and tubers are used as a basis for the complementary foods in developing countries, usually prepared as thin gruels. As a result, their energy and nutrient content and density are low (Martin et al., 2010). Moreover, if these complementary foods are consumed with breast milk, they may actually compromise the bioavailability of certain trace minerals (iron and zinc) in the breast milk. Unfortunately, the phytic acid, dietary fibre and polyphenol content of many plant-based complementary foods is high; these dietary components are known to inhibit the absorption of some macro and trace minerals (WHO, 2003).

There is strong evidence for the contribution of zinc deficiency to growth faltering among children; even mild to moderate zinc deficiency may affect growth. Vitamin A and iron deficiencies have also been demonstrated to cause growth faltering, however only when the deficiency state of these nutrients is severe (Dewey and Mayers, 2011; Rivera et al., 2003). This study, therefore, aimed to assess the dietary intake of vitamin A, iron, zinc and other micronutrients in complementary fed infants; it also investigated if these micronutrients were adequate to meet those infants' requirements for growth.

SUBJECTS AND METHODS

Study Design and Sampling

A cross-sectional study was conducted from September 2015 to January 2016 on 400 apparently healthy infants aged 6–24 months. The sample size was calculated based on the percentage of infants who consumed food rich in vitamin A, which was 36.2% according to the Egyptian Demographic and Health Survey (EDHS) for 2008 (El-Zanaty and Way, 2013). Using Epi info "6" software, a desired precision of 7%, 95% confidence level and design effect 2, the minimum required sample size was calculated to be 363 infants; this was rounded to 400 infants.

A multistage stratified random technique was used in this study. Four districts were selected at random from a list containing the eight health districts of Alexandria Governorate. Two primary health care (PHC) centres were selected at random from a list containing all PHC centres from each selected district. Therefore eight PHC centres were included in this study, namely Sidi Bishr and Toson from El-Montaza district, Sidi Gaber and Smouha from East district, El-Hadara and Moharam Bey from Middle district, and Karmouz and Mina El-Basal from West district. From each PHC centre, 50 infants were selected at random to fulfil the required sample size of the study.

Data Collection and Study Questionnaire

A structured questionnaire was used for interviewing each enrolled infant's mother, and to collect data about socioeconomic characteristics (age, sex, parents' education and work, date of birth, birth order, and birth weight), medical history (presence of any symptoms of diarrhoea, vomiting, persistent cough, and fever in the previous two weeks), and breast feeding practices (number of breast feeds per day, duration of breast feeding session in minutes, number of changed diapers per day, and length of exclusive breast feeding period).

Parents' education was categorised into middle education (primary, preparatory and secondary education) and higher education (university education or above). The breast feeding practices score was calculated from three parameters as follows: number of breast feeds per day (less than 6 feeds per day was given score 1, 6–10 feeds was given score 2, and more than 10 feeds was given score 3), duration of breast feeding session in minutes (less than 10 minutes for each session was given score 1, 10–20 minutes was given score 2, and more than 20 minutes was given score 3), and number of changed diapers per day (3 diapers per day was given score 1, 4 diapers given score 2, and 5 diapers given score 3). The total maximum score was 9 and subjects were categorised according to their own score into having poor ($<$60% of total score), fair (60–80% of total score) and good ($\geq$80% of total score) breast feeding practices.

Anthropometric measures of weight and height (length) were measured for each infant at the time of interview according to Gibson's criteria (Gibson, 2005). The anthropometric indices length for age, weight for length, and weight for age were computed using "WHO anthro" software version 3.2.2 to obtain the prevalence of stunting, wasting and underweight for age, respectively by Z-score (WHO, 2011). Body mass index (BMI) was calculated by dividing the body weight in kilograms by the square of height (length) in metres. BMI-for-age percentiles were categorised into underweight ($<5^{th}$ percentile), normal weight ($5^{th}$to$>$ 85^{th} percentile), overweight ($85^{th}$to$>$ 95^{th} percentile), and obese ($\geq$ 95^{th} percentile) according to WHO (2007) reference data (WHO, 2006).

