Zinc deficiency in the pediatric age group is common but underevaluated

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Original article

Background: **Subclinical micronutrient deficiencies have been gradually becoming more important as a public health problem and drawing attention of the health authorities. Today it has been known that detecting and treating people having deficiency symptoms alone is no longer sufficient. It is important to detect and prevent any deficiency before it displays clinical manifestations. Zinc deficiency is one of the most widespread micronutrient deficiencies. In this study, we aimed to evaluate the zinc status and the associated factors in healthy school-age children.**

Methods: **The study was carried out in schools in Altindag, the district of Ankara. A total of 1063 healthy children, 585 girls and 478 boys, aged 5-16 years were included in the study. Serum zinc, high-sensitivity C-reactive protein levels and white blood cell count were measured. A serum zinc level <65 μg/dL was considered as subclinical zinc deficiency for children <10 years of age. For children ≥10 years of age the cutoffs for serum zinc concentration were set at 66 μg/dL for females and 70 μg/dL for males. A questionnaire was developed to collect socioeconomic and demographic information of the participants.**

Results: **The prevalence of subclinical zinc deficiency in children attending the study was detected to be 27.8%. This high ratio showed zinc deficiency was an important health problem in the Altindag district of Ankara, Turkey.**

Conclusions: **Evaluating the indicators of zinc deficiency such as serum zinc concentration, dietary zinc intake and stunting prevalence, this study is the most comprehensive epidemiological study performed in children in Turkey. This study reveals the high prevalence of subclinical zinc deficiency and indicates that zinc deficiency is a public health concern for the study population.**

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Introduction

Children constitute a substantial portion of the world's ever-increasing population and malnutrition is one of the most serious problems that children are facing around the world today. Malnutrition due to macronutrient deficiencies has been on the decline as a result of studies performed and precautions taken, at the same time micronutrient deficiencies have been gaining importance.[1] Micronutrient deficiencies with clinical manifestations constitute only the tip of the iceberg. There are many milder forms of micronutrient deficiencies that do not show typical clinical findings and are located under the surface.[2]

Zinc is an important micronutrient and is essential for children to ensure a healthy life span and sustain normal growth and development. Zinc deficiency is one of the most widespread micronutrient deficiencies.[3] Zinc deficiency constitutes a substantial disease load, especially in Africa, the Eastern Mediterranean, and Southeast Asia. Nationwide public health programs to prevent and treat zinc deficiency have been implemented in countries located in Asia and Africa. International organizations such as United Nations Children's Fund, the World Health Organization (WHO) and other similar organizations have been carrying out both nationwide and worldwide studies to raise awareness and find useful solutions for zinc deficiency.[4] Before launching similar studies in our country, we need to know the prevalence of zinc deficiency in Turkey.

Turkey is a country that is under risk of zinc deficiency for several reasons. First of all, soil and plant analyses show that soil and plants in Turkey contain very small amounts of zinc.[5] Another factor playing a role in the development of zinc deficiency is grains. Grains negatively affect the bioavailability of zinc due to their high phytate content.[5] Zinc deficiency is more frequently encountered in Turkey as it is located in a region where wheat production is rather high.[5]

It is hard to define the prevalence in Turkey due to a lack of sufficient studies. Most of the available studies regarding deficiency in Turkey are of hospital origin and their samples size are limited. The majority of the studies performed in Turkey or around the world, were carried out in risky individuals in terms of zinc deficiency, such as children at a growing age and postpartum women. There are very few studies performed by screening the general population. In Turkey, so far there is not any study performed in a wide age range such as all school-age children who are healthy and not in the high-risk group. To the best of our knowlege, this study is the most comprehensive epidemiological study in Turkey regarding the prevalence of subclinical zinc deficiency in children of school age. Both in Turkey and in the whole world, there is a need for this kind of study demonstrating the prevalence of subclinical deficiencies. Such studies will provide information regarding whether this kind of deficiency constitutes a health problem for the country in which the study is performed and will lead the way in combating this deficiency. In this study, we aimed to evaluate zinc status in healthy school-age children and detect any subclinical deficiency.

