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Review Article

Zinc Paucity and its Consequences: A Review

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Abstract

Human body required energy and raw material for proper body functioning. Raw material are in two forms included macronutrient and micronutrient. Macronutrients are those required in large quantity i.e. Carbohydrates, protein etc. Micronutrients are required in small quantity i.e. iron, zinc, calcium etc. Malnutrition due to micronutrients imposes a tremendous threat to the well-being and health status of more than two billion people all around the world (WHO, 1995). Stunted growth, impaired vision, mental retardation, lethargy, low self-esteem and learning debilities are the consequences of micronutrient deficiencies vitally from Fe, Zn, Vitamin A, B_6, B_9, B_{12} and Iodine. Therefore preventive and curative measures for micronutrient deficiency in children and adolescents have gained significant importance in order to increases cognitive development, strength, immunity and to decrease morbidity rate (Underwood, 1997). Zn deficiency has been linked with various disorders that include anemia, slow wounds healing, impaired gonadal function, abnormally short stature and diminished cognitive and cerebral function. Recurrent episodes of diarrhea and pneumonia, their high severity as well as various appetite disorders are another consequence of the zinc deficiency.

Keywords: Zinc; Zinc Deficiency; Iron; Calcium; Carbohydrates; Protein

Introduction

Apart from macronutrients (fats, carbohydrates, proteins) human body requires micronutrients (vitamins, minerals) in very small amount for its optimum metabolism, growth and physical well-being. Vitamins are requisite organic nutrients, and are produced in inadequate amounts in the body and hence the scarcity is met by food sources. Several disorders occur due to vitamins deficiency if the recommended dietary allowance is not met.

Another important micronutrients in the body are the minerals that carry out a crucial role to ensure body's health and productivity. Trace elements (Zn, Cu, Mn, Fe, I, Se) are required in minute amount as compared to macro elements (Ca, Mg, K, Na) [1].

Malnutrition due to micronutrients imposes a tremendous threat to the well-being and health status of more than two billion people all around the world (WHO, 1995). Stunted growth, impaired vision, mental retardation, lethargy, low self-esteem and learning debilities are the consequences of micronutrient deficiencies vitally from Fe, Zn, Vitamin A, B6, B9, B12 and Iodine. Therefore preventive and curative measures for micronutrient deficiency in children and adolescents have gained significant importance in order to increases cognitive development, strength, immunity and to decrease morbidity rate [2].

Zn deficiency

Zn deficiency has been linked with various disorders that include anemia, slow wounds healing, impaired gonadal function, abnormally short stature and diminished cognitive and cerebral function. Recurrent episodes of diarrhea and pneumonia, their high severity as well as various appetite disorders are another consequence of the zinc deficiency.

One of the most concerning outcome of the Zn deficiency is that children become more prone to infections, less resistant to infectious disorders, and the incidence of the infections increases specifically in the case of diarrhea. Hence Zn intake is an imperative determining factor of morbidity in children [3].

Many human trials were conducted on Zn deficiency and several detrimental effects were noticed.

Prasad., *et al*. [4] performed a study to assess the symptoms of Zn deficiency in Iran male population that were deficient in Zn. His major findings were anemia, cutaneous disorders, cognitive impairment, low self-esteem, hypogonadism, geophagia and stunted growth.

Halas., *et al*. [5] studied the effects of Zn deficiency on rats and found that emotional behavior of rats was elevated. He cut off the Zn at their development stage and then refed them with Zn during their adult stage. Lutz [6], inspected the Zn levels in adult males using dithizone practice. Zn levels were 2.2g approximately in average 70kg men.

Samuel., *et al.* [7] observed the Zn deficiency in 149 children of primary schools belonging to poor peri urban regions of South Asia within the age range of 7 to 11 years by using descriptive statistical analysis. 24 call method was used in order to assess the dietary intake and FFQ (Food Frequency Questionnaire) were filled. The mean age of the subjects was 9.0 ± 1.1 years and mean intake of Zn was 4.6 ± 2.2 mg/day. 46 percent of the students had Zn deficiency as the mean value of serum Zn level was 66.4 ± 21.5 μg/Dl.

