

UNDERSTANDING INDIA'S MICRONUTRIENT SHORTAGE PROBLEM

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ABSTRACT

More than two billion people suffer from micronutrient deficiencies worldwide, with over half residing in India. The present danger of 'hidden hunger' is significant in India owing to high deficiency concerns across an array of key micronutrients. A countrywide advisory board conference attended by more than 20 Indian health care experts (HCPs) was convened to obtain their clinical stance on MiND. An indepth search of PubMed articles highlighting different elements of MiND relevant to the Indian environment was undertaken and presented to notable HCPs from throughout India who subsequently gave their ideas and insights based on their clinical experiences linked with MiND.

1. Introduction

Hidden hunger, often known as micronutrient deficiencies (MiNDs), refers to a diet lacking critical vitamins and minerals needed for most basic cellular and molecular activities.¹ The WHO defines "micronutrients" as substances needed in modest levels (<100 mg/day).² Globally, one-third of people are micronutrient deficient.³ Worldwide, MiNDs coexist. 1 Scientific data shows that MiND has reached a worrisome high in a huge number of Indians, regardless of weight. 2 So, we sought to understand the Indian clinical perspective on MiND, its origins, the logic behind multivitamin supplement use, and if these supplements help physical symptoms, immunity, and energy for everyday well-being.

2. Discussion

HCPs were supplied with pertinent information on MiND supported by

PubMed literature and clinical evidence; they subsequently offered their clinical advice and expressed their consensus related to MiND.

MiND or hidden hunger

Subnormal vitamin and mineral levels may increase morbidity and mortality without clinical symptoms, making MiNDs known as "Hidden Hunger." Micronutrients, unlike macronutrients, are needed in tiny amounts yet are necessary for physical and mental health since even mild to severe MiNDs may influence well-being and mental function. 3-5 Unlike energy-protein undernourishment, MiND's health effects are often undetected.

According to a countrywide survey of HCPs, severe MiNDs are especially recorded within a few days in hospitalized patients who refuse food and drugs, particularly following gastrointestinal procedures, which contribute considerably to disease outcomes. MiND is common and may affect even healthy people. All HCPs agreed that MiNDs are clinically difficult to diagnose or screen because to the non-specific symptoms noticed in healthy people, which has contributed to their worrying growth. MiNDs raise the risk of various illnesses such as diabetes, hypertension, osteoporosis, asthma, depression, neurological disorders, and cardiovascular.

Prevalence of MiND in India

Almost half of the two billion persons with MiND live in India. India has a high risk of "hidden hunger" owing to vitamin deficiencies. Findings indicate extensive (>80% total Indian population) risk of calcium, vitamin A, B12, and folate deficiencies, with more localized deficits in iron, zinc, and vitamin B6. ³ Serum zinc deficiency is > 20% in India, indicating public health importance.

Indians with coronary artery disease had lower plasma magnesium, zinc, and zinc/copper ratios, according to the ICMR. The National Nutrition Monitoring Bureau (NNMB) found moderate vitamin A deficiency causing night blindness and Bitot's spots. Despite year-round solar exposure, multiple Indian studies have shown significant rates of vitamin D insufficiency in adults and other populations. Osteoporosis is common among Indian women due to vitamin D and calcium insufficiency. ⁶ Indian women had greater MiNDs because they consume less nutrients than men (p < 0.001). ⁷ Indian women consumed much less vitamins A, B1, B2, B3, B12, zinc, folate, and iron than males in a community-based cross-sectional survey. ⁸ In another cross-sectional Indian study, 81%, 77%, and 96% of pregnant women had less than 50% of the required iron, calcium, and folic acid intakes. ⁹ HCPs report that urban Indians consume less micronutrients than advised (RDA). Due to poor food, anemia, and insufficient micronutrients, >62% of urban and semi-urban people have MiND.

Causes of MiND

Diet insufficiency, Indian dietary habits, food processing/cooking losses, and food contaminants affect micronutrient intakes (Table 1).

Indian food patterns are shifting owing to agricultural, economic, lifestyle, health,

and nutrition shifts, increased micronutrient needs during pregnancy and breastfeeding, illnesses, aging, infections, and surgery.

