BENHA MEDICAL JOURNAL bmj

Print ISSN 1110-208X.

Online ISSN 2357-0016

Original article

Iron and Zinc Status in Preschool Children from Rural Areas in Qalyubiya Governorate

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Received: 8 March 2023

Accepted: 18 May 2023

Abstract:

Background: Zinc deficiency is an important cause of morbidity due to infectious diseases and growth faltering among young children. Prevalence of iron-deficiency anemia among children is much higher than among adult women and may be partly attributable to the high prevalence of hookworm infestation among children. That study purposed to determine Iron and zinc status in pre schooled children from rural areas of Qalyubia governorate. **Methods:** That cross-sectional study was carried out on 2000 children in Qalyubia private nurseries. Participants were exposed to survey assessments for the children (demographic information, medical history, and nutrition and health history) and blood collection and analysis (Biochemical assessment, serum iron and Zinc estimation). **Results:** Zinc level correlated positively with BMI, height, times of eating meat per week, diversity of food and iron level. Iron level correlated positively with age, height, times of eating meat per week, diversity of food, and correlated negatively with age of introduction to complementary foods. **Conclusion:** In our community, 27.9% of children had zinc deficiency and 37% of children had iron deficiency. Zinc and iron deficiency were associated with male sex, illiterate mothers, lower diversity of food, lower weight, height and BMI. The Zinc level correlated positively to iron level, and both were correlated positively with times of eating meat per week and diversity of food.

Keywords: Iron; Zinc, Preschool, Children, Rural Areas.

Introduction

Micronutrient malnutrition alone afflicts more than 2 billion people, mostly among resource-poor families in developing countries; iron, iodine, zinc, and vitamin A are the most prevalent deficiencies. More than 5 million childhood deaths occur from micronutrient malnutrition every year (1). A diverse diet, consisting of vegetables, fruits, dairy, and meats, is rich in micronutrients but is out of the reach of many of the world's poor because of it being expensive (2).

Resource-poor people rely primarily on a few starchy staples that are rich in energy but not in micronutrients. Iron and zinc are the 2 micronutrients that are deficient in the diet of the people of Third World countries (3). Although sufficient food is available, still over 2 billion people in poorer countries of the world have iron deficiency. Since micronutrient deficiencies go unnoticed, these are termed as ‘‘hidden hunger.’’ Predictably, half of the global population is at the risk of low intake of zinc (4).

Zinc deficiency is an important cause of morbidity due to infectious diseases and growth faltering among young children. Increased demand of zinc due to rapid growth and decreased intake of zinc due to inadequate feeding practices predispose pre-school children, especially living in communities of low socioeconomic level, to an elevated risk of zinc deficiency (5).

Zinc deficiency in children leads to retardation in growth and also morbidity from many diseases such as diarrhea, pneumonia, and malaria. Around 800 000 deaths among children below 5 years of age occur annually due to diarrhea, pneumonia, and malaria. High mortality rate among children resulting from these infections has been reported to be associated with inadequate zinc intake (6).

The studies reported 54.2% of children and 37.1% preschool children to be zinc deficient. Several studies indicate that zinc deficiency results in poor growth in infants and children and depressed appetite (7, 8). Zinc deficiency may also lead to impaired motor development in infants and thus can interfere with cognitive performance. Prevalence of iron-deficiency anemia among children is much higher than among adult women and may be partly attributable to the high prevalence of hookworm infestation among children (9).

A previous Egyptian study reported that the prevalence of anemia in children is 52.25 & 54.03 % for male and female respectively which represent a problem of high degree. The cause of anemia in children may be due to anemic mother, poor, diet, bad food habit (10).

Another more recent study reported that Iron deficiency anemia IDA (iron depletion with low hemoglobin) was clearly identified among only 18.5% of the whole sample, but iron deficiency without anemia (low ferritin and normal hemoglobin) was recognized in 26.2% of the population. Almost one-fifth (20.6%) of cases had high ferritin values but still anemic (low hemoglobin). It was reported that zinc deficiency in pre-school Egyptian children is about 2.5% (11).

The current research aimed to determine Iron and zinc status in pre schooled children from rural areas of Qalyubia governorate.

Patients and methods

That cross-sectional study was carried out on 2000 children in Qalyubia private nurseries, during the period from January 2022 to July 2022. Study was done after being approved by the Research Ethics Committee (Ms.20.6.2022.) and all participants provided their informed consent.

