HY-08 Deficiency diseases and how to prevent them with what grows

HEALING after the FALL, research library, HY-08

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How to read this document

This report covers nine deficiencies that will return when fortified flour, iodised salt, imported fruit and pharmacy shelves are gone: scurvy, pellagra, beriberi, rickets, goitre and cretinism, iron-deficiency anaemia, vitamin A deficiency, folate deficiency with neural-tube defects, and B12 deficiency. For each it gives signs, time to onset, daily requirement, foods with grams per day, how those foods keep, and the history. It separates **tradition** (what people believed and did), **record** (what was counted) and **science** (what later work infers).

The setting is a household, a village of 300 and a district of 3,000 with no hospital or pharmacy. Where I turn composition figures into grams per day, the arithmetic is mine and marked [VERIFY]. Composition varies with soil, variety, season and storage, so treat every grams-per-day figure as a guide and allow a margin of about double. Growing and preserving belong to FEASTING, the food volume of THRIVING after the FALL. Library reports are cited as (THRIVING library, ID).

One lesson runs through all nine. Each appeared when people came to rely on one staple: biscuit and salt meat at sea, maize in Lombardy and the American South, polished rice in Java and Japan, bread and tea in Afghanistan. Each disappeared when the diet widened.

1. Findings by section

1.1 Scurvy (vitamin C)

Signs. In 166 children with scurvy, 92% had musculoskeletal signs, with leg pain in 88% and refusal to walk in 73%. Mucosal signs, mostly bleeding gums, appeared in 57%, and skin signs in 39 to 42% (Trapani et al. 2022). Adults show tiredness, then swollen bleeding gums, bruises, bleeds round hair follicles, poor healing and reopening of old wounds. In the Sorby experiment, 4 of 10 deprived volunteers had severe events, 2 of them cardiac (Hemilä and Chalker 2025).

Onset. Signs appear after 8 to 12 weeks of inadequate intake. The body pool is about 1,500 mg, and signs appear below about 300 mg (Trapani et al. 2022). In Crandon's 1940 self-experiment, plasma vitamin C reached zero at 41 days and follicular bleeds appeared at about 161 days (Crandon et al. 1953, search summary). A household that loses fresh food in November will see cases from January or February.

Requirement. The Sorby trial ran from October 1944 to February 1946 under Hans Krebs. Twenty volunteers aged 21 to 34 took 0, 10 or 70 mg a day for about 9 months on average. Ten milligrams prevented and cured scurvy (Hemilä and Chalker 2025, Bartley et al. 1953 not read). The UK reference intake is 40 mg and WHO gives 45 mg (search summary). Hujoel's 2021 reanalysis argued that 95 mg is needed to protect wound strength in 97.5% of people (UW News 2021). US allowances are 90 mg for men, 75 mg for women, 85 mg in pregnancy, 120 mg when breastfeeding and 15 to 45 mg for children by age (LPI vitamin C). After the Fall, 10 mg is the floor and about 45 mg the target.

Foods. USDA values in mg per 100 g raw (Wikipedia Vitamin C): rose hip 426, sea buckthorn 400, blackcurrant 200, kale 120, broccoli 90, Brussels sprouts 80, orange and lemon 53, cabbage and spinach 30, lime 30, potato 20, tomato 14, carrot 6. Human milk carries 5.0 mg and cow's milk 1.0. To reach 45 mg raw takes about 11 g of rose hip, 23 g of blackcurrant, 38 g of kale, 85 g of lemon, 150 g of cabbage or 225 g of fresh potato [VERIFY, my arithmetic]. Rose hips vary most. A review gives 1,252 mg per 100 g for *Rosa canina* (review, PMC11043540), others cite 30 to 1,300 mg, and genotype and altitude alone move values between about 112 and 360 mg (search summaries).

Sprouted pulses are the winter source for a village with a granary. Riddoch, Mills and Duthie found that germinating about half the pulse ration for 3 to 5 days gave the 10 mg protective dose, and that cooking caused marked loss (Riddoch et al. 1998, abstract only). Chick and Delf showed the antiscorbutic value of germinated seeds in 1919 (Chick and Delf 1919, citation only).

Sauerkraut holds about 15 to 36 mg per 100 g. Across 23 cabbage cultivars, raw cabbage held 12 to 112.5 mg, kraut 5.8 to 52 mg, with 62 to 100% retention (PubMed 6625831, abstract only). Cook's *Endeavour* (1768 to 1771) carried 7,860 lb of sauerkraut and issued about 2 lb per man per week, about 130 g a day, or roughly 32 mg of vitamin C at 25 mg per 100 g [VERIFY, my arithmetic]. Cook's crews had no dangerous scurvy (Hektoen International 2021).

Conifer needles carry great weight in tradition and little in the record. *Pinus sylvestris* needles held 0.5 to 15.7 mg per 100 g fresh by month, highest in winter (Redalyc study, search summary [VERIFY]). That is less than cabbage, and I found no measurement of an infusion. Cartier's crew at Stadacona in 1535 to 1536 lost 25 of 110 men before Domagaya showed them *annedda*, which cured the rest (Canadian Encyclopedia, Parks Canada). The tree is usually named as *Thuja occidentalis*, but balsam fir and others are proposed. *Thuja* contains thujone, a convulsant.

Losses. Boiling broccoli lost 34% and steaming 22% in one Italian study (search summary [VERIFY]). A Korean study of ten vegetables found retention from 0 to 91% depending on method (PubMed 30263756, abstract only). In a reconstruction of ship's cooking, cabbage soup kept 25% of its vitamin C after 40 minutes in copper against 56% in iron (Medical History paper, author not identified, search summary). Icelandic potatoes lost about half in the first 2 months of storage and a further 30 to 35% over 5 to 6 months. UK white cabbage lost about 80% in the first 3 months of cold storage (PHTnet, search summary). By February a stored potato or cabbage carries perhaps a fifth to a half of its autumn value [VERIFY].

History. Anson's voyage of 1740 to 1744 lost nearly 1,300 of 1,955 men, mostly to scurvy (Gordon 1984, search summary). On 20 May 1747, aboard HMS *Salisbury*, James Lind gave six pairs of scorbutic sailors cider, elixir of vitriol, vinegar, sea water, citrus or a purgative. The citrus pair recovered fastest, and cider came second (Lind 1753, via the James Lind Library and rdrr.io). Sources disagree on whether the ration was two oranges and one lemon (THRIVING library, FO-03) or two lemons and an orange (rdrr.io) [VERIFY]. Universal issue of lemon juice in the Royal Navy followed Gilbert Blane's advice in 1795, at three-quarters of an ounce a day (Wikipedia Gilbert Blane, Kallan, dates differ up to 1799). Haslar's scurvy admissions fell from 1,457 in 1780 to 2 in 1806 to 1810 (THRIVING library, FO-05).