De la Cruz-Góngora., *et al*. [8] performed a study for assessing serum levels of micronutrients (Zn, Fe, Mg and Cu) and prevalence pf anemia in 2447 adolescents (12-19years). Blood serum levels of Zn, Cu, Mg, Fe, sTFR, ferritin and CRP were analyzed. This nutritional survey depicted that anemia was 11.8% prevalent in females and 4.6 percent in males whereas the deficiency of iron was 18.2 percent in females 7.9% in males. The prevalence of minerals (Zn, Cu, and Mg) was 28.4% and 24.5%, 14.4% and 12.25%, 40% and 35.3% for males and females respectively. The deficiency of iron in tissues was 6.9 percent, so mineral deficiency was more prevalent in adolescents as compared to anemia.

Alshatwi [9], illustrated the importance of Zn deficiency in preschool children. His sample size was 178.He observed the dietary Zn intake and the mean intake was 5.6 for age group of 2 to 3 years, and 5.8mg/day for the age group of 4 to 6 years. 22% of the children in 2-3years, and 40% of the 4-6years age group were consuming insufficient amount of zinc. 18.3% had low serum levels of Zn below 10.0 μM/L and 3.3 of the children were suffering from major zin defecimcy as their serum levels were below 7.7 μM/L when their serum levels were analyzed.

Fiorentino., *et al.* [10] inquired the health status of 604 school (5-17years) students by anthropometric measurements and serum micronutrient levels. He investigated their BMI (Body Mass Index), Hb, Zn, RBP (Retinol Binding Protein), FER (ferritin), UIC and (TfR) transferrin receptors. Results showed that Zn deficiency was more prevalent in boys rather than girls and18.4% subjects were thin, 4.9% were stunted and 5.6% were severely thinned.

Abu Nada., *et al.* [11] pointed at the positive effect of animal based food on Zn levels in body. He chose the 296 students of age 12-15 years and measured their height, weight, serum Zn levels. He assessed the dietary intake through FFQ. Overall zinc deficiency was 42.5% whereas it was 47.7% in females and 37.2% in males. 8.8% of the male population were stunted whereas in females it was 6.4%.

Zn deficiency and height

Halsted., *et al*. [12] demonstrated the direct positive relation of Zinc and height in 15 adolescent males and 2females of age 19-20 years. Subjects were divided into 3 groups. First group was fed with balanced diet with appropriate amount of animal protein and a placebo capsule. Second group was fed with balanced diet as well as Zn sulphate capsules comprising of 27mg elemental Zn. Third group was only fed with animal diet for the period of six months. Second group that was supplemented with Zn showed a remarkable increase in height as well as early onset of sexual function in comparison to those receiving balanced diet.

Hakimi., *et al*. [13] performed another study to determine the positive effect of the supplementation of Zn on height and weight percentiles of 21 boys and 21 girls having mean age of 4.9 ± 4.1. Their mean weight was 16.5 ± 8.1 kg, mean height was 101.8± 23 cm and mean Zn serum level was 85.1 ± 31.6 μg/Dl. They were supplemented with Zn and results showed that percentile of weight was reduced from 69% to 54% and percentile of height decreased from 50% to 33%.

Zn deficiency and growth

Hassan., *et al.* [14] performed a study on 90 children for a period of 11months. These children were divided into two groups. Only first group was supplemented with Zn. On completion of his study, he concluded that first group had gained weight as well as gained height. Percentile of stunted growth was reduced from 26.7% to 2.5% in the first group. So growth was tremendously increased specifically in boys by the 5mg Zn supplementation for the period of 6months on daily basis.

Castillo-Durán., *et al.* [15] surveyed the impact of supplementation of Zn on growth in male adolescents and pre adolescents. They were supplemented with 10mg Zn for the period of 12months. Growth rate was evidently increased in males.

Perrone., *et al*. [16] supplemented the short heighted children of age 4 to 11 years with Zn and Fe for the duration of one year. Children were divided into two groups and group A was supplemented with Fe and Zn. Group A indicated an increase in growth. So Zn and Fe supplementation can be used as a treatment for children suffering from iron and zinc deficiency at pre pubertal stage.

Fesharakinia., *et al.* [17] assessed the relationship of Zn deficiency and growth in 908 children of school age (9-11years). Prevalence of underweight, stunting and wasting was calculated as (weight for age) and (weight for height) and (height for age). Atomic absorption spectrometric technique was used to investigate serum Zn levels. Chi square, ANOVA, and SPSS using t test were used to statistically analyze data. Prevalence for wasting, stunting and underweight was recorded as 5.5%, 13.2% and 6.8% respectively and mean for Zn value was 87.7 (±32.7) μg/dl considerably higher in girls.

