Fact sheet: Nutrients that reduce lead poisoning

"By Robert J. Taylor, edited by Anne Roberts, photos by Catherine Sweeny.
This fact sheet is a summary of the article Nutrition to fight lead poisoning
(which includes a complete list of references)."

Which nutrients are important in fighting lead poisoning?

Have you ever wondered what your meals are doing to your body? Good levels of nutrients can improve well-being and resistance to toxins. Deficiencies can render you more vulnerable to toxics because other chemicals replace nutrients.

Many studies have shown that there exists a relationship between our dietary intake and our blood lead level. This article refers to individual nutrients, and their effect on lead metabolism and the amount of lead in the body. It focuses on nutrients found in commonly-consumed food items or supplements. It does not cover nutrients in medicinal plants such as milk thistle (containing silymarin) or St John's wort (with very high levels of melatonin).

It does not include information on the use of nutritional supplements in conjunction with non-nutritional chelation medications (metal binders), which is a field we recommend you discuss with your medical advisor.

REDUCING LEAD ABSORPTION

For reducing lead absorption the key nutrients appear to be **vitamin C**, **calcium**, **iron** and, to a lesser degree, **zinc** and **phosphorus**. Dietary deficiencies in any of these can increase lead absorption, though supplementation of individuals with already high levels of these nutrients in their diet may not have much impact on lead absorption**.** Further, since these minerals compete with, or alter lead absorption during digestion, taking concentrated supplements at one point of time, unless you are deficient in that particular nutrient, may not affect continuing lead absorption, once the supplements have been processed through a particular stage of digestion.

Vitamin D and **folate** (vitamin B9) can actually *increase* lead absorption, but have offsetting advantages: **vitamin D** can play a role in decreasing the quantity of lead stored in the bone, while **folate** seems to increases excretion more than it increases absorption.

INCREASING LEAD EXCRETION

For increasing lead excretion, two low toxicity B group vitamins have had widely demonstrated impacts in animal studies: **B1 (thiamine or thiamin)**, which specifically increases excretion from the brain, and **B9 (folate or folic acid)**; both are now compulsory additives in non–organic bread inside Australia.

Vitamin B6 can increase lead excretion in animals, but there are few studies to draw conclusions from.

Vitamin C has chelating (metal binding) properties, and can increase lead excretion, but its impacts on excretion have not always been consistently demonstrated, particularly at higher lead levels. **Pectin** also has been linked to higher lead excretion, but questions have been raised as to its degree of effectiveness.

For reducing blood lead levels, **vitamin C, vitamin E**, **thiamine (B1)**, **folate (B9)** and **iron** have the strongest and most consistent blood lead links.

Vitamin B1: the items pictured left are rich in thiamine, a vitamin consistently linked to higher lead excretion, particularly from the brain. It has minimal toxicity with side effects generally occurring only at doses above5g. Top row: nuts (cashew nuts pictured), milk, Milo, whole-grain biscuits (Vita-Wheat) *Middle Row:* lentils, orange, whole grain bread *Bottom row:* pork, snow peas, peas, beans.

HYPERTENSION

Indicators of hypertension - hypertension is linked to cardiovascular problems - have been reduced by **vitamin E** in animal studies. However, as with similar findings for **vitamin C**, these findings have not been confirmed in long-term human studies. **Taurine, magnesium**, **calcium** and low fat milk have been linked to lower risks of hypertension in human studies.

ANAEMIA (US: anemia)

Lead–induced anaemia is caused by lead interfering with the haeme [heme] synthesis pathways (part of red blood cell manufacture). Materials, mostly manufactured by the liver and in the bloodstream, are assembled into red blood cells in the bone marrow, and it is this entire process, particularly the incorporation of oxygen-carrying haemoglobin into blood cells, which is disrupted by lead.

Good levels of **iron** in the blood help to protect against anaemia in general. **Vitamin C** and **zinc** have positive impacts on the haeme synthesis pathway (potentially protecting oxygen carrying capacity), while **vitamin E** improves the stability of red blood cell membranes

(reducing lead-induced fragility). Significant **copper** deficiency produces anemia, possibly influencing lead-based anaemia, according to some animal experiments, and it is worth noting that **iron** and **zinc** interfere with **copper** absorption, while **lead** and **vitamin C** reduce some copper indicators in the body.

