ORIGINAL ARTICLE

Detection of Micronutrients Deficiency in Egyptian Children Using Dietary Diversity Score: A cross-sectional Study

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ABSTRACT

Objective: To detect malnutrition and micronutrient deficiency using the Dietary Diversity Score (DDS).

Study Design: A Cross-Sectional study.

Place and Duration of Study: Pediatric outpatient clinic at Suez Canal University hospital for 1 year.

Material and Methods: The study was commenced recruiting 100 participants from 6 months to 6 years old attending a tertiary Hospital Pediatric clinic. The participants were divided into three groups based on diversity score: Low score for those who eat ≤ 3 food subtypes, medium score who eat 4-5 food subtypes, and a maximum score who consumed ≥ 6 food groups.

Results: Children with Low DDS had both iron and zinc deficiencies with an incidence of 90.6% and 29.7 %, respectively. Children with medium DDS had iron deficiency (27.6%) and no zinc deficiency, while children with high DDS had iron deficiency (14.3 %) and no zinc deficiency. Children with Low DDS showed a worthy difference (p=0.001) in ferritin values compared to children with medium and high DDS.

Conclusion: Dietary diversity score is a reasonable index to assess trace element insufficiency. Children with low dietary diversity had 35% zinc deficiency, about 97% iron deficiency, and 48.4 % ferritin deficiency.

Key Words: *Dietary diversity score, Malnutrition, Micronutrients Deficiency.*

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INTRODUCTION

Undernourishment is still a severe health issue in a large number of developing nations, impacting mainly at-risk groups, especially youngsters below five years. It is the main cause for about 45% of all young demise all over the world.[1] Micronutrients include a wide range of vitamins and minerals essential for physical and mental development. After six months of birth, breastfeeding cannot meet the needs of infants to supply adequate amounts of micronutrients; therefore, there is a need to consume complementary foods in adequate quality and quantity.[2]

Children enduring from undernourishment are endangered by sudden illnesses and this leads to decreased productivity in the upcoming years. In the course of the initial two years of existence, youngster had to take adequate food to allow them to grow and develop properly; otherwise, unrepairable affection to a child's growth's cognitive and physiological aspects may result.[3]

Dietary and nutritional behaviors are affected by cultural and environmental factors. Eating a valuable mixture of food is pivot on the current surrounding conditions.[4] Inadequate intake of trace elements is a great health issue. An excess of 2 billion individual nowadays has inadequate levels of crucial vitamins and minerals. A great proportion of individuals stay in poverty-stricken nations and are unfortunately has inadequate levels of multiple elements. Micronutrient inadequacy leads to infections and death from diarrhea, measles, malaria, and pneumonia. These disorders are considered the ten leading attributes for youngster death today.[5]

The essential micronutrients include zinc and iron. Zinc is involved in the immune response and the response to infection. Zinc is essential for the proper structure and function of proteins, such as enzymes, transcription factors, sites of hormone receptors, and biological membranes.[6] Iron deficiency (ID) and iron deficiency anemia (IDA) are mainly due to circumstances that cause iron deprivation or, conditions leading to impaired absorption as gastrointestinal disorders.[7]

Many indicators are applied to evaluate the status of youngsters' feeding. The dietary diversity score is suitable for evaluating children's diets**.** Multiple researches elaborated a reasonable link between diverse diet intake and micronutrient proper levels, especially in youngsters from growing nations.[8] No studies evaluated micronutrient deficiency among Egyptian children in the Suez Canal region. That is why this study was commenced.

MATERIAL AND METHODS

This cross-sectional study enrolled 100 children between six months and six years age. The participants were selected in a random manner from the patients presenting to the outpatient clinic of pediatrics, at Suez Canal University Hospital. A permission was taken from the parents or the custodians. We recruited children not known to have any chronic illness. Personal and sociodemographic histories were evaluated.

Examination for signs of micronutrient deficiency:

- Eczema, mouth ulcers, diarrhea, and seborrheic dermatitis for zinc deficiency.[9]
- Iron deficiency symptoms as pale skin, cold hands and feet, brittle or flat nails, koilonychia, and pica.[10]
- We measured weight and height for children aged >2 years and weight and length for those who were younger. Laboratory investigations included CBC, serum iron, zinc, and Ferritin. Blood samples were withdrawn at the same timing (morning), and while the participants were sitting. The same operator used the same automated machine to do all the required investigations. This operator was blinded to the data concerning participants' evaluation. We assured proper quality control of the machine used.