Islam., *et al.* [18] supplemented pre-term infants with oral Zn supplements. Group A were given Zn tablets (2mg/kg/day) and multivitamins, and group B subjects were only fed with multivitamins. Average weight of infants was 1000 to 2500g. This supplement therapy was continued for the duration of 6 weeks and no adverse effects were recorded instead an increase in height and weight was noticed. Serum Zn levels and Hb level was noticeably increased in group A.

Zn deficiency and weight

Dehbozorgi., *et al.* [19] organized a study on 60 school children of age between 6 and 12years. He supplemented 30 children with Zn sulphate tablets (8mg) and fed 30 others with placebo. Record of weight and height were maintained after 2months and 6months. There was 4.25cm increase in Zn supplemented group and 3.39cm increase in placebo group. So it was concluded that Zn supplementation can play role in increasing the growth of school boys.

Roy., *et al.* [20] elaborated the beneficial effect of Zn on the clinical course, weight of stool, diarrhea duration, serum Zn level and weight gain of 111 children suffering from acute diarrhea. Children were divided into two groups and first group was fed with Zn supplements along with multivitamins and second group was only fed with multivitamin. Weight of diarrhea stool and diarrhea duration was eminently reduced. Serum Zn level was also increased in first group as well mean weight gain also increased.

Friis., *et al.* [21] did a randomized control trial on Zimbabwean school children of 7 to 11 years of age. He used two Zn treatment of 30mg and 50mg for duration of one year. After 3 months children's weight and health status was noticeably improved.

Ebrahimi., *et al.* [22] implored that Zn supplementation causes an increase in weight and height, when he performed a randomized placebo control trial on Iranian children of age 8 to 11 years. He fed them with 10mg Zn once a day, 6days a week, for period of 7months.

Zn deficiency and memory loss

Victoria., *et al.* [23] studied the relationship of Zn serum levels on cognitive and intellectual development for two groups of students belonging from diverse socioeconomic family backgrounds. 103 students were selected from residential care and 100 students were selected from regular states. Later had higher levels of erythrocytes and serum Zn levels. They were more intellectual as compared to students from residential care that had low Zn serum levels. So higher Zn serum levels also benefit the intellectual development.

Jagveer., *et al.* [24] investigated the liaison of Zn deficiency and short term memory loss. He selected 101 children studying in government schools. He assessed their serum Zn levels, and their oral and verbal skills. Those with Zn deficiency had memory underperformances. After that he supplemented them with 5mg Zn for time period of three months. Results showed that their memory performance considerably improved.

Umamaheswari., *et al.* [25] supplemented the 6-11 years aged (Fe and Zn deficient) children with Zn and Fe to assess the supplementation response on short term memory. 101 children were divided in to three groups; Iron deficient, Zinc deficient and combined deficiency. Fe 2mg/kg and Zn 5mg/kg were fed to all groups. Deficiency of iron and zinc can cause memory problems. After supplementation memory performance was seem to be improved.

Katz., *et al.* [26] did a randomized trial by supplementing 50mg per day Zn in adolescents to study the effect on depression. After supplementation level of anxiety and depression was reduced.

Gronli., *et al*. [27] examined the Psychiatric and cognitive behaviors of 100 patients visiting psychogeriatric centers having 64 years age. Their data and blood samples were collected. 882 older people without depression were taken as a sample and their prevalence was compared with psychiatric patients. It was evident that Zn deficiency is more common in psychogeriatric patients.

Miceli., *et al.* [28] performed a trial to study the consequences of Zn deficiency on antioxidant defenses. He measured the oxidative stress in the retina and retinal pigment epithelium (RPE) of 24 Rats. They were divided into three groups (1, 2 and 3) and fed them with formula diet having 50PPM Zn, same diet having 5PPM Zn and a Zn deficient diet respectively. Their food intake was measured on weekly basis and weight as measured weekly. Subjects were killed after 6months study and their different parameters were assessed. It was concluded that in group 2 oxidative stress was increased due to Zn deficiency.

Naureen., *et al.* [29] assessed the levels of serum Zn and tryptophan in 40 people of which 20 were normal and 20 were suffering from anorexia nervosa. FAAS (flame atomic absorption spectroscopy) was used to measure Zn levels, and HPLC (high performance liquid chromatography) was used to measure tryptophan levels. Results showed that Zn level was lower and tryptophan levels were higher in patients suffering from anorexia nervosa.