KIDNEY AND LIVER FUNCTION

In animal, and a few human studies, **zinc**, **selenium**, **taurine**, **garlic**, **methionine**, **glycine** and **vitamins C**, **E, B1** and **B6** have significant protective impacts on kidney and liver function, with strong indications that most of these nutrients work better in combination with each other than alone. Good levels of **iron** can reduce lead levels in the kidneys and help protect kidney function.

BRAIN FUNCTION

In animal studies, **vitamin C**, **taurine**, **zinc**, **selenium, calcium,** and the amino acids **methionine** and **glycine** have proved somewhat effective in protecting brain function, though predominantly in combination with each other rather than alone. A human study has found indications that **folate** may be strongly neuroprotective, particularly with children. From animal experiments, it appears that **iron** can protect the blood-brain barrier and reduce lead-induced apoptosis (programmed cellular death) inside the brain. Lead-induced death of brain cells has also been linked to reduction in **glutathione**, a key antioxidant which may be poorly absorbed, at least in supplement form, so maintaining good intakes of the amino acids **cysteine, glutamic acid** and **glycine,** which are used in **glutathione's** manufacture within the body, could be helpful. **Thiamine**, **taurine**, **vitamin B12** and **methionine** have been shown in animal studies to be able to reverse some lead-induced loss of brain function.

Zinc: is found in a variety of food. *Rear row:* pecan nuts, sesame seeds, cashews, dates, linseed, wheat germ. *Middle row:* cocoa, oysters, crab, poppy seeds, beef. *Front Row:* blue cheese, eggs, pine seeds.

THE NERVOUS SYSTEM AND HEARING LOSS

Calcium, and to a lesser degree **selenium**, may help protect the nervous system from lead-induced degradation, with indications that selenium has a direct impact on lead-induced hearing loss.

BONES

Calcium, **zinc** and **vitamin D** can play a significant role in decreasing the amount of lead deposited in the bones, and resorption (release of lead and other minerals from the bone to the blood), but, given the complex nature of bone formation and resorption, these three nutrients probably require adequate supplies of **phosphorus**, **magnesium**, **vitamin B6** and **vitamin K** to be fully effective.

Vitamin D: There are few good food sources of vitamin D. Some food sources such as some milk types have vitamin D added (rear picture) but the primary unfortified source is fish (centre row: haddock, salmon and sardines) though similar quantities are available from mushrooms grown under ultraviolet light (not yet widely available). Much smaller quantities are available from egg yokes (front right) and liver.

SUMMARIES

The role of vitamins in fighting lead poisoning

Vitamins are the nutrient grouping that has been most studied in regard to lead impacts.

Vitamin C has been consistently linked to lower blood lead levels and reduced organ damage. It may inhibit lead uptake at a cellular level, thereby reducing lead's toxicity to some organs. It prolongs the useful functioning of vitamin E. Vitamin C has been used in chelation therapy in naturopathic lead treatment, though experimental results on vitamin C' s ability to increase lead excretion have not been consistent.

Vitamin C: 480 g of the foods (pictured left) eaten raw should provide sufficient Vitamin C to reach 400 mg a day (much more if cooked, for juice equivalent check labels), a level linked to significantly lower lead levels. Consistent supplementation to levels above 1g per day carries health risks for some individuals. Top row: parsley, guava (juice pictured), blackcurrant (juice pictured), kale *Middle Row:* radish, capsicum (bell pepper in US), kiwi fruits, broccoli *Bottom row:* feijoa, baby capsicums, brussel sprouts, guava, horse radish *Not pictured:* Mustard greens, red peppers, thyme.

- **Vitamin B1** has effects similar to vitamin C but does not modify as many indicators of lead impact, though it has strong impacts on increasing lead excretion from the brain and protecting brain function.
- **Vitamin B6** and its derivative **taurine** can help protect and repair organs, including the brain, from lead-induced damage.
- **Folate** and **vitamin B12** function symbiotically in the body. Folate improves lead excretion, while both vitamins help in reducing lead-induced damage to the brain. Deficiencies of these two vitamins could worsen lead-induced anaemia (reducing red blood cell production) and add independent neurological damage.