Dietary Intake Assessment

Dietary intake data were collected using a food frequency list at the time of interview. The mean daily intake of the studied sample of infants from different complementary foods most commonly consumed by the infants during the weaning period, especially foods rich in vitamins A, C, thiamine and riboflavin, and minerals iron, zinc and calcium, was estimated. The data were analysed using Egyptian Food Composition tables of the National Nutrition Institute to get the daily intake of vitamins A, C, thiamine and riboflavin, and minerals iron, zinc and calcium (National Nutrition Institute, 2006). The percentage of nutrient adequacy was calculated and compared with the dietary reference intake (DRI) (Institute of Medicine, Food and Nutrition Board, 2011) of infants as follows: percentage adequacy of nutrient $=$ (nutrient intake for each infant/ DRI of nutrient) $\times$ 100). The daily intake was considered adequate if the nutrient adequacy was equivalent to $\geq$100%.

Statistical Analysis

After the completion of the data collection, data were revised, coded and fed to the computer using the Statistical Package for Social Science (SPSS), version "21", software (Chicago, Illinois, US) for tabulation and analysis. Data were presented in tabular, graphic and mathematic forms as frequencies and percentages, while quantitative variables were presented as the mean and standard deviation (SD). For all analyses, a P value $>$0.05 was used to detect any statistically significant difference. Data were analysed using a Chi-squared test for categorical data; a student's t-test was used to evaluate the significance of the difference between means of two groups associated with Levene's test for homogeneity of variance (Levesque, 2005).

Ethical Considerations

This study was conducted according to the guidelines laid down for medical research involving human subjects, and was approved by the Ethics Committee of the High Institute of Public Health, Alexandria University, Egypt. All measurements were taken following all privacy procedures, and all collected data were kept confidential. All infants' mothers were informed about the study purpose, and their verbal consent was taken. The authors declare that there are no conflicts of interest.

RESULTS

A total of 400 healthy infants aged 6–24 months participated in this study (180 boys and

Table 1 Socioeconomic Characteristics, Medical History and Anthropometric Measures of the Studied Sample

Variable	*No (%) (n=400)*
Sex	
Boys	180 (45)
Girls	220 (55)
Age (months)	
6−<12	178 (44.5)
12–24	222 (55.5)
Mean (SD)	13.46 (6.13)
Birth order	
1st	167 (41.7)
2nd	114 (28.5)
3rd	100 (25.0)
4th	19 (4.8)
Father's education	
Low	69 (17.2)
High	331 (82.8)
Father's work	
Craftsman	14 (3.4)
Employee	193 (48.3)
≠Other	193 (48.3)
Mother's education	
Low	56 (14.0)
High	344 (86.0)
Mother's work	
Housewife	281 (70.3)
Working	119 (29.7)
§Symptoms in the last 2 weeks	
Diarrhoea	135 (33.8)
Vomiting	102 (25.5)
Persistent cough	81 (20.3)
Fever	115 (28.8)
Anthropometric measures	**Mean (SD)**
Birth weight (kg)	2.97 (0.44)
Weight (kg)	10.00 (2.67)
Height (length) (cm)	76.95 (8.84)
BMI (kg/m^2)	16.79 (3.23)

§More than one response; ≠others: lawyers, doctors, teachers, policemen or freelancers

Source: Devised by authors

220 girls). The mean age of participants was 13.46±6.13months; more than half the studied sample (55.5%) was in the age range between 12–24 months. The studied infants were ordered 1st, 2nd, or 3rd birth in their families. The majority of parents were highly educated (82.8% of fathers and 86% of mothers). Most mothers were housewives (70.3%). The most encountered symptom in the last two weeks was diarrhoea (33.8%) followed by fever (28.8%). The mean birth weight for the studied sample of infants was 2.97±0.44 kg, while mean body mass index was 16.79±3.23 kg/m^2 according to their weight and height (length), as shown in Table 1.

