

Vitamin K

Fact Sheet for Health Professionals

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Introduction

Vitamin K, the generic name for a family of compounds with a common chemical structure of 2-methyl-1,4-naphthoquinone, is a fat-soluble vitamin that is naturally present in some foods and is available as a dietary supplement [1]. These compounds include phyloquinone (vitamin K1) and a series of menaquinones (vitamin K2) [2]. Menaquinones have unsaturated isoprenyl side chains and are designated as MK-4 through MK-13, based on the length of their side chain [1,2]. MK-4, MK-7, and MK-9 are the most well-studied menaquinones.

Phylloquinone is present primarily in green leafy vegetables and is the main dietary form of vitamin K [3]. Menaquinones, which are predominantly of bacterial origin, are present in modest amounts in various animal-based and fermented foods [1,4]. Almost all menaquinones, in particular the long-chain menaquinones, are also produced by bacteria in the human gut [5,6]. MK-4 is unique in that it is produced by the body from phyloquinone via a conversion process that does not involve bacterial action [7].

Vitamin K functions as a coenzyme for vitamin K-dependent carboxylase, an enzyme required for the synthesis of proteins involved in hemostasis (blood clotting) and bone metabolism and other diverse physiological functions [3,5].

Prothrombin (clotting factor II) is a vitamin K-dependent protein in plasma that is directly involved in blood clotting. Warfarin (Coumadin) and some anticoagulants used primarily in Europe antagonize the activity of vitamin K and, in turn, prothrombin [8]. For this reason, individuals who are taking these anticoagulants need to maintain consistent vitamin K intakes.

Matrix Gla-protein (MGP), a vitamin K-dependent protein present in vascular smooth muscle, bone, and cartilage, is the focus of considerable scientific research because it might help reduce abnormal calcification [9]. Osteocalcin is another vitamin K-dependent protein that is present in bone and may be involved in bone mineralization or turnover [5].

Like dietary lipids and other fat-soluble vitamins, ingested vitamin K is incorporated into mixed micelles via the action of bile and pancreatic enzymes, and it is absorbed by enterocytes of the small intestine [10]. From there, vitamin K is incorporated into chylomicrons, secreted into the lymphatic capillaries, transported to the liver, and repackaged into very low-density lipoproteins [2,10]. Vitamin K is present in the liver and other body tissues, including the brain, heart, pancreas, and bone [2,3,11].

In the circulation, vitamin K is carried mainly in lipoproteins [2]. Compared to the other fat-soluble vitamins, very small amounts of vitamin K circulate in the blood. Vitamin K is rapidly metabolized and excreted. Based on phylloquinone measurements, the body retains only about 30% to 40% of an oral physiological dose, while about 20% is excreted in the urine and 40% to 50% in the feces via bile [2,11]. This rapid metabolism accounts for vitamin K's relatively low blood levels and tissue stores compared to those of the other fat-soluble vitamins [11].

Little is known about the absorption and transport of vitamin K produced by gut bacteria, but research indicates that substantial quantities of long-chain menaquinones are present in the large bowel [7]. Although the amount of vitamin K that the body obtains in this manner is unclear, experts believe that these menaquinones satisfy at least some of the body's requirement for vitamin K [6,7].

In most cases, vitamin K status is not routinely assessed, except in individuals who take anticoagulants or have bleeding disorders. The only clinically significant indicator of vitamin K status is prothrombin time (the time it takes for blood to

clot), and ordinary changes in vitamin K intakes have rarely been shown to alter prothrombin time [5]. In healthy people, fasting concentrations of phylloquinone in plasma have been reported to range from 0.29 to 2.64 nmol/L [12]. However, it is not clear whether this measure can be used to quantitatively assess vitamin K status. People with plasma phylloquinone concentrations slightly below the normal range have no clinical indications of vitamin K deficiency, possibly because plasma phylloquinone concentrations do not measure the contribution of menaquinones from the diet and the large bowel [12]. No data on normal ranges of menaquinones are available [2].

