Nutrition For Families

PEDIATRIC PLANT-BASED NUTRITION
GUIDE FOR CLINICAL PRACTICE

A practical guide for healthcare providers caring for children interested in or consuming plant-based diets

— *Inside*

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This guide supports healthcare providers in caring for children consuming plant-based diets with:

- an overview of the scientific evidence on health outcomes and safety of plant-based diets, including vegan diets
- diagnostic and therapeutic measurements regarding nutrient adequacy
- nutrition information (e.g., RDA, UL) and food sources for key nutrients that should be monitored

Intro

Benefits and limitations of a plant-based diet: *What you need to know*

The Academy of Nutrition and Dietetics, the World Health Organization, the National Institutes of Health, the Canadian Paediatric Society, and others recommend a diet comprising largely of whole plant foods.(6,10-12)

The nutritional needs of growing children can generally be met by eating a wide variety of foods. However, whenever food groups are restricted or eliminated, the risk of deficiencies can increase without proper replacement of the nutrients from other foods and/or supplements. A plant-based diet, including vegan and vegetarian diets, can generally meet the needs of all children given they are balanced.(10,12,13) See Appendix for studies.

For example, many studies of vegetarian and vegan children in developed countries show growth and development is comparable to omnivorous children or reference populations.(1,3,14-16) Supplements, including vitamin B12, calcium, and vitamin D are often needed.(6,10,12,13)

However, children on overly-restrictive diets (e.g., macrobiotic) are at higher risk of nutrient deficiencies or may have delayed/impaired growth (although most studies are older and use growth charts based on formula-fed infants).(17-19)

All diets are at risk for nutritional inadequacies

Across the board, children in the United States over-consume certain nutrients and food groups while under-consuming others.

Under-consume:
- iron
- fiber
- potassium
- calcium & vitamin D
- fruits and vegetables
- whole grains & other whole plant foods

Over-consume:
- calories
- sodium
- saturated fat
- added sugars
- refined carbohydrates
- animal-sourced foods

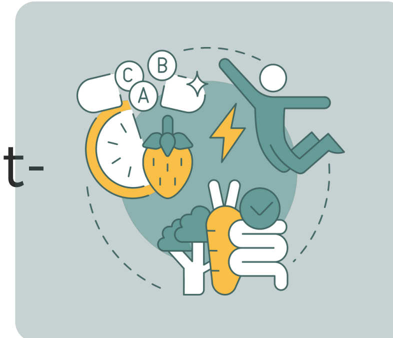
Benefits of Whole, Plant Foods

- Low/No Sodium
- No Cholesterol
- High in healthy, unsaturated fats
- High in vitamins, minerals, and fiber
- Heart-protective and immune-boosting compounds
- Abundance of antioxidant and anti-inflammatory compounds

Children consuming a plant-based diet tend to: (1-5)

- have higher-quality diets
- meet dietary recommendations better than those eating a Western diet
- be leaner than their peers & at lower risk for obesity

Nutrients



Key nutrients to monitor with plant-based diets and why

Vitamin B12
B12 is synthesized by bacteria. Many animal foods contain B12, but there are no reliable plant-based sources.

Food fortification varies widely. Taking a supplement can ensure adequate B12 is consumed when diets contain low amounts/ no animal products.

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Vitamin D
Vitamin D is in some animal foods; however, even with an omnivorous diet, many people do not meet vitamin D needs.

If endogenous vitamin D synthesis is insufficient due to low sun exposure, fortified foods or supplements may be needed.

Calcium
Amount and bioavailability of calcium in foods vary.

There are several highly bioavailable plant-based sources, including plant-based fortified milks and low-oxalate foods, such as dark green leafy greens (e.g., kale, with more calcium per 100 g than cow´s milk (20)).

Iron
Many plant foods are rich in iron; however, the bioavailability of non-heme iron in plants is lower than heme iron in meats.

Iron supplements may be needed in some infants, children, and adolescents (especially menstruating females). Families should be advised of the potential harms of excessive iron supplement intake.

Zinc
The bioavailability of zinc from plant foods is lower than from animal foods, mostly due to the high phytates; these bind minerals and can lower absorption. However, phytate can be reduced with kitchen methods like soaking, fermenting, and sprouting.

Choline
The body makes choline, but not enough to meet demands.

It is widely distributed in food, particularly in eggs. A varied plant-based diet can meet choline needs, but a supplement may help to meet the increased needs during pregnancy and lactation (many prenatal vitamins are low in/lack choline (6)).

EPA/DHA
These omega-3 fats are needed for brain and nervous system health and are mainly found in seafood. Although many seeds and oils contain omega-3 fats, including ALA (the parent fatty acid), very little is converted to EPA/DHA in the body.(21) Thus, plant-based diets may need supplements and fortified foods.

Iodine
The iodine content of plants depends on the soil concentrations in which they are grown. It may be difficult to meet iodine requirements from food alone.

Some countries, particularly without salt fortification, recommend a 50 mcg supplement for infants from 6-12 months of age.(22) Families should be advised of the harms of excessive iodine intake (e.g., supplements).

Protein
All whole plant foods contain all 9 essential amino acids, but typically in lower concentrations than animal foods.(23) Plant-based diets with sufficient energy usually meet or exceed protein requirements.(24)

Lysine often is the most limiting amino acid and is low in grains and high in legumes (lentils, beans, soy), nuts, and seeds. A diet that relies on grains and lacks legumes may have insufficient amounts of lysine.(24)

Calories
Infants and toddlers have limited stomach capacities, and too much fiber may cause premature satiety and inadequate energy and nutrient intake.(25)

Reducing fiber content may be necessary for some children (e.g., peel fruits and vegetables, emphasize high energy, low fiber foods like tofu, nut butter, and plant oils).

Nutrients

Common deficiency signs and symptoms of key nutrients

Area of Concern	Nutrient and Symptoms Associated with Deficiency
Impaired growth and/or weight loss	• Protein and/or energy • Iron • Zinc
Gastrointestinal	• Zinc (loss of appetite, smell, taste, diarrhea)
Hair and Nails	• Iron (splitting, peeling, clubbed nails) • Zinc (hair texture, pigment, and loss)
Skin	• B12, folate (mouth, tongue, skin) • Omega-3 fats (rash, poor healing) • Iron (angular stomatitis, sore tongue) • Zinc (poor wound healing, lesions)
Nervous System	• B12 (tingling, numbness, memory loss, confusion) • Iron (impaired development/ performance)
Blood	• Iron (microcytic anemia) • B12, folate (macrocytic anemia)
Bones	• Calcium (fractures) • Vitamin D (rickets)
Multiple	• Iodine (goiter, hypothyroidism)

Nutrition monitoring in clinical settings with plant-based diets

Infants at ~6 months

- [ ] Assess iron intake from complementary foods in breastfed infants (pg. 12)
- [ ] Assess zinc intake from complementary foods in breastfed infants (pg. 12)
- [ ] Assess vitamin B12 and iodine intake in breastfeeding vegetarian/ vegan mothers (pg. 12)

Infants 6-12 months

- [ ] Assess iron status (all diets; pg. 6)
- [ ] Assess zinc intake from complementary foods in breastfed infants and when formula becomes a minor part of the diet(pg. 12)
- [ ] Assess vitamin B12 intake/status of infants on vegan/vegetarian diets (pgs. 7-8)
- [ ] Assess iodine and omega-3 intake of infants on vegan/vegetarian diets (pg. 12)
- [ ] Assess calcium and vitamin D intake when breast milk/formula becomes a minor part of the diet (all diets; pg. 12)

All Pediatrics

- [ ] Assess iron status in children and adolescents when insufficiency is suspected (pg. 6)
- [ ] Assess calcium intake (pg. 12)
- [ ] Assess vitamin D supplement use and needs, particularly with insufficient sun exposure (pg. 13)
- [ ] Assess B12, iodine, and omega-3 intake in vegetarian/vegan patients (pg. 12)

Nutrients

Iron | assessment, treatment, prevention, monitoring, advisement

Iron deficiency is the most common nutrient deficiency worldwide and can occur without anemia.(26) Bioavailability is about 18% in omnivorous mixed diets, 10% in vegetarian diets, and can be as low as 5% in strict vegan diets or in food insecure situations where food variety is limited.(27)

Assess

Intake

Assess complementary foods for iron intake, especially in exclusively breastfed infants, as iron stores diminish after about 6 months and breast milk iron content is low.(6) Assess intake when formula becomes a minor part of the diet. Assess supplement use (dose, adherence). Iron-rich foods are on page 12. Daily requirements (RDA) and the UL are on pg 13. See supplement information in “Treat and Prevent” below.

Laboratory

When? At 12 months (with all diets) or when iron insufficiency is suspected, particularly in exclusively breastfed infants.(28) What? Hemoglobin and hematocrit plus serum ferritin with inflammatory markers; or sTR can be used. See “Treat” for biomarkers, as Hbg/Hct are not sensitive or specific to iron deficiency.

Clinical

Clinical Inadequate iron status may present as anemia, pallor, fatigue, irritability, cognitive deficits, motor deficits, attention deficits, memory deficits, abnormal behavior patterns, poor school performance, increased risk of infection, angular cheilitis, and loss of appetite. (26)

Serum ferritin(mcg/L)[29a]

	Iron deficiency		Risk of iron overload[b]	
	Apparently healthy individuals	Individuals with infection or inflammation	Apparently healthy individuals	Individuals with infection or inflammation
0 – 5 yrs	< 12	< 30	----	----
5+ yrs	< 15	< 70	> 150 females > 200 males	> 500[b]

a Markers of inflammation should be assessed with serum ferritin. b High ferritin levels, particularly > 500, may also be due to other diseases; further clinical and lab evaluation is needed to establish the diagnosis and underlying cause of elevated ferritin levels.