Table 2 Breast Feeding Practices for the Studied Sample

Variable	*No (%) (n=400)*
Number of breast feeds per day	
<6	75 (18.7)
6–10	284 (71.0)
>10	41 (10.3)
Duration of breast feeding session (min)	
<10	365 (91.3)
10–20	45 (8.7)
Number of changed diapers per day	
3 diapers	101 (25.3)
4 diapers	197 (49.3)
5 diapers	102 (25.4)
***Length of exclusive breast feeding period* (n=333)**	
4 months	165 (49.5)
6 months	168 (55.5)
Total breast feeding practices score	
Mean (SD)	7.75 (1.2)
Breast feeding practices level	
Poor practices	21 (5.3)
Fair practices	353 (88.3)
Good practices	26 (6.4)

Source: Devised by authors

Table 2 illustrates that about three-quarters of the studied sample of infants (71%) had 6–10 feeds per day. The duration of a breast feeding session was <10 minutes in the majority of infants (91.3%). Most infants (49.3%) had four changes of diaper per day. Half of breast fed infants were exclusively breast fed for four months and the other half for six months. Most of the studied sample (88.3%) had fair breast feeding practices, where the mean breast feeding practice score was 7.75±1.2.

The rate of stunting, wasting and underweight for age was 37%, 12.8%, and 16.7% of infants, respectively. About half the number of infants under 12 months of age were stunted (51.1%), compared to 22.8% of infants aged 12–24 months. Wasting was prevalent among 15.1% of infants under 12 months of age, and 10.5% of the older group of infants. The difference was statistically significant between both groups ($P=0.042$), as shown in Figure 1. The rate of overweight and obesity was 19.5% and 18.1% of infants, respectively. Obesity and overweight were highly prevalent among infants aged 12–24 months (27.7% and 14.1%, respectively), compared to 8.4% and 5.1%, respectively of the younger infants. In contrast, underweight was high prevalent among infants aged less than 12 months (24.2%), compared to 11.3% of the older age of infants, as shown in Figure 2.

Table 3 demonstrates that the mean daily intake of all studied micronutrients was higher among infants aged less than 12 months with a statisti-