Recommended Intakes

Intake recommendations for vitamin K and other nutrients 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 [3]. DRI is the general term for a set of reference values used for planning and assessing nutrient intakes of healthy people. These values, which vary by age and gender, include the following:

- Recommended Dietary Allowance (RDA): Average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals; often used to plan nutritionally adequate diets for individuals
- Adequate Intake (AI): Intake at this level is assumed to ensure nutritional adequacy; established when evidence is insufficient to develop an RDA
- Estimated Average Requirement (EAR): Average daily level of intake estimated to meet the requirements of 50% of healthy individuals; usually used to assess the nutrient intakes of groups of people and to plan nutritionally adequate diets for them; can also be used to assess the nutrient intakes of individuals
- Tolerable Upper Intake Level (UL): Maximum daily intake unlikely to cause adverse health effects

Insufficient data were available to establish an EAR for vitamin K, so the FNB established AIs for all ages that are based on vitamin K intakes in healthy population groups [3]. Table 1 lists the current AIs for vitamin K in micrograms (mcg). The AIs for infants are based on the calculated mean vitamin K intake of healthy breastfed infants and the assumption that infants receive prophylactic

vitamin K at birth as recommended by American and Canadian pediatric societies [3].

Table 1: Adequate Intakes (AIs) for Vitamin K [3]

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months	2.0 mcg	2.0 mcg		
7–12 months	2.5 mcg	2.5 mcg		
1–3 years	30 mcg	30 mcg		
4–8 years	55 mcg	55 mcg		
9–13 years	60 mcg	60 mcg		
14–18 years	75 mcg	75 mcg	75 mcg	75 mcg
19+ years	120 mcg	90 mcg	90 mcg	90 mcg

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Sources of Vitamin K

Food

Food sources of phylloquinone include vegetables, especially green leafy vegetables, vegetable oils, and some fruits. Meat, dairy foods, and eggs contain low levels of phylloquinone but modest amounts of menaquinones [4]. Natto (a traditional Japanese food made from fermented soybeans) has high amounts of menaquinones [1,13]. Other fermented foods, such as cheese, also contain menaquinones. However, the forms and amounts of vitamin K in these foods likely vary depending on the bacterial strains used to make the foods and their fermentation conditions [14]. Animals synthesize MK-4 from menadione (a synthetic form of vitamin K that can be used in poultry and swine feed) [15]. Thus, poultry and pork products contain MK-4 if menadione is added to the animal feed [1,4,14].

The most common sources of vitamin K in the U.S. diet are spinach; broccoli; iceberg lettuce; and fats and oils, particularly soybean and canola oil [5,7]. Few foods are fortified with vitamin K [5]; breakfast cereals are not typically fortified with vitamin K, although some meal replacement shakes and bars are.

Data on the bioavailability of different forms of vitamin K from food are very limited [1]. The absorption rate of phylloquinone in its free form is approximately 80%, but its absorption rate from foods is significantly lower [2]. Phylloquinone in plant foods is tightly bound to chloroplasts, so it is less bioavailable than that from oils or dietary supplements [1]. For example, the body absorbs only 4% to 17% as much phylloquinone from spinach as from a tablet [2]. Consuming vegetables at the same time as some fat improves phylloquinone absorption from the vegetables, but the amount absorbed is still lower than that from oils. Limited research suggests that long-chain MKs may have higher absorption rates than phylloquinone from green vegetables [7].

Several food sources of vitamin K are listed in Table 2. All values in this table are for phylloquinone content, except when otherwise indicated, because food composition data for menaquinones are limited [1].

Table 2: Vitamin K (Phylloquinone, Except as Indicated) Content of Selected Foods [4,13,16]

Food	Micrograms (mcg) per serving	Percent DV*
Natto, 3 ounces (as MK-7)	850	708
Collards, frozen, boiled, ½ cup	530	442
Turnip greens, frozen, boiled ½ cup	426	355
Spinach, raw, 1 cup	145	121
Kale, raw, 1 cup	113	94
Broccoli, chopped, boiled, ½ cup	110	92
Soybeans, roasted, ½ cup	43	36
Carrot juice, ¾ cup	28	23
Soybean oil, 1 tablespoon	25	21
Edamame, frozen, prepared, ½ cup	21	18
Pumpkin, canned, ½ cup	20	17
Pomegranate juice, ¾ cup	19	16
Okra, raw, ½ cup	16	13
Salad dressing, Caesar, 1 tablespoon	15	13
Pine nuts, dried, 1 ounce	15	13

