International Journal of Nutrition and Metabolism Vol. 4(3), pp. 45-50, March 2012
Available online at http://www.academicjournals.org/IJNAM
DOI: 10.5897/IJNAM11.043
ISSN 2141-2499 ©2012 Academic Journals

Review

Need of education and awareness towards zinc supplementation: A review

MEGHA DAS[1]* and RATNESH DAS[2]

[1]Department of Education, Dr. Harisingh Gour University, Sagar (M.P.) 470001 India.
[2]Department of Chemistry, Dr. Harisingh Gour University, Sagar (M.P.) 470003 India.

Accepted 25 November, 2011

Zinc is an essential trace element and thus zinc deficiency may severely affect human health. Zinc supplementation is commonly used to prevent and treat human diseases due to zinc deficiency. Many studies published proved zinc supplementation as a boon for preventing and treating diseases related with zinc deficiency whereas in some cases adverse affects of excess zinc supplementation have also been reported, which clearly points out to the need of health education and programmes before zinc supplementation. This review highlights the need of health education and awareness programmes for effective zinc supplementation.

Key words: Zinc deficiency, zinc supplementation, health education, awareness.

INTRODUCTION

Zinc is an essential trace element for humans, animals and plants (Shah and Sachdev, 2001). It is involved in numerous aspects of cellular metabolism and is required for the catalytic activity of more than 100 enzymes (Sandstead, 1994; Institute of medicine, 2001) it plays a role in immune function (Shah, 2001; Prasad et al., 1997) protein synthesis (Prasad, 1997), wound healing (Lansdown et al., 2007), DNA synthesis (Institute of Medicine, 2001) and cell division (Prasad, 1995). Zinc also supports normal growth and development during pregnancy, childhood, and adolescence (Simmer and Thompson, 1985) and is required for proper sense of taste and smell (Heyneman, 1996).

Intake recommendations for zinc are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies (formerly National Academy of Sciences).

The current RDAs for zinc are listed in Table 1 (Institute of Medicine, 2001). For infants aged 0 to 6 months, the FNB established an AI for zinc that is equivalent to the mean intake of zinc in healthy, breastfed infants.

Zinc is primarily obtained from food. The major sources of zinc are (red) meat, poultry, fish and seafood, whole cereals and dairy products. Zinc is most available to the body from meat. The bioavailability of plant-based foods is generally lower due to dietary fiber and phytic acid which inhibit the absorption of zinc (Institute of Medicine, 2001).

Zinc is a component of more than 300 enzymes from all six classes. Zinc is important for the catalytic activity of carbonic anhydrase which in turn is a constituent of red blood cells and gastric juices and plays an important role in deposition of calcium salts in teeth and bones. Similarly it is also an important constituent of enzyme carboxy peptidase A, a pancreatic enzyme active in protein degradation. The enzyme alcohol dehydrogenase contains zinc as is essential for the conversion of alcohol to an aldehyde, thereby facilitating alcohol metabolism in the liver. Zinc is also a constituent of lactic acid dehydrogenase which is active in glycolysis, alkaline phosphatase active in maintaining phosphate levels near bone and glutamic dehydrogenase found in platelets. It is also essential for the proper activity of the RNA synthesizing enzyme RNA polymerase. Zinc is found in alpha-macroglobulin, an important protein in the body's immune system. This globulin firmly binds about 30% of plasma albumin, which functions primarily as a transport

*Corresponding author. E-mail: megha_das1@yahoo.com

protein. Thus zinc plays an important role in biological functioning of body and its deficiency affects human health a lot (Zinc-mineral, 2004)