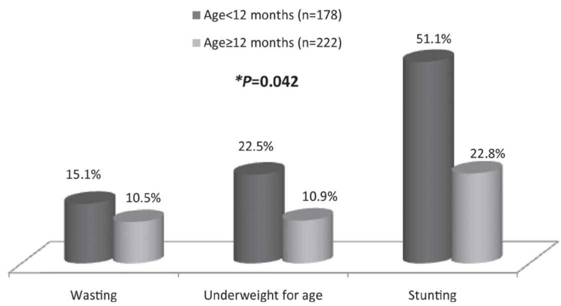

Figure 1 Wasting, underweight for age, and stunting among the studied sample

Source: Devised by authors

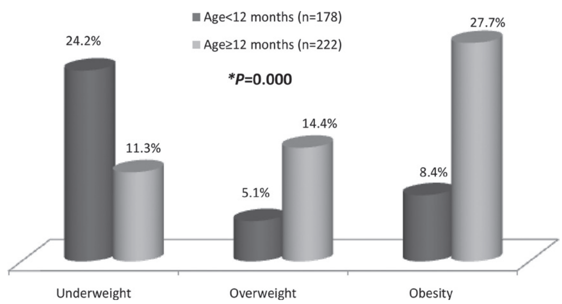

Figure 2 Obesity, overweight, and underweight among the studied sample

Source: Devised by authors

Table 3 Daily Micronutrient Intake and Adequacy Among the Studied Sample

Micronutrient	*<12 months (n=178) Mean (SD)*	*≥12 months (n=222) Mean (SD)*	*Total (n=400) Mean (SD)*	P *value†*
Nutrients intake				
Calcium (mg)	615.53 (391.3)	516.07 (377.7)	560.28 (386.5)	0.010*
Iron (mg)	6.08 (4.1)	4.82 (4.5)	5.38 (4.4)	0.004*
Zinc (mg)	4.04 (2.4)	3.14 (2.3)	3.54 (2.4)	0.000*
Vitamin A (µg)	957.30 (326.2)	761.42 (222.1)	849.02 (274.1)	0.046*
Vitamin C (mg)	56.67 (67.9)	42.53 (37.5)	48.87 (40.1)	0.015*
Thiamine (mg)	0.51 (0.3)	0.41 (0.4)	0.46 (0.3)	0.006*
Riboflavin (mg)	0.71 (0.6)	0.71 (0.5)	0.71 (0.5)	0.000*
Nutrients adequacy (%)				
Calcium	236.7 (150.5)	103.21 (95.5)	162.61 (130.3)	0.000*
Iron	88.22 (58.8)	160.80 (151.3)	128.32 (100.4)	0.000*
Zinc	161.80 (96.5)	125.62 (93.9)	141.74 (96.6)	0.000*
Vitamin A	191.46 (95.2)	362.58 (189.1)	286.14 (163.8)	0.000*
Vitamin C	113.35 (95.9)	327.2 (115.5)	231.31 (105.2)	0.000*
Thiamine	172.30 (96.5)	82.98 (76.1)	122.92 (80.8)	0.000*
Riboflavin	231.13 (153.2)	143.91 (109.2)	182.91 (137.6)	0.000*

† *P* value from Student's *t*-test; *$P < 0.05$

Source: Devised by authors

Table 4 Daily food groups intake of among the studied sample

Food group	*<12 months (n=178) Mean (SD)*	*≥12 months (n=222) Mean (SD)*	*Total (n=400) Mean (SD)*	P *value†*
Cereals	56.50 (33.9)	103 (64.1)	83.53 (58.1)	0.000*
Bakery	43.85 (23.1)	79.75 (57.3)	67.72 (59.7)	0.000*
Tubers	22.97 (16.6)	66.77 (49.5)	49.41 (37.4)	0.000*
Legumes	15.42 (11.7)	7.69 (5.6)	8.42 (7.1)	0.000*
Vegetables	15.83 (9.5)	27.5 (15.6)	22.86 (11.7)	0.000*
Fruits	34.05 (16.2)	97.92 (76.4)	70.57 (50.5)	0.000*
Animal protein	28.19 (11.5)	53.35 (39.4)	46.52 (28.6)	0.000*
Dairy	200.64 (116.3)	234.21 (115.2)	221.51 (115.2)	0.000*
Beverages	64.26 (73.9)	138.76 (98.6)	109.22 (90.1)	0.000*

† *P* value from Student's *t*-test; *$P < 0.05$

Source: Devised by authors

cally significant difference. The mean adequacy of calcium, zinc, thiamine and riboflavin was higher among younger infants, while the mean adequacy of iron, vitamin A and vitamin C was higher among the older age of infants, with a significant difference between the two groups (P=0.000). Iron was inadequate among infants aged less than 12 months, while thiamine was inadequate among infants aged ≥12 months.

As shown in Table 4, the mean daily intake of the legumes group was the only one higher among infants less than 12 months of age, with a statistically significant difference (P=0.000). This is in contrast to the mean daily intake of all food groups, which was higher among infants aged ≥ 12 months, with a statistically significant difference (P=0.000).

Figure 3 shows that the percentage of inadequacy of calcium, zinc, thiamine and riboflavin

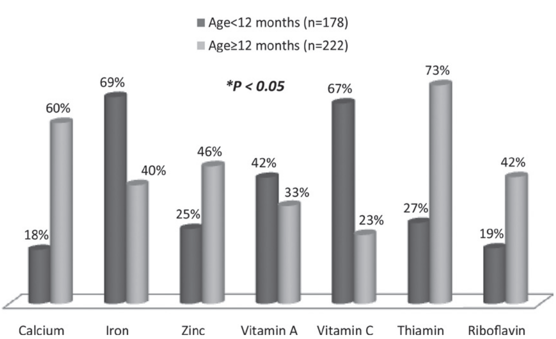

Figure 3 Inadequate intake of each micronutrient among the studied sample

Source: Devised by authors

was higher among infants aged ≥ 12 months (60%, 46%, 73%, and 42%, respectively), while the inadequacy of iron, vitamin A and vitamin C was more prevalent among infants below 12 months of age (69%, 42%, and 67%, respectively).