Note serum transferrin receptor (sTR) > 8.5 mg/L is a specific and sensitive measure of early functional iron deficiency and is unaffected by infection, inflammation, or neoplastic disorders.(27)

Nutrients

Iron | assessment, treatment, prevention, monitoring, advisement

Treat

Iron deficiency anemia

- 2-3 mg elemental ferrous iron/kg body weight
- (or 3-5 mg elemental ferric iron/kg body weight)
- in one or two doses per day for 2- 3 months.(26)

Adolescent girls with iron deficiency/iron-deficiency anemia:
Newer guidelines suggest ≤40 mg elemental iron daily or ≥60 mg on alternate days may be as effective and produce less side effects than other doses.(30)

(34)

Elemental iron	Ferrous sulfate	Ferrous fumarate	Ferrous gluconate
30 mg	150 mg	90 mg	250 mg
60 mg	300 mg	180 mg	500 mg
120 mg	600 mg	360 m	1000 mg

Monitor & Advise

Monitoring therapy response is not generally needed but might be necessary for cases with severe anemia, continued iron losses, or suspected insufficient therapy adherence.

In cases with iron deficiency anemia, therapy should be continued until normalization of Hb levels, MCV, and reticulocytes are achieved, and ferritin levels are normalized.(28)

Prevent

Most guidelines do not recommend the routine use of supplements in infants.(31) Older recommendations, published before delayed umbilical cord clamping was shown to improve iron status and recommended in the US(31), suggested exclusively and partially breastfed term infants 4 to 6 months of age (and older babies not consuming adequate iron) receive iron supplements of 1mg/kg/d and pre-term infants 1-12 months of age 2 mg/kg/d.(28) The most recent AAP policy statement (2022) report these findings without further guidance.(32)

Premature babies should receive both multivitamins and iron supplements until they are completely consuming a mixed diet and have normal growth and hematological values.(32,33)

Vitamin B12 | assessment, treatment, prevention, monitoring, advisement

Persons consuming diets with little to no animal products and exclusively breastfed infants of mothers with insufficient vitamin B12 intake are at high risk for vitamin B12 deficiency with severe health consequences.

Assess

Intake

Assess fortified food and supplement use in those who consume little or no animal products. Breast milk B12 relies on maternal intake; assess/monitor maternal B12 intake during pregnancy and postpartum for breastfed infants. Typical fortified foods are on pg. 12. Daily requirements are on pg. 13. See the supplement schedule for prevention (Table 2 below).

Laboratory

When? Consider at 12 months and every 1-2 years for vegetarian/vegan patients not consistently using supplements. What? Use at least 2 biomarkers of vitamin B12 status (serum vitamin B12 with HoloTC or MMA (37)). See B12 biomarkers pg. 8 for values and interpretation.

Clinical

Inadequate B12 intake/status may present as tingling or numbness in extremities, sore tongue/mouth, fatigue, weight loss, loss of appetite, macrocytic anemia, neurological damage, failure to thrive, developmental delays, and permanent disability.(38-41)

When a reliable source of vitamin B12 is consumed regularly (e.g., supplements), vitamin B12 deficiency is unlikely.

Treat

Children with B12 deficiency: 1000 mcg i.m. once per day for one week, 1000 mcg i.m. on alternate days for one week, 1000 mcg i.m. twice a week for one week, and then once a week.(42) OR use oral supplements as they are as effective as parenteral regimens in normalizing vitamin B12 levels. (42)

Breastfeeding women with B12 deficiency: 1000mcg i.m. 3 times a week for two weeks; OR use supplements as shown below. Note that breast milk B12 content relies on maternal intake.

Table 1. Treatment: Suggested oral supplementation for treating vitamin B12 deficiency[25]

0* – 3 years	4 – 6 years	7 – 10 years	11 + years	Pregnant/lactating
250 mcg/d	500 mcg 4x week	500 mcg 6x week	1000 mcg/d	1000 mcg/d

Treatment duration is based upon severity: serum B12 < 75 pmol/L = 4 months; <150 pmol/L = 3 months; <221 pmol/L = 2 months.(25) *Note that 0 to 24-month-olds will have adequate serum B12 levels that are lower than other groups (see biomarkers table pg. 8); thus, treatment duration may be shorter for infants (e.g., 1 to 2 months vs. longer duration cited in (25)).

Nutrients

Vitamin B12 | assessment, treatment, prevention, monitoring, advisement

Prevent

- Taking vitamin B12 in separate doses can increase bioavailability.(25)
- Supplement forms (e.g., cyano-, hydroxycobalamin) do not appear to significantly differ in their absorption or efficacy in healthy persons.(40)

Table 2. Prevention: Suggested oral supplementation for maintaining vitamin B12 adequacy(*)

6 – 12 months	1 – 3 years	4 – 8 years	9 - 13 years	14+ years or pregnant/lactating
1 mcg/d	2 mcg/d or 1000 mcg/wk	25 mcg/d or 1000 mcg/wk	50 mcg/d or 1500 mcg/wk	50 mcg/d or 2000 mcg/wk

*Weekly regimens are based on bioavailability and typical doses provided by available US supplement manufacturers. Supplement bioavailability is estimated to be 50% of 1 mcg, 20% of 5 mcg, 5% of 25 mcg, and 1% of higher doses.(37) These values are similar to the proposed doses in (25) that may meet the higher European RDAs, except no weekly recommendations were provided in (25) for those under 8 years old.

Monitor

- B12 deficiency: check vitamin B12 status 4 - 6 weeks after the initiation of therapy and again post-treatment.(25)
- When vitamin B12 status has normalized, continue vitamin B12 supplementation following the preventive supplementation regime (Table 2).

Advise

- Caution patients that vitamin B12 insufficiency can cause permanent nerve damage.
- Encourage supplement and fortified food use in those who consume little to no animal-sourced foods, and provide information on supplements (See prevention above).
- Encourage monitoring of vitamin B12 intake from food and supplements in vegetarian and vegan patients.

Nutrients

Vitamin B12 | biomarkers

No single vitamin B12 biomarker provides sufficient specificity and sensitivity to diagnose B12 deficiency.(37) Several blood biomarkers should be used in conjunction with clinical findings.

Laboratory “normal” ranges for B12 adequacy, test specificities, and sensitivities vary with the lab method used, and pediatric values often vary from adults values. Thus, reference values and cut-offs should be interpreted with caution.(37)

Serum or plasma B12	Serum holo-transcobalamin (holoTC)	Serum methylmalonic acid (MMA)
Adults adequate >221 pmol/L[37] depleted < 221 pmol/L (=300 pg/mL)[37,39] deficient < 148 pmol/L (<200pg/mL)[37,39,43]	Adults[37] adequate 40 – 150 pmol/L deficient < 35 – 40 pmol/L	Adults: adequate (likely) 120 nmol/L[37] deficient > 260 [43] to 281 nmol/L[37]
Adequate infants:[37] Newborn cord blood 120-690 pmol/L 6mo 121 – 520 pmol/L 12mo 165 – 580 pmol/L 24 mo 183 – 260 pmol/L	Adequate infants[37] Newborn (cord blood) 33-240 pmol/L 6mo 12 – 90 pmol/L 12mo 19 – 100 pmol/L 24 mo 29 – 110 pmol/L	Adequate infants: [37] Newborn (cord blood) 170-500 nmol/L 6mo 140 – 220 nmol/L 12mo 120 – 830 nmol/L 24 mo 120 – 300 nmol/L
95% RI children, adolescents[44]* 3 – 5 yr 423 – 996 pmol/L 6 – 12 yr 203 – 901 pmol/L 13 -18 yrs 113 – 458 pmol/L [Also reported RI:][45] 1 - 11 yr 260 – 1200 pmol/L 12 – 18 yr 200 – 800 pmol/L	95% RI children, adolescents[44]* 3 – 5 yr: 63.6 – 226.4 pmol/L 6 – 12 yr 48.1 – 180.2 pmol/L 13 -18 yr 32.6 – 113.3 pmol/L	95% RI children, adolescents[44]* 3 – 5 yr 98 – 345 nmol/L 6 – 12 yr 117 – 378 nmol/L 13 -18 yr 112 – 348 nmol/L
Serum B12 is not a sensitive marker of functional B12 status.[37,46] Best when combined with holoTC or MMA to improve predictive value.[43] 1 pmol/mL = 0.7378 pmol/L[37] 1 pmol/L = 1.355 ng/L[47]	Reflects recent intake and absorption and is a sensitive marker for early insufficiency;[37] predictive value improves when combined with serum total B12 or MMA[43]	Values often increase when serum B12 <287pmol/L[37] Urinary MMA/creatinine >3.6mmol/ml has been reported as the cut-off for “elevated” in adults from developed countries.[45] Urinary MMA increases after meals.[37] Serum MMA is the most sensitive indicator of deficiency[39,40] and reflects liver stores[37] and functional B12 status[37,43] but not recent intake.[37] Normal renal function is required.[37,39,41]

* 95% population reference intervals are values of “apparently healthy” individuals and may or may not coincide with cut-offs to determine B12 status.(48) Thus, these values are provided only as a reference and do not necessarily indicate deficiency, depletion, or adequacy status.