Deficiency of zinc leads to a retardation of growth and development of growth and development in children, retarded genital development and hypogonadism, dermatitis and delayed wound healing, alopecia, poor pregnancy outcomes and teratology, and decreased immune function with a resulting increased susceptibility to infections (Maret and Sandstead, 2006). Zinc deficiency places children in many low income countries at an increased risk of illness and deaths from infectious diseases. Mild to moderate zinc deficiency may be common in developing world but the public health importance of this degree of zinc deficiency is not well defined as yet more than 400,000 children die each year due to zinc deficiency (Shah and Sachdev, 2001). Current estimates of the risk of zinc deficiency indicate that approximately one third of the world's population live in countries where the risk of zinc deficiency is high (WHO Report, 2007). Due to wide prevalence of zinc deficiency and the multitude of zinc's essential biological functions nutritional correction of zinc deficiency may have a significant impact on different aspects of human health. Following this rationale, over the years several hundred zinc supplementation studies have conducted, investigating the effects of nutritional zinc supple-mentation on different diseases, often with contradictory results, which points out the need for health education and awareness for community members before such zinc supplementation programmes.

This review aims to summarize various zinc supplementation studies mainly for immune function disorders in children, elderly and adults, and to illustrate the need for health education and awareness programmes for community members to gain effective results of zinc supplementation.

Zinc supplementation for disease prevention

Immune function

Severe zinc deficiency depresses immune function (Prasad, 1998), and even mild to moderate degrees of zinc deficiency can impair macrophage and neutrophil functions, natural killer cell activity, and complement activity (Rink and Gabriel, 2000). The body requires zinc to develop and activate T-lymphocytes (Sandstead, 1994; Beck et al., 1997). The immunological consequences of zinc deficiency may be responsible for decreased cell mediated immune functions and inflammatory reactions in zinc deficient subjects. Zinc influence immunity, tissue regeneration and promote protein synthesis. The effect of zinc deficiency on the immune response was studied in an experimental model of human recently (Prasad, 2000). Zinc deficiency causes imbalance between TH_1 and TH_2 functions and the production of INFg, IL-2 and TNFa (products of TH cells) are decreased (Prasad, 2000; 1998). Zinc supplementation increases IL-2 and INFg production. As a result of zinc deficiency, the ratio of $CD4^+ CD45RA^+$ to $CD4^+ CD45RO^+$ was decreased suggesting that zinc may be required for the new $CD4^+$ T cells. Zinc deficiency caused decreased serum thymulin activity, which could be restored by zinc supplementation (Prasad, 1998). Zinc deficiency also decreased the percentage of $CD8^+ CD73^+$ T cells those are the precursor cells of cytotoxic T cells. IL-1b is involved in the zinc deficiency induced mucosal damage. Intestinal cell proliferation was also reduced by zinc deficiency.

The adverse effects of zinc deficiency on the immune system function are likely to increase the susceptibility of children to infectious diarrhea; persistent diarrhea contributes to zinc deficiency and malnutrition.

In children

Diarrhea

The adverse effects of zinc deficiency on immune system function are likely to increase the susceptibility of children to infectious diarrhea; persistent diarrhea contributes to zinc deficiency and malnutrition.

There is strong evidence to support role of zinc supplementation in diarrhea morbidity and mortality reduction. A study from India identified a 68% reduction in mortality in small-for-gestational-age term infants that were supplemented with zinc from 1 to 9 months of age (Bhutta et al., 1999). In addition, results from a pooled analysis of randomized controlled trials of zinc supplementation in developing countries suggest that zinc helps reduce the duration and severity of diarrhea in zinc-deficient or otherwise malnourished children (Black, 1998). Similar findings were reported in a meta-analysis published in 2008 and a 2007 review of zinc supplementation for preventing and treating diarrhea (Fisher Walker and Black, 2007; Lukacik et al., 2008). The effects of zinc supplementation on diarrhea in children with adequate zinc status, such as most children in the United States, are not clear. Studies show that poor, malnourished children in India, Africa, South America, and Southeast Asia experience shorter courses of infectious diarrhea after taking zinc supplements (Black, 2003). The children in these studies received 4–40 mg of zinc a day in the form of zinc acetate, zinc gluconate, or zinc sulfate (Black, 2003). The World Health Organization and UNICEF now recommend short-term zinc supplementation (20 mg of zinc per day, or 10 mg for infants under 6 months, for 10–14 days) to treat acute childhood diarrhea (WHO Report, 2004).