Discussion

The first two years in life are the most important throughout the life span of an individual. Its importance is due to the rapid growth rate paired with high nutritional demand. Unfortunately, very few children receive nutritionally adequate and safe complementary food. This can eventually lead to infant malnutrition that, if not discovered and managed properly, can have lifelong irreversible effects. Infant malnutrition can be broadly divided according to its cause into macronutrient malnutrition and micronutrient malnutrition (Ryan et al., 2016).

This study was aimed at determining the micronutrient adequacy of seven micronutrients, namely, calcium, iron, zinc, vitamin A, vitamin C, thiamine and riboflavin, from complementary foods consumed by infants aged between 6–24 months. This study did not take into consideration micronutrients supplied by breast feeding due to the difficulty in estimation. However, the amount of micronutrients supplied by breast milk after starting weaning food is relatively small and would not affect the results of this study. For example the amount of iron, zinc and calcium supplied by breast milk at the age of 6–11 months was estimated to be 3%, 13% and 28%, respectively (WHO, 2003). In addition, the vitamin content of breast milk is greatly affected by the mother's diet and a maternal diet deficient in the essential micronutrients would definitely affect her breast feeding infant, especially in iron, zinc and vitamin A (Dijkhuizen et al., 2001).

An inadequate intake of all micronutrients was found in a considerable percentage of children. The highest percentage of inadequacy was found among children below 12 months of age regarding iron and vitamin C, and among children aged 12 months and over regarding thiamine and calcium.

There is very little information from developing countries on total calcium intake in infancy and its long term consequences (Jarjou et al., 2012). This resulted in an increasing need for the estimation of calcium adequacy among Egyptian infants to highlight any foreseen effects for inadequacy. In this study, calcium adequacy from dietary sources was measured and was found to be inadequate in 18% of children under 12 months of age, and 60.4% of children over 12 months of age. The difference between both age groups may be attributed to the fact that the diet of infants below 12 months depended largely on dairy products, while infants above 12 months had more dietary diversity; this may have inversely affected the amount of dairy products consumed. These results agree with the results of another study conducted in the United Arab Emirates (UAE) in 2015 (Abdulrazzaq et al., 2016).

A study was done in Egypt in 2012 to discover anaemia predictors in poor Egyptian infants aged 6 to 24 months (Elalfy et al., 2012): iron deficiency anaemia was found to be the main cause for anaemia in this age group. The main cause for iron deficiency anaemia was inadequate dietary iron intake and delayed introduction of complementary food beyond six months of age (which coincides with the results of this study), together with the early introduction of cow's milk and birth order beyond the second child. In this study, the percentage of children consuming inadequate iron in their diet was found to be 69.1% among children below 12 months and 39.6% among children above 12 months. Comparing these results to similar studies, these values were close to the comparative study done in Egypt, Kenya and Mexico in 1992 (Murphy et al., 1992), where the mean iron intake among children aged 12–30 months was found to be 6.76, 7.02, and 6.79 mg/day in Egypt, Kenya and Mexico, respectively. An iron intake inadequate to prevent anaemia was found in 35% in Egypt, 13% in Kenya and 43% in Mexico. The relatively lower percentage in Kenya was due to the use of iron fortified foods.

The excessive reliability on iron-poor family meals, cow's milk or non-fortified infant formula, higher living standards compared to Egypt or other developing countries depending on iron fortified foods, and a higher consumption of animal source food can be explanations for the difference between results of the current studies and other studies done in the UK (Gibson and Sidnell, 2014) and USA (Ahluwalia et al., 2016).

