

# A Review of the Use of Mercury in Historic and Current Ritualistic and Spiritual Practices

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## Abstract

Mercury (Hg) occurs naturally in the environment and has been used in numerous medicinal, commercial, and industrial applications over many centuries. Also, it has played significant historical, as well as current, ethno-medical and magico-religious roles in a number of different cultures. In recent times, awareness has emerged that exposure to mercury can have serious adverse health consequences. Accompanying this, contamination of the environment by mercury is causing public health and environmental concerns. As a result, major efforts are being undertaken by industry, private organizations, and government agencies to reduce or eliminate the use of and exposure to this toxic element. However, in spite of extensive educational and socio-cultural interventions, the use of mercury in ritualistic and spiritual practices is a continuing cause for concern.

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## Introduction

Mercury (Hg) occurs as the pure elemental substance (e.g., liquid mercury), as inorganic mercury in ores such as cinnabar ( $HgS$ , mercuric sulfide) and calomel ( $Hg_2Cl_2$ , mercurous chloride), and additionally in compounds such as mercuric chloride ( $HgCl_2$ ) and mercuric acetate ( $Hg[O_2CCH_3]_2$ ). It is also found in organic form such as the organometallic cations methyl- and ethyl-mercury ( $[CH_3Hg]^+$  and  $[C_2H_5Hg]^+$ ), respectively, and as the extremely dangerous dimethyl-mercury ( $CH_3)_2Hg$  (one of the strongest neurotoxins known).

Elemental mercury is the main form of mercury entering the atmosphere and does so mostly as a vapor through natural processes,<sup>1</sup> such as during geyser and volcanic eruptions. Mercury is also freed into air, water, and soil through

anthropogenic activities, including the refining of mercury-containing ores, the burning of fossil fuels, industrial processes such as the chlorine production, electronics manufacturing, and through mining and any related activities that utilize mercury in metal recovery processes.<sup>1</sup>

Mercury has been used in numerous health and industrial applications over the centuries, and has played key roles in the ethno-medical and magico-religious rituals and spiritual practices of many African, Asian, and Latin American cultures. This intriguing metal was mined and used by the early Chinese and has been found in Egyptian tombs. It continues to be a substance of great significance in Hindu religious practices. The Vishnudharmottara Purana, a Hindu text dedicated to the arts, contains a section dated from around the 7th century AD that mentions “red lead” (in Latin mercury ore, cinnabar, is minium or “red lead”) as a source of red pigment<sup>2</sup> and the Jaina text, the *Citra Kalpadruma*, details the preparation of this pigment.<sup>3</sup> Mercury was widely employed as an agent to treat syphilis and, in addition to its use as an antibiotic, has been the active ingredient in many other medicinals, including diuretics, antiseptics, antipruritics, analgesics, and laxatives.<sup>4</sup> With the advent of the industrial revolution, mercury found its way into a plethora of other health-related, cosmetic, commercial, and industrial applications.

## Mercury Toxicity

Over the past half century it has become increasingly apparent that exposure to mercury can have adverse health consequences. This began with the recognition that “pink disease,” or acrodynia, was related to the use of mercury-containing

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medications, which eventually resulted in the exclusion of calomel ( $Hg_2Cl_2$ ) from most teething powders in 1954.<sup>5</sup>

Adverse health consequences due to environmental contamination by mercury were exemplified by the Minamata Bay disaster in 1956 in Japan.<sup>6</sup> A syndrome of progressive muscular dystrophy, blindness, neurological dysfunction, paralysis, coma, and death was shown to be related to industrial contamination by methyl-mercury of aquatic life in the Minamata Bay area, resulting in the eventual demise of over 2,265 individuals. Also related to this disaster, it was demonstrated that local pregnant women who consumed mercury-contaminated fish gave birth to infants with severe developmental disabilities.<sup>7</sup>

Recently, chronic exposure to mercury, perhaps from environmental sources such as fossil fuel emissions from power plants<sup>8</sup> or from other sources such as fish consumption, amalgam fillings, fluorescent light bulbs, and vaccines,<sup>9</sup> has been postulated to be a possible causative factor in the etiology of symptoms of central nervous system dysfunction and renal toxicity.<sup>10</sup> Mercury exposure is also believed by many to play a role in the apparently increasing incidence of developmental disorders, such as autism,<sup>11</sup> and in the etiology of learning disabilities,<sup>12</sup> such as attention deficient disorder (ADD) and attention-deficit hyperactivity disorder (ADHD).