Inclusion Criteria: 2000 children aged 2-6 years of both sex and from rural residence Qalyubia governorate were enrolled in this study.

Exclusion Criteria: Children aged less than 2years or more than 6 years and children of parents who refused to participate in the study.

All patients were subjected to:

Survey assessments for the children; first section (demographic information included 10 questions about age, sex mother education and others), second section (medical history included 5 questions about age of mother at delivery, gestational age and other maternal and child medical conditions and allergies), third section (Nutrition and health history included assessment of anthropometric measurements; child weight, height and BMI (12), mode of nutrition of the children, fourth section (Presentation included presenting signs and symptoms), fifth section included data upon investigations at presentation, sixth section included complications data and last two sections (7 , 8) included management and reporting data.

Blood Collection and Analysis:

Biochemical assessment on all selected children in Biochemical Analysis Laboratory of Benha university hospitals and other private laboratories. The samples were placed in tightly fitting slots in trays surrounded by dry ice in a thermocol box. An air-conditioned vehicle, with good suspension was used to transfer the samples from the field to the laboratory within 2 hours following blood collection. Within 2 to 3 hours from the field, samples were transported to the biochemical analysis laboratory, where they were stored prior to analysis.

Serum iron was estimated with chromazurol b method by IRON – CAB (Ref.9911 83, QUIMICA CLINICA APLICADA S.A., Spain). Serum iron concentrations below 50 µg/dL was defined as deficiency (13).

Serum zinc was analyzed by atomic absorption spectrophotometer (Alpha 4model, S/No 4200 by Chemtech Analytical, United Kingdom), utilizing flame for analysis. Serum zinc concentrations below 60 µg/dL was defined as deficiency (14).

Statistical analysis:

The data were coded, entered and processed on computer using SPSS (version 24). The results were represented in tabular and diagrammatic forms then interpreted. Mean, standard deviation, range, frequency, and percentage were used as descriptive statistics. The following tests were done Chi-Square test X^2 was used to test the association variables for categorical data; student's t-test was used to assess the statistical significance of the difference between two population means in a study involving independent samples, with normal distribution. Spearman Correlation analysis was used to show strength and direction of association between one quantitative variable and ordinal qualitative variable. The accepted level of significance was 0.05, $p<0.05$ is significant (*).

Results

The mean zinc level in the studied group was 79.96±25.26 µg/dL, and 27.9% of children had zinc deficiency. The mean iron level in the studied children was 57.38±17.73 mcg/dL, and 37% of children had iron deficiency.

Children with zinc deficiency had statistically higher frequency of male distribution, and higher frequency of illiterate mothers, compared to children without zinc deficiency. While there was no statistical difference between groups regarding age, gestational age, or maternal age at birth. They had statistically lower diversity of food and times of eating meat/week and had a statistically higher frequency of drinking tea compared to children without zinc deficiency. While there was no statistical difference between groups regarding history of breast feeding, age of introduction to complementary foods, age of weaning or history of drinking juice. They had statistically higher frequency of medical disorders, while there was no statistical difference between children with and without zinc deficiency regarding history of food allergy, iron supplementations or other medications. Children with zinc deficiency had statistically lower weight, height and BMI compared to children without zinc deficiency (Table, 1).

Children with zinc deficiency had statistically higher frequency of dental cavities, poor weight gain, recurrent infection, pallor, delayed development, easy fatigue, accelerated hair loss or damage, decrease vision, decrease taste, decrease memory, dry skin, angular stomatitis, deformed nails, delayed wound healing, cold extremities, loss of appetite compared to children without zinc deficiency (Table, 2).

Table 1: Sociodemographic data, nutritional history, medical history and anthropometric measurements of the studied group according to zinc status.