Zinc has a major role in many biological functions and is responsible for more than 300 enzymatic reactions in our bodies. Consequently, multiple functions in the human body are affected by zinc deficiency, including physical growth and neurobiological functions. In developing countries, this is usually associated with impaired growth and increased infant morbidity and mortality (Hotz and Brown, 2004). A major determinant of zinc deficiency in low-income populations is an inadequate intake of dietary zinc; this is induced by a decreased intake and low zinc bioavailability in consumed food (Gibson, 2015). Zinc was found to be a problematic nutrient according to the current study. An inadequate zinc intake was found to be 24.7% and 45.9% among children below and above 12 months of age, respectively. These results were much higher than those in the UK (Gibson and Sidnell, 2014). Percentages were even lower in the USA (Ahluwalia et al., 2016), and the UAE (Abdulrazzaq et al., 2012). This can be explained by the nature of diet among Egyptian children, which obviously lacked sufficient amounts of foods from animal sources. Factors affecting zinc intake according to this study were the father's work and father's education, which are considered an approximate indicator of the overall socioeconomic status.

Globally, child deaths annually attributable to vitamin A deficiency are estimated to be 157,000 among pre-school children of 6–59 months of age. Although the prevalence of clinical symptoms of vitamin A deficiency (e.g., signs of xerophthalmia) has declined, subclinical vitamin A deficiency affects high proportions of children in Africa and Southeast Asia (Black et al., 2008). Vitamin A inadequacy continues to be a major health problem, especially in developing countries where rice and other starchy foods constitute most of people's diet in those countries, especially infants' diet (De Moura et al., 2016).

According to an Egyptian demographic and health survey conducted in 2008 (El Zanaty and Way, 2013), the majority of children aged 6–23 months did not have any vitamin A rich food the day before the survey. In this study, the percentage of children with vitamin A intake below the DRIs was 42.1% and 32.7% among children below and above 12 months of age, respectively. Comparing these results to the comparative study (Calloway et al., 1993) comparing vitamin adequacy among infants from Egypt, Kenya and Mexico, the results were somewhat close to our study. The prevalence of vitamin A inadequacy in Egypt, Kenya and Mexico among children aged 18–30 months was 32.5%, 12.3% and 67.6%, respectively. A higher prevalence of inadequate vitamin A intake is usually attributed to a decreased intake of animal source food, or may be due to the underestimation of dietary carotene as a precursor of vitamin A. On the other hand, results from developed countries varied greatly; this can be explained by the higher intake of animal source food and fortified baby foods (Gibson and Sidnell, 2014; Ahluwalia et al., 2016).

Vitamin C is known for its antioxidant and immune boosting mechanisms. Some studies have even discussed its importance in decreasing the incidence of the common cold and upper respiratory tract infections (Bucher and White, 2016). Therefore, its deficiency may contribute to recurrent infections and add to the vicious circle of infections and nutritional deficiencies. In addition to its immune boosting functions, Vitamin C has an important role in increasing iron absorption, improving calcium utilisation and promotes wound healing (Elalfy et al., 2012).

The prevalence of vitamin C inadequacy was found to be very high, especially among the younger age group (6–12 months); it was found to be 66.9% compared to 23% in the older age group (12–24 months). This can be partly explained by the very low consumption of fruit compared to other food groups. This may be due to a lack of nutritional awareness and knowledge about the constituents of a balanced diet, together with the relatively higher prices of fruit compared with the starchy foods that constitute the main bulk of infants' foods. Results in developed countries are the opposite of our findings (Gibson and Sidnell, 2014; Ahluwalia et al., 2016), reflecting the higher awareness and higher socioeconomic status in addition to the higher consumption of fortified foods. The intake of vitamin C and most micronutrients far exceeded even the recommended intake in the Gemini twin cohort in the UK in 2016 (Syrad et al., 2016).

