# Mineral Deficiency

Related terms:

Malabsorption, Hypovitaminosis, Isotopes of Calcium, Vitamin D, Malnutrition, Folic Acid, Magnesium

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# Mineral Deficiencies

Anuraj H Shankar, in Hunter's Tropical Medicine and Emerging Infectious Disease (Ninth Edition), 2013

## Summary

Mineral deficiencies negatively affect billions of individuals worldwide, imposing a heavy burden on wellbeing and economic productivity. Most prominently, deficiencies in iron, zinc and iodine have the largest negative impact on public health; however, other minerals, including calcium, magnesium, selenium and fluoride, contribute significantly to the health burden. While the causes of mineral malnutrition are complex, the primary determinant is insufficient dietary intakes. Efforts aimed at fortifying foods or providing supplements to reduce mineral deficiencies have had some success, but substantial efforts are still needed to get effective programming at scale [98]. To ensure sufficient impact, several mutually-reinforcing strategies need to be put in place to increase access and consumption to those in need. As most nutrient deficiencies do not occur in isolation, measures for prevention and control will need to rely on dietary diversification, as well as education to promote optimum dietary intakes.

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## Summary

Mineral deficiencies negatively affect billions of individuals worldwide, imposing a heavy burden on well-being and economic productivity. Most prominently, deficiencies in iron, zinc, and iodine have the largest negative impact on public health; however, other minerals, including calcium, magnesium, selenium, and fluorine, contribute significantly to the health burden. And the mineral lead (Pb) is an important environmental contaminant affecting brain development. Although the causes of mineral malnutrition are complex, the primary determinant is insufficient dietary intake. Efforts aimed at fortifying foods or providing supplements have had some success, but substantial efforts are still needed for effective programming at scale. Mutually reinforcing strategies may increase access and consumption, as most deficiencies do not occur in isolation; measures for prevention and control will need to rely on dietary diversification, as well as education to promote optimum dietary intakes.

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# Aging: Nutrition and the Older Adults

Julia Kravchenko, in International Encyclopedia of Public Health (Second Edition), 2017

## Dietary Supplements

Vitamin and mineral deficiencies in older individuals can be exacerbated by existing diseases (e.g., during hospitalization), hypermetabolic states, alcohol use, liver disease, diuretic use, and laxative abuse. These deficiencies should be corrected not only by food but also by the dietary supplements. The randomized control trials do not support use of vitamin and mineral supplements by well-nourished individuals (Joshi and Morley, 2006). There is no significant proof that large doses of antioxidants can prevent chronic diseases associated with aging (such as CVD, diabetes mellitus, and cataracts).

Results of nine placebo-controlled double-blind studies of multiple nutrient in older adults, as well as 12 placebo-controlled studies with a single-nutrient intervention showed the trend to improvement in nutritional status of aged people, for example, for several serum vitamin levels and some biochemical parameters (Van Staveren

and de Groot, 2006). It is acceptable for old persons to supplement with vitamin B12, calcium, vitamin D, iron (extra for postmenopausal women who are using hormone replacement therapy), and vitamin B6. Also, supplementation with zinc in older adults reduces the influence of infections and decreases the markers of tumor necrosis factor  and oxidative stress (Prasad et al., 2007). Moderate intake of eicosapentaenoic acid and docosahexaenoic acid from fish may help to postpone a cognitive decline in aged group of population (van Gelder et al., 2007).

It is important that the doses of micronutrients should not exceed the recommended daily intakes, because the adverse affects of such doses have been reported (Palmer et al., 2003).

Nutritional supplementation is effective in the treatment of such large health issue among the older adults as sarcopenia. However, the main limitation is a lack of a long-term adherence to the supplements intake (Malafarina et al., 2013) The expert panel of the Society for Sarcopenia, Cachexia, and Wasting Disease has recommended the exercise (both resistance and aerobic), adequate protein and energy intake, and vitamin D support when vitamin D level is low to prevent sarcopenia among the aged individuals (Morley et al., 2010).