Methods

This study was carried out in healthy school aged children, aged 5-16, attending primary schools in the Altindag district of Ankara in 2009. The study was approved by the local ethics committee. Ten schools located in Altindag were selected randomly from the list of schools recorded on the internet page of the Ministry of Education. Questionnaires were distributed to these ten schools to a total of 5000 children. Children took the questionnaires home and the forms were filled out by their parents and collected after one week. 90% of the children agreed to participate in the study and completed the questionnaires but due to financial reasons blood samples were taken from a total of 1250 children randomly chosen. After excluding those children who had missing values, a total of 1063 healthy children, 585 females and 478 males, were included in the study on a voluntary basis with the written approval from their parents. Healthy children with no complaints were included in the study. Children having fever, infection, and chronic diseases were not included. Sociodemographic characteristics and conditions that could affect the zinc status such as infection were determined using a survey form. The survey included questions regarding the parents, such as the education level of the parents, monthly income of the family, number of individuals living in the same home and the number of children under the age of five at home, as well as questions regarding the child, such as age, gender, scheme and duration of zinc use, if any. Anthropometric evaluations were performed, weight and height measurements were carried out by the same investigator and the same well-calibrated measurement materials were used.

All blood samples were collected in the morning on a full stomach. Serum zinc concentration was used as an indicator of zinc status in this study since it reflects dietary intake and reference data are available for children. Precautions to avoid zinc contamination as described by International Zinc Nutrition Consultative Group (IZiNCG) were taken during the analysis. Disposable polyethylene gloves free of talc were worn by the people handling blood samples, stainless steel needles were used while drawing blood, trace element-free evacuated tubes were used for blood collection, samples were transported to the laboratory in a portable cool box in order to keep them cold (2-10^{o}C) and all materials were stored covered to avoid dust. The samples were centrifuged at 2000-3000×g for 10 minutes, any severely hemolyzed samples were discarded, and samples were stored in zinc-free polypropylene tubes at -80^{o}C until the day of analysis. To protect from dust and other sources of zinc contamination, samples were processed under a hood. On the day of the analysis, 4.5 mL of freshly prepared solution was added to a serum sample of 0.5 mL. After closing the top and mixing for 5 minutes in a vortex device, the material was transferred to the measurement device for reading. The solution was prepared so that it would contain 2% butanol, 1% ammonium hydroxide, 1 g EDTA, and 1 mL triton X. Certified standard solutions were used while preparing the standard solutions for the study and a zinc standard 1000 mg/L solution was used for this purpose. All quality control procedures, such as using a standard reference material with a certified, analyzed mean zinc content, were taken. Serum zinc level measurements were carried out using the inductively coupled plasma mass spectrometry technique in a device trade-marked AGILENT. All zinc analyses were carried out by the same person. A non-fasting serum zinc level <65 μg/dL was considered as zinc deficiency for children <10 years of age. For children ≥10 years of age the cutoffs for non-fasting serum zinc concentration were defined as 66 μg/dL for females and 70 μg/dL for males.[3,6]

In addition to serum zinc level measurements, high-sensitivity C-reactive protein (hsCRP) and white blood cell (WBC) counts were measured to detect any subclinical infection. Measurement of hsCRP levels was carried out using an immunonephelometric method in a BNProSpec device. Normal hsCRP values were considered as 0-0.3 mg/dL.[7] Complete blood counts were carried out automatically in a Cell Dyn 3700 (Abbott) hemogram device. Normal WBC count was considered as 5500-15 500 cells/mm^3, 4500-13 500 cells/mm^3, and 4500-11 000 cells/mm^3 for age groups of 4-7, 8-13, and 14 and over, respectively.[8]

Data analysis was carried out using SPSS for Windows. We investigated whether continuous variables were in accordance with normal values using Shapiro-Wilk test. Continuous variables were presented as mean±standard deviation or median (min-max) for continuous variables, while categorical variables were presented as number of subjects and percent (%). Importance of differences between groups in terms of mean values was evaluated with Student's *t* test while importance of differences in terms of median values was evaluated with Mann-Whitney *U* test when the independent group number was two and with Kruskal-Wallis test when there were more than two independent groups. In case statistical results of the Kruskal-Wallis test were found to be significant, a non-parametric multiple comparison test was used in order to determine the groups causing the significant difference. Categorical variables were evaluated using Pearson's Chi-square test or Fisher's exact Chi-square test. We investigated whether there was a significant correlation between continuous variables using Spearman's correlation test. Results were considered statistically significant for $P<0.05$.