Beriberi, a disease caused by severe thiamine deficiency, is rare in economically developed regions but is thought to be more common in countries where dietary sources of thiamine are low (Whitfield et al., 2015). Similarly, riboflavin deficiency is endemic in many developing countries due to the nature of their diet, which lacks sufficient dairy products and animal proteins, especially fish (Powers, 2003). What adds more to the risks of riboflavin deficiency is the fact that the symptoms for deficiency appear within a few days of inadequate dietary intake. Although this study did not take into consideration the micronutrient intake from breast milk, it is important to mention that the fact that diet in developing countries lacks sufficient animal source foods is a direct cause of the deficiency of those elements in breast milk; this is because a lactating mother's diet is deficient in those elements. This definitely adds even more to the deficiency status (Allen, 2012). The reason for an inadequate intake of B-group vitamins (thiamine, riboflavin, niacin, folate) is the nature of diet among the developing countries. Diet in developing countries is usually deficient in dairy products and animal source foods, which are the main sources for B group vitamins. On the other hand, none of the children within studies from the UK and the USA (Gibson and Sidnell, 2014; Ahluwalia et al., 2016), with a higher standard of living, had a deficient thiamine or riboflavin intake.

The duration of breast feeding in minutes was found to be a risk factor for iron, vitamin A and vitamin C inadequacy. This may be due to the displacement of weaning food meals by the longer duration of breast feeding sessions, and the failure of lower amounts of complementary food to meet the infants' high requirements. This last point is suggested as a point for further research because, to our knowledge, it has not been mentioned previously in the literature.

The use of anthropometric indices, especially stunting, was found to be largely linked to the future cognitive development of infants, which consequently affects their future school achievements

(Sudfeld et al., 2015). The results of anthropometric indices for children aged 6–12 months and 12–24 months were 15.1% and 10.5% for wasting, 22.5% and 10.9% for underweight, and 51.1% and 22.8% for stunting, respectively. These results were very close to those of the Egypt Demographic and Health Survey (EDHS) (El Zanaty and Way, 2013) for children aged 6–12 months and 12–24 months in all parameters except for stunting in the older age group[1].

The prevalence of overweight was higher among the older age group (14.4%) than of younger infants (5.1%). Obesity was highly prevalent among infants aged 12–24 months (27.7%), compared to 8.4% of younger infants. These values are close to the average percentage of overweight children under 5 in North Africa, which was estimated to be 11% according to the World Bank (UNICEF, WHO and World Bank, 2016).

Points of strength are that this study is, to our knowledge, considered to be the first study done at the sub-national level addressing these research points. It opens the way for further research regarding the issue of micronutrient inadequacy among infants, which appears to be prevalent yet underestimated by health authorities. Another point of strength is the use of a food frequency list for dietary assessments, which ensures a more detailed and fair approach to find out nutritional inadequacies. This is because such a list does not depend on a single day dietary recall, which may not be the child's usual daily diet.

Points of weakness of this study are the relatively small sample size compared to studies done on a national level in other countries: this may result in estimates that are not optimum. Another point of weakness is that most dietary data obtained are subjective, which adds even more to less accurate results.

Conclusions and Recommendations

An inadequate intake of all micronutrients was found in a considerable percentage of children. The highest percentage of inadequacy was found among children below 12 months of age regarding iron and vitamin C, and among children aged 12 months and over regarding thiamine and calcium. Most infants had fair breast feeding practices. The rate of stunting, wasting and underweight for age was 37%, 12.8%, and 16.7% of infants, respectively. Stunting, wasting and underweight for age were more prevalent among infants aged 6–12 months than those of 12–24 months. The rate of overweight and obesity was 19.5% and 18.1% of infants, respectively. Obesity and overweight were highly prevalent among infants aged 12–24 months compared to the younger age of infants. Nutrition education was recommended for mothers regarding the health and nutrition of their infants. This should include how to prepare a safe and balanced diet for their infants, and about the proper complementary feeding guidelines that can ensure an optimum supply of all the essential micronutrients. Further research was recommended on a large sample size of infants to have optimal results for adequacy of micronutrients in this vulnerable group.

1 The prevalence of wasting was 12.3% and 13.4%, respectively, the prevalence of underweight was 10.7% and 11.9%, respectively, while the prevalence of stunting was 41.9% and 68.9%, respectively.

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