6 Sedentary behavior and lifestyle variables might cause MiND in healthy people. Changes in diet, illness, and immunity impact each other.

Table 1: Causes of inadequate micronutrient intake via poor diets.

Causes	Causative features
Daily diet Inadequacy	Due to reduced bioavailability in plant sources, vegetarian diets provide an inadequate nutritional intake of omega-3 fatty acids, vitamin B12, and minerals.
	Insufficient intake owing to the weight-reducing and imbalanced diets, and wrong dietary and modern eating habits.
	Increased consumption of junk food leads to unhealthy snacking habits Eating disorders, emotional and/or physiological stress.
Micronutrient loss in food	Farming techniques and food processing results in plant micronutrient loss Cooking leads to a loss of vitamins (25%-40%).

Almost 90% of HCPs strongly agreed that increased micronutrient needs are not satisfied during pregnancy and breastfeeding, different illnesses, lifestyle-related stress, nutrient-nutrient interactions, infections, or post-surgery. Malabsorption syndrome, vitamin B12 hypovitaminosis, and persistent antibiotic usage damage the gut flora, causing MiND. They also agreed that weight-reduction programs, unbalanced diets, and poor cooking and eating practices contribute to MiND among urban Indians.

Consequences of MiND across the life span

A vicious loop involving inadequate micronutrient intake affects the immune system's many activities, resulting in lowered resistance to infections and worsening of symptoms at any stage of life (Figure 1).

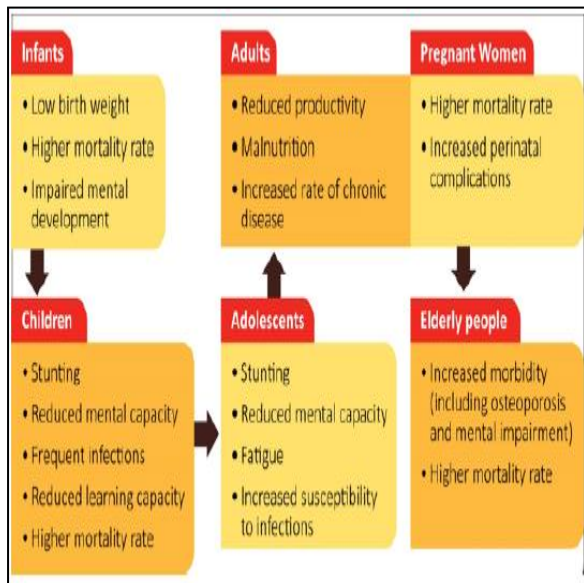


Fig. 1: Consequences of micronutrient inadequacies across the age groups.

The fact that the vicious cycle of MiNDs is linked to negative outcomes throughout an individual's life span and perpetuates through generations, with far-reaching implications on the future population, is of considerable concern.¹³

Clinical outcomes of MiND

Before deficient symptoms such as fatigue and an increased susceptibility to infections manifest clinically, MiNDs move through numerous sub-clinical phases (Figure 1).

