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Zinc Deficiency among Malnourished Children under 5 Years in Gaza City

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Abstract:

Zinc is one of the trace elements important in human nutrition and metabolism. Zinc deficiency is now recognized as one of the most severe problems of human malnutrition world-wide. It is caused by low dietary intake of zinc and related to growth retardation in children, loss of appetite, impaired immune function and diarrhea.

Objective: To investigate zinc deficiency among malnourished children under 5 years in Gaza city.

Methodology: This cross sectional study consisted of 300 malnourished children under 5 years old from both sexes. Questionnaire interview with parents was used. Anthropometric measurements (weight, length and height) were taken. Blood samples were drawn for determination of serum Zinc . Statistical analysis was performed using SPSS version 18.0.

Results: The study population was (300) cases; (50.7%) males and (49.3%) females. More than two third of the sample (79.3%) received immediate breastfeeding, and (59.7%) of them were breast fed exclusively. Zinc deficiency among malnourished children showed (25.3%) of them had serum zinc level below (65) µg/dL. There was a significant association between gender and serum zinc at (0.05) level of significant. In contrast, there was insignificant association between each of underweight, stunting and wasting with serum zinc level. In addition, there was no significant association between immediate breastfeeding, exclusive breastfeeding length of breastfeeding period, age of introducing infant formula, age of introducing complementary food with serum Zn level. **Recommendations:** Interventions to improve children's zinc nutriture should be considered in populations at risk of zinc deficiency.

Key words: zinc deficiency; malnutrition; children under 5 years old; gaza city

Introduction

Malnutrition in children often begins at birth and is associated with retarded physical and cognitive development. This, in turn, yields serious implications for the overall national development agenda. In Palestine, malnutrition appears among children under-five. Currently, (11) out of (100) children under-five suffer chronic malnutrition including (11.3%) in the West Bank (WB) and (9.9%) in Gaza Strip (GS) (Palestinian Central Bureau of Statistic (PCBS), 2011).

Micronutrients which include vitamin A, zinc and iron are defined as nutrients that are only needed by the body in minute amounts, and are essential for healthy growth and development (Taha, 2011). Micronutrient malnutrition – also called "hidden hunger" – is a widespread global problem (Roohani, 2012) which can lead to serious health problems, including wasting, reduced resistance to infectious diseases, iron deficiency anemia, blindness, lethargy, reduced learning capacity, mental retardation and in some cases to death (Taha, 2011).

Zinc is one of the trace elements important in human nutrition and metabolism, participating in all major biochemical pathways and playing multiple roles in the perpetuation of genetic material, including transcription of DNA, translation of RNA, and ultimately cellular division (Hotz & Brown, 2004).

Good animals' sources of zinc include shellfish, beef, liver, and eggs. While zinc-good plant sources include leavened whole grains, nuts and legumes. The bioavailability of zinc is higher in animal products due to the relative absence of compounds that inhibit absorption (i.e. phytates and oxalates) and the presence of certain amino acids (i.e. cysteine and methionine) that improve zinc absorption (Project Healthy Children (PHC), 2012).

Zinc deficiency (ZnD) is now recognized as one of the most severe problems of human malnutrition world-wide. It is estimated to affect up to one-third of the global human population. In general the main cause of ZnD is low dietary intake of zinc. For example, the risk of ZnD is particularly high in populations depending on diets with low levels of absorbable zinc and with no or only limited access to sources rich in bioavailable zinc such as meat ((Roohani, 2012).

A common symptom of zinc deficiency include impaired sense of taste and / or smell, growth retardation in children, loss of appetite, impaired immune function (frequent colds and infections), hair loss, diarrhea, delayed sexual maturity, impotence, eye and skin lesions, weight loss, mental lethargy, night blindness, swelling and clouding of the corneas, and behavioral disturbances (PHC, 2012).

Zinc deficiency in malnourished children contributes to growth failure and susceptibility to infections. It is also associated with complications of

child birth. This deficiency usually occurs where malnutrition is prevalent. However, severe ZnD is responsible for dwarfism and failure to mature in young Iranian and Egyptian youths eating a diet consisting largely of whole meal bread. It is observed that lesser degrees of ZnD are more common now than was appreciated and the sub clinical deficiency of zinc contributes to an increased incidence and severity of common but important infections such as diarrhea and pneumonia. Diarrhea is associated with an increased loss of zinc in faces. It is also stated that ZnD increases the risk of mortality from diarrhea, pneumonia and malaria by 13 to 21 percent and unlike other micronutrients of public health importance has often subtle rather than dramatic clinical features (Ekweagwu, et al., 2008).