Food	Micrograms (mcg) per serving	Percent DV*
Blueberries, raw, ½ cup	14	12
Iceberg lettuce, raw, 1 cup	14	12
Chicken, breast, rotisserie, 3 ounces (as MK-4)	13	11
Grapes, ½ cup	11	9
Vegetable juice cocktail, ¾ cup	10	8
Canola oil, 1 tablespoon	10	8
Cashews, dry roasted, 1 ounce	10	8
Carrots, raw, 1 medium	8	7
Olive oil, 1 tablespoon	8	7
Ground beef, broiled, 3 ounces (as MK-4)	6	5
Figs, dried, ¼ cup	6	5
Chicken liver, braised, 3 ounces (as MK-4)	6	5
Ham, roasted or pan broiled, 3 ounces (as MK-4)	4	3
Cheddar cheese, 1½ ounces (as MK-4)	4	3
Mixed nuts, dry roasted, 1 ounce	4	3
Egg, hard boiled, 1 large (as MK-4)	4	3
Mozzarella cheese, 1½ ounces (as MK-4)	2	2
Milk, 2%, 1 cup (as MK-4)	1	1
Salmon, sockeye, cooked, 3 ounces (as MK-4)	0.3	0
Shrimp, cooked, 3 ounces (as MK-4)	0.3	0

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*DV = Daily Value. The U.S. Food and Drug Administration (FDA) developed DVs to help consumers compare the nutrient contents of foods and dietary supplements within the context of a total diet. The DV for vitamin K is 120 mcg for adults and children age 4 years and older [17]. FDA does not require food labels to list vitamin K content unless vitamin K has been added to the food. Foods providing 20% or more of the DV are considered to be high sources of a nutrient, but foods providing lower percentages of the DV also contribute to a healthful diet.

The U.S. Department of Agriculture's (USDA's) [FoodData Central](https://fdc.nal.usda.gov/) (<https://fdc.nal.usda.gov/>). [16] lists the nutrient content of many foods and provides comprehensive lists of foods containing vitamin K (phylloquinone) arranged by nutrient content and by food name and of foods containing vitamin K (MK-4) arranged by nutrient content and food name.

Dietary supplements

Vitamin K is present in most multivitamin/mineral supplements, typically at values less than 75% of the DV [18]. It is also available in dietary supplements containing only vitamin K or vitamin K combined with a few other nutrients, frequently calcium, magnesium, and/or vitamin D. These supplements tend to have a wider range of vitamin K doses than multivitamin/mineral supplements, with some providing 4,050 mcg (5,063% of the DV) or another very high amount [18].

Several forms of vitamin K are used in dietary supplements, including vitamin K1 as phylloquinone or phytonadione (a synthetic form of vitamin K1) and vitamin K2 as MK-4 or MK-7 [18]. Few data are available on the relative bioavailability of the various forms of vitamin K supplements. One study found that both phytonadione and MK-7 supplements are well absorbed, but MK-7 has a longer half-life [19].

Menadione, which is sometimes called vitamin K3, is another synthetic form of vitamin K. It was shown to damage hepatic cells in laboratory studies conducted during the 1980s and 1990s, so it is no longer used in dietary supplements or fortified foods [3].

Vitamin K Intakes and Status

Most U.S. diets contain an adequate amount of vitamin K [7]. Data from the 2011–2012 National Health and Nutrition Examination Survey (NHANES) show that among children and teens age 2–19 years, the average daily vitamin K intake from foods is 66 mcg [20]. In adults age 20 and older, the average daily vitamin K intake from foods is 122 mcg for women and 138 mcg for men. When both foods and supplements are considered, the average daily vitamin K intake increases to 164 mcg for women and 182 mcg for men.

Some analyses of NHANES datasets from 2003–2006 and 2007–2010 raised concerns about average vitamin K intakes because only about one-third of the U.S. population had a vitamin K intake above the AI [21,22]. The significance of these findings is unclear because the AI is only an estimate of need, especially for vitamins (like vitamin K) that are also synthesized endogenously. Moreover, reports of vitamin K deficiency in adults are very rare [3,7]. Finally, food composition databases provide information primarily on phyloquinone; menaquinones—either dietary or from bacterial production in the gut—likely also contribute to vitamin K status [1,6,7].