		Zinc deficiency				**Test**	**P value**
		No		**Yes**			
		N=1442	**%**	**N=558**	**%**		
Sociodemographic data							
Sex	Male	657	45.6%	391	70.1%	X^2=96.8	<0.001*
	Female	785	54.4%	167	29.9%		
Age (years)		4.11±1.18		4.10±1.16		t=0.21	0.82
Gestational age (weeks)		37.15±2.72		37.12±2.23		t=0.22	0.82
Age of mother at birth (years)		26.11±4.46		26.25±4.70		t=0.65	0.52
Mother education	Illiterate	78	5.4%	207	37.1%	X^2=40.6	<0.001*
	Primary school	397	27.5%	167	29.9%		
	Secondary school	490	33.9%	148	26.5%		
	University	477	33.1%	36	6.5%		
Nutritional history							
Breast feeding		1223	84.8%	482	86.4%	X2=0.78	0.37
Age of introduction to complementary foods (month)		5.70±1.35		6.13±1.90		t=2.6	0.07
Age of weaning (years)		16.41±4.41		15.25±3.34		t=2.8	0.06
Diversity of food		6.01±0.83		5.13±1.10		t=12.7	<0.001*
Times of eating meat /week		4.82±2.10		3.21±1.71		t=6.1	<0.001*
Drink juice		1055	73.2%	386	69.2%	X2=3.2	0.17
Drink tea		239	16.6%	261	46.8%	X2=195.8	<0.001*
Medical conditions	Bronchial asthma	58	4.0%	54	9.7%	X2=17.8	0.026*
	Cardiac disorders	60	4.2%	40	7.2%		
	GIT disorders	9	0.6%	14	2.5%		
Food allergy		167	11.6%	63	11.3%	X^2=0.21	0.79
Iron supplementations		103	7.8%	40	7.1%	X^2=0.71	0.68
Other medications		447	31.0%	118	21.1%	X^2=9.4	0.064
Height (percentile)		40.49±11.75		37.66±10.35		t=4.9	<0.001*
Weight (percentile)		41.89±11.59		37.77±16.03		t=6.3	<0.001*
BMI (percentile)		41.19±14.59		36.88±15.20		t=5.8	<0.001*

Table 2: Clinical data of the studied group according to zinc status

	Zinc deficiency				Test	P value
	No		Yes			
	N=1442	%	N=558	%		
Dental cavities	234	16.2%	171	30.6%	X^2=51.7	<0.001*
Poor weight gain	94	6.5%	211	37.8%	X^2=304.5	<0.001*
Recurrent infection	206	14.3%	233	41.8%	X^2=177.2	<0.001*
Pallor	76	5.3%	215	38.5%	X^2=350.9	<0.001*
Delayed development	112	7.8%	135	24.2%	X^2=101.2	<0.001*
Easy fatigue	140	9.7%	130	23.3%	X^2=63.6	<0.001*
Accelerated hair loss or damage	122	8.5%	130	23.3%	X^2=80.4	<0.001*
Decrease vision	58	4.0%	121	21.7%	X^2=154.3	<0.001*
Decrease taste	0	0.0%	59	10.6%	X^2=151.4	<0.001*
Decrease memory	122	8.5%	112	20.1%	X^2=52.7	<0.001*
Dry skin	72	5.0%	247	44.3%	X^2=465.7	<0.001*
Angular stomatitis	135	9.4%	95	17.0%	X^2=23.2	<0.001*
Deformed nails	0	0.0%	85	15.2%	X^2=229	<0.001*
Delayed wound healing	18	1.2%	175	31.4%	X^2=418.3	<0.001*
Cold extremities	113	7.8%	195	34.9%	X^2=226.9	<0.001*
Loss of appetite	628	43.6%	300	53.8%	X^2=16.8	<0.001*

Data presented as frequency (%). X^2; Chi-square test, *: significant

Children with iron deficiency had statistically higher frequency of male distribution, and higher frequency of illiterate mothers, and statistically lower age compared to children without iron deficiency. While there was no statistical difference between groups regarding gestational age, or maternal age at birth. They had statistically higher age of introduction of complementary foods, lower diversity of food and times of eating meat/week and had a statistically higher frequency of drinking tea compared to children without iron deficiency. While there was no statistical difference between groups regarding history of breast feeding, age of weaning or history of drinking juice. They had statistically higher frequency of medical disorders, lower frequency of iron supplementation and other medications, compared to children without iron deficiency. While, there was no statistical difference between groups regarding history of food allergy; children with iron deficiency had statistically lower weight, height and BMI compared to children without zinc deficiency (Table, 3).

Moreover, children with iron deficiency had statistically higher frequency of dental cavities, poor weight gain, recurrent infection, pallor, delayed development, easy fatigue, accelerated hair loss or damage, decrease vision, decrease memory, dry skin, angular stomatitis, delayed wound healing, cold extremities, loss of appetite compared to children without iron deficiency. While there was no statistical difference between groups regarding decreased taste sensation or deformed nails (Table, 4).