Results

A total of 1063 healthy children aged 5-16 years were included in the study. The mean age of the children included in the study was 10.2±2.5 (5.2-16.2) years. Subjects between the ages of 5-8, 9-12, and 13-16 constituted 39.4%, 41.9%, and 18.7% of the population, respectively. 76.1% of the mothers and 59.1% of the fathers were primary school graduates. While a great majority of the fathers (78.6%) were unskilled laborers, 96.3% of the mothers did not work. 92.6% of the families had a monthly income level of 1000 TL ($650) or lower; and 58.8% of the subjects were living in rental houses (Table 1). A monthly income level of 1000 TL was chosen as a cut-off value since this was the minimum wage for unskilled laborers in Turkey.

Zinc deficiency was detected in 27.8% of the subjects. The median zinc level was 72.7 μg/dL (39.9-157.1 μg/dL). There was no statistically significant difference between the median serum zinc levels of the females and those of the males. While the lowest median serum zinc level was found in the 5-8 age group, it was found to be highest in the 13-16 age group (Table 2). Zinc levels were low in 31.3% of the children whose fathers were not working and in 30% of the children whose fathers were unskilled laborers. While the zinc level was low in 16.7% of the subjects living in their own houses, it was low in 33% of the subjects living in rental houses and in 32.7% of the subjects living in shacks. Serum zinc levels according to socioeconomic indicators are given in Table 3. When correlating serum zinc level with certain clinical parameters, such as age and anthropometric measurements including body weight, height, and body mass index *Z* scores, the only significant correlation was detected between age and zinc level ($R=0.067$, $P=0.03$). There was no statistically significant correlation between serum zinc levels and certain socioeconomic indicators, such as parents' educational levels, the number of individuals living in the same home, number of siblings, or number of children under the age of five at home (Table 4).

Infections in the previous two weeks, such as lower and

Table 1. Distribution of the subjects according to the socioeconomic indicators ($n=1063$)

Education level, *n* (%)	Mother's	Father's
No education	40 (3.8)	3 (0.3)
Primary school	809 (76.1)	628 (59.1)
Mid school	112 (10.5)	210 (19.8)
High school	94 (8.8)	196 (18.4)
College	8 (0.8)	26 (2.4)
Work status, *n* (%)	Mother's	Father's
Not working	1024 (96.3)	16 (1.5)
Working	39 (3.7)	1047 (98.5)
Monthly income of the family, *n* (%)		
≤1000 TL ($650)	984 (92.6)	
>1000 TL ($650)	79 (7.4)	
The ownership of the house the subject is living, *n* (%)		
Owner of the house	276 (26.0)	
Rental house	625 (58.8)	
Other (shack)	162 (15.2)	

Table 2. Serum zinc levels according to gender and age groups

Variables	Zinc level (μg/dL) median (min-max)	Percent of subclinical zinc deficiency	*P* value
Gender			
Female	73.2 (39.9-143.8)	150/585 (25.6)	0.070
Male	72.0 (47.6-157.1)	145/478 (30.3)	
Age groups			
5-8 y	71.4 (47.6-157.1)	125/419 (29.8)	0.006
9-12 y	72.5 (39.9-143.8)	127/445 (28.5)	
13-16 y	76.3 (48.5-147.6)	43/199 (21.6)	

Table 3. Serum zinc levels according to socioeconomic indicators

Variables	Zinc level (μg/dL) median (min-max)	Percent of subclinical zinc deficiency	*P* value
Mother's occupation			
Not working	72.8 (39.9-157.1)	281/1024 (27.4)	0.455
Working	70.8 (51.1-147.6)	14/39 (35.9)	
Father's occupation			
Unskilled laborer	71.8 (39.9-141.6)*	250/835 (30.0)	0.003
Civil-servant/self-employed	74.5 (51.5-143.8)*,†	41/212 (19.3)	
Not working	69.9 (56.3-157.1)†	5/16 (31.3)	
The ownership of the house the subject is living			
Owner of the house	76.2 (48.7-147.6)‡,§	46/276 (16.7)	<0.001
Rental house	70.6 (39.9-141.6)‡	206/625 (33.0)	
Other (shack)	69.5 (47.8-157.1)§	53/162 (32.7)	

*: unskilled laborer group *vs*. civil-servant/self-employed group, $P<0.001$; †: civil-servant/self-employed group *vs*. not working group, $P<0.001$; ‡: the group living in their own houses *vs*. the group living in rental houses, $P<0.001$; §: the group living in their own houses *vs*. the group living in shack, $P<0.001$.