Mercury now is clearly recognized as a hazardous chemical that can cause serious health problems,<sup>13</sup> especially in children and during fetal development.<sup>14</sup> It is known to react with sulphydryl, phosphoryl, carboxyl, and amide groups, and is a neurodevelopmental toxicant that can adversely affect enzymes, cellular membrane function, and neurotransmitter levels;<sup>15,16</sup> can increase oxidative stress, lipid peroxidation, and mitochondrial dysfunction; and can disrupt synaptic transmission, microtubule formation, amino acid transport, and cellular migration in the developing brain.<sup>17</sup>

### Mercury Risk Reduction

Through the combined efforts of governmental agencies at the international,<sup>18,19</sup> national,<sup>20,21</sup> and local<sup>22,23</sup> levels, the initiatives of private organizations,<sup>24</sup> and the cooperation of industry,<sup>25</sup> the non-essential industrial and commercial use of mercury is being markedly reduced. Mercury reduction by the health industry is also notable. The use of the preservative thimerosal, which contains ethyl-mercury, in many vaccines has been

virtually eliminated and now all major U.S.-licensed vaccines, except for tetanus toxoid, are available in "mercury-free" form,<sup>26</sup> at least in single-dose vials. Very few medical devices now use mercury, except where absolutely necessary. Public health initiatives aimed at reducing consumption of piscivorous fish, such as tuna, salmon, swordfish, and marlin (well known to concentrate methyl-mercury), have been widely implemented. The non-essential use of mercury amalgam ("silver") dental fillings and mercury-containing medicinals is well on the way toward being effectively minimized if not eliminated.

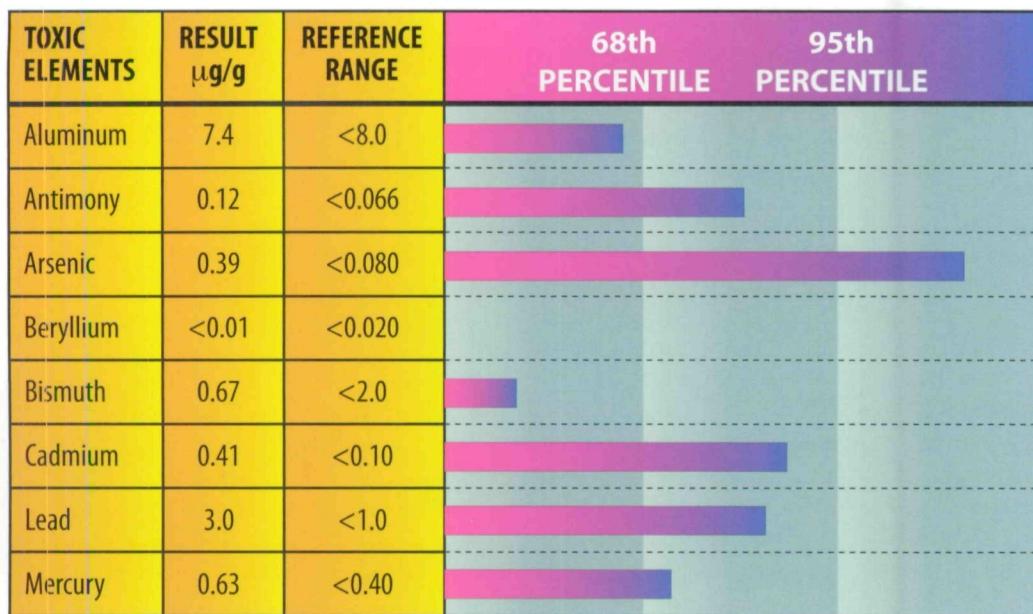
### The Broad Historical Ethno-Medical, Magico-Religious Perspective