Zinc level correlated positively with BMI, height, times of eating meat per week, diversity of food and iron level. And iron level correlated positively with age, height, times of eating meat per week, diversity of food, and correlated negatively with age of introduction to complementary foods (Table, 5).

Table 3: Sociodemographic data, nutritional history, medical history and anthropometric measurements of the studied group according to iron status.

		Iron deficiency				Test	P value
		No		Yes			
		N=1261	**%**	**N=739**	**%**		
Sociodemographic data							
Sex	Male	594	47.1%	454	61.4%	X^2=38.3	<0.001*
	Female	667	52.9%	285	38.6%		
Age (years)		4.3±1.1		3.8±1.15		t=9.8	<0.001*
Age of mother at birth (years)		25.7±4.33		26.8±4.5		t=2.65	0.065
Gestational age (weeks)		37.2±2.8		37.02±2.11		t=0.42	0.75
Mother education	Illiterate	99	7.9%	186	25.2%	X^2=53.6	<0.001*
	Primary school	324	25.7%	240	32.5%		
	Secondary school	423	33.5%	215	29.1%		
	University	415	32.9%	98	13.2%		
Nutritional history							
Breast feeding		1101	87.3%	604	81.7%	X^2=5.5	0.09
Age of introduction to complementary foods (month)		5.5±1.39		6.3±1.66		t=11.2	<0.001*
Age of weaning (years)		15.71±4.41		15.35±3.5		t=0.57	0.56
Diversity of food		6.25±0.75		5.17±0.86		t=29.5	<0.001*
Times of eating meat /week		4.64±2.06		2.5±1.43		t=21.1	<0.001*
Medical conditions	Bronchial asthma	67	5.3%	55	7.4%	X2=12.1	0.036*
	Cardiac disorder	45	3.6%	55	7.4%		
	GIT disorders	5	0.4%	18	2.4%		
Food allergy Yes		122	9.7%	108	14.6%	X^2=6.2	0.091
Iron supplementations		113	8.9%	40	5.4%	X^2=8.2	0.031*
Other medications		443	35.1%	122	16.5%	X^2=19.4	<0.001*
Anthropometric measurements							
Height (percentile)		40.9±11.8		37.63±10.43		t=5.2	<0.001*
Weight (percentile)		42.57±11.78		37.62±14.59		t=8.2	<0.001*
BMI (percentile)		41.1±14.6		38.1±15.1		t=4.3	<0.001*

GIT: gastrointestinal tract, BMI: body mass index, Data presented as mean ± SD or frequency (%). X^2; Chi-square test, t: Student t-test, *: significant

Table 4: Clinical data of the studied group according to iron status.

	Iron deficiency				Test	P value
	No		Yes			
	N=1261	%	N=739	%		
Dental cavities	116	9.2%	289	39.1%	X^2=258.1	<0.001*
Poor weight gain	17	1.2%	288	38.9%	X^2=614.3	<0.001*
Recurrent infection	50	3.9%	389	52.6%	X^2=441.7	<0.001*
Pallor	11	0.9%	291	37.9%	X^2=581.1	<0.001*
Delayed development	72	5.7%	175	23.7%	X^2=139.2	<0.001*
Easy fatigue	11	0.9%	270	35.0%	X^2=532,7	<0.001*
Accelerated hair loss or damage	40	3.2%	212	28.7%	X^2=275.4	<0.001*
Decrease vision	36	2.9%	143	19.4%	X^2=155.6	<0.001*
Decrease taste	23	1.8%	36	4.9%	X^2=5.1	0.08
Decrease memory	18	1.4%	216	29.2%	X^2=348.5	<0.001*
Dry skin	54	4.3%	265	35.9%	X^2=346.3	<0.001*
Angular stomatitis	5	0.4%	225	30.4%	X^2=443.4	<0.001*
Deformed nails	41	3.3%	44	6.0%	X^2=6.3	0.072
Delayed wound healing	36	2.9%	157	21.2%	X^2=180.7	<0.001*
Cold extremities	172	13.6%	136	18.4%	X^2=9.5	0.041*
Loss of appetite	414	32.8%	514	69.6%	X^2=474.2	<0.001*

Data presented as frequency (%). X^2; Chi-square test, *: significant

Table 5: Correlation between serum iron and serum zinc with other clinical parameters.