Zn deficiency and taste

Bartoshuk [30] did a trial to assess the link of Zn supplementation on taste receptors of young men. 5men were fed with 15mg Zn supplement once a day, and the second group was fed with 025mg Zn per day. Results of this study showed that Zn deficient group showed a change in taste for salty foods.

Larsen Wright., *et al*. [31] investigated the taste discernment of saltiness and bitterness on young men that were divided into two groups. One was fed with basal diet 15mg Zn per day and other was fed with 0.25mg Zn deficient diet. Zn deficiency did not change bitterness perception but altered the discernment for salty foods.

Zn and different diseases

Modarresi., *et al*. [32] did a cross sectional study on 90 Febrile Convulsion patients (9months-5years age) for a period of one year. 30patients were placed in febrile convulsion group, 30 were placed in febrile group (without seizures) and 30 were placed in control group. GF-AAS (Graphite Furnance Atomic Absorbance Spectrophotometry) was used to measure Zn serum levels. Zinc levels were found to be lower in febrile convulsion group in comparison to other groups.

Mashhadi., *et al.* [33] performed a cross section study on 369 thalassemia patients from Iran to assess Zn serum levels. Atomic absorption spectrometry was used to measure Zn levels and results showed Zn deficiency is prominent in all patients.

Albanna., *et al.* [34] surveyed the levels of Zn and Cu on children suffering from pneumonia. He selected 37 pneumonia patients (21boys and 16girls) and 37 healthy children (19boys, 18girls) as a control group. Pneumonia patients had higher ESR (Erythrocyte sedimentation rate), WBCs, CRP (C-reactive protein), lymphocytes, platelets and neutrophils and significantly lower Hb, Cu and Zn levels.

Roy., *et al.* [35] studied the positive effect of Zinc supplementation on stool output and duration of diarrhea in179 children (3-14years) that were suffering from cholera. They were divided into two groups. Group 1(n=90) was supplemented with 30mg Zn per day, whereas second group was given placebo tablets till were suffering from the disease. All children were also given 12.5 mg per Kg dose of erythromycin suspension for 3 days apart from Zn and placebo doses. Results showed that in group 1(Zn supplemented) diarrhea period was reduced to 12% and stool output to 11%.

Demirci., *et al.* [36] studied the impact of levels of Fe, Zn and Cu and their effect on lipid peroxidation in 34 chronic giardiasis patients. Their blood samples were collected and compared with control group. Level of Zn and Fe was much lower in chronic giardiasis patients. No major difference in Cu level was recorded for both groups.

Sazawal., *et al.* [37] inspected the role of Zn supplementation on duration and severity of acute diarrhea. 937 children were selected of age 6 to 35months. One group was supplemented with 20mg Zn and after the completion of study it was perceived that Zn supplementation has reduced diarrhea to 23%.

El-Ghareeb., *et al.* [38] studied the relationship of Zn deficiency and parasitic infection in 129 children (ages ranged between 4-10 years). Zn level was investigated from blood serum and stool was also examined. 69% children showed Zn deficiency while 31% having normal Zn concentration. Those children who showed Zn deficiency, had higher parasitic infections. The low Zn group also showed diarrhea (29.2%), abdominal pain (41.6%), anorexia nervosa (14.6%) and abdominal distention (27%).

Galvao., *et al.* [39] conducted a study on children (5 years) who's suffering from acute diarrhea and receiving Zn supplementation. Control group was fed with placebo tablets and experimental group was fed with oral Zn supplementation. Zn were very effective against diarrhea duration within the hour.

Abdulhamid., *et al*. [40] had checked the efficacy of Zn supplementation in those children who were suffering from cystic fibrosis (CF). They were examined the effect of 30 mg Zn daily for one year in twenty six children ages between 7 to 18 years. Oral antibiotics days were lower in Zn treated children as compared to the placebo group. Zn supplementation showed positive effects for the treatment of CF and also decreases the respiratory tract infection.

Dong., *et al*. [41] conducted a study to determine the micronutrient status of children having ages 24 to 60 months after 1 year of the earthquake. 152 boys and 118 girls were included in this study. Blood samples were drawn in order to determine the level of Zn, Fe, Vitamin A, D and B12. After blood analysis, deficiency of Fe was 45.7% and anemia status was 17.3%. Prevalence of Zn was 65.5%, Vitamin D 90%, Vitamin B12 19.2% and Vitamin A 45.7%. Stunning and wasting were 14.7% and 0.7% correspondingly. Children showed higher level deficiencies in Fe, Zn, Vitamin A, D and B12 and also Fe deficiency anemia.