From the 1860s the Navy switched to West Indian lime juice, which carries about half the vitamin C of lemon (THRIVING library, FO-06). The Nares Arctic expedition of 1875 to 1876 wintered beyond 82°N and suffered scurvy with deaths. The inquiry blamed the absence of lime juice on the sledges, but diaries show it was carried, and Freeze Frame points to the processing of the juice (Canadian Encyclopedia, Freeze Frame). Chick, Hume and Skelton showed in 1918 that lime juice had little antiscorbutic value against lemon (Chick et al. 1918, search summary). Carpenter tells the whole story of a cure known, lost and found (Carpenter 1986, not read in full).

Modern record. In Taywara district, Ghor, Afghanistan (population about 79,000), 4,588 cases and 323 deaths occurred in three months of winter 2001 to 2002, an attack rate of 6.3% and case fatality of 7%. The diet was bread and tea. In one village everyone who died had not eaten the wild green *seech*. ACF and WHO recommended sprouted wheat or pulses and household tomatoes, peppers, greens and potatoes (ENN Field Exchange 17).

Treatment. MSF gives 100 mg three times a day for children aged 1 month to 11 years and 250 mg three times a day from 12 years, for at least 2 weeks, then 50 mg a day (MSF ascorbic acid). Resolution takes 1 week to 3 months (Trapani et al. 2022).

Voices. Tradition offered vinegar, sea water and vitriol, all useless, and conifer brews of uncertain worth. The record shows citrus, greens, sauerkraut and potatoes worked and processed lime juice failed. Science explains why: vitamin C is destroyed by heat, air, copper and time.

1.2 Pellagra (niacin and tryptophan)

Signs. Dermatitis, diarrhoea, dementia and death. The rash is symmetrical on sun-exposed skin, often as a collar round the neck. The tongue is bright red and sore (LPI niacin, MSF pellagra).

Onset. At Rankin Prison Farm, Mississippi, in 1915, Goldberger fed 11 volunteer prisoners grits, fat and syrup. Six developed pellagra within about six months (Schmitz and Lowenstein 2018, Georgia Encyclopedia). Another account says 7 [VERIFY]. Pellagra appears in spring after a winter on maize.

Requirement. Men need 16 mg niacin equivalents a day, women 14 mg, pregnancy 18 mg, breastfeeding 17 mg, children 6 to 12 mg. The body makes 1 mg of niacin from 60 mg of tryptophan. The upper limit of 35 mg applies to nicotinic acid supplements, which cause flushing (LPI niacin). MSF gives about 15 mg for prevention (MSF pellagra).

Foods. Peanuts give 4.1 mg per ounce, lentils 2.1 mg per cooked cup and chicken 8.9 mg per 3 oz (LPI niacin). About 100 g of groundnuts gives some 15 mg before counting their tryptophan [VERIFY, my arithmetic]. A daily handful of groundnuts or a bowl of beans protects a maize-eating community.

History. Lombardy counted 39,000 cases in 1862 among 2.5 million people, and Lombardy and Veneto together about 150,000 (Termedia). The American South had an estimated 3 million cases and 100,000 deaths from 1906 to 1940, with Black Southerners affected at more than twice the white rate (Schmitz and Lowenstein 2018). Goldberger ended pellagra in orphanages in Jackson, Mississippi, by changing the diet, with one new case in two years. In 1927 the Red Cross gave brewer's yeast to 50,000 flood survivors. Niacin was identified in 1937, eight years after Goldberger died (Schmitz and Lowenstein 2018, Georgia Encyclopedia).

Modern record. Among Mozambican refugees in Malawi, 17,878 cases occurred in February to October 1990 among 285,942 people, an attack rate of 6.3%, after groundnut distribution stopped for about five months. Women were affected 7.8 times as often as men. Eating groundnuts gave an odds ratio of 0.08, a garden 0.34 and home milling 0.3 (CDC MMWR 1991, Epicentre).

Why Mesoamerica escaped. There, maize is boiled with lime before grinding (nixtamalisation). The usual account is that lime frees niacin bound in the grain and adds calcium (Wacher review, search summary). Household guides give lime at 1 to 3% of grain weight and a boil of 30 to 60 minutes (ECHO). The mechanism is disputed (see the case against). Mesoamerican diets also included beans and squash.

Treatment. Nicotinamide 100 mg three times a day for children and adults, with protein-rich food, until healed (MSF pellagra). In Kuito, Angola, MSF gave adults two 50 mg tablets three times a day for 15 days (ENN Field Exchange 10).

Voices. Tradition blamed spoiled maize or contagion. Goldberger's record showed diet. Science named niacin and tryptophan but still argues about lime.

1.3 Beriberi (thiamine)

Signs. Dry beriberi brings burning feet, weak legs and inability to rise from a squat. Wet beriberi brings fast heart, swelling and heart failure, and its fulminant form, shoshin, kills within days. Wernicke's encephalopathy brings con-

fusion and unsteady gait (LPI thiamin). Breastfed infants of thiamine-poor mothers die quickly (Luxemburger et al. 2003).

Onset. The body holds only 25 to 30 mg, depleted in 2 to 3 weeks on a deficient diet (search summaries). This is the fastest deficiency here, and why a starved person must have thiamine before refeeding (THRIVING library, HY-09).

Requirement. Men 1.2 mg, women 1.1 mg, pregnancy and breastfeeding 1.4 mg, children 0.5 to 0.9 mg (LPI thiamin).

Foods. Pork gives 0.80 mg per 3 oz, peas 0.21 mg per half cup, brown rice 0.18 mg per half cup, lentils 0.17 mg per half cup and unenriched white rice 0.016 mg (LPI thiamin). A day of 300 g cooked brown rice, 200 g lentils and 160 g peas gives about 1.3 mg [VERIFY, my arithmetic]. Bran and germ hold 65 to 85% of the grain's vitamins, and washing rice leaches thiamine (FAO 1993). Parboiling drives thiamine into the grain, and Braddon reported in 1907 that parboiled-rice eaters escaped beriberi (Cambridge parboiling paper, search summary). Thiaminases in raw fish and some ferns destroy thiamine, and heavy tea and betel reduce it (LPI thiamin).

History. In 1882 to 1883 the Japanese training ship *Ryujo* sailed with 376 men, of whom 169 (44.9%) developed beriberi and 25 died. Kanehiro Takaki sent the *Tsukuba* on the same route in 1884 with more barley, meat and milk. Of 333 men, 14 (4.2%) fell ill, none died, and all 14 had refused the new rations. The Navy adopted the diet and beriberi disappeared within a few years (Sugiyama and Seita 2013). Takaki thought protein was the cause, wrong about why and right about what to do. In Java, Eijkman found chickens fed polished rice developed polyneuritis that rice polishings cured, and Vorderman's survey of about 100 prisons found beriberi in fewer than 1 in 10,000 prisoners eating brown rice against 1 in 39 eating white (Vorderman 1897 via James Lind Library, Nobel Committee 1929).