	Zinc (µg/dL)		Iron (mcg/dL.)	
	r	P value	r	P value
Age (years)	-0.009	0.697	0.200	<0.001*
Gestational age (weeks)	0.071	0.072	-0.004	0.859
BMI (percentile)	0.208	<0.001*	0.065	0.930
Height (percentile)	0.327	<0.001*	0.129	0.008*
Weight (percentile)	-0.022	0.318	0.087	0.091
Age of introduction to complementary foods (month)	-0.058	0.079	-0.172	<0.001*
Age of weaning (years)	0.041	0.081	0.097	0.061
Times of eating meat /week	0.124	<0.001*	0.222	<0.001*
Diversity of food	0.323	<0.001*	0.435	<0.001*
Iron (mcg/dL.)	0.555	<0.001*	1	-

r: correlation

Discussion

Zinc deficiency is an important cause of morbidity due to infectious diseases and growth faltering among young children. Increased demand of zinc due to rapid growth and decreased intake of zinc due to inadequate feeding practices predispose pre-school children, especially living in communities of low socioeconomic level, to an elevated risk of zinc deficiency (5).

Iron deficiency results from depletion of iron stores and occurs when iron absorption cannot keep pace over an extended period with the metabolic demands for iron to sustain growth and to replenish iron loss, which is primarily related to blood loss (15).

In the current study, the mean zinc level in the studied group was 79.96±25.26 µg/dL, and 27.9% of children had zinc deficiency. Our results were comparable with another study which reported that the prevalence of zinc deficiency in the Philippines preschool children was 21.6%, with a mean serum zinc level of 94.5 ± 0.9 µg/dL (16). In contrast to another research, which reported that of the 182 children whose zinc serum levels were measured, only one (0.5%; 1/182) child showed low zinc serum level (40 µg/dL). Overall mean zinc serum level was 118.7 µg/dL and the first quartile, median and third quartile values were 103.0, 116.4 and 133 µg/dL, respectively, while its range was 40-212 µg/dL (17).

In the present study, the mean iron level in the studied children was 57.38±17.73 mcg/dL, and 37% of children had iron deficiency. Similarly, it was reported that the prevalence of iron deficiency anemia among children aged 24–59 months was 48.6% , in Tanzania (18). However, other study reported that the prevalence of anemia among preschool children in Karma Albalad village, Sudan was 80.4% (19).

In the present study, children with zinc deficiency had statistically higher frequency of male distribution, and higher frequency of illiterate mothers, compared to children without zinc deficiency. While there was no statistical difference between groups regarding age, gestational age, or maternal age at birth. Our results also agreed with a study which reported that educational attainment of household head below high school also significantly correlates to low zinc status of school children (20). However, a study observed that there were no significant differences in mean serum zinc levels between boys and girls and between urban and rural populations (21).

In the current study, children with zinc deficiency had statistically lower diversity of food and times of eating meat/week and had a statistically higher frequency of drinking tea compared to children without zinc deficiency. While there was no statistical difference between groups regarding history of breast feeding, age of introduction to complementary foods, age of weaning or history of drinking juice. Similarly, a study reported that lower average intakes of most nutrients; consumption of lesser amounts of fish, meats, and poultry; and higher intake of corn and corn products and green leafy vegetables were also noted among zinc-deficient children (20).

In the present study, children with zinc deficiency had statistically higher frequency of medical disorders, while there was no statistical difference between children with and without zinc deficiency regarding history of food allergy, iron supplementations or other medications. In the current study, children with zinc deficiency had statistically lower weight, height and BMI compared to children without zinc deficiency. Similarly, a recent research reported that zinc deficiency was significantly more prevalent among underweight (21.0%) and stunted children (24.5%) compared to those with normal nutritional status (22).

In the present study, children with zinc deficiency had statistically higher frequency of dental cavities, poor weight gain, recurrent infection, pallor, delayed development, easy fatigue, accelerated hair loss or damage, decrease vision, decrease taste, decrease memory, dry skin, angular stomatitis, deformed nails, delayed wound healing, cold extremities, loss of appetite compared to children without zinc deficiency.