There is evidence that mercury has been used in ethno-medical and magico-religious rituals and spiritualistic practices in China and India since before the historical record,<sup>27</sup> and mercury has been found in Egyptian tombs dating back to 1,500 BC.<sup>28</sup> Ores such as cinnabar ( $HgS$ ) and calomel ( $Hg_2Cl_2$ ) were used by the Chinese in the making of pigments, cosmetics, soaps, and laxatives. The Chinese emperor Shen Nung, considered to be the father of Chinese medicine, authored the 40-volume *Great Herbal* or *Chinese Materia Medica* around 2735 BC<sup>29</sup> and included mercury in his list of drugs. Physicians and scientists in the court of Emperor Qin Shihuang prescribed for him a potion containing powdered jade and mercury that was purported to promote eternal life. Unfortunately for the Emperor, the mercury in the mixture had the opposite of the desired effect and resulted in his death from mercury poisoning in 210 BC.<sup>30</sup>

Traditional Chinese medicine (TCM) herbal preparations used today may be contaminated with mercury and/or other metals,<sup>31</sup> and there have been reports of these treatments resulting in the oral ingestion of up to 1.2 g of mercury per day, probably as  $HgS$ .<sup>32</sup>

Figure 1 shows the results of an analysis for potentially toxic elements conducted on the hair of a one-year-old girl who was recently adopted from China. By history from the adoptive parents,<sup>33</sup> it was revealed that the child had been treated in China with TCM herbal preparations (it could not be clarified whether or not the elevated levels of antimony, arsenic, lead, and mercury found in the hair sample were present as the result of excretory processes or if they were due to contamination from external sources).

**Figure 1. Potentially Toxic Elements Report on a Sample of Scalp Hair from a One-Year-Old Girl**



Hinduism, the world's third largest, and perhaps the oldest, living religious tradition,<sup>34</sup> has among its roots the Vedic religion, which dates back to India's Iron Age (around 1000 BC). Mercury (*parad*) has long held a prominent role in Hinduism, where it is thought to be the best of all metals and is representative of the seed of Lord Shiva, one of the most popular Hindu deities. When *parad* is amalgamated with silver the solidified material is used in the construction of *lingas* (representations of the phallus of Lord Shiva), *Sri Yantras* (instruments to bring health, wealth, and good fortune), and other magico-religious and ethno-medical items, such as idols of major and minor deities, *malas* (strings of *parad* beads), and *parad* rings.

Ayurvedic medicines, even those in use today, may contain mercury and other metals. One recent study reported that about 29 percent of samples of these medicines (half of which were manufactured in the United States) purchased at random on the internet contained significant levels of one or more metals, including mercury, lead, and arsenic.<sup>35</sup> Importantly, there are two common streams of Ayurvedic practice: one using herbal medicines alone and the other (*Rasa Shastra* – the science of minerals; the science of mercury), which intentionally combines herbal medicines with metals (such as mercury, lead, iron, or zinc), minerals (such as mica), and gems (for example, pearls). *Rasa Shastra*

practitioners are adamant that the agents used in these compounds are safe and therapeutic.<sup>36</sup>

In spite of claims that mercury, lead, and other metals in Ayurvedic "herbal" preparations somehow have been denatured and no longer are toxic, Figure 2 demonstrates that metals either contaminating, or intentionally added to, these preparations still are absorbed by, and excreted in whole or in part from, the body.