Modern record. In Karen refugee camps on the Thai and Burmese border, infant mortality was 18% in 1987 to 1990, and beriberi caused 40% of infant deaths. After recognition and treatment, case fatality fell from almost 100% to 7%, and infant mortality from 183 to 78 per 1,000 (Luxemburger et al. 2003, abstract only).

Treatment. Infants: 10 mg by mouth daily for 3 to 4 weeks, or 25 mg by injection when severe. Acute adults: 50 mg three times a day for a few days, then 10 mg a day (MSF thiamine). Wet beriberi responds within hours.

Voices. Tradition in Asia linked beriberi to white rice. Takaki and Vorderman counted it. Eijkman's work led to the vitamin.

1.4 Rickets (vitamin D and calcium)

Signs. Softened skull, wide wrists, beaded ribs, bowed legs, bossed forehead, late-closing fontanelle, and in infants fits from low calcium and heart failure (Munns et al. 2016). Adults develop bone pain and weak muscles.

Onset. Months of growth. A BMJ report described six breastfed infants with florid rickets whose mothers took no supplements and wore concealing clothing (BMJ 1999).

Requirement. Infants need 400 IU (10 μg) a day, children over 1 and pregnant women 600 IU. Calcium below 300 mg a day is deficient and above 500 mg sufficient (Munns et al. 2016, LPI vitamin D).

Sun. In Boston (42°N) skin made no vitamin D from November to February, and in Edmonton (52°N) from October to March (Webb et al. 1988). UK advice is about 10 to 15 minutes of midday summer sun on face and arms several times a week, and later work by Webb gives about 9 to 13 minutes for fair skin in late spring (search summaries, figures differ [VERIFY]). Darker skin needs longer (LPI vitamin D).

Foods. A teaspoon of cod-liver oil gives about 450 IU of vitamin D and about 1,350 μg of vitamin A (LPI vitamin A, search summaries), varying by brand. Oily fish, egg yolk and liver contribute. Plants give none.

History. Sniadecki linked rickets to lack of sun in Warsaw in 1840. In 1919 Mellanby cured rickety dogs with cod-liver oil and Huldschinsky cured children with ultraviolet light. Hess and Unger showed sunlight worked in 1921, and Chick's team in Vienna (1919 to 1922) showed that both oil and sun healed it (search summaries). By 1900 over 90% of children in polluted European cities and over 80% in Boston were said to have rickets, though these are estimates (vitamin D history review, PMC1994178). Rickets returned in Britain from the 1960s among South Asian and West Indian children (search summaries).

Calcium in Nigeria. Thacher's team treated 123 Nigerian children for 24 weeks. Near-complete healing came in 19% with vitamin D alone, 61% with 1,000 mg of calcium and 58% with both. Usual calcium intake was about 200 mg a day (Thacher et al. 1999, abstract only).

Treatment. At least 2,000 IU a day for 3 months with 500 mg calcium (Munns et al. 2016).

Voices. Northern folk practice gave cod-liver oil long before anyone knew why. The record of smoky cities showed the role of sun. Science found the vitamin and the part played by calcium.

1.5 Goitre and cretinism (iodine)

Signs. The thyroid swells. Hypothyroid adults are slow and cold. Children of iodine-deficient mothers may be born with cretinism: severe intellectual disability, deafness, short stature and spastic limbs. Milder deficiency lowers intelligence invisibly. Selenium deficiency is linked to the myxoedematous form (LPI iodine).

Onset and timing. Goitre grows over months to years, but cretinism is fixed in pregnancy. In the Jimi valley of Papua New Guinea in 1966, alternate families received iodised oil or saline. Saline-group mothers bore 26 cretins in 534 births, oil-group mothers 7 in 498, and 6 of those 7 were already pregnant when injected (Pharoah et al. 1971, search summary). Iodine must reach women before conception.

Requirement. Adults 150 µg a day, pregnancy 220 µg (WHO says 250 µg), breastfeeding 290 µg, children aged 1 to 8 90 µg. The upper limit is 1,100 µg for adults (EFSA says 600 µg) and 200 µg at ages 1 to 3. Intake above 18 mg a day causes goitre (LPI iodine).

Foods. Cod gives 146 µg per 3 oz, milk 88 µg per cup, iodised salt 78 µg per quarter teaspoon, an egg 31 µg (LPI iodine). Food grown on iodine-poor soils, in mountains and old glaciated land, carries little.

Seaweed is the obvious coastal source and the hardest to dose. Zava and Zava found *Laminaria* averaging 1,542 µg per gram dry, kombu 2,500 to 10,000 µg, kelp flakes over 8,000 µg, wakame typically 42 to 66 µg (range 30 to 185), nori 16 to 43 µg, dulse 44 µg and hijiki 391 µg. Boiling removed 38 to 94%, unpredictably (Zava and Zava 2011). One gram of dried kelp may carry ten times the daily need. Dried wakame at 2 to 4 g or nori at 4 to 9 g a day comes near 150 µg [VERIFY, my arithmetic]. The American Thyroid Association advises against kelp supplements of 500 µg or more a day (ATA 2023).

Goitrogens. Cassava releases cyanide, converted to thiocyanate, which blocks iodine uptake. Millet, crucifers and soy also act (LPI iodine). Poorly processed cassava in famine also causes konzo, a permanent paralysis (ANU Konzo Prevention Unit). Grass pea (*Lathyrus sativus*) as a famine staple causes neurolathyrism, and about 1,200 were crippled at Vapniarka camp in 1942 (ENN Field Exchange 22, search summary).

Campaigns. Marine and Kimball gave iodine to Akron schoolgirls from 1917 to 1920. Goitre developed in 0.2% of about 2,190 treated girls against 14% of controls (Wikipedia David Marine, Case Western Encyclopedia). Other counts differ [VERIFY]. Michigan began selling salt iodised at 1 part in 5,000 on 1 May 1924. Goitre in schoolchildren fell from 38.6% to 9.9% by 1928 (MSU thesis, search summary [VERIFY]). In Switzerland, Eggenberger won iodised salt for Appenzell Ausserrhoden by popular initiative in 1922, and cretinism disappeared (University of Bern IML). Swiss salt now carries 20 to 25 ppm (search summary).