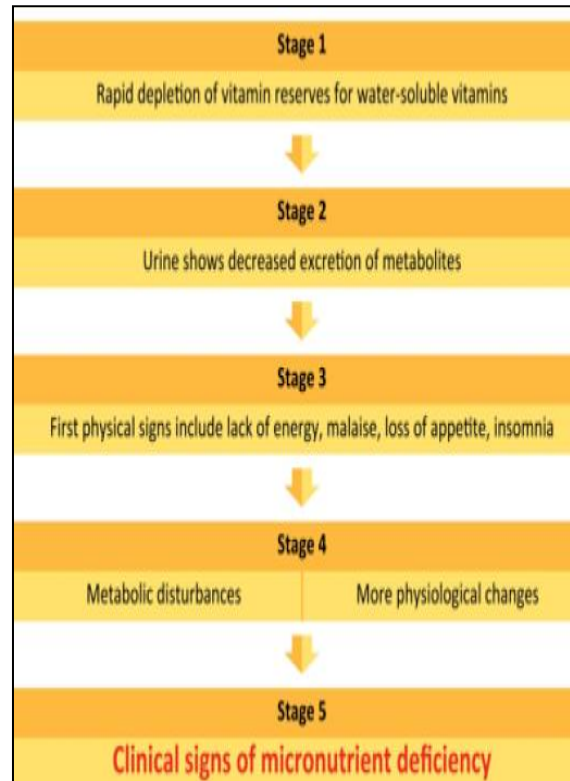


Fig. 2: Sub-clinical stages of mind

Most HCPs believed that micronutrients have a profound molecular and cellular influence and that deficiency might cause tiredness and impaired immunity. Although MiND starts three to six months before clinical indications, the patient may already have it. Dementia may be the first clinical symptom of iron deficiency, vitamin B12 insufficiency can induce neurological diseases, folic acid deficiency can cause hematological issues, and vitamin D deficiency can cause muscular weakness, bone pain, and fatigue.¹⁵

Inadequacy of daily diet to fulfill RDA of micronutrients

The ICMR recommends RDAs as daily dietary nutrient consumption levels that fulfill the needs of most healthy people in a given life stage and gender group. ⁶ The

National Nutrition Monitoring Bureau's findings are alarming: 70% of Indians consume less than 50% of the RDA for numerous micronutrients. Agrawal et al. examined 502 Indian urban OPD patients' micro and macronutrient intake during regular follow-ups and compared it to the RDA.

The Indian population consumes below Recommended levels of calcium, copper, iron, magnesium, zinc, and vitamin B12.

7 According to the ICMR, diet-related iron deficiency is the leading cause of anemia in all age categories, with a median risk of 48%-78%. 6 According to the health survey responses of 220 HCPs in urban India (Mar-Apr 2021), nearly 85% of Indian doctors (GPs, ENTs, Internal Medicine experts) and 93% of Indian nutritionists believe that our daily Indian diet only meets 70% (or even lower) of our micronutrient requirements in urban adults aged 25-45. 16 Most HCPs agreed that Indians consume below RDA levels of calcium, iron, folic acid, zinc, vitamin D3, and B12. Iron, vitamin A, and riboflavin deficiencies are common MiNDs in India.

Important micronutrients to enhance immunity

Zinc, vitamin A, vitamin C, and vitamin D boost immunity and affect the incidence and course of viral respiratory infections, according to research (Table 2). 17 Multivitamins may improve immunity by aiding each other in different chain reactions, respiratory chain cycles, and many phases of immunity development, but no one vitamin can do it alone.

Due to decreased food intake and medication depletion, micronutrient intake must be sufficient to help infection recovery. Insufficient micronutrients may impede immune response. MN supplementation may boost immune cells and reactions. Vitamins C and D, which

must be taken in quantities greater than the RDA to be immune-effective, are challenging to get from a well-balanced and diversified diet alone.

Plugging the daily gap of MiND with multivitamin/mineral supplements

Micronutrient supplementation to restore concentrations to appropriate levels, particularly after an illness and throughout recovery, supports immune function and maintenance. Vitamin A supplementation reduces vitamin A deficiency-related infection-related morbidity and death. 17 WHO/UNICEF suggest zinc supplementation for diarrheal infections and severe malnutrition. 6 A comprehensive review and meta-analysis found a borderline significant preventative impact of micronutrient supplementation (vitamin A, B12, C, D, iron, and zinc) against viral respiratory tract infections (RTIs). Micronutrients' immune-boosting properties prevent viral RTIs. 20 Zinc supplementation reduced diarrhea, pneumonia, and death. Yet, peak bone densities avoid osteoporotic fractures in later life. Vitamin D and calcium supplementation helps children reach peak bone densities and adults avoid osteoporosis. 6 Micronutrient supplementation may assist healing following surgery or illness, according to 90% of HCPs. Several HCPs underlined that nutritional deficiency is not limited to thin and vulnerable malnourished persons. Obesity increases nutritional deficits. Obesity is caused by vitamin D deficiency. Obese folks need micronutrients too. Patients with diabetes, hypertension, COPD, asthma, or cardiovascular disorders, as well as the elderly owing to gastrointestinal tract (GIT) absorption difficulties, require vitamin supplementation. Folic acid alone or with vitamin B12 lowered homocysteine levels

in Indian vascular disease patients, according to a recent research. Chronic and severe folate deficiency causing aberrant hemopoiesis and megaloblastic anemia (MBA) responds quickly to folate therapy. Vitamin C intake reduces the incidence of cardiovascular events, asthma, cataracts, and the common cold, according to strong evidence. 6

Impact of multivitamin/mineral supplementation on immunity/energy/cognition

Micronutrient supplementation may help restore concentrations to appropriate levels, particularly after an illness, and promote immune function and maintenance (Table 3). Among swimmers, vitamin C administration decreased upper RTIs, pneumonia risk, and cold duration and symptoms.