Wound healing

Zinc helps to maintain the integrity of skin and mucosa

Table 1. Recommended dietary allowances (RDAs) for Zinc (Institute of Medicine, 2001).

Age	Male	Female	Pregnancy	Lactation
0–6 months	2 mg*	2 mg*		
7–12 months	3 mg	3 mg		
1–3 years	3 mg	3 mg		
4–8 years	5 mg	5 mg		
9–13 years	8 mg	8 mg		
14–18 years	11 mg	9 mg	12 mg	13 mg
19+ years	11 mg	8 mg	11 mg	12 mg

*Adequate Intake (AI).

membranes (Anderson, 1995). Patients with chronic leg ulcers have abnormal zinc metabolism and low serum zinc levels (Wilkinson and Hawke, 1998), and clinicians frequently treat skin ulcers with zinc supplements (Lansdown et al., 2007). The authors of a systematic review concluded that zinc sulfate might be effective for treating leg ulcers in some patients who have low serum zinc levels (Wilkinson and Hawke, 1998, 2000).

The common cold

One disease for which the use of zinc has been extensively investigated is the common cold, and the results have already been summarized in detail elsewhere (Hulisz, 2004). These results are contradictory to some extent and design and sample size of several studies has been criticized.

Overall, it can be concluded that zinc is effective in shortening the duration of the common cold, but only if it is administered no later than 24 h within the onset of the symptoms (Hulisz, 2004). The mechanism by which zinc acts against the common cold is still not completely understood. It has been found that zinc inhibits the rhinovirus 3C protease, and hereby viral replication, but this effect was only observed in vitro and not in vivo (Turner, 2001). Also discussed is an interference of zinc with the binding of the rhinovirus to its cellular receptor, the adhesion molecule ICAM-1, or an interaction of zinc with host immune function (Hulisz, 2004).

Pneumonia

Zinc supplementation may also reduce the incidence of lower respiratory infections, such as inflammation of the lungs ('pneumonia'). A growing body of research highlights the importance of zinc to child survival and to specifically reducing deaths from pneumonia. Zinc intake helps reduce the incidence of pneumonia and the severity of the disease. Specifically, research has shown that zinc intake during the acute phase of severe pneumonia decreased the duration and severity of pneumonia and reduced treatment failure rates when compared with a placebo intervention (Unicef/WHO, 2006).

A pooled analysis of a number of studies in developing countries demonstrated a substantial reduction in the total number of cases of pneumonia in children supplemented with zinc (Bhutta et al., 1999) A meta-analysis found that zinc supplementation reduced the incidence but not duration of pneumonia or respiratory tract illnesses in children less than five years of age (Aggarwal et al., 2007).

Malaria

Some studies have indicated that zinc supplementation may reduce the incidence of clinical attacks of malaria in children (Black, 2003). A randomized controlled trial in preschool-aged children in Papua New Guinea found that zinc supplementation reduced the frequency of health center attendance due to malaria by 38% (Shankar, 2000). Additionally, the number of malaria episodes accompanied by high blood levels of the malaria-causing parasite was reduced by 68%, suggesting that zinc supplementation may be of benefit in preventing more severe episodes of malaria.

However, a 6-month trial in more than 700 West African children did not find the frequency or severity of malaria episodes (Muller et al., 2001). Additionally, a randomized controlled trial in over 42,000 children aged one to 48 months found that zinc supplementation did not significantly reduce mortality associated with malaria and other infections (Sazawal et al., 2007).

Due to conflicting reports, it is not yet clear whether zinc supplementation can be used in treating childhood malaria.

In elderly and adults

Age-related declines in immune function have been associated with the vulnerability of the elderly to mild zinc deficiency. However, the results of zinc supplementation trials on immune function in the elderly have been mixed.