### New World Religions May Use Mercury in Their Practices

The Lucumi (Lukumi; *La Regla de Lukumi*) religion, which originated with the Yoruba culture in Nigeria, was brought to the Americas with the slave trade.<sup>37</sup> It became intertwined with other religions, such as Catholicism in Cuba, Brazil, Haiti, Trinidad, and other South American and Caribbean countries. This culturo-religious co-mingling gave rise to local religions such as Espiritismo (a belief system indigenous to Puerto Rico and other Caribbean territories and countries) and Santeria (a Cuban-based Afro-Caribbean religion that venerates both African deities and Catholic saints).<sup>38</sup>

Other similar folkloric traditions include Candomble (practiced chiefly in Brazil), Obeah (generally found in the West Indies and other Caribbean countries), Palo (Palo Mayombe, Palo Monte; similar to Santeria and also thought to

**Figure 2. Potentially Toxic Metals Report on Urine from a Patient with General Neurotoxicity Symptoms after Taking an Ayurvedic Herbal Preparation**

TOXIC ELEMENTS	RESULT µg/g CREAT	REFERENCE RANGE	WITHIN REFERENCE RANGE	ELEVATED	VERY ELEVATED
Aluminum	< dl	<25			
Antimony	< dl	<0.06			
Arsenic	50	<120			
Beryllium	< dl	<0.5			
Bismuth	< dl	<10			
Cadmium	2.6	<2			
Lead	9100	<15			
Mercury	39	<3			

have originated with Central African slaves brought to Cuba), and Voodoo (Vodoun; a combination of Catholicism and African spirit-religion having its origins in Haiti). These New World religions of African origin have herbal-based traditions and may also utilize elemental mercury in some of their ethno-medical and magico-religious rituals and spiritual practices.

Mercury, also known as *azogue* in colloquial Spanish or *vidajan* in Creole, is believed to have magical and curative powers and is prescribed by practitioners (*santeros* or “spirit doctors”) to attract luck, love, money, and good, or to ward off witches and/or evil spirits (*brujos*). The element has been used to treat indigestion (*empacho*) and is taken orally.<sup>39</sup> It is one of the seven basic metals of Santeria and is believed to give either protection (*resguardo*) or serve as a strike against a person, bringing them harm and illness (*cantazo*). It has particular significance in the Lucumi religion, where the metal is said to “work” for Elegua (Elegba, Echu) an African Yoruba god and one of *Las Siete Potencias Africanas* (The Seven African Powers) called upon by believers to open paths and remove obstacles.<sup>37</sup>

The manner of use of *azogue* can vary widely among individual adherents. It can be carried in capsules on the person, worn enclosed in vials in amulets or pendants, and, when enclosed,

generally presents little risk to anyone or to the environment unless the containers are broken. Other more hazardous uses can include oral ingestion,<sup>32</sup> sprinkling it on the floor of a home or vehicle, burning it in a candle, mixing it with soaps and detergents, and/or using it as an ingredient in cosmetics and perfumes.<sup>38,40,41</sup> In addition, there are reports in the literature of adherents injecting it.<sup>42</sup>

## Discussion

### Personal, Public, and Environmental Health Impact of the Ethno-medical and Magico-religious Ritual and Spiritual Use of Mercury

The number of Santeria followers, and those of similar religions in the United States, is estimated by LaPeter to be 1-4 million,<sup>40</sup> while others provide estimates of 0.5-5 million.<sup>7</sup> Large numbers of adherents may be found in areas with greater Latino populations; there is some indication that about 60,000 adherents reside in the state of Florida,<sup>40</sup> while other estimates place the figure at about 100,000.<sup>43</sup> It appears that other states, for example, Massachusetts and New York,<sup>37,44,45</sup> have segments of their populations with similar religious beliefs and practices.

Currently the United States has no prohibitory legislation against the sale of liquid mercury to the general public. The only regulation is in the form of the Federal Hazardous Substances Act,<sup>46</sup> requiring

that any mercury sold must have an appropriate hazardous substance warning label attached. This lack of regulation at the individual consumer level is difficult to comprehend in light of the volumes of legislation and regulations regarding mercury as a hazardous substance and as a pollutant. These regulations, however, are directed mainly at its commercial and industrial uses.