Making iodine after the Fall. I answer only from the historical record. Courtois discovered iodine in 1811 in the ash of kelp burnt for the saltpetre trade (Wikipedia Bernard Courtois). Kelp burning was already a large industry in the Scottish islands, where communities cut, dried and burnt weed in kilns (The Past). In 1841, 2,565 tons of kelp were imported into the Clyde for iodine works, and by 1864 Paterson's works in Glasgow were the largest (search summaries [VERIFY]). These were chemical works with skilled labour, large tonnages of weed, fuel and acids. I found no reliable yield of iodine per ton. The trade died when Chilean nitrate and German potash deposits supplied iodine more cheaply. A district needs no works. Three thousand people at 150 μg a day need about 165 g of iodine a year [VERIFY, my arithmetic]. A stock of iodised salt or iodine laid in before trade fails covers decades, and measured dried wakame or nori, eaten rather than processed, is safer than any attempt at extraction.

Voices. Alpine tradition treated goitre with burnt sponge, which contains iodine, and folk cures abounded where iodised salt was the real answer (THRIVING library, FO-03). The record from Akron, Michigan, Switzerland and the Jimi valley is among the clearest in public health.

1.6 Iron-deficiency anaemia

Signs. Pale inner eyelids, palms and nail beds, tiredness, breathlessness, fast heart, spoon-shaped nails, and eating soil. Children learn more slowly.

Requirement. Men 8 mg a day, women 18 mg, pregnancy 27 mg, children aged 1 to 3 7 mg and 4 to 8 10 mg, infants of 7 to 12 months 11 mg. Those eating no meat need 1.8 times as much (LPI iron).

Absorption. Haem iron from meat is absorbed at about 15 to 35% (search summary [VERIFY]). Non-haem iron from plant diets is absorbed at about 10% against 18% from a mixed diet (LPI iron), or 5 to 12% against 14 to 18% (Hurrell and Egli 2010). Phytate in grain and pulses halves absorption even at small doses, and soaking, sprouting and fermenting reduce it. Calcium at the same meal inhibits (LPI iron). Black tea with a meal cut absorption by 79 to 94% and herbal teas by 47 to 84% (Hurrell et al. 1999, secondary summary). Doubling the ratio of vitamin C to iron raised absorption from 14.8% to 22.1%, and removing phytate from 20.7% to 33.1% (Davidsson et al. 2001, search summary). The rules: eat iron with vitamin C, keep tea away from meals, sprout or ferment, and eat a little meat or offal.

Foods. Cooked spinach gives 6.4 mg per cup (poorly absorbed), lentils 3.3 mg per half cup, chicken liver 3.6 mg per ounce and beef 1.6 mg per 3 oz (LPI iron).

Iron pots. In Ethiopia, Adish and colleagues randomised 407 children to food cooked in iron or aluminium pots. Anaemia fell from 57% to 13% with iron and from 55% to 39% with aluminium (Adish et al. 1999, via ENN Field Exchange 7). A Malawi trial found no effect, probably because malaria caused the anaemia (search summary). In Cambodia an iron ingot cooked with food did not raise haemoglobin in 340 women, of whom only about 9% were iron deficient (Rappaport et al. 2017, abstract only).

Hookworm. A 1972 Thai isotope study of 15 patients gave about 0.1 mL of blood per worm per day (range 0.023 to 0.26), and heavy infections lose up to 9 mL a day (Mahidol repository, Merck Manual). The Rockefeller Commission found about 40% of those examined infected in 11 southern states, and shoes matter as much as latrines (THRIVING library, HY-04).

Overdose. Iron tablets are the leading cause of poisoning deaths in children under 6. Toxicity begins at 20 to 60 mg per kg and death at 180 to 250 mg per kg (LPI iron).

Voices. Tradition gave liver and iron water to the pale. The record supports iron pots where iron is the problem. Science explains absorption.

1.7 Vitamin A and night blindness

Signs. WHO grades run from night blindness (XN) through dry conjunctiva and Bitot's spots, foamy grey patches on the white of the eye (X1A, X1B), to dry cornea (X2), ulcer and melting cornea (X3A, X3B), and scars (EyeWiki). Corneal involvement is a blinding emergency. Deficiency raises deaths from measles and diarrhoea before any eye sign.

Onset. Liver stores protect well-fed adults for months. I found no reliable figure for time to night blindness [VERIFY].

Requirement. Men 900 µg RAE, women 700 µg, pregnancy 770 µg, breastfeeding 1,300 µg, children aged 1 to 3 300 µg. The upper limit for preformed vitamin A is 3,000 µg in adults and 600 µg under 4 (LPI vitamin A).

Foods. A 68 g slice of beef liver gives 6,420 µg, half a cup of sweet potato 960 µg, pumpkin 955 µg, carrot 534 µg, cooked spinach 472 µg and an egg 98 µg (LPI vitamin A). Plant carotene converts at about 12 to 1 in food but at a median of about 3.7 to 1 when dissolved in oil (search summaries). Red palm oil holds about 375 µg of beta-carotene per gram, and repeated frying cuts it to 70%, 42% and 14% (search summaries [VERIFY]). A Burkina Faso programme used 15 mL three times a week (search summary [VERIFY]).

Trials. In Aceh, Sommer's team gave capsules to children in 450 villages, and mortality fell by 34% at ages 12 to 71 months (Sommer et al. 1986). Beaton's meta-analysis of eight trials found a 23% reduction (Beaton et al. 1993), and the Cochrane review 12% (THRIVING library, IN-01). DEVTA, with about a million children in north India, found 4% (THRIVING library, IN-01). WHO advises 100,000 IU at 6 to 11 months and 200,000 IU at 12 to 59 months every 4 to 6 months where deficiency is a public health problem (WHO 2011). In 2013, 29% of children in poorer countries were deficient, 48% in sub-Saharan Africa (Stevens et al. 2015).

Toxicity. Chronic intake of 8,000 to 10,000 µg a day causes toxicity, and infants show a bulging fontanelle. High intake in early pregnancy causes birth defects, though no increase in risk was seen below 3,000 µg a day of supplements (LPI vitamin A). Polar bear liver carries about 18,000 IU per gram and has poisoned explorers (Rodahl 1939 via search summary, StatPearls).

Voices. Treating night blindness with liver is ancient [VERIFY]. The record shows a real but setting-dependent effect on child deaths.

1.8 Folate and neural-tube defects

Signs and timing. Folate deficiency causes megaloblastic anaemia. On a folate-free diet in 1962, Victor Herbert's serum folate was low at 3 weeks, neutrophils were hypersegmented at 7 weeks, his marrow megaloblastic at 18 weeks and anaemia appeared at about 133 days (MedLink, Golding 2018). The danger in pregnancy is earlier and silent: the neural tube closes by about day 28 after conception (search summaries).