Justifications of the Study:

- Globally, malnutrition is the most important risk factor for illness and death.
- Although more and more national surveys have included the assessment of plasma zinc concentration in recent years, there is still insufficient data on the global prevalence of zinc deficiency.
- The extent of zinc deficiency among toddlers remains unknown whereas there is one study conducted by 2009 among children aged 1-3 years which showed that (72.2 %) of stunted male children and (67.7 %) of stunted female had a high percentage of zinc deficiency meaning that zinc deficiency is a serious public health problem in the Occupied Palestinian Territory (OPT). Thereby, this study finding requires further investigation.

Objective of the Study:

1. General Objective:

This study aimed to investigate zinc deficiency among malnourished children under 5 years in Gaza city.

2. Specific Objective:

- To clarify the prevalence of ZD among malnourished children under 5 years.
- To identify socio-economic and economic factors and their relation to ZD level of the children.
- To determine neonatal history that may effect on the ZD level of the children.
- To investigate nutritional history and its relation to ZD level of the children.

Methodology

Study Design

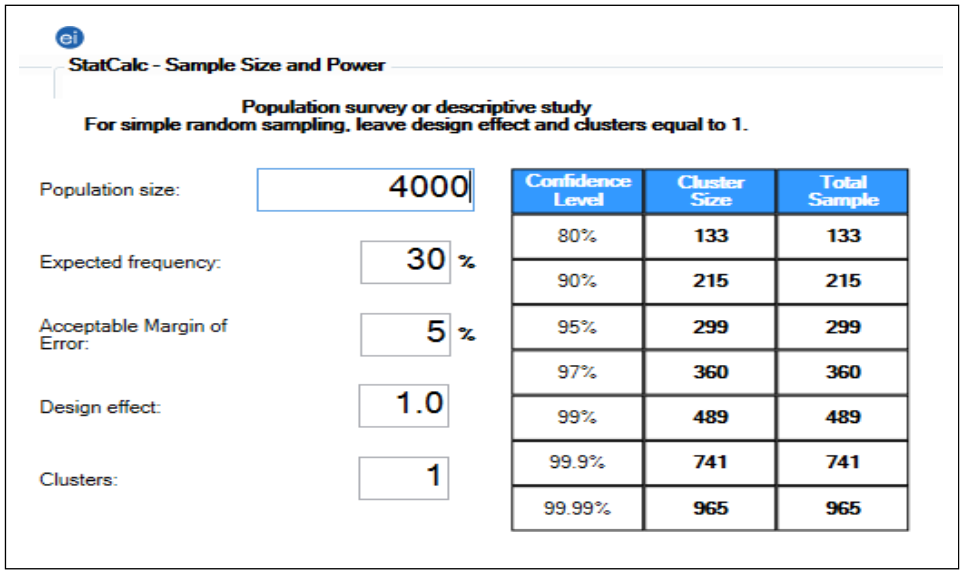
Cross sectional study was applied among malnourished children in Gaza city.

Sample Population

The sample population was malnourished children under 5 years old in Gaza city which diagnostic by WHO child growth standards and the identification of severe acute malnutrition in infants and children (WHO, 2009).

Sample Size

The sample size was consisted of (300) malnourished children (male and female) who were attending AEI services in the Gaza center. Sample size was calculated by epiInfo program at population size 4000, Expected frequency 30%, margin error 5% at 95 % CI.



Confidence Level	Cluster Size	Total Sample
80%	133	133
90%	215	215
95%	299	299
97%	360	360
99%	489	489
99.9%	741	741
99.99%	965	965

Study period

The study was conducted during the period from October, 2015 to June, 2016.

Questionnaire Interview

A meeting interview was used for filling the questionnaire. The questionnaire was based on AEI Benevolent Association questions. The questionnaire included questions about child personal data (area, age, and sex); occupation of children parents; socioeconomic status (family income, source of income, number of household and type of home); child anthropometric measurements (bodyweight, length/height); child neonatal history (birth weight, admission to ICU and neonatal Jaundice) and child nutrition history (immediate breast feeding, exclusive breast feeding, duration of breastfeeding and introducing each of infant formula and complementary food).

Blood Sample Collection and Processing

The blood sample collection process began with blood collection at AEI, followed by immediate processing at stationary laboratories. The samples then transported to storage at (-20°) C in the central laboratories.