Federal legislation and regulatory statements in the United States include the following:<sup>47</sup>

- The Consumer Product Safety Commission, under the authority of the Federal Hazardous Substance Act, requires cautionary labeling for products containing mercury (the commission has taken action by enforcement letters to major suppliers of mercury to botanical wholesalers – the large number of small distributors makes further enforcement too resource-intensive).
- Mercury is a hazardous air pollutant under the Clean Air Act.
- Mercury is a pollutant under the Clean Water Act.
- There is a safe drinking water mercury standard under the Safe Drinking Water Act.
- Mercury is regulated by the Occupational Safety and Health Administration (work place limit of ≤0.1 mg per cm of air in an 8 hour (weighted average) period).
- Mercury is designated as a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (with a reportable quantity of 1 lb – a spill may be cleaned up by the Environmental Protection Agency [EPA] to protect health or environment).

It is important to note that, at least in the United States, there are no regulatory limits for mercury in residential air. This is because the EPA has no authority to regulate indoor air quality, except for radon levels.<sup>47</sup> Consider this lack of regulatory involvement in view of the all-too-common Santeria practice of sprinkling mercury in and around the home and burning it in candles for health, love, luck, and to ward off evil spirits!

Little is known about how the clients of *santeros*, or other practitioners for that matter, acquire *azogue*, but one likely route is through direct purchases at local shops (called *botanicals*, *herboristerias*, or *yerberias* in Hispanic neighborhoods) that sell a variety of herbal remedies and religious items used in folkloric traditions.<sup>38,48</sup> Capsules of mercury cost \$2-10 each and contain about 10 g of mercury. With increasing access to the internet, liquid mercury may be acquired by mail-order on-line.

Several websites advertising mercury for sale can be easily found. One company (website accessed April 29, 2010) offered a 250-g container (about 1 tablespoon by volume; about 0.5 lb) of "Mercury Metal (quicksilver)" for \$52.95 plus shipping.

The fact that mercury is available for purchase, even in sealed vials, is troublesome. Vials may break and/or may be discarded in the trash and the mercury either contaminates a residence or ends up in sewer systems and/or landfill sites.

Information on the safe disposal of mercury may be hard to find, incorrect, or inconsistent.<sup>42</sup> This being said, the U.S. EPA does provide advice<sup>49</sup> on how to properly deal with, and dispose of, spilled mercury, but it is difficult to "drill down" to this information on the EPA web site.

In the United States, the directions for dealing with mercury spills are, generally, as follows:

- For mercury spills of less than 1 lb. (454 g; about 2 tablespoons), perform cleanup as per EPA guidelines, without vacuuming, and call the local and/or state environmental agency for further advice and disposal (refer to Zayas et al<sup>49</sup> for details).
- For spills of a greater magnitude, do not attempt a clean-up; instead it is mandatory to notify the National Response Center (800-424-8802).

Mercury, freely available in botanical medicines and on the internet, is meant by spiritual and magico-religious practitioners to be sprinkled, burned, swallowed, or carried on the person. It is difficult to believe that "small" spills of mercury such as those occurring in residences would be taken seriously by most individuals. In a study in one community in Lawrence, MA,<sup>44</sup> 344 out of 898 respondents said they or someone they knew had used mercury for religious, spiritual, or health purposes. If each "yes" response was equal to the purchase of just one capsule, about 3 kg of mercury had been sold into that segment of the community.

If swallowed, mercury eventually finds its way into the municipal sewer system. If a capsule is purposely or inadvertently broken, the metal is released, usually into a home or vehicle, and contaminates everything exposed to it and, eventually over years, vaporizes into the air. The volatility and long residence time of mercury indoors create the potential for direct inhalation exposures to individuals; mercury is difficult to remove from home materials and small amounts can lead to contamination for extended periods of time.<sup>50</sup>