A well-prepared 24-hour recall questionnaire was designed to interview mothers of infants and children attending the Pediatric clinic to collect data about the intake of variable food types using dietary diversity score to detect micronutrient deficiency. Dietary history inquired about proper food intake represented by intake of:

- seeds, roots, and bulbs;
- leguminous plants, and nuts, milk and its products;
- flesh, fish, chicken, and organ meats;
- eggs;
- food rich in vitamin A;
- and other fruits and vegetables.

Each class was recorded as "0" for harmful intake or as "1" if at least one food item was reported.[11]

The participants were classified into 3 classes depending on diversity score: Low diverse food score who eat ≤ 3 food classes, medium diverse food score who eat 4-5 food classes, and high diverse food score who eat ≥ 6 food classes.[11]

Mothers were interviewed in a private room after properly examining their children. The examination was done by a researcher blinded to the dietary diversity score and the laboratory results.

The required sample estimation was computed at a significance level of 95% and an error level of 10% with a prevalence of micronutrient deficiency of 39.6%.[12] A lost percentage of 10% was summed to the end figure leading to a total number of 100 children.

Statistical analysis: The data was gathered, and processed using Microsoft Excel 2013 program. Statistical Package for Social Sciences (SPSS) for windows version 20.0 (SPSS, Chicago, IL, USA) was used for data analysis. Data was presented as figures, and percentages. Kruskal-Wallis, Mann-Whitney U, and Spearman's correlation tests were used for non-parametric tests. While t-test, chi-square, and ANOVA tests were used in parametric data. Correlation between the dietary scores and the laboratory tests was done. A p value < 0.05 was considered significant.

Ethical approval: An approval was obtained from the research ethics committee at Faculty of Medicine, Suez Canal University on 23/9/2019 with a registration number of 3953#, before recruitment.

RESULTS

One hundred youngsters (with an age ranging from 6 months to 6 years) were included in the study. There were an equal percentage of males (50%) and females (50%) with 58% living in cities and 42% from country side, of children with Low DDS, 43.8% living in cities and 56.3% living in country side. Of children with medium DDS, 82.8% live in cities, and 17.2% live in a country side. In contrast, of children with high DDS, 85.7% live in cities, and 14.3% live in a country side. The difference was statistically significant. Low dietary diversity was prevalent in rural areas (table 1).

The mean for weight and height was 12.77 ± 3.85 and 89.43 ± 12.89, respectively, compared to different dietary diversity score levels. Generally, 45% were underweight (weight ≤ 5th), from which 64% had a low dietary diversity, and 33% were stunted (height ≤ 5th), from which 45% had a low dietary diversity (table 2).

The study included 14 children aged <1.5 years. Inquiry about breastfeeding was done. Only 5/100 (5%) children had exclusive breastfeeding. Artificial feeding and mixed feeding were reported in 4/100 (4%) and 5/100 (5%) children, respcectively. Among the 100 children recruited, 67% had positive iron deficiency signs, and 19% had positive zinc deficiency signs. Children with Low DDS had 90.6% iron deficiency signs and 29.7% zinc deficiency signs. Children with medium DDS had 27.6% iron deficiency signs and no zinc deficiency signs. Children with high DDS had 14.3% iron deficiency signs and no zinc deficiency signs (table 3**)**.

As shown in table 4:

- Children with Low DDS had 35% zinc deficiency, about 97% iron deficiency, and 48.4 % ferritin deficiency. Children with medium DDS had 3.4 % zinc deficiency, about 31.0 % iron deficiency, and 10.3 % ferritin deficiency. Children with high DDS had no zinc, Iron, or ferritin deficiency.
- Children with Low dietary DDS had mean zinc (89.05 ± 24.06), children with medium DDS had mean zinc (111.1 ± 18.32), and children with high DDS had mean zinc (112.7 ± 19.98). The contrast was statistically noteworthy (p=0.001). Children with decreased dietary diversity scores showed zinc deficiency than children with medium diversity scores and children with high diversity scores.
- Children with Low DDS had mean iron of 29.55 ± 16.37, children with medium DDS had mean Iron of 69.03 ± 18.09, while children with high DDS had mean iron of 85.0 ± 4.0. The contrast was statistically noteworthy ($p=0.001^*$). Children with decreased dietary diversity scores had Iron deficiency than children with medium and high DDS.
- Children with Low DDS had mean ferritin (28.40 ± 32.58), children with medium DDS had mean ferritin (44.83 ± 31.14), and children with high DDS had mean ferritin (46.57 ± 19.50) (p=0.001). Children with Low DDS had ferritin deficiency than those with medium and high DDS.

TABLE 1: Comparison between the three studied groups according to socio-demographic data

	Total (n = 100)		Food: Low dietary diversity (n = 64)		Food: Medium dietary diversity (n = 29)		Food: High dietary diversity (n = 7)		Test of Sig.	p
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**		
Sex										
Male	50	50.0	35	54.7	13	44.8	2	28.6	χ^2= 2.093	^{MC}p= 0.376
Female	50	50.0	29	45.3	16	55.2	5	71.4		
Age groups										
≤ 2 years	41	41.0	38	59.4	2	6.9	1	14.3	χ^2= 24.9	^{MC}p= $<0.001^*$
>2 years	59	59.0	26	40.6	27	93.1	6	85.7		
Age										
Min. – Max.	6m – 6.0y		6m – 6.0y		6m – 6.0y		2.0 – 6.0		H= 27.676^*	$<0.001^*$
Mean ± SD.	3.11 ± 1.58		2.48 ± 1.34		4.19 ± 1.39		4.29 ± 1.38			
Significant between groups.			$p_1<0.001^*$,$p_2=0.004^*$,$p_3=0.883$							
Geo data										
Urban	58	58.0	28	43.8	24	82.8	6	85.7	χ^2= 14.925^*	^{MC}p $<0.001^*$
Rural	42	42.0	36	56.3	5	17.2	1	14.3		
Significance between groups.			$p_1<0.001^*$,$^{FE}p_2=0.049^*$,$^{FE}p_3=1.000$							

χ^2: **Chi-square test** FE**: Fisher Exact** MC: **Monte Carlo**
H: H for **Kruskal Wallis test,** Pairwise comparison bet. every two groups were done using **Post Hoc Test (Dunn's for multiple comparisons test)**
p: p-value for comparing the studied groups
p_1: p-value for comparing between **low** and **medium**
p_2: p-value for comparing between **low** and **high**
p_3: p-value for comparing between **medium** and **high**
*: Statistically significant at p ≤ 0.05

TABLE 2: Comparison between the three studied groups according to weight and height

	Total (n = 100)		Food: Low dietary diversity (n = 64)		Food: Medium dietary diversity (n = 29)		Food: High dietary diversity (n = 7)		Test of Sig.	p
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**		
Weight										
Min. – Max.	7.0 – 25.0		7.0 – 22.0		9.0 – 25.0		13.0 – 22.0		F= 31.332^*	$<0.001^*$
Mean ± SD.	12.77 ± 3.85		11.0 ± 2.97		15.55 ± 3.16		17.43 ± 3.15			
Median (IQR)	12.0(10.0 – 16.0)		11.0(9.0 – 12.0)		16.0(13.0 – 17.0)		18.0(15.5 – 19.0)			
Significance between groups.			$p_1<0.001^*$,$p_2<0.001^*$,$p_3=0.310$							

Weight percentile										
≤5th	45	45.0	41	64.1	4	13.8	0	0.0	χ^2= 27.621*	^{MC}p <0.001*
>5th	55	55.0	23	35.9	25	86.2	7	100.0		
Height (for children > 2yrs)										
Min. – Max.	82.0 – 124.0		82.0 – 108.0		87.0 – 112.0		95.0 – 124.0		F= 7.427*	0.001*
Mean ± SD.	98.3 ± 8.21		94.23 ± 7.23		100.04 ± 6.90		105.5 ± 10.43			
Median (IQR)	97.0(90.0 – 104.0)		93.5(89.5 – 97.5)		102.0(96.0–108.0)		103.0(95–111.0)			
Significance between groups.	p_1=0.006*,p_2=0.001,p_3=0.109									
Length for children ≤ 2yrs	57-88		76.85±6.78		81±7.07		--		1.504	0.235
Height percentile										
≤5th	33	33.0	29	45.3	4	13.8	0	0.0	χ^2= 12.671*	^{MC}p= 0.002*
>5th	67	67.0	35	54.7	25	86.2	7	100.0		