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# Aging: Nutrition and the Older Adults☆

J. Kravchenko, in Reference Module in Biomedical Sciences, 2014

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# Protein-Energy Malnutrition in Children

Tahmeed Ahmed, ... M. Jobayer Chisti, in Hunter's Tropical Medicine and Emerging Infectious Diseases (Tenth Edition), 2020

## Step 6: Correct Micronutrient Deficiencies

All severely malnourished children have vitamin and mineral deficiencies. Although anemia is common, iron is not given until the child has a good appetite and starts gaining weight (usually by the second week). They should receive the daily recommended nutrient intake of vitamin A (5000□IU/day) throughout the treatment period either as an integral part of therapeutic foods or as part of a multi-micronutrient formulation.

The following micronutrients are provided daily for the entire period of nutritional rehabilitation (at least 4 weeks):

- Multivitamin supplements
- Folic acid 1□mg/day (5□mg on day 1)
- Zinc 2□mg/kg/day

- Copper 0.3 mg/kg/day
- Iron 3 mg/kg/day, but only when gaining weight

A combined electrolyte/mineral/vitamin mix for severe malnutrition is available commercially. This can replace the electrolyte/mineral solution and multivitamin and folic acid supplements mentioned in Steps 4 and 6. However, the large single dose of vitamin A and folic acid on day 1 are still given.

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## Step 6: Correct Micronutrient Deficiencies

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# Inflammatory Bowel Disease

Alyssa M. Parian MD, ... Amy C. Brown PhD, in Integrative Medicine (Fourth Edition), 2018

## Vitamin-Mineral Supplements in IBD

Patients suffering with IBD frequently have vitamin and mineral deficiencies due to decreased intake or poor absorption secondary to inflamed mucosa. Some vitamins and minerals are believed to have antiinflammatory, immunogenic, and antineoplastic properties. However, serious toxicities are possible with excessive intake of certain nutrients, and caution should be taken regarding interactions between medications and supplements.

### Vitamin A

Vitamin A (retinol) is a fat-soluble vitamin important for wound healing[49] and is found to be deficient in up to 44% of IBD patients.[50-52] Vitamin A requires an intact enterohepatic biliary circulation to be adequately absorbed, which is altered in patients with large ileal resections or extensive ileal disease as is commonly seen in Crohn's Disease (CD), which involves the ileum in 80% of cases. Two studies failed to demonstrate a benefit of high-dose vitamin A for maintaining remission in CD, although both studies comprised patients without acute inflammation.[53,54] Supplementation is only recommended to sufficiency in patients with vitamin A deficiency.

### Vitamin $B_{12}$

Vitamin B12 (cobalamin) deficiency is common in IBD patients and has been reported in up to 50% of Crohn's patients.[55-58] Vitamin B12 deficiency can manifest clinically with a variety of signs and symptoms, including nervous system dysfunction or megaloblastic anemia.[57,59,60] The absorption of B12 requires the secretion of intrinsic factor by the stomach, which is essential for the absorption of vitamin B12 in the ileum. Because the ileum is the most frequent location affected in Crohn's disease, there is a significantly increased risk of B12 deficiency and insufficiency among this patient population.[60]

True cobalamin deficiency leads to elevated serum levels of methylmalonic acid (MMA) and homocysteine, which have both been linked to higher risks of cardio-

vascular disease and stroke. The sensitivity and specificity of serum B12 levels in the diagnosis of B12 deficiency is poor[61-64] and some experts, including NHANES, have recommended that an elevated MMA or homocysteine level be required for an accurate diagnosis of cobalamin deficiency.[61,65] The daily requirement of B12 is 2.4 mcg in the general population.[66] Higher doses are needed if a patient is deficient according to the severity of symptoms. Supplementation via the subcutaneous route is best in patients with ileal inflammation or resection due to poor absorption. However, the malabsorption can be overcome with high doses of oral cobalamin (1000–2000 mcg daily), which are absorbed through passive diffusion or the sublingual route.[66,67]