Clinical symptoms may occur with adequate hematological markers and vice-versa.(37,46,47) The broad clinical picture must be taken into account when diagnosing vitamin B12 deficiency.(37,47)

Treatment should not be delayed to avoid permanent neurological damage when discordant agreement between strong clinical features and hematological values occur.(47)

Nutrients

Zinc

Zinc is essential for growth. Breast milk zinc concentration decline over the duration of breastfeeding, and infants will need zinc-rich complementary foods by 6 months of age.(6)

The bioavailability of zinc in plants is lower than in animal-sourced foods.

Assess intake when complementary foods are started, especially in breastfed infants and throughout infancy in those who consume little or no animal products. Zinc-rich foods are on pg 12, and daily requirements are on pg 13.

Diets lacking animal foods need as much as 50% more zinc than the RDA due to the high phytate concentration in many plant foods, such as legumes (soy, beans, lentils) and whole grains.(49)

Mild zinc deficiency is treated with zinc supplementation at 2 to 3 times the RDA, and moderate to severe deficiency can be treated at 4 to 5 times the RDA with a treatment duration of six months.(50)

However, taking supplements in doses above the UL (see pg 13) for prolonged periods is not recommended and should be monitored by a healthcare provider (excessive zinc may reduce copper absorption).(49,50) Zinc supplement use above the UL in well-nourished pregnant and lactating women is contraindicated.(50)

Iodine

Essential for fetal growth and development and production of thyroid hormones

Insufficient iodine may be suspected with poor growth, elevated TSH, or hypothyroidism.(51) Because nearly 50% of U.S. women may have insufficient breast milk iodine concentrations,(51) the AAP recommends breastfeeding women consume a daily supplement with 150 mcg of iodine.(52)

Using iodized salt can provide ~45 mcg iodine/g salt (e.g., 150 mcg iodine in ½ tsp (3 g) salt) in U.S. varieties).(20) Iodine supplements may be considered when iodine intake is insufficient; however, families should be advised about the potential harms of excessive iodine intake (see UL pg. 13).

Nutrients

Calcium & Vitamin D

Most children, regardless of diet, often lack adequate dietary intake of calcium and vitamin D.

Calcium

Assess dietary intake (pg. 12) and supplements to estimate adequacy (pg. 13) when solid foods start and throughout childhood. Bone mineral density measures may be used in older persons.

Vitamin D

Insufficiency risk is higher with low sun exposure, darker skin tones, living in higher latitudes, and non-supplement use. All breastfed babies should receive 400 IU of vitamin D daily. (6)

Status	Serum 25-hydroxyvitamin D concentrations[53,54]	
	nmol/ mL	ng/ mL
Vitamin D deficiency	<30	<12
Low/ inadequate vitamin D	30 to <50	12 to <20
Adequate vitamin D	>50 to 125	>20 to 50
Potential for adverse effects	>125	>50

There is no universal consensus on cut-off values that define vitamin D status, particularly for insufficiency; values should be interpreted with caution for diagnostic purposes.

Omega-3 Fats

Essential for cell membranes, involved in growth and development, and cellular communication

Inadequate intake of omega-3 fatty acids may be suspected if the diet lacks omega-3-rich foods (see pg. 12), fat malabsorption conditions, poor wound healing, scaly, dry rash, and poor growth.(54)

For infants, fortified foods/ supplements may increase breast milk omega-3s in vegetarian/vegan women.

For older children, no official recommendations exist in the US for EPA and DHA, although 10% of total omega-3's can be consumed as DHA and/or EPA(54) (e.g.,70-60 mg of DHA/EPA for children ≥2 years old). However, some international organizations have suggested 250 mg of DHA/day for children (not infants).(55)

Nutrients

Daily Requirement and Upper Limits of Key Nutrients (RDA/AI/UL)

RDA- *recommended daily allowance that is considered to meet the needs of most healthy persons*
AI - *adequate intake, nutritionally adequate level used when the RDA has not been established*
Tolerable Upper Intake Level (UL) *is the highest level of daily intake that is likely to pose no risk of adverse health effects to almost all healthy individuals in the general population.*

RDA/AI	0 - 6 months	7 - 12 months	1 - 3 years	4 - 8 years	9 - 13 years	14 - 18 years	Lactating women
B12 mcg	0.4	0.5	0.9	1.2	1.8	2.4	2.8
Calcium mg	200	260	700	1000	1300	1300	1000 <19 yr 1300 19+yr
Choline mg	125	150	200	250	375	400 females 550 males	550
Vitamin D IU	400	400	600	600	600	600	600
Iodine mcg	110	130	90	90	120	150	290
Iron mg	0.27	11	7	10	8	15 females 11 males	10 <19 yr 9 19+yr
Omega-3 fats g from all types	0.5	0.5	0.7	0.9	1.0 females 1.2 males	1.1 females 1.6 males	1.3
Zinc mg	2	3	3	5	8	9 females 11 males	13 <19 yr 12 19+yr

UL	0 - 6 months	7 - 12 months	1 - 3 years	4 - 8 years	9 - 13 years	14 - 18 years	Lactating women
Calcium mg	1000	1500	2500	2500	3000	3000	3000 <19 yr 2500 19+yr
Choline mg	not established	not established	1000	1000	2000	3000	3000 <19 yr 2500 19+yr
Vitamin D IU (without medical supervision)	1000	1500	2500	3000	4000	4000	4000
Iodine mcg	not established	not established	200	300	600	900	900 <19 yr 1100 19+yr
Iron mg	40	40	40	40	40	45	45
Zinc mg	4	5	7	12	23	34	34 <19 yr 40 19+ yr

Vitamin B12: No UL established.
Omega-3: No UL established. Under 1 year of age should come from breast milk or formula.(58). Suggested limits are 1.5 g EPA/DHA in children (54) and 3 to- 4.4 grams in adults.(67,68)

Food & Nutrition

Daily Recommended Amount of Food by Age

2-4 years

Food Group	Daily recommended amount by age
Whole grains	3 – 5.5 (oz-equivalent)
Protein	1 – 2.5 (oz-equivalent)
Calcium-enriched soy milk/ products	2 – 3 (cup-equivalent)
Vegetables	1 – 2 (cup-equivalent)
Fruits	1 – 1.5 (cup-equivalent)
Plant oils/fats	1-2 (tablespoons)

5-8 years

Food Group	Daily recommended amount by age
Whole grains	4 - 6.5 (oz-equivalent)
Protein	1.5 - 4.5 (oz-equivalent)
Calcium-enriched soy milk/ products	2.5 - 3 (cup-equivalent)
Vegetables	1 .5 – 2.5 (cup-equivalent)
Fruits	1 – 2 (cup-equivalent)
Plant oils/fats	1 - 2 (tablespoons)

9-13 years

Food Group	Daily recommended amount by age
Whole grains	5 - 9.5 (oz-equivalent)
Protein	2 – 5.5 (oz-equivalent)
Calcium-enriched soy milk/ products	2.5 – 3 (cup-equivalent)
Vegetables	1.5 – 3 (cup-equivalent)
Fruits	1.5 – 2 (cup-equivalent)
Plant oils/fats	1-2.5 (tablespoons)

14-18 years

Food Group	Daily recommended amount by age
Whole grains	6.5-10.5 (oz-equivalent)
Protein	4-8 (oz-equivalent)
Calcium-enriched soy milk/ products	3 (cup-equivalent)
Vegetables	2.5 - 3.5 (cup-equivalent)
Fruits	1.5 – 2.5 (cup-equivalent)
Plant oils/fats	2 - 4 (tablespoons)

The following tables provide recommendations for the amount of each food group to help meet nutrition requirements for children 2 to 18 years of age. (2)

Food Group	Amount equal to to 1-ounce or 1-cup equivalent (11)
Whole grains *At least half should be whole grains. Choose iron- & zinc-fortified when using refined grains.*	1 slice (30 g) of bread, tortilla, or flatbread ½ cup (70 g) cooked pasta, rice, or cereal 1 oz. (30 g) dried pasta or rice 1 oz. (30 g) ready-to-eat cereal 1 cup (50 g) flaked cereal
Protein *Include a wide variety of plant foods to obtain all of the necessary essential amino acids.*	¼ cup (50 g) cooked beans or tofu ½ oz. (15 g) nuts or seeds 1 Tbsp (15 g) nut/seed butters 1 oz. (30 g) tempeh 1 oz. (30 g) plant-based meat alternatives 6 Tbsp (90 g) hummus
Calcium-enriched soy milk/ products	1 cup (250 mL) fortified soy milk 1 cup (170 g) of fortified soy yogurt *Check labels for added calcium and other ingredients (e.g., sugar content)*
Vegetables *Focus on red, orange, and dark green vegetables.*	1 cup (250 mL) raw, cooked, or juiced 2 cups (70 g) leafy greens ½ cup (80 g) dried
Fruits *Focus on whole fruit, and limit juice to ½ cup (younger than 6 years old) to 1 cup daily.*	1 medium fruit 1 cup (160 g) raw fruit 1 cup (250 mL) fruit juice ½ cup (80 g) dried fruit
Plant oils/fats	1 Tbsp (15 mL) plant oil (e.g., olive, canola) or margarine; many other foods, such as avocados, nuts, and seeds, also provide healthy fats.