χ^2: **Chi-square test** MC: **Monte Carlo**
F: **F for ANOVA test**, Pairwise comparison between each two groups was done using **Post Hoc Test (Tukey)**
p: p-value for comparing the studied groups
p_1: p-value for comparing between **low** and **medium**
p_2: p-value for comparing between **low** and **high**
p_3: p-value for comparing between **medium** and **high** *: Statistically significant at p ≤ 0.05

TABLE 3: Comparison between the three studied groups according to Zinc deficiency signs and iron deficiency signs

	Total (n = 100)		Food						χ^2	P
			Low dietary diversity (n = 64)		Medium dietary diversity (n = 29)		High dietary diversity (n = 7)			
	No.	%	No.	%	No.	%	No.	%		
Zinc deficiency signs										
Negative	81	81.0	45	70.3	29	100.0	7	100.0	13.194*	0.001*
Positive	19	19.0	19	29.7	0	0.0	0	0.0		
Significance between groups			p_1=0.001*,$^{FE}p_2$=0.092,p_3=–							
Iron deficiency signs										
Negative	33	33.0	6	9.4	21	72.4	6	85.7	45.670*	^{MC}p <0.001*
Positive	67	67.0	58	90.6	8	27.6	1	14.3		
Significance between Groups			p_1<0.001*,$^{FE}p_2$<0.001*,$^{FE}p_3$=0.652							

χ^2: **Chi-square test** FE**: Fisher Exact** MC: **Monte Carlo**
p: p-value for comparing the studied groups
p_1: p-value for comparing between **low** and **medium**
p_2: p-value for comparing between **low** and **high**
p_3: p-value for comparing between **medium** and **high**

TABLE 4: Comparison between the three studied groups according to lab

Lab	Total (n = 100)		Food						Test of Sig.	p
			Low dietary diversity (n = 64)		Medium dietary diversity (n = 29)		High dietary diversity (n = 7)			
	No.	%	No.	%	No.	%	No.	%		
Zinc										
Normal	76	76.0	41	64.1	28	96.6	7	100.0	χ^2=	0.001*

Deficient	24	24.0	23	35.9	1	3.4	0	0.0	13.926*	
Mean ± SD.	97.11 ± 24.58		89.05 ± 24.06		111.1 ± 18.32		112.7 ± 19.98		F=	<0.001*
Median (IQR)	100.0(79.0–112.5)		91.50(67.0– 106.0)		106.0(98.0– 126.0)		108.0(98.5–129.0)		11.629*	
Significance between groups.			$p_1<0.001^*,p_2=0.024^*,p_3=0.985$							
Iron										
Normal	29	29.0	2	3.1	20	69.0	7	100.0	$\chi^2=$	^{MC}p
Deficient	71	71.0	62	96.9	9	31.0	0	0.0	62.722*	<0.001*
Mean ± SD.	44.88 ± 26.47		29.55 ± 16.37		69.03 ± 18.09		85.0 ± 4.0		H=	<0.001*
Median (IQR)	39.0(21.5 – 74.0)		25.0(17.5 – 39.0)		77.0(63.0 – 81.0)		85.0(83.0 – 87.0)		53.789*	
Significance between groups.			$p_1<0.001^*,p_2<0.001^*,p_3=0.120$							
Ferritin										
Normal	66	66.0	33	51.6	26	89.7	7	100.0		
Deficient	34	34.0	31	48.4	3	10.3	0	0.0	$\chi^2=$	^{MC}p
Mean ± SD.	34.43 ± 32.23		28.40 ± 32.58		44.83 ± 31.14		46.57 ± 19.50		17.248*	<0.001*
Median (IQR)	28.0(9.0 – 51.0)		13.50(7.0 – 42.5)		37.0(30.0 – 53.0)		48.0(37.0 – 53.5)			
Significance between groups.			$p_1=0.001^*,p_2=0.020^*,p_3=0.671$							