## Vitamin D

Vitamin D has been shown to regulate cell growth and is a key cofactor in the immune system.[68-70] Vitamin D may act as an antiinflammatory and immune regulatory agent. Between 22% and 70% of Crohn's patients and up to 45% of UC patients have been reported to have vitamin D deficiency.[71-74] The Nurses' Health Study has demonstrated two important findings: a lower risk of UC in those with the highest intake of vitamin D supplementation and a lower risk of CD in those with higher vitamin D levels.[75] Patients with CD appear to have less frequent flares and improved disease activity scores with vitamin D supplementation.[76,77] A prospective study showed that CD patients supplemented with vitamin D to sufficiency (30–50 ng/mL) had a decreased risk of hospitalization and surgery.[78] A subsequent prospective, randomized, placebo-controlled study found that daily supplementation with 1200 IU of vitamin D3 decreased the rate of relapse (P = 0.06) in 108 CD patients in remission.[76] Vitamin D levels (25 hydroxy-D) should be assessed on at least an annual basis in IBD patients and repleted to maintain levels > 30 ng/mL.

## Vitamin K

Vitamin K has been shown to play a role in bone health along with magnesium, calcium, and vitamin D. IBD patients with ileitis or those treated with sulfasalazine or antibiotics are at risk of vitamin K deficiency.[78a] Dietary intake of vitamin K has been shown to be lower in IBD patients in several studies. Currently, there is insufficient evidence to support daily vitamin K supplementation. Patients should instead be encouraged to consume green leafy vegetables to obtain vitamin K naturally through the diet.[79]

## Vitamin E

Vitamin E has been shown to significantly reduce oxidative stress by preventing the production of reactive oxygen species and terminating chain reactions in cell

membranes.[52,80,81] IBD patients have been found to have decreased levels of vitamin E (tocopherol).[82] Several rodent studies and a small human study have shown promise in the treatment of colitis with vitamin E enemas.[83-85] Vitamin E is another fat-soluble vitamin; therefore, large doses can lead to toxicity, and caution needs to be taken with this therapy. Large population-based studies have actually found increased rates of all-cause mortality with high doses of vitamin E supplementation.[86,87]

## Vitamin C

Vitamin C or ascorbic acid is an essential water-soluble vitamin that has been found to be low in IBD patients, at least partially due to inadequate intake.[50,52,56] More than 50% of Crohn's patients have been reported to be vitamin C deficient.[56] The wound-healing effects of vitamin C are particularly important.[88] Although excess vitamin C is not life threatening because it is water soluble, high levels may cause diarrhea, nausea, vomiting, abdominal pain, and oxalate kidney stones. Excessive repletion of vitamin C (i.e., intravenous infusions) has not been shown to have any proven health benefits and is not recommended.

## Folate

Folate deficiency is observed in up to 26% of CD patients.[50,58] Mesalamines, particularly sulfasalazine and methotrexate, inhibit folate absorption. Folate supplement of 1 mg daily is therefore advised.[89] Folic acid deficiency is associated with elevated homocysteine levels[90] and thromboembolism.[91] Additionally, low folic acid levels are associated with an increased risk of colorectal dysplasia or cancer in IBD patients[92-94] as well as the general population.[95-98] Folate supplementation beyond sufficiency has not been shown to prevent colorectal neoplasia or dysplasia.[99-102] Red cell folate levels are more accurate than serum levels and should be monitored at least annually in patients on the aforementioned medications that predispose to folate deficiency. Low folate levels may also reflect an inherited posttranslational modification of the enzyme methylene tetrahydrofolate reductase (MTHFR), requiring supplementation with folinic acid to sufficiency to bypass the defective metabolic process. Genetic testing for MTHFR mutation is therefore recommended and offered by most commercial laboratories and covered by insurance carriers.

## Calcium

Calcium is an essential macronutrient and requires vitamin D for adequate absorption from the intestines. It has been reported that 80% of IBD patients have inadequate calcium intake[50,56] and up to 50% have osteopenia.[103,104] Low magnesium levels, commonly caused by diarrhea, also cause calcium malabsorption. Corticos-

teroids used to treat IBD are known to inhibit calcium absorption. Calcium deficiency leads to an inability to maintain bone health that eventually causes osteoporosis. Glucocorticoids are also known to accelerate the development of osteoporosis.[79]

The majority of IBD patients likely should be on standard daily calcium supplementation (1000–1500 mg). Because calcium requires vitamin D to be absorbed, IBD patients should be on both calcium and vitamin D supplementation to maintain bone health and prevent osteoporosis, particularly those currently on steroids.[79]

Monitoring of bone health is essential in all patients with IBD because they are at high risk for osteoporosis and bone fractures. To maintain adequate bone health, IBD patients should not smoke cigarettes and should limit or avoid corticosteroid use. Bone homeostasis requires adequate calcium, vitamin D, magnesium, and vitamin K.