In randomized controlled trials, certain aspects of immune function (e.g., increased levels of immune cells) in men and women over 65 years of age have been found to improve with zinc supplementation (Salgueiro et al., 1998; Fortes et al., 1998).

However, other studies have reported that zinc supplementation does not improve parameters of immune function, indicating that more research is required before any recommendations can be made regarding zinc and immune system response in the elderly.

Pregnancy complications

Poor maternal zinc nutritional status has been associated with a number of adverse outcomes of pregnancy, including low birth weight, premature delivery, labor and delivery complications, and anomalies in developing fetuses (Prasad, 1979). Association of maternal zinc deficiency with adverse pregnancy outcome is still an unresolved issue (Goldengerg et al., 1995).

Observational studies in human populations have produced strong associations between a poor maternal zinc status and various indicators of a poor pregnancy outcome but supplementation trials have not produced strong or even consistent results (Caulfield et al., 1998). Antenatal zinc supplementation did not improve birth outcome in Bangladeshi urban poor. Positive results were observed only in subgroups of the pregnant population in some studies (Goldenberg et al., 1995).

A review of 17 randomized controlled trials found that zinc supplementation during pregnancy was associated with a 14% reduction in premature deliveries; the lower incidence of preterm births was observed mainly in low-income women (Mahomed et al., 2007).

HIV/AIDS

Zinc is of particular importance for the development of T cells (Fraker and King, 2004; Wellinghausen et al., 1997). Hence, it seems reasonable to use it as a supporting therapeutic intervention for patients with HIV/AIDS. Studies show that short term supplementation of a relatively small group of five patients led to an improvement of immune function, with an increase in the number of activated (HLA-DR positive) T cells, augmented lymphocyte transformation by phytohaemagglutinin and concanavalin A, and increased phagocytosis by polymorphonuclear neutrophils (Zazzo et al., 1989). This was supported by another study which described an increase in the number of T helper cells and a protective effect against infections with Pneumocystis carinii and Candida (Mocchegianie et al., 1995). It has been shown that zinc deficiency is prevalent among HIV infected persons, especially in malnourished patients or users of illicit drugs (Baum et al., 2000, 2003). However, it can not be generalized that patients with AIDS are zinc deficient, since antiretroviral therapy can normalize the zinc status (Rousseau et al., 2000). A recent study has addressed the safety of zinc supplementation, using a moderate dose of 10 mg elemental zinc per day and the authors came to the conclusion that zinc supplementation has no adverse effects (Bobat et al., 2005). However, it was performed in HIV-infected South African children, a population with high prevalence of malnutrition and limited access to medication. Although the zinc status of the children has not been determined, it can be assumed that many of them were zinc deficient (Bobat et al., 2005; Green et al., 2006). Moderate supplementation to zinc-deficient patients can help stabilize their immune system; supplementation to zinc-sufficient ones may accelerate disease progression and increase mortality.

Health risks and zinc supplementations

Zinc supplementation at physiological doses is considered to be safe, although there are potential side-effects that need to be considered. The FNB has established Upper Intake Levels (UL) for zinc (Table 2). Long-term intakes above the UL increase the risk of adverse health effects (Institute of Medicine 2001).

Moderate doses of zinc supplements can give a metallic flavour and induce nausea and vomiting. These symptoms, however, have not been reported as significant side-effects in clinical trials that used short-term supplementation for the prevention or treatment of acute diarrhea or respiratory infections. Large oral doses of zinc can interfere with copper bio-availability as they compete for absorption, and clinical signs of immune dysfunction have been reported with daily doses in excess of 150 mg. In addition, a small, randomized clinical trial of 141 severely malnourished children in Bangladesh reported that children receiving 6 mg/kg of zinc for 15 days had a higher mortality than children receiving lower doses. In addition, in poorly ventilated mining industries and during galvanization of iron, welding and manufacture of brass, zinc in the air can reach toxic levels, posing a significant health risk to workers chronically exposed. Finally, a recent large study in the USA reported that men who consumed 100 mg/day had an increased risk of advanced prostate cancer. These findings were observed only in patients receiving high-dose supplements and chronic zinc deficiency has also been associated with an increased risk of prostate cancer. Elderly patients in the United States are currently recommended to consume moderate amounts of zinc as a preventive measure against age-related macular degeneration and prostate cancer. It is therefore prudent to recommend that further studies should use zinc supplementation at low to moderate doses and within

Table 2. Tolerable upper intake levels (ULs) for Zinc (Institute of Medicine, 2001).