Five ml venous blood samples were obtained from each child and divided into EDTA tube (1.0 ml) and vacutainer plain tube (4.0 ml). Vacutainer plain tubes were left for short time to allow blood to clot, and then clear serum samples were obtained by centrifugation at 1000 rpm for 20 minutes. The separated serum was placed in plain tubes and sealed. Samples that used within 5 days were stored at 2-8OC, otherwise samples stored at -20OC to avoid loss of bioactivity and contamination.

Anthropometric Measurements

Anthropometric measurements (weight and height) of the children were measured by a well-trained nurse to determine their nutritional status. Weight was measured in kg (to the nearest 100 grams) using an electronic digital scale (Seca model 770; Seca Hamburg, Germany) and its accuracy was periodically verified using reference weights. The child was weighed in light clothing, by determining the mean weights of light clothes dressed, and a correction for the clothing was made during weighing by subtracting 100 grams from each children weight.

Length was measured in cm (measured to the nearest mm) using a pediatric measuring board. Children were measured in a recumbent position (lying down). The software program for assessing growth and development of the world's children was used to make comparisons to the reference standards. The software program combines the raw data on the variables (age, sex, length, weight) to compute a nutritional status index such as weight-for-height, weight-for-age and height-for-age.

Biochemical Analysis

Zinc assay

Zinc was analyzed by spectrophotometric methods, using a colorimetric biochemistry auto analyzer system (Chem.Well, Awareness Technology Inc.).

Reference Values

Serum or plasma 60-107 µg/dl

Data Analysis

Data processing and analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 18.0. The cross tabulations and the Chi-square tests at a significance level of (5%) were used to investigate the statistical correlation between the VA level and other factors.

Results and Discussion

1. Socio-demographic Characteristics of the Study Population

Table (1) shows nearly equal percentage of the males and females among children under 5 years. This characterizes the Gazan community that has almost equal percentages of males and females. PCBS (2015) estimated that the population of GS totaled (1.82) million of which (925) thousand males and (895) thousand females.

In addition, the majority of the surveyed children had family members ranged from (1-10). PCBS (2013) reported that the majority of Palestinian households have children.

It was also observed that about fourty five percent of the families' heads were not employed. PCBS (2016) reported that the unemployment rate was about fourty percent in GS.

On the other hand, about fourty seven percent of the children participants belong to families with no monthly income. This indicates that, there was a considerable proportion of families in the GS who did not have adequate monthly income which reflected the state of poverty in the Palestinian community.

Middle East

Monitor (2016) reported that the Israeli siege imposed on the GS for a decade has damaged the enclave's economy.

Variable	No.	%
Gender		
Male	152	50.7
Female	148	49.3
Total	300	100.0
Age (Year)		
<2	262	87.3
2-3	24	8.0
>3	14	4.7
Number of household		
1-5	108	36.0
6-10	133	44.3
11-15	43	14.3
16-20	11	3.7
Source of income		
Employee	79	26.3
Free profession	74	24.7
Owner	3	1.0
Unemployed	136	45.3
Relief receiver	8	2.7
Monthly income (NIS)		
No income	140	46.7
< 500	55	18.3
500 - 1000	53	17.7
1000 - 3000	50	16.7
>3000	2	0.7

Table 1 Socio-demographic Characteristics of the Study Population.

2. Anthropometric Assessment Measurements of the Study Population

Anthropometric measurements of children participating in the study is shown in table (2). It was found that the majority of surveyed children were mildly moderately underweight. The causes of malnutrition are complex and multifaceted. In developing countries; dietary factors, exclusive breast- feeding for (4-6) months, complementary feeding at 6 months), maternal education, maternal mental health, family socioeconomic and environmental factors (deprivation, social support and hygiene) all may be associated with malnutrition. In addition, maternal mental health has been shown to suffer with exposure to war-related violence (Massad et al, 2012).

Moreover, prevalence of stunting was higher in study sample which (25%) mildly, (38%) moderately and (22.3%) severely stunted. Studies showed that there was a strong relationship between a child's age, familysize, birth interval and stunting. In communities that have little access to/and contact with health care, children are more vulnerable to malnutrition as a consequence of inadequate treatment of common illnesses, low immunization rates, and poor antenatal care. Poor environmental sanitation, including insufficient safe water supply, also puts children at risk of infection which increases susceptibility to malnutrition (Gugsa, 2000). In addition, chronic malnutrition was a disease of poverty in Gaza, where the World Bank estimated that Gaza had the highest rate of unemployment in the world (43%) among adults and (60%) among youth. The diet of Palestinians in Gaza is largely focused on bread, meaning that many people lack the variety and nutritional components needed to remain healthy (Ferguson, 2015).