Vitamin K Deficiency

Vitamin K deficiency is only considered clinically relevant when prothrombin time increases significantly due to a decrease in the prothrombin activity of blood [3,7]. Thus, bleeding and hemorrhage are the classic signs of vitamin K deficiency, although these effects occur only in severe cases. Because vitamin K is required for the carboxylation of osteocalcin in bone, vitamin K deficiency could also reduce bone mineralization and contribute to osteoporosis [23].

Vitamin K deficiency can occur during the first few weeks of infancy due to low placental transfer of phyloquinone, low clotting factor levels, and low vitamin K content of breast milk [7]. Clinically significant vitamin K deficiency in adults is very rare and is usually limited to people with malabsorption disorders or those taking drugs that interfere with vitamin K metabolism [3,7]. In healthy people consuming a varied diet, achieving a vitamin K intake low enough to alter standard clinical measures of blood coagulation is almost impossible [3].

Groups at Risk of Vitamin K Inadequacy

The following groups are among those most likely to have inadequate vitamin K status.

Newborns not treated with vitamin K at birth

Vitamin K transport across the placenta is poor, increasing the risk of vitamin K deficiency in newborn babies [3]. During the first few weeks of life, vitamin K

deficiency can cause vitamin K deficiency bleeding (VKDB), a condition formerly known as classic hemorrhagic disease of the newborn. VKDB is associated with bleeding in the umbilicus, gastrointestinal tract, skin, nose, or other sites [7,24,25]. VKDB is known as early VKDB when it occurs in the first week of life. Late VKDB occurs at age 2–12 weeks, especially in exclusively breastfed infants due to the low vitamin K content of breast milk or in infants with malabsorption problems (such as cholestatic jaundice or cystic fibrosis) [7]. VKDB, especially late VKDB, can also be manifested as sudden intracranial bleeding, which has a high mortality rate [7,25]. To prevent VKDB, the American Academy of Pediatrics recommends the administration of a single, intramuscular dose of 0.5 to 1 milligram (mg) vitamin K1 at birth [24].

People with malabsorption disorders

People with malabsorption syndromes and other gastrointestinal disorders, such as cystic fibrosis, celiac disease, ulcerative colitis, and short bowel syndrome, might not absorb vitamin K properly [3,5,23]. Vitamin K status can also be low in patients who have undergone bariatric surgery, although clinical signs may not be present [26]. These individuals might need monitoring of vitamin K status and, in some cases, vitamin K supplementation.

Vitamin K and Health

This section focuses on two conditions in which vitamin K might play a role: osteoporosis and coronary heart disease.

Osteoporosis

Osteoporosis, a disorder characterized by porous and fragile bones, is a serious public health problem that affects more than 10 million U.S. adults, 80% of whom are women. Consuming adequate amounts of calcium and vitamin D, especially throughout childhood, adolescence, and early adulthood, is important to maximize bone mass and reduce the risk of osteoporosis [27]. The effect of vitamin K intakes and status on bone health and osteoporosis has been a focus of scientific research.

Vitamin K is a cofactor for the gamma-carboxylation of many proteins, including osteocalcin, one of the main proteins in bone [28]. Some research indicates that high serum levels of undercarboxylated osteocalcin are associated with lower bone mineral density [5,28]. Some, but not all, studies also link higher vitamin K intakes with higher bone mineral density and/or lower hip fracture incidence [29-34].

Although vitamin K is involved in the carboxylation of osteocalcin, it is unclear whether supplementation with any form of vitamin K reduces the risk of osteoporosis. In 2006, Cockayne and colleagues conducted a systematic review and meta-analysis of randomized controlled trials that examined the effects of vitamin K supplementation on bone mineral density and bone fracture [35]. Most of the trials were conducted in Japan and involved postmenopausal women; trial duration ranged from 6 to 36 months. Thirteen trials were included in the systematic review, and 12 showed that supplementation with either phytonadione or MK-4 improved bone mineral density. Seven of the 13 trials also had fracture data that were combined in a meta-analysis. All of these trials used MK-4 at either 15 mg/day (1 trial) or 45 mg/day (6 trials). MK-4 supplementation significantly reduced rates of hip fractures, vertebral fractures, and all nonvertebral fractures.