Trials. The MRC Vitamin Study gave 4 mg folic acid to women with a previous affected pregnancy. Recurrence fell from 21 of 602 (3.5%) to 6 of 593 (1.0%), a 71% reduction (MRC 1991). Czeizel and Dudás found no first neural-tube defects with a 0.8 mg multivitamin against 6 in controls (Czeizel and Dudás 1992).

Requirement and foods. Adults need 400 µg dietary folate equivalents a day, pregnant women 600 µg (search summaries). Raw spinach gives 194 µg per 100 g, cooked lentils 181 µg and chickpeas 172 µg, with wide variation between sources (42 to 557 µg for chickpeas). So 200 g of cooked lentils plus 100 g of lightly cooked greens covers 400 µg [VERIFY, my arithmetic]. Boiling loses about half and steaming little (search summaries [VERIFY]). A woman planning pregnancy should eat pulses and greens daily from at least three months before.

1.9 Vitamin B12 for those without animal food

Signs. Megaloblastic anaemia, tingling hands and feet, unsteady gait, memory loss. In about a quarter of cases nerve signs are the only sign (LPI B12), and they may not reverse.

Onset. Adults store over 2,500 µg (LPI B12), enough for 3 to 5 years (Merck Manual). Breastfed infants of vegan mothers deteriorated neurologically at 3 to 6 months, with incomplete recovery (PubMed 502936, abstract only).

Requirement and foods. Adults 2.4 µg, pregnancy 2.6 µg, breastfeeding 2.8 µg. Clams give 84 µg per 3 oz, beef 7.0 µg, milk 1.3 µg per cup and an egg 0.4 µg (LPI B12). Two cups of milk a day, or meat or fish every few days, covers an adult [VERIFY, my arithmetic]. Dried nori held 55 to 59 µg per 100 g and restored B12 status in deficient rats (Takenaka et al. 2001), but spirulina carries an inactive analogue and human evidence for nori is unsettled. A community keeping no animals has about three years before adults show signs and months before infants do.

1.10 Plants: binomials, parts used and lookalikes

Plant	Part used	Supplies	Danger or lookalike
Dog rose, *Rosa canina*	Ripe hips, hairs removed	Vitamin C	Content varies tenfold
Blackcurrant, *Ribes nigrum*	Berries	Vitamin C	None found
Sea buckthorn, *Hippophae rhamnoides*	Berries	Vitamin C	None found
Cabbage and kale, *Brassica oleracea*	Leaves, raw or fermented	Vitamin C, folate	Mild goitrogen in quantity (LPI iodine)
Potato, *Solanum tuberosum*	Tuber	Vitamin C	Green tubers are toxic [VERIFY]
Scots pine, *Pinus sylvestris*	Young needles	Little vitamin C	Yew, *Taxus baccata*, kills (PMC7047065). *Pinus ponderosa* causes abortion in cattle (PubMed 8826003)
Eastern white cedar, *Thuja occidentalis*	Proposed *annedda*	Uncertain	Thujone convulsant. Do not use
Mung bean *Vigna radiata*, lentil *Lens culinaris*, chickpea *Cicer arietinum*, pea *Pisum sativum*	Seeds, sprouted or cooked	Vitamin C when sprouted, thiamine, folate, iron	Not grass pea, *Lathyrus sativus*, as a staple
Groundnut, *Arachis hypogaea*	Seeds	Niacin, tryptophan	Mouldy nuts carry aflatoxin [VERIFY]
Maize, *Zea mays*	Grain, nixtamalised	Staple	Pellagra if eaten alone
Rice, *Oryza sativa*	Grain, brown or parboiled	Thiamine	Beriberi if polished
Oil palm, *Elaeis guineensis*	Unrefined red oil	Carotene	Refined oil carries none
Sweet potato, *Ipomoea batatas*, orange-fleshed	Root	Carotene	None found
Carrot, *Daucus carota*	Root	Carotene	Wild carrot resembles hemlock, *Conium maculatum* [VERIFY]

Plant	Part used	Supplies	Danger or lookalike
Kelp, *Laminaria* and *Saccharina*	Dried frond	Iodine	Dose too high and variable
Wakame *Undaria pinnatifida*, nori *Porphyra* and *Pyropia*, dulse *Palmaria palmata*	Dried frond	Iodine, some B12 in nori	Weigh the dose
Cassava, *Manihot esculenta*	Root, fully processed	Staple	Cyanide, konzo, goitre

1.11 Today and after the Fall

Today these diseases hide behind fortified flour, iodised salt, imported citrus, cheap meat and tablets. They surface in refugee camps, prisons, the very poor, heavy drinkers and covered or housebound people, and a clinician may see one scurvy case in a decade and miss it. After the Fall the protection goes in a known order. Vitamin C, thiamine and folate fail within weeks or months of a monotonous diet. B12 stores last adults about three years. Iodine failure shows in children born after the salt runs out. The hungry gap from late winter to early summer will bring scurvy and pellagra in spring as it did in Lombardy and Ghor. A village that plans its store well will see none of these. A village that grows one crop will see several.

2. Evidence grades

A: controlled trials or large consistent natural experiments. **B**: strong historical or observational record with a clear mechanism. **C**: plausible from mechanism or small studies. **D**: tradition only. **X**: shown not to work or to harm.

Claim	Tradition	Record	Science	Grade
Citrus and fresh vegetables prevent and cure scurvy	Yes	Lind, Navy, Cook	Vitamin C	A
10 mg vitamin C a day prevents frank scurvy	No	Sorby trial	Yes	A
Sprouted pulses prevent scurvy	Some	Riddoch, ENN	Yes	B
Sauerkraut prevents scurvy	Yes	Cook	Yes	B
Pine needle tea prevents scurvy	Strong	Low measured content	Weak	C
Vinegar, sea water, vitriol cure scurvy	Yes	Lind	No	X
Processed lime juice prevents scurvy	Navy belief	Nares, Chick	Low content, processing loss	X
Groundnuts and pulses prevent pellagra	Some	Malawi, Goldberger	Yes	A
Nixtamalised maize prevents pellagra	Mesoamerica	Absence there	Mechanism disputed	B

Claim	Tradition	Record	Science	Grade
Brown or parboiled rice prevents beriberi	Some	Takaki, Vorderman	Yes	A
Thiamine treats infant beriberi	No	Karen camps	Yes	A
Summer sun prevents rickets in temperate zones	Some	Hess, Chick	Yes	A
Calcium heals rickets in low-dairy settings	No	Thacher	Yes	A
Cod-liver oil prevents rickets	Strong	Mellanby, Chick	Yes	A
Iodised salt prevents goitre and cretinism	No	Akron, Michigan, Switzerland	Yes	A
Iodine must precede conception	No	Pharoah	Yes	A
Seaweed as daily iodine source	Coastal	Japan	Dose variable	C
Village extraction of iodine from kelp	Industrial only	No village record	Chemistry feasible	D
Iron pots reduce anaemia	Some	Ethiopia yes, Malawi and Cambodia no	Depends on cause	B
Vitamin C with meals raises iron absorption	No	Isotope studies	Yes	A
Single-dose deworming raises haemoglobin	No	Cochrane: little	Partly	C
Vitamin A capsules reduce child deaths	No	Sommer, Beaton, DEVTA	Yes	A, smaller today
Folic acid before conception prevents neural-tube defects	No	MRC, Czeizel	Yes	A
Food folate alone suffices	No	Not tested	Plausible	C
Nori supplies usable B12	No	Rats only	Disputed	C

3. Means ledger

Rungs: (1) hands and knowledge, (2) hearth, (3) garden and still, (4) village dispensary, (5) district infirmary, (6) hospital before the Fall.