Table 4. Correlation coefficients (*R*) and level of significance (*P* value) between serum zinc level and child's age, antropometric measurements, socioeconomic indicators

Variables	Zinc level	
	R	*P*
Child's age	0.067	0.030
Body weight *Z* score	0.051	0.098
Height *Z* score	0.056	0.072
Body mass index *Z* score	0.029	0.320
Mothers' age	0.031	0.310
Mothers' educational level	0.040	0.197
Fathers' educational level	0.029	0.354
The number of individuals living in the same home	0.023	0.462
The number of siblings	-0.004	0.909
The number of children under the age of five at home	-0.057	0.065

upper respiratory tract infections, fever, and diarrhea, were inquired with a questionnaire since it was expected that this would reduce serum zinc levels. The median serum zinc level of subjects who had infections within the previous two weeks was 72.3 (47.9-143.8) μg/dL while it was 73.0 (39.9-157.1) μg/dL in those who did not have infections in the previous two weeks ($P=0.455$). In addition, the status of having diarrhea in the last year was inquired separately as it impairs intestinal absorption and affects serum levels for a long time.[9] The median serum zinc level of subjects who had diarrhea in the last year was 72.9 (47.6-157.1) μg/dL while it was 72.6 (39.9-143.8) μg/dL in those who did not have diarrhea in the last year ($P=0.287$). No significant difference was detected in terms of serum zinc levels between the subjects who had a history of infectious disease and those who did not. This study, which aimed to screen subclinical zinc deficiency, was carried out in healthy individuals, so children having clinical infections were not included. However, subclinical infections might be present in these individuals and hsCRP and WBC counts were measured to detect any subclinical infection. In 23.1% of the children (246/1063) included in the study, hsCRP was found to be elevated and in 0.9% of the children (10/1063) white blood cell count was found to be elevated, which was interpreted as the presence of subclinical infection. When relationships between serum zinc level, WBC counts, and hsCRP values were investigated, a significant correlation was found between serum zinc level and WBC counts (for WBC R=-0.058, $P=0.05$; for hscrp R=0.029, $P=0.356$).

When diets of the subjects regarding the intake of foods rich in zinc content, such as liver, beef, lamb, dark chocolate, cocoa powder, peanuts, and seafoods were investigated, no correlation was detected between zinc level and consumption of these foods. The history of using zinc supplements was also asked and the median serum zinc level of the subjects taking supplements was found as 73.2 (39.9-157.1) μg/dL while it was 69.4 (47.8-137.8) μg/dL in those who did not take any supplement ($P=0.002$).

Discussion

Although zinc deficiency is one of the most prevalent nutrient deficiencies worldwide, the number of studies performed in healthy communities to investigate the prevalence of zinc deficiency is limited since obtaining a reliable biological indication of zinc is technically rather difficult. There is no generally acknowledged sensitive and specific marker for measuring zinc status. Various tests have been used for diagnosis of zinc deficiency but none of them alone were found to be adequate for diagnosis.[3] To detect zinc deficiency, zinc concentrations in certain tissues and fluids of the human body can be measured. The most common method used in determining zinc status is measuring the plasma/serum zinc levels. Therefore, serum zinc levels were used in the current study to evaluate zinc status. Blood sample collection time and status of hunger affect serum zinc levels. In the performed studies, serum zinc level was 9.5% higher in blood samples taken in the morning compared with samples taken in the afternoon or the evening. Similarly, serum zinc level was 7.3% higher in samples taken in the morning on an empty stomach compared with samples taken in the morning on a full stomach. In 2003, Iavicoli et al[10] reanalyzed the data from the 2nd national health and nutrition evaluation study performed in the USA between 1976-1980 and found the subclinical serum zinc level to be <65 μg/dL in the measurements performed in the morning on a full stomach in both males and females <10 years of age. In our study, blood samples were collected in the morning

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on a full stomach and this value was considered as the borderline value.

Zinc deficiency was found to be 27.8% in healthy children in our study. This rate is similar to the findings of other studies performed around the world. IZiNCG recommends that if more than 20% of the population has a serum concentration below the relevant cutoff, the whole population should be considered to be at risk of zinc deficiency.[3] This study demonstrates that zinc deficiency is an important public health problem in the Ankara province, which is the capital city of Turkey. A national study in Mexico carried out by Villalpando et al,[11] demostrated 25.3% of Mexican children under the age of 12 had a zinc deficiency. which was similar to the zinc deficiency rate in our study. Subclinical zinc deficiency in healthy children is detected to be as low as 0-2% in developed countries[12-14] whereas as high as 13%-55.7% in the developing countries.[15,16] In our study, the median serum zinc level was found as 72.7 (39.9-157.1) μg/dL and this value is one of the lowest values in the literature. Donangelo and Azevedo[17] investigated 103 healthy Brazillian children, aged between 3 months and 6 years, coming from families with low income levels and found a mean serum zinc level of 98.3±15.7 μg/dL. In Canadian children aged 1-5, the zinc level was found to be 67.3 μg/dL and 118.3 μg/dL for the 2.5 percentile and 97.5 percentile, respectively;[18] on the other hand, the mean serum zinc level was measured as 62.7 μg/dL in Thailand in children aged 6-13.[19]