## Chromium

Chromium deficiency can occur in patients on long-term central parenteral nutrition (CPN),[105] and 10–15 mcg should be added to the daily mix to prevent it. Glucocorticoids have been shown to increase urinary excretion of chromium. Signs of chromium deficiency include a hypochromic microcytic anemia and poor glucose control. Supplementation with chromium up to 600 mcg daily may reverse steroid-induced diabetes.[106]

## Iron

Iron is the most commonly deficient nutrient in IBD patients, with a prevalence of approximately 30%.[107] Repletion of iron is clinically challenging in IBD patients. Cholestyramine and antacids impair absorption of iron, whereas ascorbic acid facilitates absorption. Oral iron can be harsh on the GI tract, causing nausea, gastritis, and constipation. There is some evidence that oral iron may increase oxidative stress in the intestines by increasing superoxide anion generation according to Fenton chemistry analysis in animal models.[108] Intravenous iron repletion may be the most effective approach despite a risk of anaphylaxis, particularly in patients with severe deficiency.[109] Ferric carboxymaltose is a new formulation of iron that can be safely administered at higher doses (1000 mg) to achieve normal levels more rapidly while decreasing the required number of infusions. Due to the decreased number of infusions, patients are more compliant with this therapy. Additionally, ferric carboxymaltose (1000 mg) has been shown to be more effective than standard iron sucrose (200 mg) in improving hemoglobin levels.[110]

## Magnesium

Magnesium plays a role in maintaining adequate bone health, parathyroid function, and calcium absorption. Magnesium deficiencies have been reported in patients with diarrhea, high fistula output, malabsorption, or inadequate oral intake. To most accurately measure the body stores of magnesium, a 24-hour urine is required.[111,112] Red blood cell (RBC) magnesium levels also provide an additional measure of intracellular magnesium status. Decreased levels of magnesium in the urine increase the risk of urolithiasis, for which CD patients are already at risk.[113] Magnesium formulations, such as heptogluconate and magnesium pyroglutamate, may have less association with diarrhea than citrate.

### Selenium

Selenium is a mineral that plays a vital role in antioxidant functioning by acting as a cofactor for glutathione peroxidase and reducing vitamin E regeneration. Selenium deficiency is associated with cardiomyopathy, hypothyroidism, and cartilage degeneration.[79] The long-term use of CPN and small bowel resection can lead to selenium deficiency.[114] Several studies have confirmed lower levels of selenium in both UC and CD patients compared with the general population.[115-120]

### Zinc

Zinc deficiency can develop in patients with severe diarrhea, high output ostomies, and long-term corticosteroid or CPN use.[121] Zinc is required for the metabolism of vitamin A, including the oxidative conversion of retinol to retinal and vitamin A transport.[122] Measuring the overall zinc status in the body is challenging; however, many use the levels of zinc in RBCs to reflect intracellular status.[79] Supplementation with 220 mg of zinc sulfate once or twice daily is recommended in patients with draining fistulae, recent surgery, or active and severe diarrhea.[79] Zinc repletion should be provided with vigilance because excess zinc interferes with the absorption of iron and copper.[88] Copper deficiency with profound neurological manifestations has been described with high-dose supplementation of zinc because these two micronutrients compete for binding to metallothionine.

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# RENAL FUNCTION AND DISORDERS | Nutritional Management of Renal Disorders

B.E. Engel, in Encyclopedia of Food Sciences and Nutrition (Second Edition), 2003

## Vitamins and Minerals

Some of the clinical features of uremia may be linked to subclinical vitamin and mineral deficiencies. Dietary protein, phosphate, and potassium restrictions will limit the intake of various micronutrients, and even when intake is adequate, the metabolic pathways may be affected, reducing the availability or efficacy of the nutrients. Specifically, a low-protein diet was found to contain low levels of B vitamins ($B_1$, $B_2$, $B_6$, $B_{12}$), iron, calcium, and zinc. A low-potassium diet will limit folic acid and vitamin C intake. However, there may be reduced renal losses of some nutrients, and cases of hypervitaminosis A have been recorded. It is recommended that vitamin and mineral status should be part of a renal patients regular nutritional assessment.