- Higher levels of **vitamin E** are linked to lower blood lead levels to a similar degree as **vitamin C**, but supplementation carries significant risks; it is not recommended for pregnant women or individuals at risk of internal bleeding (e.g. at risk of stroke, on anti-coagulants, or vitamin K deficient). It protects cell membranes, notably of red blood cells, from lead-induced weakness and damage.
- Lead toxicity distorts the **vitamin D** metabolism that is necessary for the formation of bones. Adequate dietary levels of **Vitamin D** and **calcium** reduce this impact, and, in some cases, decrease the blood lead level along with lead deposition in bones, but probably only in the presence of sufficient levels of other minerals to replace the lead and allow bone formation.

The role of minerals in fighting lead poisoning

Many minerals compete with lead for both absorption and uptake by organs within the body. Many aspects of lead toxicity relate to lead's ability to replace key minerals: notably iron, calcium, and zinc, within the body.

1. The replacement of **calcium** by lead in both the brain and nervous system is one of the primary paths of lead toxicity, so good levels of calcium reduce the capacity of lead to impair these functions. High **calcium** levels, when combined with adequate levels of nutrients such as **magnesium** and **vitamin D**, can potentially reduce the release of lead from the bone to the bloodstream and hence to organs of the body. There is strong evidence that **calcium** supplements reduce blood lead during pregnancy, thereby reducing lead concentrations in the newborn. The continuous maintenance of **calcium** levels is important for individuals with high lead exposures, to reduce brain and organ toxicity caused by the ongoing release of lead from the bone. However, **calcium** does not work in isolation, and good levels of **phosphorus** and **magnesium** may have supplementary effects on lead absorption, toxicity and bone stability. Due to increased bone turnover during pregnancy, lactation and menopause, this is of particular importance to women.

Calcium: This nutrient has many sources. However its impact on bone health is dependant on many other nutrients. Back row: Chinese cabbage, yogurt, milk, cheese, aniseed seeds (fennel), bok choi *Middle row:* seeds (poppy, sesame), tofu and coriander *Front row:* Fish (sardines, salmon anchovy), dill, kale, broccoli. *Not pictured:* Chinese spinach (araminth), mustard greens.

2. **Iron** functions similarly to **calcium**, competing with lead for absorption in the gut and uptake within the body. Good levels of iron can reduce lead-induced brain and kidney damage, while lessening the impact of lead-induced anaemia. **Iron** deficiency, which significantly increases lead absorption, is the most common nutrient deficiency, found predominantly among pre-menopausal women and children. **Iron** deficiency has independent impacts on the brain and blood cells, which can exacerbate lead impacts, particularly in children.

3. The impact of **zinc** is similar in nature to **iron** and **calcium,** but more muted, with no strong evidence of impacts on blood lead levels, and mixed impacts on organs and bones. However, it appears to significantly lessen lead impacts on the liver, kidneys, testes and especially the brain, an organ with very high concentrations of **zinc**.

Phytates: The items pictured are high in phytates and can reduce the absorption of calcium and zinc by up to 67%, magnesium absorption by somewhat less and iron absorption by up to 90%. Phytate content is reduced when baked with yeast (right rear: wholegrain bread*), fermented (*as with some soy products*) or subject to prolonged soaking in water (*used with beans*) and iron absorption is improved if consumed with vitamin C* (*left rear:* apple & blackcurrant juice). *Middle row:* baked beans, beans (black turtle, black eye, lima, white, barlotti), bran, peanuts *Front row:* sunflower & sesame seeds, peas, beans, nuts (almond, brazil, cashew), muesli. *Individuals seeking to boost levels of iron, calcium and zinc should avoid consuming these foods within 2-3 hours of meals rich in the mentioned nutrients. This is less important in the case of magnesium as high phytate food is usually also high in magnesium.*

4. From a small handful of mostly animal studies, there are indications that **magnesium** may reduce lead retention in blood and tissues, and may ameliorate lead-induced hypertension.

5. **Selenium** combines with lead to form non-toxic compounds, potentially reducing lead absorption and toxicity.