Table 2 Mechanism of action of vitamins A, C, D, & zinc in supporting immune response

In the Inflammatory and innate immune response	In the adaptive immune response
Vitamin A Integrity of epithelia Differentiation and function of NK cells Promotion of Foxp3+ Treg generation Inhibition of Th1/Th17 generation Phagocytic and oxidative burst activity of macrophages Secretion of the pro-inflammatory cytokines IL-12 and IL-23	Vitamin A Growth and differentiation of B cells Production of antibodies and immunoregulatory function of Treg cells
Vitamin C Barrier integrity Scavenger of ROS Chemotactic ability and antibacterial activity of neutrophils Apoptotic process of neutrophils Reduction of formation of NETS	Vitamin C Differentiation and proliferation of B and T cells Immunostimulator of antibody production (IgM and IgG) T cell maturation via epigenetic mechanisms
Vitamin D Production of antimicrobial peptides Modulation of macrophages/monocytes and dendritic cell functions. Limits the over production of pro-inflammatory cytokines from macrophages (IL, TNF- α)	Vitamin D limits the over production of pro-inflammatory cytokines from T cells (INF- γ , IL-2, IL-8, and IL-6). Th1 to Th2 shift, increases Th2 cytokines (IL-4, IL-10). Induces differentiation of Treg cells. Reduces excessive antibody production.
Zinc Maintenance of membrane barrier integrity. Direct antiviral effects. Decreases oxidative stress.	Zinc Limits excessive release of Pro-inflammatory cytokines (IL-2, IL-6, and TNF- α) Enhances the number of Treg cells. Omega 3 FA [Specialized pro-resolving mediators (SPMs)] Treg cell formation and B cell activation Upregulates CCR5 expression

Table 3 Impact of multivitamin/mineral supplementation on immune function

Micronutrient	Impact of supplementation on immune functions
Vitamin C	High doses stimulate phagocytic and T-lymphocytic activity. Antioxidant properties to combat oxidative stress. Aids in wound healing.
Vitamin D	Calcitriol restores the immune function of macrophages. Increased resistance to infection especially RTIs.
Zinc	Beneficial effects on intestinal immune functions Increases cytotoxicity of NK cells Restores thymulin activity Reduces the number of activated T helper cells (which can contribute to autoimmunity)
Vitamin A	Retinoic acid modulates specific microbiota in the gut Helps reverse adverse effects on immune functions of neutrophils, eosinophils, NK cells, and macrophages Improves antibody titer response to vaccines
Iron	Improves intracellular microbial killing and cellular immunity
Copper	Increased ability of neutrophils to engulf pathogens
Selenium	Improves cell-mediated immunity Improves T helper cell counts Enhances immune response to viruses in deficient individuals
Magnesium	Reduces oxidative damage to DNAs of peripheral blood lymphocytes in athletes and sedentary young men. Reduces leukocyte activation.

Three clinical investigations found that vitamin C groups had a >80% decreased pneumonia rate, especially in those with low plasma vitamin C levels. Vitamin C also lowered pneumonia severity and death in elderly individuals, especially the sickest. 17 Nevertheless, vitamin D supplementation protected against acute RTIs. 21 During influenza.

A lung infection that vitamin D lowered IFN-, TNF-, IL-8, and IL-6. Vitamin D therapy promoted NF-kB inhibition in respiratory syncytial virus infection. 17 Zinc also decreased cold and RTI symptoms. Zinc supplementation reduced oxidative stress and directly inhibited viruses. Zinc therapy for three months decreased diarrhea and respiratory infections.