Development

Child and Adolescent Nutrition

- Diet quality of US children is considered poor starting as young as 2 years of age.(6)
- Nearly all children do not meet fruit, vegetable, or whole grain needs but meet or exceed animal-based protein recommendations.(6)
- Teens have the widest gap between recommendations and what they consume, and their diet quality often is the lowest it will be in life.(6)
- Many children exceed added sugar, sodium, and saturated fat recommendations, and 41% of US children and 20% of children worldwide are overweight or obese.(6,66)

Recommendations are to increase whole plant foods in all diets to improve public and planetary health.(6,9)

Sources of Key Nutrients

Vitamin B12
Foods with added vitamin B12 include some plant milk and yogurts, veggie meats, cereals, and nutritional yeast. Check labels as food fortification varies widely. Supplements are the most reliable source of B12 for diets with low/no animal-sourced foods

Calcium
Tofu made with calcium, calcium-fortified plant yogurt and milk, tempeh, edamame, dark leafy greens (e.g., kale, bok choy), and white beans

Vitamin D
Fortified foods (plant milk, yogurt) and supplements

Iron
Iron-fortified cereals and grain products, whole grains (e.g., oats, millet), beans, lentils, nut and seed butters, potatoes, dark green leafy vegetables

Omega-3 Fats
Chia seeds, flaxseeds, walnuts, hempseeds, walnut oil, hempseed oil, and flaxseed oil provide the omega-3 fatty acid ALA (parent fat of DHA and EPA)

Iodine
Seaweed † and iodized salt (only for children > 1 year) In the US, salt is fortified at ~45 mcg iodine/g salt (e.g., 150 mcg iodine in ½ tsp (3 g) salt).(20)
†Caution some types of seaweed contain iodine levels that exceed recommendations (moderate iodine levels are in nori).

Zinc
Zinc-fortified cereals, fortified and whole grains, beans, soy, peas, and nut and seed butters Sprouting foods helps increase zinc absorption, but they need to be cooked before eating to reduce the risk of foodborne illness. Soaking and fermenting foods can improve absorption.

Protein
Legumes, whole grains, nut and seed butters (lentils and tofu are easy to digest and particularly suitable for infants). Legumes (e.g., soy, beans) provide high-quality protein and considerable amounts of lysine, which is essential for growth. As such, legumes should be offered to children on plant-based diets at least one to two times per day.

Development

Child growth, obesity, and bone health

A child with normal neurodevelopment and adequate growth is likely to meeting energy and nutrient requirements.

For children who are **not gaining weight as expected** (without underlying health conditions) assess calorie intake and inquire about feeding behavior (breastfeeding, formula preparation and amount, and the number and types of meals and snacks).

To increase energy intake:

- Add calorie-dense foods, like tofu, nut and seed butters, plant oils, and avocados
- Reducing fiber may be needed to prevent premature satiety in small children (e.g., peel skins, strain legumes, choose low-fiber foods like tofu).

If an otherwise healthy child's growth continues to be inadequate, consider consulting a feeding specialist or dietitian.

Child obesity

Obesity can be a sensitive topic. Communicating the importance of diet quality rather than focusing on weight may improve patient reception. Educating parents on growth chart percentiles and percentile trends may encourage growth monitoring.

In addition, a whole-food, plant-based diet may help to reduce calories and improve nutrient intake more easily.

Bone Health

Inadequate intake of calcium and vitamin D is common in children, including those consuming an omnivorous diet. (2,6) As vegan diets may be at a higher risk for inadequate intake of these nutrients, encourage parents to focus on calcium- and vitamin D-rich foods and supplementation. (See pgs. 12-13)

Infant Feeding

Breast Milk

Except for a few nutrients, the full-term, normal-weight infant can get most nutrients from breastmilk, provided that the mother has adequate status and meets her nutrient requirements.

However, infants rely on stores (iron, copper) or partially rely on stores (zinc, B6) developed during pregnancy. They do not receive adequate vitamin K or vitamin D from breast milk. (56) Thus, recommendations are:

Vitamin D supplements (400 IU) for breastfed infants and infants consuming less than 28 oz formula/d (32); continue as needed.(6) Alternatively, breastfeeding mothers may consider 6400 IU/d to increase milk amounts.(32)

Vitamin K supplementation continues to be recommended for all babies at birth (single 1 mg intramuscular dose for babies weighing >1500 g; for preterm infants weighing ≤1500 g, 0.3 mg/kg to 0.5 mg/kg as a single, intramuscular dose).(57)

Nutrient considerations for breastfeeding people who consume plant-based diets

Vitamin B12
Plants are not a reliable source of B12, and amounts can vary widely in fortified foods. Supplements are recommended for diets containing little to no animal products. See pg. 7 and 12.

DHA/EPA
Although there are no RDAs specifically for DHA and EPA in the US, except that 10% of total omega-3's can be consumed as DHA/EPA,(58) several organizations recommend 200 – 300 mg of DHA for pregnant and breastfeeding women. (33,55,59) Mothers can increase breastmilk concentrations by consuming supplements and foods rich in DHA/EPA (pg.12).

Choline
Pregnant and breastfeeding women tend to under-consume choline, and most multivitamin/prenatal supplements do not provide adequate choline.(6) A supplement providing 100 mg of choline may help to meet increased requirements.

Iodine
Women should consume a daily supplement with 150 mcg of iodine (52) and avoid more than 1100 mcg/d of total iodine from food & supplements (≤18 years old should avoid ≥ 900 mcg/d) (27,51). See also pg. 9 and 12.

Infant Feeding

Infant Formula

Soy Based Formula
These are safe alternatives to dairy-based options. Patterns of growth, bone health, metabolic, reproductive, endocrine, immune, and neurological functions are similar to those observed in children fed milk-based formulas.(60)

They are not recommended for pre-term infants because they may have a negative impact on bone density (61) or for infants with inborn hypothyroidism on thyroid hormone replacement therapy because they may interact (62)

Dairy Based Formula The most common type of formula. Not suitable for vegans or infants with milk allergies
Hydrolyzed/ amino acid-based Good choice for infants with increased allergy risk or with diagnosed milk or soy allergies. They do not prevent atopic diseases.(63)

Complementary Feeding

- Start around 6 months of age; offer a variety of foods in no particular order focusing on iron- and zinc-rich foods
- Repeat exposure of foods (8-10+ times) with various textures can help improve food acceptance (6) and diet quality
- Introduce allergens (presented herein)
- Do not restrict fat in the first 2 years of life
- Advise on good oral health practices to the reduce risk of cavities
- Diets low in/without animal products should focus on:
  - a reliable source of vitamin B12 (supplements)
  - iron and zinc, and techniques to improve absorption
  - a reliable source of calcium and vitamin D

Allergens

Early exposure to potential allergens may reduce the risk of food allergies later in life. (63,64)
Recommendations are that peanuts and eggs should be introduced around 6 months of life, but not before 4 months. (63,64) Screening before the introduction is not required except with infants with severe eczema, food allergies, or both. (64)

Other potential allergens should be introduced early during complementary feeding.(63)

There are no official guidelines for allergy prevention for vegetarian or vegan diets. We suggest the following:

Assess risk and inform parents that diet diversity in the first year of life has a protective effect on the development of atopic diseases. A one-time exposure followed by a long avoidance period generally is not recommended as this may lead to sensitization.

If the infant is not at increased risk for developing a food allergy, exposing the child to commonly eaten family foods is generally recommended.(65) For the child who has developed atopic disease, treatment may require specific identification and restriction of causal food proteins.(64)

Troubleshooting Common Diet-Related Health Concerns

Inadequate food intake, unintended weight loss or early satiety

- Encourage frequent meals and snacks
- Encourage energy-dense foods and beverages, such as nuts and seeds and their butters, soy products, avocados, vegetable oils, and fortified plant milks and yogurts
- Reduce dietary fiber, if necessary, by using some refined grain products, peeling fruits and vegetables, and straining legumes
- Offer a larger variety of foods, particularly pairing with foods well-liked, to increase intake
- Encourage monitoring of dietary intake. Online personalized calculators may be useful to educate on nutrient needs (e.g., “DRI calculator for health professionals” at nal.usda.gov)
- For infants, evaluate breastfeeding and formula feeds (e.g., frequency, duration of feeds, amount, formula preparation)

Constipation

- Ensure adequate hydration
- Consider formula use and preparation (e.g., improper mixing) and dietary changes (e.g., formula change, abrupt switch from breastmilk, the introduction of complementary foods)
- Evaluate fiber intake as both excessive or inadequate intake may contribute to constipation.
- Not all fibers are effective for constipation in children, and some (particularly insoluble fiber) can exacerbate it. Thus, a gradual and individualized dietary adjustment should be based on stool consistency and symptoms (e.g., gas, pain, bloating).
- A slow increase of fiber along with fluids may be helpful for some children with low intake. Add small amounts (< 5g/d) of extra fiber gradually to the diet along with extra fluids up to the RDA (14g/1000 kcal/d for children 2+ yrs, and for 12-23 mo-olds, up to 19 g/d)
- Low/slow fermentable fiber (FODMAP) foods may also help reduce GI symptoms (see Monash University for details)
- Consider small amounts of 100% apple, pear, or prune juice for osmotic laxation (e.g., 2-4 oz for infants older than 4 mo; under 4 mo give 1 oz per age in months (e.g., 3 oz for a 3-month-old) (69)
- Evaluate behaviors associated with stool withholding (e.g., readiness to be toilet trained, public bathroom avoidance)
- Evaluate supplement and medication use (e.g., iron)