Due to their higher growth rates, the need for zinc is higher in males, breastfed infants, and in little children, especially those with low birth weight, and these groups are under a greater risk in terms of deficiency. In this study, the median serum zinc level was found similar for both genders. Vaghri et al[20] did not detect any difference between genders in terms of serum zinc levels. On the other hand, Thurlow et al[19] observed male gender as a risk factor for zinc deficiency. In this study, a significant correlation was detected between the child's age and serum zinc level, with the lowest zinc levels detected in the 5-8 year old age group. In a recent screening study performed in Mexico, the prevalence of zinc deficiency was demonstrated to decrease with age.[11] In another study carried out in Canada, mean hair zinc levels of children under the age of four were lower compared with children of older ages.[20] No correlation was detected between serum zinc level and the children's anthropometric measurements in our study. Similarly, in a study carried out by Laitinen et al[14] in Finland, no correlation was demonstrated between serum zinc level and anthropometric measurements.

In order to estimate the prevalence of zinc deficiency in a certain region, dietary zinc intake and stunting prevalence must be known, in addition to blood plasma or serum zinc concentration. According to IZiNCG, the risk of zinc deficiency is of public health concern when the prevalence of inadequate intake is >25%.[3] Surveys designed either to estimate the prevalence of inadequate zinc intake or to estimate the mean zinc intake in a population are necessary to collect data on dietary zinc. Weighed food records or 24-hour recalls should be collected and based on the food intakes the dietary intake of total zinc, total phytate and the phytate:zinc molar ratio in the diet must be calculated. If total zinc intake is known, the prevalence of zinc intake below the estimated average requirement can also be determined. Alternatively, the percent of zinc absorption, the amount of absorbable zinc and the prevalence of absorbable zinc intake below the physiological requirements can all be estimated based on the diet type and the phytate:zinc molar ratio. In this study, consumption of foods rich in zinc content and the relation between serum zinc levels and consumption of these foods were investigated. By means of a survey, parents were asked regarding how many days per week and how many meals per day they provided certain foods to their children. The amount of food eaten in one meal may vary from child to child even though the number of meals remains the same. Use of more standardized measures, such as weighed food records, would be more appropriate in order to evaluate food intake more objectively. According to the information obtained from the surveys, children consumed meat at a mean of one meal per week, whereas they consumed bread at a mean of 15 meals per week. Since meat is an important source of zinc and bread is the main dietary source of phytate, it can be remarked that the dietary intake of absorbable zinc is low in the study population. In addition, Turkey is among the largest wheat producers in the world and Ankara province, which was the study site, is located in Central Anatolia, the country's major wheat growing area. Wheat is the main source of dietary calories, providing up to 75% of the daily calorie intake in low socioeconomic areas, such as in the study site, where bread is one of the fundamental nutrition sources.[5] Wheat has a very low zinc bioavailability due to having very high phytate:zinc ratios. In the studies performed, almost 50% of the soil samples in Turkey were zinc deficient; Central and Eastern Anatolia being the main areas with very low zinc content soil.[5] It is therefore not surprising that zinc deficiency occurs in regions such as the Altindag district in Turkey where soils are low in available zinc, and cereals are the major source of calorie intake.

With zinc deficiency, growth decreases in order to conserve zinc to maintain tissue concentration and function. Poor growth and stunting is the result of this type of deficiency. Nutritional stunting can be defined as height-for-age *Z* scores <-2 in relation to the reference data. The stunting prevalence among children under 5 years of age can be used as indirect indicator of a population's risk of zinc deficiency.[3] According to the WHO survey in 2004, Turkey has a stunting rate of 15%.[21] The overall stunting rate of the study population was 18%, which was similar to the national stunting prevalence of Turkey. This high stunting rate supports the high prevalence of zinc deficiency in the district where the study was performed.