The data analysis also revealed that about fourty one percent of the children were mildly wasted. Children become wasted when they lose weight rapidly, usually as a direct result of a combination of infection and diets that do not cover nutritional needs. In addition, other reasons may cause wasting such as: poor access to appropriate; timely and affordable health care; inadequate caring and feeding practices (e.g. exclusive breastfeeding or low quantity and quality of complementary food); poor food security – not only in humanitarian situations, but also an ongoing lack of food quantity and diversity, characterized in many resource-poor settings by a monotonous diet with low nutrient density, together with inadequate knowledge of patterns of food storage, preparation and consumption; and lack of a sanitary environment including access to safe water, sanitation and hygiene services (WHO, 2014).

Anthropometric Measurements	No.	%
Body weight (kg)		
<5	13	4.3
5-8	203	67.7
>8	84	28.0
Length/Height (cm)		
<60	14	4.7
60- 80	234	78.0
>80	52	17.3
Degree of weight for age W//A (SD)		
-1 to 3(normal)	4	1.3
-1.01 to -2.0(mild)	27	9.0
-2.01 to -3.0(moderate)	204	68.0
<-3(severe)	65	21.7
Total	300	100.0
Degree of length-height for age L-H//A (SD)		
-1 to 3(normal)	31	10.3
-1.01 to -2.0(mild)	75	25.0
-2.01 to -3.0(moderate)	113	37.7
<-3(severe)	67	22.3
Missing Values	14	4.7
Total	300	100
Degree of weight for length-height W//L-H (SD)		
-1 to 3(normal)	35	11.7
-1.01 to -2.0(mild)	119	39.7
-2.01 to -3.0(moderate)	106	35.3
<-3(severe)	22	7.3
Missing Values	18	6.0
Total	300	100

Table 2 Anthropometric Assessment Measurements of the Study Population.

3. Neonatal History of the Study Population

Low birth weight (LBW) has been defined by the WHO as weight at birth of less than (2,500) grams (WHO, 2004). Table (3) shows that more than third of the sample their birth weight was between (2.5-4) kg. A previous study carried out in Gaza city showed there was a direct correlation between ethnicity, age, marital status and educational status with increased negative pregnancy outcomes, such as low birth weight. In addition the nutritional status of pregnant mother was the most important determinant of infant birth weight (AlShawwa, 2014). Moreover, about thirty one percent of children's birth weight was less than (2.5) kg which might be due to status of maternal nutrition during pregnancy, stress (psychological) factors previous premature delivery, poor socio-economic status and early marriage which are very common in the Palestinian community.

In addition, twelve percent of the children participants in the study entered to ICU that was because of several reasons such as: premature birth, lack of oxygen, respiratory distress, problems in the chest, a hole in the roof of the mouth and problems in the trachea. While the majority of study sample did not enter to ICU.

Furthermore, about thirty percent of the surveyed children had neonatal jaundice, while more than two third of them didn't have neonatal jaundice. Jaundice is common in newborns and even among premature infants. Jaundice may result from serious disorders such as: incompatibility of the newborn's and mother's blood type, excessive breakdown of red blood cells or/and severe infection (Kopelman, 2016).

Variable	No.	%
Birth weight (kg)		
<2.5	94	31.3
2.5-4	203	67.7
>4	3	1.0
Admission to ICU		
Yes	36	12.0
No	264	88.0
Total	300	100.0
Neonatal Jaundice		
Yes	91	30.3
No	209	69.7
Total	300	100.0

Table 3 Neonatal History of the Study Population

4. Nutritional History of the Study Population

The nutrition history of study sample is shown in table (4). The majority of the participants received immediate breastfeeding and more than half of them were breast fed exclusively. This finding is consistent with the Palestinian Family Health Survey (2006) which indicated that (97.5%) of children received breastfeeding, more than half of infants (65%) started breastfeeding in the first hour after birth, (9.0%) had breastfeeding six hours or more after their birth for one reason or another (El Najjar, 2014). Other cross-sectional study evaluated data of (690) clinic files from (3) refugee camps in Nablus, Palestine in (2007) and revealed that about (70%) of infants aged (0–6) months were exclusively breastfed and only (14.3%) were exclusively formula fed (Musmar et.al. 2012).