Age	Male	Female	Pregnant	Lactating
0-6 months	4 mg	4 mg		
7-12 months	5 mg	5 mg		
1-3 years	7 mg	7 mg		
4-8 years	12 mg	12 mg		
9-13 years	23 mg	23 mg		
14-18 years	34 mg	34 mg	34 mg	34 mg
19+ years	40 mg	40 mg	40 mg	40 mg

physiological ranges (Luis et al., 2005). Two nutritional studies showed that increased intake of zinc in HIV-1 infected patients led to an augmented risk for the progression to AIDS (Tang et al., 1993) and lower survival (Tang et al., 1996). In the quartile of patients with the highest total daily zinc intake (>20 mg/day) combined from food and supplements, the risk for progression to AIDS and poorer survival was doubled compared to the quartile with the lowest intake of zinc (<11.6 mg/day) (Tang et al., 1993, 1996).

Health education and zinc supplementation

Health Education is to impart basic knowledge to people aware of all the aspects of keeping good health by avoiding diseases. Health Education is necessary for ensuring a good personal health as well as community health. Due to the lack of awareness several people have lost there lives in Nepal about, 15,000 children die from diarrhea, just because they do not have zinc to treat it, “According to health workers on the ground, factors hindering zinc coverage include inadequate supply of zinc tablets; weak logistical management; low awareness regarding zinc and its availability within the community; and inadequate understanding of the treatment among health service providers.” UNICEF is currently working to conduct a strategic review of Nepal’s zinc program and to increase public awareness of how this critical mineral can save lives (Nepal-Zinc Supplements, 2001).

The various elements of health education are knowledge of various nutrients present in various food materials, of making balanced diet from foods available, of the causes of various common diseases, of how various diseases spread, of the prevention measures for various diseases, of vaccines available for immunizing children, of the causes of environmental pollution, and of methods to protect environment from pollution.

Before imparting zinc supplementation programme to community members it is necessary to make them aware of various aspects of zinc, its recommended values as well as its dietary sources etc. through health education programmes. So that the community after gaining knowledge about this vital nutrient, may become attitudinal to its balanced consumption, and remain healthy.

Conclusions

1. Zinc supplementation has the potential to improve child survival.
2. Research to map out prevalence of zinc deficiency should be encouraged further.
3. Education programmes should be promoted before zinc supplementation programs at community levels for effective results.
4. People should be educated through media towards zinc deficiency and other micronutrient deficiencies and their preventive measures by appropriate dietary intake.