In the current study, children with iron deficiency had statistically higher frequency of male distribution, and higher frequency of illiterate mothers, and statistically lower age compared to children without iron deficiency. While there was no statistical difference between groups regarding gestational age, or maternal age at birth. Similarly, a recent study reported that being a male child [OR: 1.46; 95% CI: (1.17, 1.82)], and having a mother with no schooling [OR: 1.54; 95% CI: (1.18, 2.00)], and a child being stunted [OR: 1.46; 95% CI: (1.25, 1.71)] were the factors associated with increased odds of anemia among children aged 24–59 months (18). In contrast, to another research that observed that the prevalence of anemia was insignificantly related to any of the studied demographic and socioeconomic factors (sex, economic status of the family, mother's literacy or family size) (19).

In the present study, children with iron deficiency had statistically higher age of introduction of complementary foods, lower diversity of food and times of eating meat/week and had a statistically higher frequency of drinking tea compared to children without iron deficiency. While there was no statistical difference between groups regarding history of breast feeding, age of weaning or history of drinking juice. Similarly, another study stated that continued breastfeeding (AOR = 1.9 (95% CI: 1.19–2.91) was positively associated with anemia (23).

In the current study, children with iron deficiency had statistically higher frequency of medical disorders, lower frequency of iron supplementation and other medications, compared to children without iron deficiency, while there was no statistical difference between groups regarding history of food allergy. Similarly, another study reported that children with food allergy have a higher rate of iron deficiency anemia (8%) than children with no FA (5%, $p < .001$) (24).

In the present study, children with iron deficiency had statistically lower weight, height and BMI compared to children without zinc deficiency. This agreed with a recent research reported that being stunted [OR: 1.46; 95% CI: (1.25, 1.71)] was associated with increased odds of anemia among children aged 24–59 months (18).

In the current study, children with iron deficiency had statistically higher frequency of dental cavities, poor weight gain, recurrent infection, pallor, delayed development, easy fatigue, accelerated hair loss or damage, decrease vision, decrease memory, dry skin, angular stomatitis, delayed wound healing, cold extremities, loss of appetite compared to children without iron deficiency. While there was no statistical difference between groups regarding decreased taste sensation or deformed nails. In contrast to a published research reported that microcytic anemia was associated with Koilonychia (i.e., spoon-shaped nails) which usually affects the first three digits (25). Although classically associated with iron deficiency anemia, it was reported that koilonychia is seen in only 5% of cases (26).

In the present study, zinc level correlated positively with BMI, height, times of eating meat per week, diversity of food and iron level. This was in agreement with a study reported that zinc correlated positively with weight for age (WAZ), $p<0.001$, height-for-age (HAZ) $p=0.048$, body mass index-for-age (BAZ), p<0.001, z-scores and iron level, *p*=0.028 (27).

In the current study, iron level correlated positively with age, height, times of eating meat per week, diversity of food, and correlated negatively with age of introduction to complementary foods. Our results also agreed with a recent research reported that a diversity of food≤ 4 was associated with higher odds of being anemic (*p* = 0·006) and being iron deficient (ID) (*p* < 0·001), consumption of meat, chicken and fish was associated with lower odds of being anemic (*p* = 0·045) (28).

In the current study, the mean zinc level in the studied group was 79.96±25.26 µg/dL, and 27.9% of children had zinc deficiency.

Some Egyptian studies measured serum zinc in different populations and revealed different concentrations. The mean of serum zinc concentration in these studies ranged from 57 up to 117.4 µg/dL (29-31).

In the present study, the mean iron level in the studied children was 57.38±17.73 mcg/dL, and 37% of children had iron deficiency.

Our results were in agreement with a previous study from Egypt, who reported that the prevalence of IDA was 25.6% (32). This result is similar to the study done before where it was shown that the prevalence of anemia in children was ~29.9% **(33)**.

Conclusion

In our community, 27.9% of children had zinc deficiency and 37% of children had iron deficiency. Zinc and iron deficiency were associated with male sex, illiterate mothers, lower diversity of food, lower weight, height and BMI. Zinc level correlated positively iron level, and both were correlated positively with times of eating meat per week and diversity of food.

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To cite this article: Ahmed A. Sobeih , Adel S. Elsayed , Reham S. Lotfy , Yasser M. Ismail . Iron and Zinc Status in Preschool Children from Rural Areas in Qalyubiya Governorate. BMFJ 2023;40(2);420-431.