About half of the children participating in the study received infant formula with age less than 6 months (the majority in the first month) that was for several reasons such as: the mother was pregnant, child refused the breastfeeding, inadequate child from breast milk and the mother was employed.

Moreover, more than half of study population (61.3%) received complementary foods with age less than 6 months. The previous study conducted in GS showed that (24.9%) of children up to 2 years old received complementary feeding before the age of three months while

(55%) received complementary feeding between ages of (3-5) months (Kanoa et al., 2011).

Variable	No.	%
Immediate breastfeeding		
Yes	238	79.3
No	62	20.7
Exclusive breastfeeding		
Yes	179	59.7
No	121	40.3
Length of breastfeeding period (month)		
<1	9	3.0
1-10	137	45.7
11-20	121	40.3
Missing Values	33	11.0
Total	300	100
Infant formula (month)		
<6	149	49.7
6-12	24	8.0
>12	4	1.3
Missing Values	177	59.0
Total	300	100
Complementary foods (month)		
<6	184	61.3
6-12	86	28.7
>12	3	1.0
Missing Values	27	9.0
Total	300	100

Table 4 Nutritional History of the Study Population.

5. Zinc Status in the Study Population

According to WHO/UNICEF/IAEA/IZiNCG the recommended cutoff of zinc for children under 10 years of age is 65 µg/dL. In the present study, (25.3%) of the malnourished children had Zn levels below (65)µg/dL and about seventy five percent of them had serum Zn level more than 65 µg/dL. Zakout (2010) showed that (70.1%) of the stunted children had zinc deficiency (< 65 µg/dl), while (29.9%) stunted children had normal zinc level (≥ 65 µg/dl).

Zinc Intervals (µg/dL)	NO.	%
<65(deficiency)	76	25.3
≥65(normal)	224	74.7
Total	300	100.0

Table 6 Zinc Status in the Study Population

6. Socio-Demographic Characteristics and Serum Zinc Level of the Study Population

Table (6) shows that a statistical significance association between genders with serum Zn level for the study population. This finding is inconsistent with the previous study which revealed that (72.2 %) of male stunting children had zinc deficiency, while (67.7 %) which had zinc deficiency was females (Zakout, 2010).

The study results also observed that there was an insignificance relationship between family's monthly income and source of income with serum of Zn level for the study sample. A previous study conducted among school children in a rural setting in North-Central Nigeria showed that the socio-economic status (SES) of subjects had an effect on their serum zinc level as those from the lower SES had significantly lower serum zinc than their counter-parts from the middle and higher SES (Abah et al., 2015).

Socio-demographic Characteristics	Zinc Intervals (µg/L)		Total	P-value
	Low <65	Normal ≥65		
Gender				
Male	32	120	152	0.05*
Female	44	104	148	
Number of Household				
1-5	30	78	108	0.26
6-10	28	105	133	
11-15	15	28	43	
16-20	2	9	11	
Source of Income				
Employee	18	61	79	0.13
Free Profession	23	51	74	
Owner	2	1	3	
Unemployed	33	103	136	
Monthly Income (NIS)				
No Income	36	104	140	0.93
<500	15	40	55	
500-999	13	40	53	
1000-2999	12	38	50	
>3000	0	2	2	

***Statistically significant (p-value <0.05)**

Table 6 Socio-demographic and Serum Zinc Level of the Study Population.

7. Anthropometric Assessment Measurements and Serum Zinc Level of the Study Population

The association between anthropometric assessment measurements with serum Zn level of the study population is shown in table (7). The results of the current study found an insignificant association between each of the underweight, stunting and wasting with serum of Zn level. A meta-analyses (2009) of single and multiple nutrient interventions in the children under 5 years of age showed that zinc had no significant effect on height or weight gain (Ramakrishnan, et al., 2009). Another previous study conducted to investigate the effect of supplemental zinc on the growth and serum zinc concentrations of prepubertal children revealed that there was no significant effect of zinc on weight-for-height indexes (Brown, et al., 2002).

Anthropometric Measurements	Zinc Intervals (µg/L)		Total	P-value
	Low <65	Normal ≥65		
Degree of W//A (SD)				
-1 to 4	0	4	4	0.07
-1.01 to -2.0	12	15	27	
-2.01 to 3.0	48	156	204	
<-3	16	49	65	
Degree of L-H//A (SD)				
-1 to 4	11	24	35	0.16
-1.01 to -2.0	28	91	119	
-2.01 to 3.0	32	74	106	
<-3	2	20	22	
Total	73	209	282	
Degree of W//L-H (SD)				
-1 to 4	8	23	31	0.89
-1.01 to -2.0	19	56	75	
-2.01 to 3.0	25	88	113	
<-3	18	49	67	
Total	70	216	286	

Table 7 Anthropometric Assessment Measurements and Serum Zinc Level of the Study Population.