Social and economic factors are underlying predictors for all types of micronutrient deficiencies, including zinc deficiency. Socioecomic indicators can be used to select populations for targeting intervention, since deficiencies are assumed to be higher in low socioeconomic classes. The Altindag district, which was the study site, is a region where families of lower socioeconomic class live compared with other parts of Turkey. The percentage of mothers having completed secondary or higher levels of schooling was low in the study population. Monthly income levels of 92.6% of the families were found to be $650 or less. Employment status and type of employment are also important indicators of socioeconomic status. The majority of the fathers were unskilled laborers in this study. Settlement is another risk factor for zinc deficiency. It is easier for individuals living in cities to obtain correct information about nutrition, to reach foods that are rich in zinc content and to access health services. Dietary habits and diseases negatively affect vitamin and mineral levels of the children living in rural areas.

In performed studies, serum zinc levels were found to be reduced in cases of inflammation or infection.[22] These factors should be taken into consideration when determining the prevalence of deficiencies. Zinc levels decrease during some infections as a result of the increase in both zinc use and zinc loss. Since serum zinc levels are affected by infection, children having clinical infections were not included in the study and the children who were included were questioned regarding recent infections. No correlation was demonstrated between serum zinc level and recent disease. Since data for these diseases was obtained from the survey filled out by the parents, it may not have included sufficient and reliable information and this could be one of the reasons why no correlation was found. Mild infections can go unidentified without yielding any findings and children may seem like healthy individuals when findings are not adequately prominent at the beginning of an infection or during the incubation period. In this study, acute phase reactants such as hsCRP and WBC counts were examined in order to demonstrate the presence of subclinical infection. The increase in acute phase response detected in subclinical infection usually causes a reduction in serum zinc level. In this study, a negative correlation was detected between serum zinc level and WBC counts.

To our knowledge, this study is the most comprehensive epidemiological study identifying the frequency of zinc deficiency in healthy school-age children in Turkey. In the study, the rate of zinc deficiency was 27.8% in Altindag, the district of Ankara in which this study was performed, and this shows that zinc deficiency is an important health problem in this region. Zinc is an essential nutrient for public health. Ensuring adequate levels of zinc intake reduces the frequency of recurring infections, diarrhea and pneumonia. Adequate zinc intake is required for normal growth and development and zinc supplements enhance the physical growth of stunted children. Adequate zinc nutrition decreases morbidity and mortality in children. In spite of all the benefits of zinc, approximately 2 billion people are still at risk of zinc deficiency and approximately one third of the world's population live in areas at high risk of zinc deficiency.[3] There may be many causes of zinc deficiency. Due to rapid population growth and developing technology, changes in nutritional habits develop, causing new nutritional problems. Methods used during preparation and processing of food in order to get it ready for consumption cause considerable losses in vitamin and mineral content. Another factor causing insufficient intake in the diet is socioeconomic incapability. Depending on the weakness in purchasing power, nutritional disorders are encountered in all individuals, especially in children. Individuals may not be able to take sufficient amounts of vitamins and minerals required by a healthy diet because of personal characteristics, regional conditions and socioeconomic and sociocultural characteristics. Whatever the reason, some precautions must be taken to prevent these vitamin and mineral deficiencies. Nutritional guidelines can be prepared and these guidelines should be compatible with socioeconomic and cultural factors and the ecological structure of the society where the individual lives. Adding the deficient micronutrients into commonly used food products, increasing the intake of foods that are rich in micronutrients via diet, and providing vitamin and mineral support can be other methods in order to prevent deficiencies. To eliminate zinc deficiency, zinc supplementation for diarrhea and malnutrition must be implemented. Zinc can be added to the minerals used in fortification programs. Dietary modification with zinc-rich foods and zinc-fortified foods should be encouraged. Breastfeeding should be supported since breast milk is an important source of zinc. Food processing technologies can be applied to increase the amount of absorbable zinc.

Vitamin, mineral and trace element deficiency problems are to a great extent under control in the developed countries. In Turkey, our goal should be to bring these deficiencies under control in our country as well. First of all, the frequency of these deficiencies should be defined before launching nationwide public health programs with this purpose. There is a need for examining population samples with different characteristics with an adequate number of subjects in order to determine the frequency of all types of micronutrient deficiencies around the world.

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Competing interest: There's no conflict of interest.
Contributors: Vuralli D contributed to the literature search, the design of the study, data collection, data analysis and writing of the study. Tumer L and Hasanoglu A contributed to the design, data interpretation and helped in writing the manuscript.

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