Initially, the U.S EPA stated that there is no indication or clinical data to confirm that people who use mercury for cultural and spiritual purposes (and people who share their living space) have elevated mercury levels. However, the EPA did admit that socioeconomic and political barriers can inhibit reporting of health problems related to cultural and spiritual mercury use.<sup>50</sup> In subsequent documents, the EPA agreed that the ritual use of mercury poses a health risk due to exposure to mercury vapors.<sup>47</sup> Some private groups, such as the Mercury Poisoning Project,<sup>51</sup> want the private use of mercury in religious and ethno-medical practices to be regulated and, further, want the potential mercury contamination of many homes in the United States to be addressed. The EPA on the other hand<sup>47</sup> appears to believe that regulation is not necessary and that the issue would be better addressed through education and monitoring. The additional concern of the EPA is that prohibitory regulation would not eliminate the practice of using mercury for religious and ethno-medical purposes, but would drive it underground.

### Conclusion

In spite of the major efforts being undertaken to reduce or eliminate the use of, and opportunities for exposure to, mercury, its utilization in ethno-medical and magico-religious rituals and spiritual practices continues. Extensive educational and socio-cultural interventions aimed at curtailing these practices appear to lack significant effect. The adverse health effects of, and the environmental contamination by, these uses of mercury likely will continue to present major personal, public, and environmental health challenges.

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## **Relation between methylmercury exposure and plasma paraoxonase activity in Inuit adults from Nunavik.**

**Ayotte P, Carrier A, Ouellet N, et al.** *Environ Health Perspect* 2011;119:1077-1083.

**Background:** Methylmercury (MeHg) exposure has been linked to an increased risk of coronary heart disease (CHD). Paraoxonase 1 (PON1), an enzyme located in the high-density-lipoprotein (HDL) fraction of blood lipids, may protect against CHD by metabolizing toxic oxidized lipids associated with low-density lipoprotein and HDL. MeHg has been shown to inhibit PON1 activity *in vitro*, but this effect has not been studied in human populations.

**Objectives:** This study was conducted to determine whether blood mercury levels are linked to decreased plasma PON1 activities in Inuit people who are highly exposed to MeHg through their seafood-based diet.

**Methods:** We measured plasma PON1 activity using a fluorogenic substrate and blood concentrations of mercury and selenium by inductively coupled plasma mass spectrometry in 896 Inuit adults. Sociodemographic, anthropometric, clinical, dietary, and lifestyle variables as well as PON1 gene variants (rs705379, rs662, rs854560) were considered as possible confounders or modifiers of the mercury-PON1 relation in multivariate analyses.

**Results:** In a multiple regression model adjusted for age, HDL cholesterol levels, omega-3 fatty acid content of erythrocyte membranes, and PON1 variants, blood mercury concentrations were inversely associated with PON1 activities [ $\beta$ -coefficient = -0.063; 95% confidence interval (CI), -0.091 to -0.035;  $p < 0.001$ ], whereas blood selenium concentrations were positively associated with PON1 activities ( $\beta$ -coefficient = 0.067; 95% CI, 0.045-0.088;  $p < 0.001$ ). We found no interaction between blood mercury levels and PON1 genotypes.

**Conclusions:** Our results suggest that MeHg exposure exerts an inhibitory effect on PON1 activity, which seems to be offset by selenium intake. PMID: 21543280

### **Commentary**

I am rating this as one of the major findings in environmental medicine for this decade. As explained in the abstract, high blood methyl mercury (occurring in this population presumably from consuming mercury-contaminated fish and other marine foods) was associated with reduced functioning of paraoxanase 1 (PON1) enzyme in the blood. There is a wide (up to 15-fold) variation in PON1 activity in humans. Studies have reported an association between persons with certain PON1 gene polymorphisms (genotype), as well as phenotypes that result in low PON1 activity levels, and a higher risk for cardiovascular disease. While this study provides another mechanism that might underlie the link between methylmercury and increased risk for heart disease, these findings have implications that extend beyond cardiovascular health.