A two-month multivitamin/mineral supplement therapy improved superoxide dismutase (SOD) activity and reduced tiredness, sleep problems, autonomic nervous system symptoms, headache frequency, and severity. Hence,

antioxidant-boosting multivitamin/mineral intake may safely reduce tiredness symptoms. Another placebo-controlled, double-blind, and randomized research demonstrated substantial reductions in homocysteine and physical weariness on day 62 ($p < 0.05$ and $p = 0.006$, respectively). The multi-tasking framework and particular activities were more accurate (Mathematical Processing, Stroop Color-Word). Consequently, 62 days of multivitamin/mineral supplementation in females improved task-induced physical weariness and cognitive function. Scientific research shows that micronutrient supplements decreased tiredness (vitamins B1 and D, iron), increased activity and energy (vitamin B1), enhanced muscular endurance (zinc), improved exercise tolerance (magnesium) and physical capacity/performance (CoQ10), and improved physical recovery (CoQ10). Wellbeing was linked to vitamin B1-induced calmness and seasonal affective disorder symptoms including sadness (vitamin D).

The HCP consensus supported prescription micronutrient supplements to treat micronutrient deficits.

Impact of multivitamin/mineral supplementation on fulfilling MiNDs (as per RDA in daily diet)

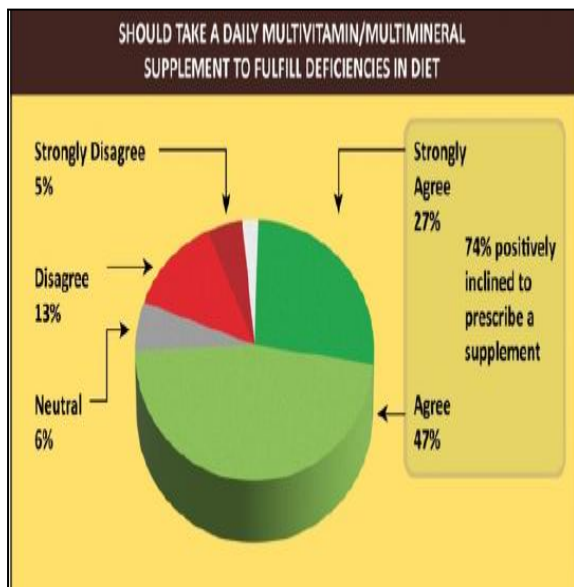


Fig. 3: Abbreviations: HCP, health care professional; MiND, micro nutrient deficiencies; RDA, recommended allowance. HCP Urban survey impact of multivitamin/mineral supplementation on fulfilling Mind (as per RDA) in daily diet

According to replies from 220 HCPs in urban India to a health study conducted between March and April of 2021, 74% of Indian physicians and nutritionists are inclined to recommend multivitamin/mineral pills to make up for micronutrient deficits (as per RDA) in the typical Indian diet (Figure 3).

Benefits of natural or herbal ingredients to boost immunity

Stimulating the immune system to fight viruses and germs is effective. Natural/herbal substances boost the immune system, according to research. Immune-stimulating herbs manage and prevent infections. Stimulated immune systems fight infections better and prevent stress- and infection-induced immunosuppression. In vitro and animal research show that turmeric, Shatavari, giloy, amla, and tulsi alter immune processes through immunostimulation/immunoregulation to control and prevent infections (Table 4).

Tulsi enhanced immunological response with increased natural killer (NK) and T-helper cells, decreased tiredness, creatine kinase, cognitive flexibility, short-term memory, and attention, and reduced stress-related symptoms in psychosomatic issues by 31.6%–39%.