Bilan., *et al.* [42] analyzed the serum Zn and Cu level in children who were suffering from asthma. 68 boys and 38 girls were included in this study and they were divided into two groups, in first group all those children were included who had asthma and in the control group healthy children were added. Mean age of children who were included in the asthma group was 5.68±2.52 year and mean age of healthy children who were included in the control group was 5.12 ± 3.65 year. Mean Cu level in children with asthma was 98.52 ± 30.78 and mean Cu level in control group children was 75.48 ± 15.77. Mean Zn level in children with asthma was 20.12 ± 10.14 and mean Zn level in children included in the control group was 25.20 ± 8.95.

Results showed that Cu level in children with asthma was notably higher compared with control group children and Zn level in children with asthma was considerably less as compared to Zn level in control group children [43].

Bibliography

1. Shenkin A. "Micronutrients in Health and Disease". *Postgraduate Medical Journal* 82.971 (2006): 559-567.
2. Underwood E., "Trace Elements in Human and Animal Nutrition" 4th Edition, New York, Academic Press (1977).
3. Prasad A S. "Clinical manifestations of zinc deficiency". *Annual Review of Nutrition* 5.1 (1985): 341-363.
4. Prasad A S., *et al*. "Syndrome of iron deficiency anaemia, hepatosplenomegaly, hypogonadism, dwarfism and geophagia". *American Journal of Medicine* 31 (1961): 532-546.
5. Halas E S., *et al*. "Learning and memory impairment in adult rat due to severe zinc deficiency during lactation". *Physiology and Behaviour-Journal* 30.3 (1983): 371-3782.
6. Lutz R E. "The normal occurrence of zinc in biological materials: a review of the literature, and a study of the normal distribution of zinc in the rat, cat, and man". *Journal of Industrial Hygiene* 8 (1926): 177-207.
7. Samuel., *et al*. "Prevalence of zinc deficiency among primary school children in a poor peri-urban informal settlement in South Africa". *Health SA Gesondheid* 15.1(2010): 433.
8. De la Cruz-Góngora., *et al*. "Anemia and iron, zinc, copper and magnesium deficiency in Mexican adolescents: National Health and Nutrition". *Salud Publica de Mexican* 54.2 (2012): 135-145.
9. Alshatwi AA. "Zinc nutritional status of preschool children in Riyadh City". *Jawaharlal Nehru University* 5 (2006): 429-431.
10. Fiorentino M., *et al*. "Anthropometric and Micronutrient Status of School-Children in an Urban West Africa Setting: A Cross-Sectional Study in Dakar (Senegal)". *Public Library of Sciences-Journals* 8.12 (2013).
11. AbuNada., *et al*. "Nutritional assessment of zinc among adolescents in the Gaza Strip-Palestine". *Open Journal of Epidemiology* 3.03 (2013): 105.
12. Halsted., *et al*. "Zinc deficiency in man: the Shiraz experiment". *American Journal of Medical* 53.3 (1972): 277-284.
13. Hakimi., *et al*. "The effect of supplemental zinc on the height and weight percentiles of children". 9.2 (2006).
14. Hassan., *et al*. "Effects of Zinc Supplementation on Physical Growth in 2-5-Year-Old Children". *Biological Trace Element Research* 128.2 (2008): 118 127 .
15. Castillo-Durán., *et al*. "Zinc supplementation increases growth velocity of male children and adolescents with short stature". *Acta Paediatrica* 83.8 (1994): 833-837.

16. Perrone L., *et al*. "Long term zinc and iron supplementation in children of short stature: effect of growth and trace element content in tissues". *Journal of Trace Element and Medical Biology* 13 (1999): 51.

17. Fesharakinia., *et al*. "Prevalence of zinc deficiency in elementary school children of South Khorasan Province (East Iran)". *Iranian Journal of Pediatrics* 19.3 (2009): 249-254.

18. Islam., *et al*. "Effect of Oral Zinc Supplementation on the Growth of Preterm Infants". *Indian Pediatric* 47.10 (2010): 845- 849.

19. Dehbozorgi P., *et al*. "The influence of zinc sulfate supplementation on the growth of school age children in village around Shiraz". *Journal of Medical Sciences* 7.4 (2007): 690-693.