Troubleshooting Common Diet-Related Health Concerns

Diarrhea

- Provide frequent, small meals
- Offer plenty of fluids; ORS may be needed & zinc may be helpful with extended diarrhea duration
- Offer foods the child is willing to eat; it is not necessary to withhold foods (or only give the BRAT diet) as this may reduce nutrient intake
- Avoid greasy, spicy, hyperosmotic, caffeinated, and possibly lactose-containing foods & beverages (sugary drinks, full-strength juices, sugar alcohols like sorbitol, milk, and tea)
- As diarrhea subsides, a very slow return to consuming adequate dietary fiber with fluids may help to restore gut health
- Although some, but not all, studies have shown beneficial effects of supplements with probiotics on acute diarrhea in children, there is a lack of broad consensus for specific probiotic strains and doses. Thus, current data limits the systematic administration of probiotics to children. (70)

Nausea, vomiting, or reflux

- Offer smaller, more frequent meals/ snacks
- Trial bland, dry, starchy, or salty foods to curb nausea
- Avoid strong odors, greasy, and high-fiber foods
- Keep hydrated; encourage ORS when necessary
- Focus on energy-dense foods (e.g., tofu, avocados, nut butters) and possibly electrolytes (e.g., fruits and vegetables are high in potassium and magnesium)
- Eat slowly and chew well; for infants, interrupt feedings for more frequent burping
- Rise slowly from supine to sitting or standing, and avoid jostling infants after feeds
- Hold infants upright 20-30 minutes after feeds; for older children, sit upright 2-3 hours post meal
- Consider thickening foods, if necessary, for chronic reflux (e.g., formula, breastmilk)
- Rinse mouth with water, water with baking soda, or brush teeth after vomiting to protect teeth

Health Concerns

Troubleshooting Common Diet-Related Health Concerns

Poor dietary quality due to poor or limited food choices

- Express the importance of food variety in obtaining needed nutrients
- Encourage meal planning tools, such as the USDA's Healthy Eating for Vegetarians (choosemyplate.gov), and vegan food guides, like The Vegan Plate (becomingvegan.ca) and The Plant Plate theveganRD.com)
- Encourage mild-flavored foods, especially if vegetables are not liked
- Promote the exploration of different food preparation techniques to improve taste and food variety (e.g., roasting vs. boiling vegetables)
- Explore more healthful foods available when not at home and ideas to plan/pack meals & snacks
- Consider supplement needs

Constipation

- Ensure adequate hydration
- Consider formula use and preparation (e.g., improper mixing) and dietary changes (e.g., formula change, abrupt switch from breastmilk, the introduction of complementary foods)
- Evaluate fiber intake as both excessive or inadequate intake may contribute to constipation.
- Not all fibers are effective for constipation in children, and some (particularly insoluble fiber) can exacerbate it. Thus, a gradual and individualized dietary adjustment should be based on stool consistency and symptoms (e.g., gas, pain, bloating).
- A slow increase of fiber along with fluids may be helpful for some children with low intake. Add small amounts (< 5g/d) of extra fiber gradually to the diet along with extra fluids up to the RDA (14g/1000 kcal/d for children 2+ yrs, and for 12-23 mo-olds, up to 19 g/d)
- Low/slow fermentable fiber (FODMAP) foods may also help reduce GI symptoms (see Monash University for details)
- Consider small amounts of 100% apple, pear, or prune juice for osmotic laxation (e.g., 2-4 oz for infants older than 4 mo; under 4 mo give 1 oz per age in months (e.g., 3 oz for a 3-month-old) (69)
- Evaluate behaviors associated with stool withholding (e.g., readiness to be toilet trained, public bathroom avoidance)
- Evaluate supplement and medication use (e.g., iron)

Health Concerns

Troubleshooting Common Diet-Related Health Concerns

Picky Eating

- Don’t pressure, praise, or punish. The long-term goal is to teach children to be independent with food.
- Allow the child to decide what and how much they want to eat. Let them learn how to respond to their hunger signals and never force them to finish their plate.
- It can take offering food 10 times or more before a child will accept it.(6) Continue to offer a variety of foods with repetition, especially with different textures as this is a primary reason for refusal.
- Give choices of different foods to try. Let the child decide which one to try.
- Mix new foods with foods already well-liked
- Try freezing small bites of different foods (to avoid food waste)
- Involve the child in the planning and preparing of food (e.g., shopping, mixing ingredients)
- Continue to offer the same foods as the family and avoid reacting to refusal/conflict. Be firm, consistent, and patient.
- Consider if snacking throughout the day may be reducing hunger and subsequently limiting nutrient intake at meal times
- Share the video, “Tips for Feeding Picky Eaters: American Academy of Pediatrics (AAP)” on YouTube

Poor dietary quality due to poor or limited food choices

- Express the importance of food variety in obtaining needed nutrients
- Encourage meal planning tools, such as the USDA’s Healthy Eating for Vegetarians (choosemyplate.gov), and vegan food guides, like The Vegan Plate (becomingvegan.ca) and The Plant Plate theveganRD.com)
- Encourage mild-flavored foods, especially if vegetables are not liked
- Promote the exploration of different food preparation techniques to improve taste and food variety (e.g., roasting vs. boiling vegetables)
- Explore more healthful foods available when not at home and ideas to plan/pack meals & snacks
- Consider supplement needs

Troubleshooting Common Diet-Related Health Concerns

Obesity

- Encourage a healthy whole-foods, plant-based diet as it may help promote weight loss, help to keep weight off, and prevent obesity (4)
- Focusing on diet quality rather than focusing on weight may improve patient reception
- Educate parents on growth chart percentiles and trends to encourage growth monitoring
- Online personalized calculators may be helpful to educate the child/parent on nutrient needs (e.g., "DRI calculator for health professionals" at nal.usda.gov)
- Encourage parents to model eating healthful foods and exercise regularly, communicating the principles of healthy eating, and avoiding conversations about dieting around children
- Suggest stocking the kitchen with healthy foods and limiting the availability of processed foods high in calories and low in nutrients. Place healthy foods front and center in the refrigerator, cabinets, and counters to make them the easy choice.
- Encourage water and limit sugary drinks
- Avoid using food as a reward (e.g., ice cream, candy). Instead, consider other non-food items, such as visiting a park or going to the movies
- Educate on reading labels/menus & portion sizes. It can be easy to overeat, especially in restaurants
- Discourage eating out of the bag, carton, or box because it encourages overeating. Instead, serve a reasonable portion and put the package away.
- Encourage eating mindfully: eating slowly and paying attention to hunger and satiety
- Encourage awareness of satiety and to stop eating when no longer hungry
- Encourage exercise
- Older children should be physically active for at least 1 hr/d; preschool-aged kids need 3 hours
- Find activities they like, such as sports, dance, biking, or martial arts, to promote enjoyable exercise
- Include the family in fun physical activities can also encourage active lifestyles

Breastfeeding

- Provide resources, such as a lactation specialist, National Breastfeeding Helpline (1-800-994-9662) and WIC's breastfeeding webpage (wicbreastfeeding.fns.usda.gov)

Troubleshooting Common Diet-Related Health Concerns

Body image, extreme dieting, and disordered eating behavior

- Focus on health and not weight
- Educate on healthy growth trajectories and expected body changes during adolescence (e.g., “Adolescent development explained” at opa.hhs.gov)
- Ask reasons for the specific type of diet consumed. If severely restricting food or fad dieting for appearance, for example, further examination of possible eating disorder development and consultation with behavioral specialists may be necessary. See the National Eating Disorders Association and reference (72) for more information.
- If severely reducing calories, explain its ineffectiveness for long-term weight loss and can cause nutrient deficiencies; refocus the conversation on health and growth
- Encourage parents to help the child navigate social media and other unrealistic images
- Encourage parents to be good role models (e.g., no dieting/ dieting talk in front of children)

Athletes

- Athletes that are weighed as part of their sport (e.g., wrestlers) or who are historically encouraged to have low body weight (e.g., ballet) may need education and encouragement to maintain a healthy weight and growth trajectory
- Educate that the nutritional needs of most athletes are similar to other children with regular physical activity, but high-performance athletes often need extra energy and protein
- Encourage a variety of complex carbohydrates, protein, and healthy fats as fuel for muscles and cells
- Online personalized calculators may be helpful to educate the child/parent on nutrient needs (e.g., “DRI calculator for health professionals” at nal.usda.gov)
- Energy-dense foods, such as tofu, nuts, seeds, and their butters, & avocados can help some children to meet calorie requirements
- Reducing fiber may be necessary for some children who consume a high amount of whole plant foods to ensure adequate energy and nutrient intake
- Encourage good sources (or supplements) of iron, vitamin B12, vitamin D, calcium, and other “key” nutrients described herein; a healthy athlete can get protein and most other nutrients they need from foods without taking supplements
- Discourage the use of performance-enhancing supplements and encourage evidence-based resources for information on supplements, such as the National Center for Complementary and Integrative Health (nccih.nih.gov) and the Office of Dietary Supplements (ods.od.nih.gov)
- Encourage adequate hydration, especially during very cold and warm weather:(71)
  - 1-2 hours before the event: ~12-22 oz of beverages
  - events lasting longer than 60 minutes: replace electrolyte and carbohydrate losses with fluids
  - after the event: ~ 16-22 oz (2-3 cups) for every pound of weight lost

Appendix: Child growth and nutritional adequacy

Summary of studies, guidelines, and position statements on plant-based diets and growth and nutritional adequacy

In the last ten years, only a few studies in developed countries have measured growth in children consuming plant-based diets: one longitudinal cohort study in Canada, a retrospective study in Italy, and two cross-sectional in Europe (where food availability, fortification, and RDAs are different than in the US).