Disease	1	2	3	4	5	6
Scurvy	Know gums, leg pain, the 10 mg floor	Sprout pulses, steam, no copper	Brassicas, currants, hips, potatoes, sauerkraut	Ascorbic acid tablets, hip syrup	Treatment doses, wound care	Blood levels, IV
Pellagra	Know the sun-exposed rash	Nixtamalise, add beans	Groundnuts, beans, milk animals	Nicotinamide	Care of delirium	Blood tests
Beriberi	Squat test, swollen legs	Parboil, do not over-wash rice	Pulses, whole grain, pigs	Thiamine tablets	Thiamine injection	Intensive care
Rickets	Wrists, legs, skull, sun calendar	Fish, cod-liver oil if traded	Dairy, small fish	Vitamin D drops	Treatment doses, calcium	X-ray
Iodine	Feel the neck, watch births	Weighed seaweed, salt stock	Seaweed harvest	Iodised salt stock	Iodised oil before pregnancy	Thyroid tests
Iron	Pallor of eyelid and palm	Iron pots, vitamin C, tea apart	Meat, offal, pulses	Iron tablets, locked	Deworming	Transfusion
Vitamin A	Ask about dusk vision, look for Bitot's spots	Red palm oil, liver, carrots in fat	Orange sweet potato, squash, hens	Capsules by age	Measles doses	Eye surgery
Folate	Know the day-28 window	Steam greens, daily pulses	Greens, lentils, chickpeas	Folic acid	4 mg after an affected birth	Ultrasound
B12	Know who eats no animal food	Milk, eggs, fish	Hens, goats, fish ponds	B12 tablets	Injections	Blood tests

4. Harm test

Vitamin A. One 68 g slice of beef liver holds 6,420 µg (LPI vitamin A), twice the adult upper limit and ten times the limit under 4. Weekly liver is safe for most adults [VERIFY]. In early pregnancy, high preformed vitamin A causes birth defects (LPI vitamin A), so pregnant women eat liver only in small portions and never polar bear or seal liver. Capsules of 200,000 IU are for children over one, not pregnant women (THRIVING library, IN-01). Plant carotene is not toxic.

Cod-liver oil. One teaspoon gives about 450 IU of vitamin D and about 1,350 µg of vitamin A, more than double the infant vitamin A limit of 600 µg [VERIFY, my arithmetic]. Infants should get a quarter to half teaspoon at most, or plain vitamin D.

Vitamin D. Toxicity is defined by blood levels above 250 nmol/L (Munns et al. 2016). Without a laboratory, keep to consensus doses.

Iodine. Kelp and kombu carry 1,500 to 10,000 µg per gram (Zava and Zava 2011). Above 18 mg a day causes goitre (LPI iodine). People with long-standing goitre may become hyperthyroid when iodine arrives suddenly [VERIFY].

Start with weighed wakame or nori.

Iron. Toxicity begins at 20 mg per kg (LPI iron), so a 10 kg toddler is at risk from about 200 mg, a few adult tablets [VERIFY, my arithmetic]. Lock tablets away.

Niacin. Nicotinic acid above 35 mg a day causes flushing. Nicotinamide is safer (LPI niacin).

Vitamin C. The upper limit is 2 g a day (LPI vitamin C). Food sources pose no risk.

Lime. Calcium hydroxide burns eyes and skin. Wash grain well. Above about 0.5% lime, protein quality fell (FAO 1992).

Conifer teas. Yew kills, with no antidote, and a tea of three spoons of needles has proved fatal (PMC7047065). Pregnant women should avoid pine teas (PubMed 8826003). *Thuja* contains thujone.

Famine staples. Grass pea, unprocessed cassava and maize alone each cause their own disease. Monoculture is the root harm.

Sprouts and seaweed. Sprouts grown warm and wet can carry bacteria, and hijiki is reported to carry arsenic [VERIFY both]. Rinse sprouts in clean water and harvest weed away from outfalls.

5. Red flags

Act the same day on any of these.

- A child who will not walk, cries when the legs are touched, or has bleeding gums: give vitamin C.
- Old scars reopening in late winter.
- A breastfed infant of a few months with fast heart, swelling, vomiting or weak cry, whose mother eats mostly rice: give thiamine to infant and mother. Death can follow within hours to days [VERIFY].
- An adult who cannot rise from a squat or has burning feet and swollen legs.
- Confusion and staggering in a starved or heavy-drinking person: thiamine before food (THRIVING library, HY-09).
- A symmetrical spring rash on hands, forearms and neck, with diarrhoea or confusion: pellagra.
- A child who cannot see at dusk or has Bitot's spots. A hazy or ulcerated cornea is an emergency.
- Measles in a poor community: vitamin A on two days (THRIVING library, IN-01).
- An infant with a fit and no fever, or soft skull bones: low calcium from rickets.
- A growing neck swelling in a pregnant woman or child, or a cluster of deaf or slow children born in the same years: iodine.
- A pale, breathless child who eats soil: iron and hookworm (THRIVING library, HY-04).
- A vegan mother's infant who stops developing.
- The same deficiency in several households at once: the food supply has failed.

6. The case against

The vitamin C figure. Hemilä and Chalker (2025) argue that the UK recommendation rests on a narrow reading of the Sorby trial, and Hujoel's reanalysis of the same data put the need at 95 mg (UW News 2021). This report uses 10 mg as the floor against death and 45 mg as the target. A stricter reader would aim nearer 90 mg, which is hard in winter.

Lind as a founding trial. Two men per arm is a story, not a trial. The strong evidence came from the Navy's later experience.

Nixtamalisation. The FAO's 1992 review reports that Bressani and colleagues found in vitro digestion freed as much niacin from raw maize as from tortilla, and that cats used niacin from raw and limed maize equally. It links

pellagra to the amino-acid balance of maize (FAO 1992). A University of Pretoria study disputes nixtamalisation as the explanation and points to near-single-food diets (University of Pretoria, abstract only). The safe practice is to lime the maize and add beans.