20. Roya S K., *et al*. "Randomised controlled trial of zinc supplementation in malnourished Bangladeshi children with acute diarrhoea". 77.3 (1997): 196-200.

21. Friis H., *et al*. "The impact of zinc supplementation on growth and body composition: a randomized, controlled trial among rural Zimbabwean schoolchildren". *European Journal of Clinical Nutrition* 51.1 (1997): 38.

22. Ebrahimi S., *et al*. "Study of zinc supplementation on growth of schoolchildren in Yasuj, Southwest of Iran". *Pakistan Journal of Nutrition* 5.4 (2006): 341-342.

23. Victoria P., *et al*. "Zinc levels, cognitive and personality features in children with different socioeconomic backgrounds". *Europe's Journal of Psychology 6* (2010): 82-101.

24. Jagveer C., *et al*. "A study of iron and zinc deficiency on short term memory in children & effect of their supplementation". *Asian Journal of Biomedical and Pharmacutical Sciences* 5.42 (2015): 12-15.

25. Umamaheswari K., *et al*. "Effect of Iron and Zinc Deficiency on Short Term Memory in Children". *International Journal of Food Science and Nutrition 48.4* (2011): 289-293.

26. Katz R L., *et al*. "Zinc deficiency in anorexia nervosa". *Journal of Adolescent Health Car*e 8.5 (1987): 400-406.

27. Gronli O., *et al*. "Zinc Deficiency Is Common in Several Psychiatric Disorders". Public Library of Sciences 8.12 (2013): 82793.

28. Miceli M V., *et al*. "Zinc deficiency and oxidative stress in the retina of pigmented rats". *Investigative Ophthalmology and Visual Science* 40.6 (1999): 1238-1244.

29. Faiza N., *et al*. "Zinc and Tryptophan Levels in Anorexia Nervosa A Co-Relational Study". *International journal of Biomedical Engineering and Science* 1 (2014): 1.

30. Bartoshuk L M., "The psychophysics of taste". *American Journal of Clinical Nutrition* 3l.6 (1978): 1068-1077.

31. Wright A L., *et al*. "Experimental zinc depletion and altered taste perception for NaCl in young adult males". *The American journal of clinical nutrition* 34.5 (1981): 848-852.

32. Modarresi M R., *et al*. "The relationship between Zinc deficiency and Febrile Convulsion in Isfahan,Iran". *Iranian Journal of Child Neurology* 5.2 (2011): 29-33.

33. Mashhadi M A., *et al*. "The selenium status in thalassemia patients in South East of Iran". *International Journal of Hematology-Oncology and Stem Cell Research* 8.4 (2014): 1-4.

34. Albanna E A and Ahmed H S. "The Effect of Serum Copper and Zinc Levels on the Immunity of Children". *Universal Journal of Medical Science* 1.3 (2013): 78-82.

35. Roy S K., *et al*. "Zinc supplementation in children with cholera in Bangladesh: randomised controlled trial". *International Centre for Diarrhoeal Disease Research, Bangladesh* (2007): 266-268.

36. Demirci M., *et al*. "Serum iron, zinc and copper levels and lipid peroxidation in children with chronic giardiasis". *Journal of Health, Population and Nutrition 21.1* (2003): 72-75.

37. Sazawal S., *et al*. "Zinc supplementation in young children with acute diarrhea in India". *New England Journal of Medicine* 333.13 (1995): 839-844.

38. El-Ghareeb A S., *et al*. "Zinc Deficiency and Gastrointestinal Parasitic Infections Among Children". *International Journal of Medical and Health Sciences* (2015).

39. Galvao T F., *et al*." Zinc supplementation for treating diarrhea in children: a systematic review and meta-analysis". *Revista Panamerican Salud Publica* 33.5 (2013): 370-377.

40. Abdulhamid I., *et al*. "Effect of Zinc Supplementation on Respiratory Tract Infections in Children with Cystic Fibrosis". *Pediatric Pulmonology* 43.3 (2008): 281-287.

41. Dong C., *et al*. "The Micronutrient Status of Children Aged 24-60 Months Living in Rural Disaster Areas One Year after the Wenchuan Earthquake". *Public Library of Sciences Journal* (2014): 88444.

42. Bilan N., *et al*. "Serum copper and zinc levels of children with asthma". *Childhood* 4 (2014): 6.

43. Ramakrishnan U. "Prevalence of micronutrient malnutrition worldwide". *Nutrition reviews* 60.5 (2002): S46-S52.

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