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# Non-Communicable Diseases and Conditions

Theodore H. Tulchinsky MD, MPH, Elena A. Varavikova MD, MPH, PhD, in The New Public Health (Third Edition), 2014

## Osteoporosis

Osteoporosis is a bone disorder resulting from a reduction of bone tissue density due to mineral and vitamin deficiency (calcium, vitamin D, and fluoride). The deficiency leads to weakening of the skeleton in older adults, thus causing fractures, most commonly of the spinal cord, hip, and wrists. It is a major cause of disability and death, as well as costly institutional care. It appears to be more common in northern countries and in cultural groups where women are completely covered for religious reasons and have darker skin coloring, reducing sun exposure and vitamin D production.

According to the US National Osteoporosis Foundation, osteoporosis is a major health threat for approximately 48 million Americans over 50 years of age and 10.7 million will have clinical osteoporosis by 2020. By 2030, the numbers will reach 11.9 million with clinical disease and 64.3 million with low bone mass. Osteoporosis results in more than 2 million fractures annually and is predicted to rise to more than 3 million by 2025, with an associated cost of US$25.3 billion in the USA (National Osteoporosis Foundation, April 2013). National surveys in the USA show adequate levels of folic acid, and vitamins A and D in most of the population, likely to be related

to fortification of basic foods, but low vitamin D levels in black Americans, and low iodine levels as well (CFC, 2012).

Postmenopausal women are the primary group at risk, owing to low bone mass. The lifetime risk of a woman suffering an osteoporosis-related fracture is about 40 percent, and the chance of developing a hip fracture is equivalent to her combined risk of developing cancer of the breast, uterus, or ovary combined (US National Osteoporosis Foundation: http://www.nof.org/). The number of osteoporotic women is estimated to have been 3.8 million in 2005 and is projected to increase to 5.3 million by 2025.

Screening of those at risk by X-ray assessment of bone density is now being replaced by a relatively inexpensive, portable ultrasound instrument for use in ambulatory clinics. Postmenopausal women are at high risk for vitamin D deficiency and osteoporosis with factures of hip, spine, and other bones.

Age, gender, genetics, lifestyle (especially nutrition), and menopausal status are the major risk factors for osteoporosis. Other important factors include lack of adequate calcium and vitamin D intake, lack of appropriate exercise, smoking, and excessive alcohol intake. Fracture of the hip remains a serious threat to life despite improvements in surgical management. Osteoporosis management includes lifestyle issues as well as new advances in medical therapeutics. Osteoporosis is amenable to primary prevention and reducing risk factors. Primary prevention is directed towards adolescent, young adult, and perimenopausal women to ensure adequate physical activity, avoidance of smoking, adequate dietary intake of calcium and vitamin D, reduction of excess alcohol consumption, and prevention of falls. For postmenopausal women, prevention should also include home safety measures, bone density screening, and hormone replacement therapy to inhibit bone resorption.

In countries that do not mandate fortification of milk with vitamin D, as required for enriched milk in the USA, Canada, and other countries, vitamin D levels may be low in many parts of the population. Fortification is an essential public health measure, but not sufficient to prevent deficiency. This is important for children and, as a result, the American Academy of Pediatrics recommends supplements for children until they reach adolescence. This recommendation is associated with the shift in child play practices, from playing sports outdoors to using computers inside the home.

Vitamin D adequacy is increasingly linked to prevention of CVD and cancers such as breast and colorectal cancer. Fortification of a basic food with vitamin D, along with other fortificants, is a vital public health measure and should be augmented by vitamin D supplements for children, adolescents, adults, and elderly people,

especially if confined to institutional care. Promotion of moderate sun exposure daily for 20–30 minutes should also be recommended.

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