8. Neonatal History and Serum Zinc Level of the Study Population

The results show that there was insignificant relationship between birth weight with serum Zn level at (0.05) level of significant. The majority of the children which had low birth weight)>2.5), their serum Zn level was normal.

In addition, the result showed that there was no significant association between neonatal jaundice with serum Zn level. More than two third of the participants which had neonatal jaundice, their serum Zn level was normal.

The data analysis also revealed an insignificant association between admission to ICU with serum Zn level. Seventy eight percent of the children with normal serum Zn level, entered to ICU.

Neonatal History	Zinc Intervals (µg/L)		Total	P-value
	Low <65	Normal ≥65		
Birth Weight (kg)				
< 2.5	22	72	94	0.89
2.5-4	53	150	203	
> 4	1	2	3	
Total	76	224	300	
Admission to ICU				
Yes	8	28	36	0.64
No	68	196	264	
Total	76	224	300	
Neonatal Jaundice				

Yes	22	69	91	0.76
No	54	155	209	
Total	76	224	300	

Table 8 Neonatal History and Serum Zinc Level of the Study Population.

9. Nutrition History and Serum Zinc Level of the Study Population

In the present study, it was found that there was no association between breastfeeding, length of breastfeeding period and age of introducing each of infant formula and complementary foods with serum Zn level for malnourished children participants in the study. Zakout (2010) revealed that (74.5 %) of stunted children, who were weaned had zinc deficiency. More than, there is no statistical significant difference between weaning age and serum Zn level among the participants (stunted and non-stunted children). In addition, a randomized, prospective trial was conducted to identify the effect of timing of introduction of complementary foods on iron and zinc status of formula fed infants at 12, 24, and 36 months of age showed that the early introduction group consumed slightly less zinc than the late introduction group at 5 months and 6 months, and the serum zinc concentration was not associated with dietary zinc. Furthermore, both groups had normal serum zinc concentrations at 12, 24, and 36 months and there were no differences between groups (Kattelmann, et al., 2001). The micronutrient therapy include magnesium intake and measurement of plasma magnesium levels that may be as important for malnutrition in children (Martins et al., 2018). Several study showed that Food practices such as food contamination lead to increased bacterial lipopolysaccharides (LPS) that may be critical to zinc deficiency and magnesium deficiency. The role of raising the level of nutritional knowledge may require food end products to be measured such as LPS (food and blood plasma) to determine the effects on children's zinc and magnesium nutrition (AbuNada et al., 2018; Martins et al., 2013; Martins et al., 2018; Pitt et al., 1997)

Nutrition History	**Zinc Intervals (µg/L)**		**Total**	**P-value**
	Low <65	Normal ≥65		
Immediate Breastfeeding				
Yes	60	178	238	0.92
No	16	46	62	
Total	76	224	300	
Exclusive Breastfeeding				
Yes	45	134	179	0.91
No	31	90	121	
Total	76	224	300	
Length of Breastfeeding Period (month)				
1-10	45	134	179	0.92
>10	31	90	121	
Total	76	224	300	
Age of Introducing Infant Formula(month)				
<6	2	7	9	0.94
6-12	36	101	137	
>12	33	88	121	
Total	71	196	267	
Age of Introducing				

Complementary Foods (month)				
<6	40	109	149	0.568
6-12	4	20	24	
>12	1	3	4	
Total	45	132	177	

Table 9 Nutrition History and Serum Zinc Level of the Study Population Recommendation

Childhood malnutrition among children under 5 years appears to be a public health problem in GS and interventions to improve children nutritional status must be in concern. In addition, zinc supplementation may be an effective public health intervention means to improve the zinc status of the population. So, the following recommendations are suggested:

- Protocols that include micronutrient practices, based both on Palestinian needs and international standards.
- Behavior change strategies to inform and motivate - both the community and health providers - about the importance of zinc and other micronutrients. Issues to be addressed will include the safety of any supplements for the general population, the level of need in the overall population and the impact and effects of ZD.
- Raising the level of nutritional knowledge among health professionals and their staff on the health of children and the need for clinical nutritionist to be present within the follow-up group for malnourished children must be in concern.

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