6. **Copper** deficiency, which can be magnified by high intakes of lead, iron zinc and vitamin C, causes anaemia, and might influence lead-induced anaemia.

The role of amino acids and other nutrients in fighting lead poisoning

Other nutrients that have influence on lead level are methionine, glycine, curcumin, methionine, carotene and pectin, and nutrients found in garlic.

- From animal studies there are indications that **garlic** could reduce blood and tissue lead levels, probably because it contains a wide range of sulfur-based compounds essential for amino acid construction and antioxidant function, including **methionine**.
- **Methionine** could repair some lead-induced learning and memory decline and help protect against liver and kidney damage.
- **Curcumin** (an active ingredient in turmeric) and **glycine** could be protective against lead-induced brain damage.
- **Cysteine** (which can be replaced using **methionine**), **glutamic acid** or **glutamate** and **glycine** are used to manufacture **glutathione**, a major antioxidant, which, when depleted by lead can increase lead toxicity in the organs, particularly the brain and liver.
- High serum (blood) **carotene** levels have been linked to lower blood lead levels, but there is no real evidence, as yet, that the relationship is causative.
- **Pectin** prophylaxis (preventative dosing as opposed to treatment after lead poisoning) is being used to enhance lead excretion, though there are ongoing arguments about measuring its degree of effectiveness.
- **Melatonin** may have significant capacity to protect organs, including the heart, liver and kidneys, as well as reducing lead-induced anemia, but is available only in small amounts from food, and produces drowsiness (with all the attendant risks) in significant quantities.

DANGERS OF NON-MEDICALLY SUPERVISED NUTRITIONAL SUPPLEMENTATION

As the saying goes, too much of anything is never healthy - there can be significant risks from high levels of vitamin and mineral supplementation. For example:

- **Vitamin C** can increase the risks of kidney stones, cataracts and high iron levels, while adversely impacting some copper indicators.
- **Vitamin E** increases the risk of internal bleeding and heart defects in the unborn fetus.
- **Folate** has been linked to cognitive decline in the elderly and possibly - particularly in its supplemental form (folic acid) – to some cancer types.
- **Melatonin** produces drowsiness and increased likelihood of falling asleep.

- **Calcium** and **Vitamin D** can damage the heart and renal system by increased deposition of calcium in soft tissue.
- **Zinc** can cause anaemia (by blocking copper absorption), and kidney and liver damage.
- **Phosphorus** and **magnesium** are readily excreted but, in the event of renal problems, which can be lead induced, can build to dangerous levels. **Phosphorus** can then cause bone problems and calcium deposition in soft tissues, while **magnesium** can cause seizures and heart attacks.
- **Copper** can damage the liver and kidneys, even inducing coma.
- **Selenium** is toxic at levels above 1000 μg (micrograms) a day, producing selenosis.
- **Iron** supplements have been the largest source of acute accidental childhood poisoning in the USA. When combined (and only when combined), high levels of iron and Very Low Density Lipoprotein (VLDL) cholesterol greatly increase the risk of cancer and Alzheimer's disease. (VLDL production is not governed by consumption of fat, but of sugar.)

IT'S NOT THE FOOD, IT'S THE TABLETS…

It should be noted that vitamins and minerals found in food are generally not sufficiently concentrated to cause problems. *The primary risk remains unsupervised vitamin and mineral supplementation.* Significant vitamin or mineral supplementation, even of non-toxic substances such as vitamin C, should only be undertaken with the advice of your physician or a qualified dietitian.

CONCLUSION

Vitamin C, **thiamine**, **taurine** (a **vitamin B6/cysteine** derivative), **folate**, **vitamin B12**, **garlic** and the amino acids **methionine** and **glycine** may offer significant advantages to lead exposed individuals with few risks. **Calcium, iron**, **zinc**, and **selenium** along with **vitamins B6**, **D** and **E** offer large advantages along with significant offsetting risks at high doses. Good intakes of **phosphorus, magnesium, copper** and **glutamic acid (glutamate)** offer possible smaller advantages with little risk. **Curcumin, pectin** and **cysteine** offer possible significant advantages but their impacts are difficult to gauge. **Melatonin** may also have significant impacts but is only available from food in trace quantities. It must be emphasized that a combination of these nutrients is needed to offset lead's diverse impacts, though if one were to nominate a single nutrient it would probably be **vitamin C** since, in spite of some inconsistent results, it has strong, widespread impacts combined with minimal risks for most individuals (the main exception would be individuals with high iron levels, since it increases iron absorption). If **vitamin C** is taken as a supplement, it should be taken in numerous smaller doses throughout the day. The low toxicity of many **B group** vitamins (especially **thiamine**) offers significant advantages with very low risks. Of the minerals **iron** and **calcium** are essentials, but there is little evidence that very high intakes of these minerals deliver better results than more moderate intakes.