In nearly all studies, child growth was similar when consuming vegan, vegetarian, or omnivorous diets. Children on plant-based diets are often leaner than their peers and at lower risk for overweight and obesity. Only 1 study (17) suggested slightly lower height in vegan children, but they may not have adjusted for age or gender and did not provide actual values to make clinically meaningful comparisons (i.e., height-for-age z scores not provided). Low calcium and vitamin D intake in all diets is commonly reported, particularly in countries that lack fortified foods, and calcium and vitamin D are considered nutrients of public health concern in the US (all typical diets; (6)). See pages 19-21 for more details.

The remaining studies are typically much older (the 1970s-90s) and use outdated growth charts based on formula-fed white children. The food environment has dramatically changed since then, and more plant-based and fortified foods and supplements are available to the public, especially in the US. Nevertheless, numerous older studies suggest children have adequate growth with a vegan or vegetarian diet. Note that macrobiotic, fruitarian, and other overly-restrictive and fad diets are sometimes placed into the vegan category but are usually not assumed as "vegan" in most current scientific literature, and these diets have been shown to result in nutrient deficiencies and delayed/depressed growth and children. Thus, severe dietary restrictions are not recommended due to the very high risk of nutrient deficiencies. See pg. 22 for details of older studies.

Reviews on vegetarian and vegan diets in children typically report adequate growth, lower obesity risk, higher-quality diets, and the ability to meet dietary recommendations better than those eating a Western diet.(4,5) Vitamin B12, calcium, and vitamin D are typical concerns, especially with vegan diets. Furthermore, a systematic review reported that the use of animal-sourced foods has been inconsistent in improving growth in children of developing countries, with many studies showing no improvements in measures of height or weight.(73). Thus, <u>diet as a whole</u> should be considered for nutritional adequacy versus focusing specifically on the use or lack of animal-sourced foods, particularly in young children, as meat intake is a tiny proportion of the diet in all children (e.g., <1-8% in US infants; (74)).

Guidelines worldwide highly recommend that all children and adults increase their intake of whole-plant foods to improve diet quality and reduce the risk of chronic diseases.(6,75). The Dietary Guidelines for Americans, Canadian Guidelines, and Australian Guidelines support plant-based dietary patterns to meet the nutritional needs of children.(6,76,77) The Academy of Nutrition and Dietetics (AND; (10)), the German Society for Pediatric and Adolescent Medicine (13), the Canadian Paediatric Society (12), and the Italian Society of Human Nutrition (78) also states that the nutritional needs of growing children and adolescents can generally be met through a balanced, vegetarian diet, but they require planning and patient education. On the other hand, some professional groups do not support a vegan diet, including the German Nutrition Society, as several nutrients (e.g., B12, DHA, iron, iodine) may be challenging to obtain from food alone (Germany does not fortify foods except table salt).(79) However, AND (formally American Dietetics Association) and the Australian Dietary Guidelines state that well-planned vegan diets are healthy and appropriate for all ages and life stages, but supplementation of B12 is usually needed.(10,77). In addition, a recent NIH study (2022) modeling the American food system indicates that when the current vegetarian diet recommendations in the Dietary Guidelines for Americans are slightly modified, a vegan diet can provide adequate nutrients (at least in adults).(80)

In conclusion, all diets have the potential to contain inadequate nutrients. Some children studied lacked sufficient calcium, vitamin D, and sometimes iron or iodine, regardless of whether animal-sourced foods or supplements were included. A plant-based diet, including a vegan and vegetarian diet, is at high risk for vitamin B12 deficiency, and supplements are necessary. In countries lacking food fortification, other micronutrients may be of concern in some children (e.g., vitamin A, B2). Thus, all diets should be balanced and critical nutrients monitored, especially when foods are restricted or eliminated from the diet.

Details of studies presented herein

Elliot, et al. Vegetarian Diet, Growth, and Nutrition in Early Childhood: A Longitudinal Cohort Study. Pediatrics. 2022; 149(6): e2021052598.

This longitudinal cohort study of Canadian children aged 6 months to 8 years (mean at baseline 2.2y; N=8907, n= 248 vegetarians, with 10% as vegan) found no association between a vegetarian diet and zBMI or height-for-age z-score. Vegetarian children had higher odds of being underweight (<2 zBMI; 1.87 (95% CI 1.19, 2.96) p=0.007); exploratory analysis of underweight children showed that they also tended to be younger and of Asian descent regardless of diet (growth charts may overestimate underweight in Asian American populations, and the small sample size prohibited meaningful subgroup analyses).

Serum ferritin, serum vitamin D, or serum lipids did not differ by diet group. However, serum lipids (LDL, total, non-HDL cholesterol) were lower in children who did not consume milk.

Strengths include the longitudinal design, strong measurement tools (e.g., WHO standardized growth charts, biomarkers), and analyses that account for numerous clinically-meaningful confounding variables. Limitations include a relatively short follow-up time (2.8 y).

Conclusion: Vegetarian diet in early childhood results in normal growth compared to an omnivore diet. Nutrient status, including iron and vitamin D, did not differ by dietary pattern. However, children consuming vegetarian diets, particularly those that are very young, may be at higher risk of being underweight.

Ferrara. Minerva Pediatr (Torino). 2021 Apr 16. doi: 10.23736/S2724-5276.21.06262-5.

A retrospective study in Italy compared vegan, vegetarian, and omnivore diets and infant growth during the first year of life (n=63) with consideration of maternal dietary patterns during pregnancy (n=55)).

There were very slight differences in weight and length in infants of mothers with vegan than omnivore dietary patterns, but all babies were within healthy population growth parameters regardless of diet (e.g., WHO growth charts). For example, length was around the 50% percentile for all babies at 12 months (i.e., vegan 47 percentile, and vegetarian and omnivore 55 percentile). Note that more vegan mothers exclusively breastfed than omnivore mothers which can influence growth rates. No differences in head circumference were found between groups.

A much higher proportion of vegan (95%) and vegetarian (84%) mothers consumed supplements during pregnancy than omnivores (27%), and more infants in the vegan (95%) and vegetarian group (76%) were supplemented than the omnivore group (66%). No statistical differences were found in anthropometrics between maternal diet groups.

Strengths include considering the type and length of maternal dietary patterns and using validated food questionnaires and standardized growth charts. Limitations include parent-reported child anthropometric data, the unclear criteria for excluding highly restrictive diets, such as macrobiotic, raw, and fruitarian diets (not recommended due to the high risk of nutrient deficiencies), and a small sample size.

In conclusion, although there were very slight differences between groups, infant growth was adequate regardless of diet. Vegan and vegetarian Italian mothers studied herein were likely to use and provide supplements to their infants, indicating a high nutrition awareness.

Weder, et al. Energy, macronutrient intake, and anthropometrics of vegetarian, vegan, and omnivorous children (1–3 years) in Germany (VeChi Diet Study). Nutrients. 2019; 11, 832.

Weder et al. Intake of micronutrients and fatty acids of vegetarian, vegan, and omnivorous children (1–3 years) in Germany (VeChi Diet Study) Eur J Nutr. 2022; 61, 1507–1520.

This cross-sectional study of 1 to 3-year-old German children compared 127 vegetarian, 139 vegan, and 164 omnivorous children and found no significant differences in anthropometrics (weight-for-height, height-for-age, weight-for-age) even after adjustments for many covariates. Energy intake, dietary energy density, and macronutrient intake did not differ between groups, and all groups had moderate numbers of children not meeting their energy needs (28-42%, highest in omnivores).

Food diaries suggested that all groups did not meet calcium, vitamin D, or iodine recommendations with or without supplement use (although iodized salt intake was not recorded). Iron intake, although higher in vegetarian and vegan groups than in omnivores, may be sufficient to meet recommendations in all children; however, the lower bioavailability of plant-based iron may increase needs. Without vitamin B12 supplements, the vegan and vegetarian group fell short of intake recommendations, and vitamin B2 intake was low in the plant-based groups whether or not supplements were used (grains are not fortified in Germany). Overall, vegans had the highest intakes of other micronutrients reported.

Stunting in 6% of children on a vegetarian or vegan diet was reported, which may be explained by extremely low-calorie intake, SGA, being exclusively breastfed for 7 and 9 months, and having parents with below-average height. About 4% of children (vegan and omnivore) were classified as wasted (1 being very tall). The omnivore group had a higher proportion of at risk/overweight children (23% vs.18%). These sample sizes, however, could not allow for statistical analysis between groups to assess the impact of diet on the prevalence of stunting or wasting, and group analyses indicated no differences in anthropometrics between groups based on diet.

Strengths include proper anthropometric measures (i.e., weight-for-height) and analyses with and without supplements. Limitations include a parent or reported weight and height during the last medical check-up, cross-sectional design, self-reported dietary and supplement intake, and discussions of inane differences (e.g., between-group contrasts for nutrients that were not statistically significantly different and fell within recommendations).

Conclusion: Vegetarian and vegan diets in early childhood can provide the same amount of energy and macronutrients as omnivorous diets, leading to normal growth. Calcium, vitamin D, and iodine (and possible iron in very strict plant-based diets) should be monitored in all children, and vegan and vegetarian diets should include vitamin B12 supplements. Because some countries do not fortify grains, vitamin B2 may be of concern in these areas.