REFERENCES

Anderson I (1995). Zinc as an aid to healing. Nurs Times, 91(68): 70.
Aggarwal R, Sentz J, Miller MA (2007). Role of zinc administration in prevention of childhood diarrhea and respiratory illnesses: a meta-analysis. Pediatrics, 119(6):1120–1130
Baum MK. Campa A, Lai S, Lai H, Page JB (2003). Zinc status in human immunodeficiency virus type 1 infection and illicit drug use. Clin. Infect. Dis., 37: S117–S123.
Baum MK, Shor-Posner G, Campa A (2000). Zinc status in human immunodeficiency virus infection, 130:1421S-1423S.
Bhutta ZA, Black RE, Brown KH, Gardner JM, Gore S, and Hidayat A (1999). Prevention of diarrhea and pneumonia by zinc supplementation in children in developing countries: pooled analysis of randomized controlled trials. Zinc Investigators’ Collaborative Group. J. Pediatr., 135: 689-97
Black MM (1998). Zinc deficiency and child development. Am. J. Clin. Nutr., 68(2 Suppl):464S–469S
Black RE (2003). Zinc deficiency, infectious disease and mortality in the developing world. J. Nutr. 133:1485S-9S.
Black RE (1998) Therapeutic and preventive effects of zinc on serious childhood infectious diseases in developing countries. Am. J. Clin. Nutr., 68(2 Suppl):476S–479S
Bobat R, Coovadia H, Stephen C, Naidoo KL, McKerrow N, Black RE, Moss WJ (2005). Safety and efficacy of zinc supplementation for children with HIV-1 infection in South Africa: a randomized double-blind placebo-controlled trial. Lancet, 366:1862-1867.
Caulfield LE, Zavaleta N, Shankar AH, Merialdi M (1998). Potential contribution of maternal zinc supplementation during pregnancy to maternal and child survival. Am. J. Clin. Nutr., 68: 499S-508S.
Fisher Walker CL, Black RE (2007). Micronutrients and diarrheal disease. Clin Infect Dis., 45 (1 Suppl):S73-7.
Fortes C, Forastiere F, Agabiti N (1998). The effect of zinc and vitamin