A subsequent clinical trial found that MK-7 supplementation (180 mcg/day for 3 years) improved bone strength and decreased the loss in vertebral height in the lower thoracic region of the vertebrae in postmenopausal women [36]. Other randomized clinical trials since the 2006 review by Cockayne et al. have found that vitamin K supplementation has no effect on bone mineral density in elderly men or women [37,38]. In one of these studies, 381 postmenopausal women received either 1 mg phylloquinone, 45 mg MK-4, or placebo daily for 12 months [38]. All participants also received daily supplements containing 630 mg calcium and 400 IU vitamin D3. At the end of the study, participants receiving either phylloquinone or MK-4 had significantly lower levels of undercarboxylated osteocalcin compared to those receiving placebo. However, there were no significant differences in bone mineral density of the lumbar spine or proximal femur among any of the treatment groups. The authors noted the importance of considering the effect of vitamin D on bone health when comparing the results of vitamin K supplementation studies, especially if both vitamin K and vitamin D (and/or calcium) are administered to the treatment group but not the placebo group [38]. The administration of vitamin D

and/or calcium along with vitamin K could partly explain why some studies have found that vitamin K supplementation improves bone health while others have not.

In Japan and other parts of Asia, a pharmacological dose of MK-4 (45 mg) is used as a treatment for osteoporosis [5]. The European Food Safety Authority has approved a health claim for vitamin K, noting that “a cause and effect relationship has been established between the dietary intake of vitamin K and the maintenance of normal bone” [39]. FDA has not authorized a health claim for vitamin K in the United States.

Coronary heart disease

Vascular calcification is one of the risk factors for coronary heart disease because it reduces aortic and arterial elasticity [40]. MGP is a vitamin K-dependent protein that may play a role in the prevention of vascular calcification [5,41]. Although the full biological function of MGP is unclear, a hypothesis based on animal data suggests that inadequate vitamin K status leads to undercarboxylated MGP, which could increase vascular calcification and the risk of coronary heart disease. These findings might be particularly relevant for patients with chronic kidney disease because their rates of vascular calcification are much higher than those of the general population [9].

In an observational study conducted in the Netherlands in 564 postmenopausal women, dietary menaquinone (but not phylloquinone) intake was inversely associated with coronary calcification [42]. Menaquinone intake was also inversely associated with severe aortic calcification in a prospective, population-based cohort study involving 4,807 men and women age 55 years and older from the Netherlands [41]. Participants in this study who had dietary menaquinone intakes in the mid tertile (21.6–32.7 mcg/day) and upper tertile (>32.7 mcg/day) also had a 27% and 57% lower risk of coronary heart disease mortality, respectively, than those in the lower tertile of intake (<21.6 mcg/day). Phylloquinone intake had no effect on any outcome.

Despite these data, few trials have investigated the effects of vitamin K supplementation on arterial calcification or coronary heart disease risk. One randomized, double-blind clinical trial examined the effect of phylloquinone

supplementation in 388 healthy men and postmenopausal women age 60–80 years [43]. Participants received either a multivitamin (containing B-vitamins, vitamin C, and vitamin E) plus 500 International Units (IU) vitamin D3, 600 mg calcium, and 500 mcg phylloquinone daily (treatment) or a multivitamin plus calcium and vitamin D3 only (control) for 3 years. There was no significant difference in coronary artery calcification between the treatment and control groups. However, among the 295 participants who adhered to the supplementation protocol, those in the treatment group had significantly less coronary artery calcification progression than those in the control group. Furthermore, among those with coronary artery calcification at baseline, phylloquinone treatment reduced calcification progression by 6% compared to the control group. Based on these findings, the authors did not make any clinical recommendations, and they called for larger studies in other populations.

At this time, the role of the different forms of vitamin K on arterial calcification and the risk of coronary heart disease is unclear, but it continues to be an active area of research in the general population and in patients with chronic kidney disease [5,9,44].

Health Risks from Excessive Vitamin K

The FNB did not establish ULs for vitamin K because of its low potential for toxicity [3]. In its report, the FNB stated that “no adverse effects associated with vitamin K consumption from food or supplements have been reported in humans or animals.”

Interactions with Medications

Vitamin K interacts with a few medications. In addition, certain medications can have an adverse effect on vitamin K levels. Some examples are provided below. Individuals taking these and other medications on a regular basis should discuss their vitamin K status with their health care providers.