Alexy, et al. Nutrient Intake and Status of German Children and Adolescents Consuming Vegetarian, Vegan or Omnivore Diets: Results of the VeChi Youth Study. Nutrients. 2021;13(5):1701.

This cross-sectional study of 6 to 18-year-old German children (mean 12.7 ± 3.9 years) compared anthropometric measures and dietary intake and status between children consuming a vegetarian (n= 149), vegan (n= 115), and omnivorous (n= 137) diet. There were no significant differences between groups for anthropometrics (height, weight, BMI-SDS) or energy intake. All groups met or exceeded protein intake recommendations, and all macronutrients fell with requirements (except omnivores did not meet fiber recommendations).

More than half of all children used supplements, with the highest use among vegans followed by vegetarians; however, micronutrient intake analyses did not include supplements. Nevertheless, all intakes of micronutrients were within the range of recommendations, except vitamin B12 and calcium (including omnivores). Blood biomarkers suggested B12 deficiency was likely in about 13% of vegetarians, 8% of vegans, and 4% of omnivores. Few children had low ferritin (≤ 10%), but 28-36% of all children had low vitamin D levels, and roughly half of all children had low vitamin B2 levels (no fortification of grains occurs in Germany).

Strengths of the study include the use of blood biomarkers and the moderate sample size. Limitations include the cross-sectional design, not including supplements in dietary intake analyses, and the use of self-reported 3-day weighed home food records/online questionnaire (vs. multipass dietary recall).

Conclusion: Children and adolescents consuming a vegan or vegetarian diet grow similarly to those consuming an omnivorous diet. Calcium, vitamin D, B12, and B2 intake and/or status were low in many children, regardless of diet, particularly in vegans who did not use supplements. Note that Germany does not fortify their grains as is done in the US and numerous other countries.

Desmond. Growth, body composition, and cardiovascular and nutritional risk of 5- to 10-y-old children consuming vegetarian, vegan, or omnivore diets. Am J Clin Nutr. 2021; 13(6): 1565-1577.

A cross-sectional study of 5 to 10-year-old Polish children consuming omnivorous (n= 72), vegetarian (n= 63), or vegan diets (n= 52) compared anthropometric, dietary intake and status, physical activity, cardiovascular, and bone health.

Anthropometrics: The vegan group was shorter than the omnivore group (height z-score difference -0.57, or an estimated 3 cm), although age distribution did not appear to be accounted for (i.e., did not use height-for-age z-score). Because differences were reported and not actual values, it is unknown if these children followed a normal growth trajectory or were within the average distribution of population heights. Children consuming a vegan diet had lower BMIs than children on an omnivore diet (-0.53 BMI-z-score) and were leaner (e.g., skinfold measures). The clinical significance of these differences is unknown, as actual values for BMI were not reported.

Dietary intake and status measures: Although some were reported, there were no meaningful differences between groups for energy, protein, or other macronutrients (i.e., all are within recommendations), except omnivores did not meet fiber recommendations and overconsumed saturated fat. Calcium intake was low in all groups, especially children consuming a vegan diet. Vitamin D intake was also very low in all groups, particularly those on an unsupplemented vegan diet (~65% of all children did not take supplements, and milk is not fortified in Poland). Finally, vitamin B12 intake and status were lowest in children consuming a vegan diet if not supplemented (not surprisingly).

Markers of health: Children on a vegan diet had 3.7 to 5.6% lower bone mineral density measures than children consuming an omnivorous diet, but these differences may not be clinically significant. On the other hand, the vegan group had the most favorable cardiovascular measures. Physical activity did not differ between groups.

Strengths include strong measures of physical activity, cardiovascular and bone health (e.g., DEXA), and stratifying micronutrients by supplement use. Limitations are the cross-sectional design, small sample size, parent self-reported dietary intake (food diary), unclear statistics to address age distributions when comparing height between groups (height vs. height-for-age z-scores), and the lack of actual values to make meaningful interpretation of most differences between groups (e.g., when all values fall within normal range but only differences are reported).

Conclusion: Compared to omnivores, consumption of vegan diets was associated with a healthier cardiovascular profile but also with increased risks of calcium, vitamin D, and B12 inadequacies if not supplemented, slightly lower bone mineral content, and possibly lower height (see limitations).

Hovinen et al. Vegan diet in young children remodels metabolism and challenges the statuses of essential nutrients. EMBO Molecular Medicine. 2021; 13:e13492.

This cross-sectional study of 40 Finnish children (median age 3.5 y) consuming vegan (n= 6), vegetarian (n= 10), and omnivorous (n= 24) diets compared anthropometrics, nutrient status, and intake. There were no differences in height (z-scores, corrected for age and gender), BMI-SDS, or upper arm circumference (MUAC z-scores) between groups. The vegan group had lower vitamin A status based upon RBP, but after controlling for inflammation, none of the children were deficient. Other nutrients (energy, protein, iron, iodine, folate, zinc, vitamin D, B12, saturated fat) either did not differ between groups and/or were not clinically meaningful (e.g., recommendations or values within or normal ranges).

Strengths included the clear assignments of dietary patterns based on food records (vs. self-report) and strong anthropometric measures. Limitations included extremely small and unequal sample size, cross-sectional design, and inane comparisons between groups (e.g., not clinically meaningful; values within recommendations or normal ranges).

Conclusion: Finnish children consuming vegan and vegetarian diets grow similarly to children on omnivorous diets. As food fortification and supplement use vary widely in different populations, some micronutrients, such as vitamin A, may be lower in some diets.

Older studies on vegan and vegetarian diets during childhood are highly heterogeneous, mostly cross-sectional, often use small sample sizes, and the majority use inaccurate growth charts that are outdated and based primarily on formula-fed white infants. Definitions of vegan and vegetarian diets often vary and sometimes include fad and extremely restrictive diets. Overall, the majority of studies show that children have adequate growth compared to available growth charts. Examples include:

- In a longitudinal study of matched pairs of English vegetarian and omnivorous children (7-11 y; N= 100), both groups lay close to the 50th percentiles for both height and weight (published in 1997). (16).
- A mixed-longitudinal study in the Netherlands (published in 1994) of matched pairs of 418 macrobiotic (severely restricted diet) and omnivorous infants reported deficiencies of energy, protein, vitamin B–12, vitamin D, calcium, and riboflavin, retarded growth, fat and muscle wasting, and slower psychomotor development. (18)
- A prospective study of 20 vegan children in the UK published in 1992 reported normal growth. The children tended to be leaner, and calcium intake was low (2 children had low vitamin B12 intakes).(81)
- A 1990 US study of 2272 vegetarian children aged 6 through 18 years found that the mean height and weight were at or above national reference values. (14)
- A 1989 study of 4-month to 10-year-old children (N= 404) living in a US collective community found children's height-for-age, weight-for-age, and weight-for-height within the population 25th-75th percentile reference range. (15).
- A prospective cohort study of 37 vegan children in the UK (published in 1988) reported height, weight, chest, and head circumference were within normal range; education and physical development were also normal. (82)
- A 1983 study of 142 vegetarian children (0- 6 y) reported lower height (1-2 cm) and weight (0.5-1 kg) compared to reference populations, especially when the diets were severely restricted (e.g., macrobiotic), Energy intake, but not protein, was below recommendations.(19)

Reviews on iron, zinc, calcium, vitamin D, and bone health in children

Zinc: A review of zinc in infants and young children from industrialized countries (74) indicates there are no differences in serum zinc or growth between young vegetarian and omnivorous children, and there is insufficient evidence to conclude that a well-planned vegetarian diet cannot meet the needs for zinc for young children. However, as the bioavailability of zinc from plant foods can be lower, zinc needs can be higher for an exclusively plant-based diet.

Iron: In two reviews on iron in young children, the prevalence of iron deficiency was higher in omnivores in some studies, but in other studies, vegetarians had a higher iron deficiency.(74,83) Study heterogeneity was large, and the degree of deficiency varied considerably from one study to another. In the studies described herein, iron intake and/or status were similar for plant-based and omnivorous diets. As iron deficiency and iron-deficiency anemia in children are public health concerns in most countries, including the US (84), it is important to assess and monitor iron intake and status in all children. Notably, children from underprivileged households may be at a higher risk of deficiencies because of non-dietary factors (e.g., chronic inflammation).

Calcium, vitamin D, and bone health
In the international studies described herein, calcium and vitamin D inadequacy were common among all diets, with vegans sometimes at a higher risk for insufficiency. In the US, calcium and vitamin D inadequacy is common with most diets.(6) Therefore, supplements/fortified foods with calcium and vitamin D may be needed for many children, particularly teenagers, minorities, and those who are of underserved populations.(85)

Reviews on bone health and fracture risk in vegetarians/vegans have yielded inconsistent results, which may be attributable to small sample sizes, differences in types of diets studied, and failure to control for confounders, such as physical activity level and nutrient intake. For example, in several reviews (including children but most studies are in adults), vegetarians appear to have similar bone mineral densities and fracture rates as non-vegetarians when adequate calcium intake and good sources of protein are included in the diet. (85-87) In a review of adults, older vegan adults (> 50 years) had higher fracture rates, and older vegan and vegetarian adults had lower bone mineral densities than omnivores (>50 years). (88)

Because gains in a child's bone mass are highly variable, even in children of the same age and sexual maturity (85), adequacy of calcium, vitamin D, protein, and other nutrients (B12), as well as physical activity throughout childhood, is of utmost importance. Thus, educating parents on the importance of diet on growth should occur in <u>all</u> children.