Vitamin A capsules. DEVTA, led by Awasthi and Peto, found a 4% reduction in deaths against Sommer's 34%. Sommer, West and Martorell criticised DEVTA's conduct (THRIVING library, IN-01). The effect shrinks where measles and diarrhoea deaths are fewer.

Deworming. Taylor-Robinson, Garner and colleagues found single-dose deworming changed haemoglobin by only 0.1 g/dL across five trials with 1,252 participants (Taylor-Robinson et al. 2019). Others dispute their selection of trials.

Iron pots and fish. Rappaport and colleagues found no effect in Cambodia, where few women were iron deficient (Rappaport et al. 2017), and the Malawi pot trial failed where malaria caused the anaemia. What works in Ethiopia may fail elsewhere.

Vitamin D alone. Thacher found calcium healed three times as often as vitamin D (Thacher et al. 1999). Sun advice is wrong where calcium is the gap, and useless in winter above about 42°N (Webb et al. 1988).

Folk cures. Pine needles are weak in vitamin C on the evidence found, and Cartier's tree is unidentified. Burnt sponge for goitre worked only through unmeasured iodine. Lind's vinegar and sea water show how many cures were useless (THRIVING library, FO-03).

Composition tables. Rose hips vary tenfold, cabbage ninefold, chickpea folate thirteenfold and seaweed iodine several hundredfold. Soil sets iodine and selenium in everything grown on it. Grams per day are guides, not doses.

7. Ten-line summary

1. Every deficiency here is a disease of a narrow diet. Variety prevents all of them.
2. Ten milligrams of vitamin C a day prevents scurvy and about 45 mg is the target. Sprouted pulses, sauerkraut, brassicas, currants and hips carry a village through winter.
3. Heat, copper, air and storage destroy vitamin C. Processed lime juice failed the Navy in 1875.
4. Maize alone causes pellagra. Groundnuts or beans prevent it, and liming helps for disputed reasons.
5. Polished rice causes beriberi within weeks. Brown or parboiled rice and pulses prevent it. Infants die fastest.
6. Rickets needs summer sun at temperate latitudes and calcium everywhere. Calcium alone healed rickets in Nigeria.
7. Iodine must reach women before conception. A district needs only about 165 g a year, so stock it rather than make it.
8. Seaweed iodine varies several hundredfold. Weigh wakame or nori and avoid kelp as daily food.
9. Plant iron is poorly absorbed. Eat it with vitamin C, keep tea apart, cook in iron, wear shoes.
10. Liver, orange vegetables and red palm oil prevent vitamin A deficiency. Folate before conception prevents most neural-tube defects. B12 needs some animal food.

8. Open questions

- Was Lind's citrus ration two oranges and a lemon, or two lemons and an orange?
- How much vitamin C does a conifer needle infusion carry, and which tree was *annedda*?
- Does liming protect against pellagra by freeing niacin or by other routes?
- What was the iodine yield per ton of kelp in the 19th-century trade?
- How fast does iodised salt lose iodine in damp storage?
- Does nori supply usable B12 to humans?
- How much folate does a temperate cottage diet deliver across the year?

- How long from zero vitamin A intake to night blindness in a child?
- Who wrote the Medical History paper on copper boilers and scurvy?

9. Sources to read in full

1. Lind (1753), *A Treatise of the Scurvy*.
2. Carpenter (1986), *The History of Scurvy and Vitamin C*, especially the Arctic chapter.
3. Kraut (2003), *Goldberger's War*. Not read.
4. Munns et al. (2016), the rickets consensus tables.
5. Sommer and West (1996), *Vitamin A Deficiency: Health, Survival and Vision*. Not read.
6. Hetzel (1989), *The Story of Iodine Deficiency*. Not read.
7. Riddoch, Mills and Duthie (1998), the sprouting method in full.
8. WHO (2000), *Pellagra and its prevention and control in major emergencies*. Blocked.
9. Luxemburger et al. (2003), the infant beriberi tables.
10. Zava and Zava (2011), seaweed iodine by species.
11. Bartley, Krebs and O'Brien (1953), the Sorby report. Scanned, not read.

At the bedside after the Fall

A deficiency first presents as tiredness, and the question that finds it is about food. Ask what the family has eaten for three months, whether anything green, fresh, sprouted, fermented or animal has been in it, and who eats last.

Then look. Open the mouth for swollen, bleeding gums and a raw red tongue. Look at the legs for bleeds round the hairs and at the backs of the hands and neck for a symmetrical rash. Pull down the lower eyelid for pallor and look at the white of the eye for foamy spots. Feel the front of the neck. In a child, feel wrists and ribs, look at the legs and press the skull gently. Ask an adult to squat and rise without hands. Ask the mother whether the child sees at dusk.

One deficiency suggests others, because the same narrow diet causes them. Treat the person and the household, which shares the pot, and tell the village, because one case means the store has failed. Response is fast: wet beriberi improves in hours (MSF thiamine) and scurvy within a week to three months (Trapani et al. 2022). If the person does not improve on the right food or tablet, look for infection, worms, malaria or blood loss.

Protocols

Protocol 1. Winter vitamin C for a village of 300

- ☐ Per person per day: at least 10 mg (floor), about 45 mg (target) (Hemilä and Chalker 2025, LPI vitamin C).
- ☐ Village need at 45 mg: about 13.5 g a day, about 2 kg of vitamin C over a 150-day winter [VERIFY, my arithmetic].
- ☐ Sauerkraut at about 25 mg per 100 g: 180 g per person per day for the target, 40 g for the floor. For 300 people over 150 days, about 8 t or 1.8 t [VERIFY, my arithmetic]. Cook's 130 g a day lies between. Recipe in FEASTING.
- ☐ Sprouted pulses: germinate about half the daily pulse ration for 3 to 5 days and eat raw or barely cooked (Riddoch et al. 1998, ENN Field Exchange 17). Rinse in clean water at least twice a day [VERIFY].
- ☐ Rose hips: dry or make syrup in autumn, but do not rely on them alone.
- ☐ Potatoes: count on half the autumn value by mid-winter.
- ☐ Cook briefly or steam. Never in copper.
- ☐ Expect first cases about 8 weeks after fresh food stops.
- ☐ Treatment: 100 mg three times a day for children, 250 mg three times a day from 12 years, at least 2 weeks, then 50 mg a day (MSF ascorbic acid).