Warfarin (Coumadin) and similar anticoagulants

Vitamin K can have a serious and potentially dangerous interaction with anticoagulants such as warfarin (Coumadin) as well as phenprocoumon,

acenocoumarol, and tiocloamarol, which are commonly used in some European countries [7,8]. These drugs antagonize the activity of vitamin K, leading to the depletion of vitamin K-dependent clotting factors. People taking warfarin and similar anticoagulants need to maintain a consistent intake of vitamin K from food and supplements because sudden changes in vitamin K intakes can increase or decrease the anticoagulant effect [45].

Antibiotics

Antibiotics can destroy vitamin K-producing bacteria in the gut, potentially decreasing vitamin K status. This effect might be more pronounced with cephalosporin antibiotics, such as cefoperazone (Cefobid), because these antibiotics might also inhibit the action of vitamin K in the body [6,46]. Vitamin K supplements are usually not needed unless antibiotic use is prolonged (beyond several weeks) and accompanied by poor vitamin K intake [46].

Bile acid sequestrants

Bile acid sequestrants, such as cholestyramine (Questran) and colestipol (Colestid), are used to reduce cholesterol levels by preventing reabsorption of bile acids. They can also reduce the absorption of vitamin K and other fat-soluble vitamins, although the clinical significance of this effect is not clear [46,47]. Vitamin K status should be monitored in people taking these medications, especially when the drugs are used for many years [47].

Orlistat

Orlistat is a weight-loss drug that is available as both an over-the-counter (Alli) and prescription (Xenical) medication. It reduces the body's absorption of dietary fat and in doing so, it can also reduce the absorption of fat-soluble vitamins, such as vitamin K. Combining orlistat with warfarin therapy might cause a significant increase in prothrombin time [48]. Otherwise, orlistat does not usually have a clinically significant effect on vitamin K status, although clinicians usually recommend that patients taking orlistat take a multivitamin supplement containing vitamin K [49-51].

Vitamin K and Healthful Diets

The federal government's 2020–2025 *Dietary Guidelines for Americans* notes that “Because foods provide an array of nutrients and other components that have benefits for health, nutritional needs should be met primarily through foods. ... In some cases, fortified foods and dietary supplements are useful when it is not possible otherwise to meet needs for one or more nutrients (e.g., during specific life stages such as pregnancy).”

For more information about building a healthy dietary pattern, refer to the *Dietary Guidelines for Americans* (<https://www.dietaryguidelines.gov>) and the USDA's *MyPlate*. (<https://www.choosemyplate.gov/>).

The *Dietary Guidelines for Americans* describes a healthy dietary pattern as one that

- Includes a variety of vegetables; fruits; grains (at least half whole grains); fat-free and low-fat milk, yogurt, and cheese; and oils.
 - Many vegetables are excellent sources of vitamin K, and some fruits and fruit juices contain vitamin K. Cheese contains vitamin K.
- Includes a variety of protein foods such as lean meats; poultry; eggs; seafood; beans, peas, and lentils; nuts and seeds; and soy products.
 - Soybeans and nuts contain vitamin K.
- Limits foods and beverages higher in added sugars, saturated fat, and sodium.
- Limits alcoholic beverages.
- Stays within your daily calorie needs.

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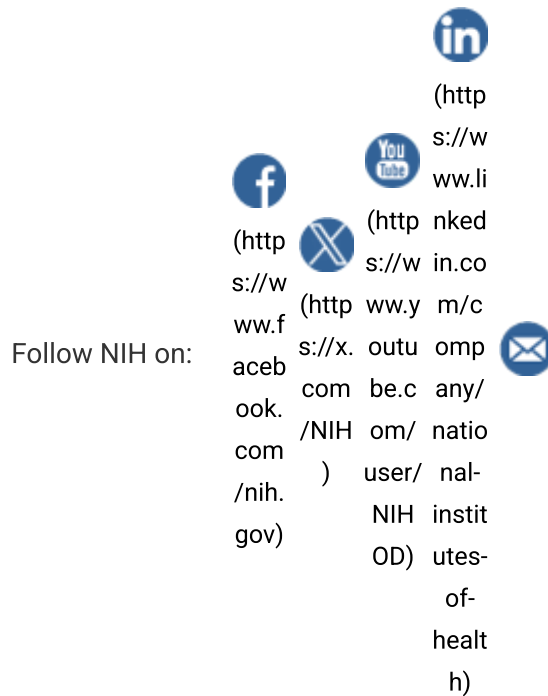
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