Table 4: Pharmacological properties of natural ingredients

Natural Ingredients	Pharmacological Properties of Natural Ingredients
Tulsi ^{21,26}	Adaptogenic, immunomodulatory, antimicrobial, cardioprotective, anti-inflammatory, antiviral, antifungal, antibacteria l, and hepatoprotective actions Enhances the immune response by phagocytic activity and index with a rise in the lymphocyte count, neutrophil count, and antibody titer
Turmeric ^{26,27}	Anti-inflammatory activity of curcumin in both acute/chronic cases of inflammation Potent antioxidant to lower lipid peroxidation in cells by sustaining activities of antioxidant enzymes (catalases, superoxide dismutase, and glutathione peroxidase) at higher levels
Ashwagandha ²⁶	Anti-inflammatory, antitussive, and antioxidant agent Enhances nitric oxide (NO) synthase activity of macrophages to increase their microbe killing power Stimulatory effect on the immune system, enhances antibody and red blood cell levels, and increases the number of white blood cells to destroy germs Marked increase in the primary and secondary antibodies and also a cell-mediated immune response to possess immunostimulatory properties
Shatavari ^{26,28,29}	Antioxidant, immunomodulatory, anti-inflammatory, anti-bronchitis, anticholesterolemia, and potential broad-spectrum antibiotic properties
Giloy ^{26,30}	Boosts the immune system by immunomodulatory and cytoprotective activities through augmentation of antibody production and various non-specific immune mechanisms
Amla	Antimicrobial, antiviral, antioxidant, anti-inflammatory, immunomodulatory, larvicidal, cardioprotective, and wound healing activities. Interferes with the adhesion of <i>Candida albicans</i> to buccal epithelial cells and denture acrylic surfaces in vitro. Antimicrobial effect by inhibiting adhesion and synergistic increase in zone of inhibition against <i>Staphylococcus aureus</i> with amoxicillin by agar diffusion and disk diffusion methods. Significant reduction in mean colony count of <i>Escherichia coli</i> , <i>Staphylococcus aureus</i> , and <i>Klebsiella pneumoniae</i> by tube dilution method.

Immune-modulating turmeric reduces respiratory tract infections. In vivo effects of Shatavari on effector T cell immunity indicate its application in respiratory infections where wider activation of T-helper type 1 (Th1) and Th2 immunity supports its immunoadjuvant potential. Amla extract's broad-spectrum antibacterial pattern outperformed multidrug-resistant pathogens. Giloy's

immunomodulatory characteristics are active in several chronic inflammatory illnesses including diabetes and cognitive impairment.

The HCP consensus acknowledged that natural/herbal substances have diverse pharmacological properties but need substantial clinical investigation.

Summary

MiND has reached a worrisome level in a big number of Indians, whether overweight or underweight, causing a massive dietary shift. Urban India suffers from MiND. "Hidden Hunger" or MiNDs are low vitamin and mineral levels that might increase morbidity and death without clinical symptoms. In healthy people, MiNDs increase the risk of diabetes, hypertension, osteoporosis, asthma, depression, neurological, cardiovascular, endocrine, and other diseases. MiND may also affect healthy people.

Calcium, iron, magnesium, zinc, and vitamin B12 insufficiency concerns are high in India. Indian women have significant micronutrient deficits because they eat less than men. Reports

The National Nutrition Monitoring Agency is alarmed that 70% of Indians have micronutrient intakes below 50% RDA. Micronutrient intakes vary greatly across Indian dietary patterns, diet insufficiency owing to an unbalanced diet, improper dietary practices, contemporary eating habits, increasing junk food consumption, and unhealthy snacking. Insufficient micronutrient intake at any age disrupts immune system processes, lowering infection resistance and worsening symptoms. MiNDs evolve through numerous subclinical phases before clinical symptoms arise, causing fatigue and infection susceptibility. Zinc, vitamin A, vitamin C, and vitamin D have

been shown to boost immunity and reduce the incidence and severity of viral respiratory infections. Regular micronutrient supplementation prevents or restores concentrations to recommended levels. Micronutrients promote energy, focus, mental stamina, mood, and depression, anxiety, and stress.

Micronutrient supplementation (vitamin A, B12, C, D, iron, and zinc) reduces viral respiratory tract infections, according to strong evidence. Malnourished persons are not only skinny and frail. Obese individuals need additional nutritional supplementation. Even healthy seniors or those with comorbidities require vitamin supplementation. Micronutrient supplementation may cure diseased patients and prevent respiratory infections in healthy persons. MMS improves energy, cognition, and well-being in healthy people, according to many scientific research.

Many pharmacological actions of natural/herbal compounds alter immune processes to control and prevent infections. Stimulated immune systems fight infections better and prevent stress- and infection-induced immunosuppression.

In vitro and animal research show that turmeric, Shatavari, ashwagandha, giloy, amla, and tulsi alter immune processes through immuno stimulation/immuno regulation to control and prevent infections.

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