Suggested Reading

1. **Medscape Lead Fact Sheet (highlighting nutrition)** www.medscape.com/viewarticle/552359_2

2. **Effects of Micronutrients on Metal Toxicity** Marjorie A. Peraza, Felix Ayala-Fierro, David S. Barber, Elizabeth Casarez, and Leonard T. Rael *Environ Health Perspect 106(Suppl 1):203-216 (Feb 1998).* [section on lead on pages 206-207] *www.pubmedcentral.nih.gov/picrender.fcgi?artid=1533267&blobtype=pdf*

3. **How Does Lead Effect the Nervous System?** Anjali Patel *Bryn Mawr College, Biology 202 paper* http://serendip.brynmawr.edu/bb/neuro/neuro00/web2/Patel.html

4. **Lead toxicity, a review of the literature** Lyn Patrick Part 1 *Alternative Medicine Review Volume 11, Number 1 2006* www.thorne.com/media/Lead_2.pdf

5. **Lead toxicity Part II: the role of free radical damage and the use of antioxidants in the pathology and treatment of lead toxicity** Lyn Patrick *Alternative Medicine Review Volume 10, Number 4 December 2005 www.thorne.com/altmedrev/.fulltext/11/2/114.pdf*

6. **Managing Elevated Blood Lead Levels Among Young Children: Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention Chapter 4** James Sargent www.cdc.gov/nceh/lead/CaseManagement/chap4.pdf

7. **Relation of Nutrition to Bone Lead and Blood Lead Levels in Middle-aged to Elderly Men The Normative Aging Study** Yawen Cheng, Walter C. Willett, Joel Schwartz, David Sparrow, Scott Weiss, and Howard H *American Journal of Epidemiology Vol. 147, No. 12* www.aje.oxfordjournals.org/cgi/content/abstract/147/12/1162

8. **Determinants of the Blood Lead Level of US Women of Reproductive Age** Lee, Mi-Gyung; Chun, Ock Kyoung and Sung, Wan O. *J Am College of Nutr, Vol. 24, No. 1, 1–9 (2005)* www.jacn.org/cgi/reprint/24/1/1

9. **Maternal Blood Lead Concentration, Diet During Pregnancy, and Anthropometry Predict Neonatal Blood Lead in a Socioeconomically Disadvantaged Population** Lawrence M. Schell, Melinda Denham, Alice D. Stark, Marta Gomez, Julia Ravenscroft, Patrick J. Parsons, Aida Aydermir, and Renee Samelson *Environ Health Perspect Vol 111, No 2, Feb 2003* www.pubmedcentral.nih.gov/picrender.fcgi?artid=1241350&blobtype=pdf

10. **Testing of chelating agents and vitamins against lead toxicity using mammalian cell cultures** Anna B. Fischer, Cristine Hess, Tilo Neubauer and Thomas Eikmann *Analyst, January 1998, Vol. 123 (55-58)* www.rsc.org/delivery/_ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN

11. **Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occup Hygiene 2009 53(4):341-351* http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341

12. **Do You Have Strong Bones Or Are You At Risk For Osteoporosis?** Priscilla Slagle M.D. *The Way Up Newsletter 12/01/08 Volume 40* www.thewayup.com/newsletters/120108.htm [Included as a general outline of bone health because of the importance of bone resorption to blood and tissue lead levels]

For further information on individual nutrients, better coverage of mechanisms and further suggested reading see the article **Nutrition to fight lead poisoning** by Robert Taylor, edited by Anne Roberts, at www.lead.org.au/lanv10n2/LEAD_Action_News_vol_10_no_2.pdf

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