A supplementation on immune response in an older population. J. Am. Geriatr Soc., 46(1):19–26.
Fraker PJ, King LE (2004). Reprogramming of the immune system during zinc deficiency. Annu. Rev. Nutr., 24: 277-298.
Goldenberg RL, Tamura T, Neggers Y, Copper RL, Johnston KE, DuBard MB, Hauth JC (1995) The effect of zinc supplementation on pregnancy outcome. JAMA, 274: 463-8
Green JA, Lewin SR, Wightman F, Lee M, Ravindran TS, Paton NI (2005). A randomised controlled trial of oral zinc on the immune response to tuberculosis in HIV- infected patients. Int. J. Tuberc. Lung Dis., 9: 1378-1384.
Heyneman CA (1996). Zinc deficiency and taste disorders. Ann. Pharmacother, 30: 186-7.
Hulisz D (2004). Efficiency of zinc against common cold viruses: an overview. J. Am. Pharm. Assoc., 44: 594-603.
Institute of Medicine, Food and Nutrition Board (2001). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academy Press, pp. 442-501.
Lansdown AB, Mirastschijski U, Stubbs N, Scanlon E, Agren MS (2007). Zinc in wound healing: theoretical, experimental, and clinical aspects. Wound Repair Regen, 15:2-16
Luis E, Cuevas, AI Koyanagi (2005). Zinc and infection a review. Annals Trop. Paediatr., 25:149-160.
Lukacik M, Thomas RL, Aranda JV (2008) A meta-analysis of the effects of oral zinc in the treatment of acute and persistent diarrhea. Pediatrics, 121: 326-36.
Mocchegiani E, Veccia S, Ancarani F, Scalise G, Fabris N (1995)Benefit of oral zinc supplementation as an adjunct to zidovudine (AZT) therapy against opportunistic infections in AIDS. Int. J. Immunopharmacol., 17: 719-727.
Mahomed K, Bhutta Z, Middleton P (2007). Zinc supplementation for improving pregnancy and infant outcome. Cochrane Database Syst. Rev.2: CD000230.
Muller O, Becher H, Van Zweeden AB (2001). Effect of zinc supplementation on malaria and other causes of morbidity in west African children: randomised double blind placebo controlled trial. BMJ, 322(7302): 1567.
Nepal: Zinc Supplements Can Save Childrens' Lives (2001) (http://www.associatedcontent.com/article/7855994/nepal_zinc_supplements_can_save_childrens.html?cat=5).
Prasad AS, Beck FW, Grabowski SM, Kaplan J, Mathog RH (1997). Zinc deficiency: changes in cytokine production and T-cell subpopulations in patients with head and neck cancer and in noncancer subjects. Proc. Assoc. Am. Physicians, 109:68-77.
Prasad AS (1995). Zinc: an overview. Nutrition, 11: 93-9.
Prasad AS (2000). Effects of zinc deficiency on Th1 and Th2 cytokine shifts. J. Infect. Dis., 182 Suppl 1: S62-8.
Prasad AS (1998). Zinc and immunity. Mol. Cell Biochem., 188(1-2):63-69.
Prasad AS (1979). Zinc in human nutrition. Prasad AS, ed. Florida: CRC Press Inc. Florida, 66-68.
Report of a WHO/UNCEF/IAEA/*IZINCG* Interagency Meeting on Zinc Status Indicators, Held in*IAEA* Headquarters, Vienna, December 9, (2005). de Benoist B, Darnton-Hill I, Davidsson L, Fontaine O (editors). Food Nutr. Bull. (2007); 28(Supplement 3):S399-S486.
Rink L, Gabriel P (2000). Zinc and the immune system. Proc. Nutr. Soc. 59:541-52.
Rousseau MC, Molines C, Moreau J, Delmont J (2000). Influence of highly active antiretroviral therapy on micronutrient profiles in HIV infected patients. Ann. Nutr. Metab., 44: 212–216.
Sazawal S, Black RE, Ramsan M (2007). Effect of zinc supplementation on mortality in children aged 1-48 months: a community-based randomised placebo-controlled trial. Lancet, 369(9565): 927–934.
Salgueiro MJ, Zubillaga M, Lysionek A (2000). Zinc status and immune system relationship: a review. Biol. Trace Elem. Res. 76(3):193–205.
Sandstead HH (1994). Understanding zinc: recent observations and interpretations. J. Lab. Clin. Med., 124: 322-7.
Shankar AH (2000). Nutritional modulation of malaria morbidity and mortality. J Infect Dis.182 Suppl 1:S37–53.
Shah D, Sachdev HP (2001). Effect of gestational zinc deficiency on pregnancy outcomes: summary of observation studies and zinc supplementation trials. Br. J. Nutr., 85: S101-8.
Simmer K, Thompson RP (1985). Zinc in the fetus and newborn. Acta Paediatr. Scand Suppl.319:158-63.
Tang AM, Graham NM, Kirby AJ, McCall LD, Willett WC, Saah AJ (1993). Dietary micronutrient intake and risk of progression to acquired immunodeficiency syndrome (AIDS) in human immunodeficiency virus type 1 (HIV-1)-infected homosexual men. Am. J. Epidemiol., 138, 937-951.
Tang AM, Graham NM, Saah AJ (1996). Effects of micronutrient intake on survival in human immunodeficiency virus type 1 infection.Am. J. Epidemiol., 143, 1244–1256.
Turner RB (2001). The treatment of rhinovirus infections progress and potential. Antiviral Res., 49: 1-14.
UNICEF/WHO (2006). Pneumonia: The forgotten killer of children.www.unicef.org.
Wellinghausen N, Kirchner H, Rink L (1997). The immunobiology of zinc. Immunol. Today, 18: 519-521.
Wilkinson EA, Hawke CI (1998). Does oral zinc aid the healing of chronic leg ulcers? A systematic literature review. Arch Dermatol., 134: 1556-60.
Wilkinson EA, Hawke CI (2000). Oral zinc for arterial and venous leg ulcers. Cochrane Database Syst. Rev., 2: CD001273.
World Health Organization and United Nations Children Fund. Clinical management of acute diarrhoea. WHO/UNICEF Joint Statement, August, (2004). [http://www.unicef.org/nutrition/files/ENAcute_Diarrhoea_reprint.pdf
Zazzo JF, Rouveix B, Rajagopalon P, Levacher M, Girard PM (1989). Effect of zinc on the immune status of zinc-depleted AIDS related complex patients. Clin. Nutr., 8: 259-261.
Zinc –Mineral (2004). [file:///E:/zinc/Minerals%20~%20Zinc.htm]