References

1. Weder. Nutrients. 2019; 11, 832.
2. Weder. Eur J Nutr. 2022; 61, 1507–1520.
3. Alexy. Br J Nutr, 2021; 1–12.
4. Sutter. Nutr Res. 2021; 91, 13–25.
5. Schürmann. Eur J Nutr. 2017; 56, 1797–1817.
6. Dietary Guidelines for Americans, 2020-2025. https://DietaryGuidelines.gov.
7. Wright. Nutr & Diabetes. 2017; 7, e256. https://doi.org/10.1038/nutd.2017.3
8. Dinu. Crit Rev Food Sci Nutr. 2017; 57(17):3640-3649.
9. Whitmee. Lancet 2015;14:386(10007):1973-2028.
10. Melina. Acad Nutr Diet. 2016; 116(12):1970-1980.
11. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/healthy-diet Accessed Aug 2021.
12. Amit. Paediatrics Child Health. 2010; 15(5):303-314.
13. Rudloff. Molec Cell Pediatr. 2019; 6:4.
14. Sabate. Am J Dis Child. 1990;144(10)1159-1163.
15. O'Connell. Pediatr. 1989;84(3):475-481.
16. Nathan. Eu J Clin Nutr.1997;51(1):20-25.
17. Desmond. Am J Clin Nutr. 2021; 113(6):1565-1577.
18. Dagnelie. Am J Clin Nutr. 1994; 59(5): 1187S-1196S.
19. Dwyer. J Am Diet Assoc. 1980; 77(4): 434-9.
20. USDA. FoodData Central. https://fdc.nal.usda.gov/
21. Office of Dietary Supplements. Omega-3 Fact Sheet for Health Professionals https://ods.od.nih.gov/factsheets/Omega3FattyAcids-HealthProfessional.
22. Remer. Dtsch Med Wochenschr. 2010 Aug;135(31-32):1551-6. PMID: 20665419.
23. Gardner. Nutr Rev. 2019; 77(4):197–215.
24. Mariotti. Nutr. 2019;11(11):2661.
25. Baroni. Nutrients. 2018;11(1):5.
26. Mattiello. Eur J Pediatr. 2020; 179(4):527-545.
27. Dietary Reference Intakes for Vitamin A...Iodine, Iron... Zinc. The National Academies Press 2001. Washington, DC. https://doi.org/10.17226/10026.
28. Baker. Pediatrics. 2010; 126(5):1040-50.
29. WHO Guideline: Use of ferritin concentration to assess iron status in individuals and populations. Executive Summary. Apr 2020. https://www.who.int/publications/i/item/9789240000124.
30. Stoffel. Mol Asp Med. 2020; 75,100865.
31. NASEM. 2020. Feeding Infants and Children from Birth to 24 Months: Summarizing Existing Guidance. Washington, DC: The National Academies Press.https://doi.org/10.17226/25747.
32. Meek. Policy Statement: Breastfeeding and the Use of Human Milk. Pediatrics. 2022; 150 (1): e2022057988. 10.1542/peds.2022-057988
33. Eidelman. Pediatrics 2012; 129: e827–41.
34. Daily iron supplementation in adult women and adolescent girls. World Health Organization e-Library of Evidence for Nutrition Actions (eLENA). Last Update Feb 2019. https://www.who.int/elena/titles/iron_women/en/. Accessed Dec 2021.
35. Office of Dietary Supplements. Iron Fact Sheet for Health Professionals. Sept 2020. https://ods.od.nih.gov/factsheets/Iron-HealthProfessional.
36. Taking iron supplements: MedlinePlus Medical Encyclopedia. https://medlineplus.gov/ency/article/007478.htm.
37. Biomarkers of Nutrition for Development (BOND): Vitamin B-12 Review. J Nutr. 2018; 1;148(suppl_4):1995S-2027S.
38. Black. Food Nutr Bull. 2008; 29(2 Suppl):S126-31.
39. Allen LH. Vitamin B12. Adv. Nutr. 2012; 3: 54–55.
40. Office of Dietary Supplements. Vitamin B12 Fact Sheet for Health Professionals. Accessed Sept 2020. https://ods.od.nih.gov/factsheets/VitaminB12-HealthProfessional/

41. Dietary Reference Intakes for Thiamin...Vitamin B12....and Choline. Institute of Medicine 1998. Washington, DC: The National Academies Press. https://doi.org/10.17226/6015
42. Sezer. Hematology. 2018;23(9):653-657.
43. Green. Am J Clin Nutr; 2011; 94(suppl):666S–72S.
44. Heiner-Fokkema. Pediatr Res. 2021 Nov;90(5):1058-1064.
45. Abildgaard. Clin Chim Acta. 2022; 525, 62–68.
46. Green. Blood. 2017; 129, 2603–2611.
47. Devalia. British Committee for Standards in Haematology. Guidelines for the diagnosis and treatment of cobalamin and folate disorders. Br J Haematol. 2014;166, 496–513.
48. Personal communication with Joshua W. Miller, PhD, Professor and Chair, Dept. of Nutritional Sciences, Rutgers University, USA. July 20, 2022.
49. Office of Dietary Supplements. Zinc Fact Sheet for Health Professionals. https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional. Accessed Dec 2021.
50. Saper. Am Fam Physician. 2009 May 1;79(9):768-72.
51. Office of Dietary Supplements. Iodine Fact Sheet for Health Professionals. Accessed Nov 2020. https://ods.od.nih.gov/factsheets/Iodine-HealthProfessional/
52. Leung. Pediatrics. 2014 Oct;134(4):e1282. doi: 10.1542/peds.2014-2111A.
53. Office of Dietary Supplements. Vitamin D Fact Sheet for Health Professionals. Accessed Sept 2020. https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/
54. Dietary Reference Intakes for Calcium and Vitamin D. Institute of Medicine 2011. Washington, DC: The National Academies Press. https://doi.org/10.17226/13050.
55. EFSA assesses safety of long-chain omega-3 fatty acids. European Food Safety Authority. July 2012. https://www.efsa.europa.eu/en/press/news/120727. Accessed Jan 2022.
56. Dror. Adv Nutr 2018; 9: 278S-294S.
57. Hand. Pediatrics 149, e2021056036 (2022).
58. Dietary Reference Intakes for Energy... Fat, Fatty Acids, ...and Amino Acids. Institute of Medicine 2005. Washington, DC: The National Academies Press, 2005 DOI:10.17226/10490.
59. Koletzko. J Perinat Med 2008; 36: 5–14.
60. Vandenplas. Br J Nutr. 2014; Apr 28;111(8):1340-60.
61. Bhatia, Pediatrics. 2008 May;121(5):1062-8.
62. Concerns for the use of soy-based formulas in infant nutrition. Paediatr Child Health. 2009 Feb;14(2):109-18. PMID: 19436562
63. Fleisher. J Allergy Clin Immunol. 2021; 9(1):22-43.
64. Greer. Pediatrics. 2019; 143(4): e20190281.
65. Kopp. S3 guideline Allergy Prevention. Allergol Select. 2022;4(6):61-97. PMID: 35274076.
66. World Health Organization. Obesity and Overweight. Accessed Aug 2021. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
67. Essential Fatty Acids. Linus Pauling Inst. April 2014. https://lpi.oregonstate.edu/mic/other-nutrients/essential-fatty-acids. Accessed Jan 2022.
68. Brown. BMJ. 2019; 366: l4697.
69. How can I tell if my baby is constipated? AAP. https://www.healthychildren.org. Updated 5/12/2022. Source adapted from Dad to Dad: Parenting Like a Pro, American Academy of Pediatrics 2012.
70. Depoorter. Nutrients. 2021; 13(7):2176.
71. Pediatric Nutrition Care Manual. Academy of Nutrition and Dietetics. 2023. https://www.nutritioncaremanual.org/pediatric-nutrition-care
72. Hornberger. Pediatrics. 2021; 147(1): e2020040279. doi: 10.1542/peds.2020-040279.
73. Shapiro. Adv Nutr. 2019; 10(5):827-847.
74. Gibson. Am J Clin Nutr. 2014; 100:459S-468S.Herforth. Adv Nutr. 2019; 10(4):590-605.

75. Herforth. Adv Nutr. 2019; 10(4):590-605.
76. Canadian Dietary Guidelines. 2019. https://food-guide.canada.ca/en/guidelines/
77. Eat for Health. Australian Dietary Guidelines. 2013. https://www.eatforhealth.gov.au
78. Agnoli. Nutr Metabol Cardiovas Dis. 2017; 27(12):1037-1052.
79. Richter. Ernahrungs Umschau. 2016; 63(4):92-102. doi:10.4455/eu.2016.021.
80. Hess. J Nutr. 2022; 152(9):2097-2108.
81. Sanders. J Hum Nutr Diet. 1992; 5:11–21 18.
82. Sanders. Am J Clin Nutr. 1988; 48:822–825.
83. Pawlak. Ann Nutr Metab. 2017; 70(2):88-99.
84. Gupta. Am J Clin Nutr. 2017; 106(Suppl 6):1640S-1646S.
85. Wallace. J Am Coll Nutr 32:321–330.
86. Mangels. Am J Clin Nutr. 2014; 100(Suppl 1): 469S-475S.
87. Karavasiloglou.J Nutr. 2020. https://doi.org/ 10.1093/jn/nxaa018
88. Iguacel. Nutr Rev. 2019; 77(1):1-18.