Protocol 2. Household nixtamalisation of maize

- ☐ Lime (calcium hydroxide) at 1 to 3% of dry grain weight (ECHO). A patent found in search gives 1 to 2% [VERIFY]. Use the lower end: 10 to 20 g per kg.
- ☐ Water about three parts to one of grain (ECHO).
- ☐ Boil 30 to 60 minutes (ECHO) or 30 to 40 minutes (patent [VERIFY]).
- ☐ Stand, then rinse until the skins rub off [VERIFY standing time].
- ☐ Grind wet. Gloves and eye care with lime, stored out of children's reach.
- ☐ Always serve with beans or groundnuts.

Protocol 3. Pellagra

- ☐ Prevention: about 15 mg niacin equivalents a day (MSF). About 100 g of groundnuts, or beans, milk, meat or fish daily [VERIFY, my arithmetic].
- ☐ Never let the groundnut or bean supply lapse. A five-month gap preceded 17,878 cases in Malawi (CDC MMWR 1991).
- ☐ Treatment: nicotinamide 100 mg three times a day with protein until healed (MSF pellagra).
- ☐ Watch in spring.

Protocol 4. Beriberi

- ☐ Prevention: 1.1 to 1.4 mg thiamine a day (LPI thiamin). Brown, undermilled or parboiled rice, washed once, and pulses daily.
- ☐ Breastfeeding mothers on rice diets first.
- ☐ Infants: 10 mg by mouth daily for 3 to 4 weeks, 25 mg by injection if severe. Treat the mother (MSF thiamine).
- ☐ Adults, acute: 50 mg three times a day for a few days, then 10 mg a day (MSF thiamine).
- ☐ Thiamine before refeeding any starved person (THRIVING library, HY-09).

Protocol 5. Rickets

- ☐ Infants 400 IU vitamin D a day in year one. Children over 1 and pregnant women 600 IU (Munns et al. 2016).
- ☐ Calcium above 500 mg a day for children (Munns et al. 2016).
- ☐ Sun on face and arms around midday several times a week from late spring to early autumn. None useful from November to February at 42°N (Webb et al. 1988).
- ☐ Cod-liver oil for infants: no more than a quarter to half teaspoon [VERIFY, my inference from LPI vitamin A].
- ☐ Treatment: at least 2,000 IU a day for 3 months with 500 mg calcium (Munns et al. 2016).

Protocol 6. Iodine for a district of 3,000

- ☐ Need: 150 µg adults, 220 to 250 µg pregnancy, 290 µg breastfeeding (LPI iodine).
- ☐ District need about 165 g of iodine a year [VERIFY, my arithmetic]. Stock iodised salt or iodine before trade fails.
- ☐ Salt at 20 to 25 ppm: 6 to 7.5 g a day gives about 150 µg [VERIFY, my arithmetic].
- ☐ Coastal: dried wakame 2 to 4 g or dried nori 4 to 9 g a day, weighed [VERIFY, my arithmetic from Zava and Zava 2011].
- ☐ Never kelp or kombu daily. One gram of dried kelp can exceed the adult upper limit.
- ☐ Girls and women before pregnancy first (Pharoah et al. 1971).
- ☐ Process cassava fully and avoid grass pea as a staple.

Protocol 7. Iron

- ☐ Need: 8 mg men, 18 mg women, 27 mg pregnancy (LPI iron).
- ☐ Cook stews in an iron pot (Adish et al. 1999).
- ☐ A vitamin C food with every pulse or grain meal.
- ☐ Tea and coffee well apart from meals [VERIFY interval].
- ☐ Soak, sprout or ferment pulses and grain.
- ☐ Shoes outdoors and latrines used (THRIVING library, HY-04).
- ☐ Iron tablets locked away.

Protocol 8. Vitamin A

- ☐ Need: 700 to 900 µg RAE adults, 300 to 400 µg young children (LPI vitamin A).
- ☐ Orange sweet potato or carrot daily, cooked with a little fat.
- ☐ Red palm oil 15 mL three times a week (search summary [VERIFY]).
- ☐ Liver weekly for adults and older children, small portions in pregnancy.
- ☐ Capsules if held: 100,000 IU at 6 to 11 months, 200,000 IU at 12 to 59 months, every 4 to 6 months (WHO 2011). Measles: dose on two days (THRIVING library, IN-01).

Protocol 9. Folate before pregnancy

- ☐ Every woman who could conceive: 400 µg a day, 600 µg in pregnancy.
- ☐ About 200 g cooked lentils or chickpeas plus 100 g steamed greens daily [VERIFY, my arithmetic].
- ☐ After an affected pregnancy: 4 mg folic acid daily if tablets exist (MRC 1991).

Protocol 10. B12

- ☐ Need: 2.4 µg adults, 2.6 µg pregnancy, 2.8 µg breastfeeding (LPI B12).
- ☐ Two cups of milk daily, or eggs with fish, meat or shellfish weekly [VERIFY].
- ☐ Pregnant and breastfeeding women without animal food first.
- ☐ Do not rely on spirulina. Nori is uncertain.

Numbers to carry

- Vitamin C: 10 mg floor, 45 mg target. Signs after 8 to 12 weeks. Pool 1,500 mg.
- Rose hip 426 mg per 100 g (30 to 1,300). Blackcurrant 200. Kale 120. Lemon 53. Cabbage 30. Potato 20. Sauerkraut 15 to 36.
- Cook's sauerkraut: 2 lb per man per week.
- After 40 minutes: copper pot 25% of vitamin C left, iron pot 56%.
- Niacin 14 to 16 mg. Nicotinamide 100 mg three times a day to treat.
- Thiamine 1.1 to 1.4 mg. Stores last 2 to 3 weeks. Infant dose 10 mg.
- *Ryujo* 169 of 376 ill, 25 dead. *Tsukuba* 14 of 333, none dead.
- Vitamin D 400 IU infants, 600 IU children and pregnancy. No winter synthesis above 42°N.
- Calcium above 500 mg. Nigeria: calcium 61% healed, vitamin D 19%.
- Iodine 150 µg, 250 µg pregnancy, limit 1,100 µg. District of 3,000: 165 g a year.
- Kelp 1,500 to 10,000 µg per gram. Wakame 42 to 66. Nori 16 to 43.
- Jimi valley: 26 cretins in 534 births without iodine, 7 in 498 with.
- Iron 8, 18 and 27 mg. Plant iron absorbed 5 to 12%. Tea cuts it up to 94%.
- Ethiopian iron pots: anaemia 57% to 13%.
- Iron toxic from 20 mg per kg in children.
- Vitamin A 700 to 900 µg. Limit 3,000 adults, 600 under 4. Liver slice 6,420 µg.

- Capsules 100,000 IU at 6 to 11 months, 200,000 IU at 12 to 59 months.
- Folate 400 μg, 600 μg in pregnancy. Neural tube closes by day 28. Recurrence cut 71%.
- B12 2.4 μg. Adult stores 3 to 5 years. Infants fail at 3 to 6 months.

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