χ^2: **Chi-square test** MC: **Monte Carlo**
F: **F for ANOVA test**, Pairwise comparison between every two groups were done using **Post Hoc Test (Tukey)**
H: H for **Kruskal Wallis test,** Pairwise comparison bet. every two groups were done using **Post Hoc Test (Dunn's for multiple comparisons test)**
p: p-value for comparing the studied groups
p_1: p-value for comparing between **low** and **medium**
p_2: p-value for comparing between **low** and **high**
p_3: p-value for comparing between **medium** and **high**
*: Statistically significant at $p \le 0.05$

DISCUSSION

Trace element undernourishment is still a considerable nutrition related health issue all over the world, impacting citizens in advanced and advancing nations.[5] Youngsters are specifically at risk to trace element insufficiency because of their increased needs for growth and vulnerability to contagious diseases, which decrease elements absorption and affect their desire to eat.[13] Zinc and iron are the essential components involved in homeostasis. They impart an essential role in iron metabolism, transport, and bio-availability.[14]

In the present study, micronutrient deficiency was more evident among children with low DDS than among their peers. This agreed with previous results where children with low DDS had 35% zinc deficiency, about 97% iron deficiency, and 48.4% ferritin deficiency.[15] The amount of trace elements in the diet provided to youngsters was found to be deficient to keep up with their needs. Maximizing the different types of food given to youngsters, especially flesh, eggs, fruits, and vegetables, is required to enhance trace element intake.[16] There is a positive association between DDS and adequate nutrition. An increase in diverse food provided was linked to enhanced element supply in youngsters 4–8. There was great proof for the use of diverse food as an index for improper eating of food.[16] Eating multiple food classes is paramount to provide the required nutrients and may aid to treat decreased trace elements supply and ameliorate the possibility of food related anemia.[17]

Zinc deficiency was reported to be close to the figures reported at the Southwestern area in Guatemala mentioned by a study (36.8%).[18] However; it was higher than those reported from Mexico and Ecuador (27.5% and 28.8%, respectively)**.** About 30% of the world's population is zinc deficient, especially among youngster below 5 years in low-income nations.[19] Zinc deficiency is mainly due to improper consumption. It is most abundant and easily absorbable from animal proteins. However, its absorption is hindered by vegetables and cereals because of its binding to phytates.[20]

Iron deficiency was prevalent in 71% of the whole population. A study conducted among Iranian children <6 years reported ID to affect 27.7%, with males being more affected than females.[21] Lower rates were reported among Spanish children aged 1-11 years (7.7%) and Lebanese schoolchildren.[22,23] A prevalence of 39.6% was reported among preschool children in Egypt.[24] It has been reported that IDA is due to consuming diets with poor iron bioavailability, especially in developing countries, as people depend on plant sources only. Also, people in rural areas consume diets rich in cereal containing high amounts of phytates (iron-binding agents).[25]

Children with low DDS had more symptoms of micronutrient deficiency than the other children with higher DDS. It is known that zinc is paramount for multiple metabolic reactions involved in growth, maintained immunity, and even proper vision. Also, decreased zinc levels has been associated with about 116,000 child demise yearly. This was rendered to increased infectious diseases such as diarrhea.[1]

There was an equal number of boys and girls in the study. Low DDS was evident in the rural area. This would be explained by the fact that plant derived foods in advancing nations are weak providers for active iron, zinc, and other trace elements. Proper nutrition provided by breast feeding through the initial 6 months of existence, together with maximum quality of food through the after coming 6 months, are essential for youngsters' proper growth and development.[16]

Strength and limitations: The current study evaluated the impact of dietary intake and micronutrient deficiency which is not widely evaluated in our country. The sample size was small, larger studies would be more representative. This study was hospital-based, carried on in a single hospital which limits results generalizability.

CONCLUSION

Dietary diversity score is a good indicator to assess adequate micronutrient supply. Children with low DDS had more zinc and iron deficiency than other children. Deficiencies of iron and zinc are widespread in many developing countries because lower socioeconomic and rural populations consume predominantly plant-based diets.

Conflict of interest: None

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