PON1 is an enzyme that, among its biological activities, plays a key role in the detoxification of organophosphate pesticides (OPs). Biotransformation of OPs in humans is complex; however, in general, it appears that certain cytochrome P450 enzymes activate OPs into more toxic intermediates. PON1 enzyme activity inactivates these intermediates, resulting in less toxic metabolites. Because of this, a decrease in PON1 activity has been proposed to result in increased OP toxicity and susceptibility to negative health consequences from OP exposure (OP exposure is increased with exposure to OP pesticides and from eating members of the "dirty dozen" fruits and vegetables list [see [www.ewg.org](http://www.ewg.org) for their shoppers guide that shows the 12 fruits and vegetables with the highest pesticide content that they refer to as "the dirty dozen"]). Persons who have genetic polymorphisms resulting in lower activity of PON1 enzymes have a far higher risk for neurologic problems if they have had OP exposure, compared to persons without these PON1 gene polymorphisms. Persons with these same PON1 genotypes are also more likely to become chemically reactive after an OP exposure. Children with a genotype or phenotype causing low PON1 activity are at higher risk for childhood brain tumors if their parents were using OPs around the house. Now we find that high blood methyl mercury levels (presumably a direct result of consuming a high amount of contaminated fish) is an environmental factor that might result in a low PON1 activity phenotype. This means that methyl mercury might have an indirect, but major role in a host of other problems related to OP pesticides. That is why I rate the value of this paper so highly.

## **Prenatal exposure to organophosphate pesticides and IQ in 7-year-old children.**

**Bouchard MF, Chevrier J, Harley KG, et al.** *Environ Health Perspect* 2011;119:1189-1195.

**Context:** Organophosphate (OP) pesticides are neurotoxic at high doses. Few studies have examined whether chronic exposure at lower levels could adversely affect children's cognitive development.

**Objective:** We examined associations between prenatal and postnatal exposure to OP pesticides and cognitive abilities in school-age children.

**Methods:** We conducted a birth cohort study (Center for the Health Assessment of Mothers and Children of Salinas study) among predominantly Latino farmworker families from an agricultural community in California. We assessed exposure to OP pesticides by measuring dialkyl phosphate (DAP) metabolites in urine collected during pregnancy and from children at 6 months and 1, 2, 3.5, and 5 years of age. We administered the Wechsler Intelligence Scale for Children, 4th edition, to 329 children 7 years of age. Analyses were adjusted for maternal education and intelligence, Home Observation for Measurement of the Environment score, and language of cognitive assessment.

**Results:** Urinary DAP concentrations measured during the first and second half of pregnancy had similar relations to cognitive scores, so we used the average of concentrations measured during pregnancy in further analyses. Averaged maternal DAP concentrations were associated with poorer scores for Working Memory, Processing Speed, Verbal Comprehension, Perceptual Reasoning, and Full-Scale intelligence quotient (IQ). Children in the highest quintile of maternal DAP concentrations had an average deficit of 7.0 IQ points compared with those in the lowest quintile. However, children's urinary DAP concentrations were not consistently associated with cognitive scores.

**Conclusions:** Prenatal but not postnatal urinary DAP concentrations were associated with poorer intellectual development in 7-year-old children. Maternal urinary DAP concentrations in the present study were higher but nonetheless within the range of levels measured in the general U.S. population. PMID: 21507776

### **Commentary**

Three strikes and you are OUT! For the first time ever three articles (the above abstract and the next two) appear in the same journal issue all linking prenatal exposure to organophosphate (OP) pesticides to persistent neurological problems as the exposed children age.

This first study by Bouchard et al assessed urinary OP pesticide metabolites (DAP concentrations specifically, which is a biomarker used to monitor exposure for about 80% of the most commonly used OP pesticides) from pregnant mothers and from their children through 5 years of age. The levels of OP pesticide metabolites during the prenatal time period were directly correlated with a host of cognitive problems with the children, including reduced IQ points (OP levels in the children as they aged were not associated with IQ). This suggests that OP pesticide exposure *in utero* had long lasting ramifications for the fetus. The women in this study were farm workers (a group exposed to higher levels of OP pesticides than an average person). While these female farm workers had urinary levels of OP pesticide metabolites that were above the U.S. mean, they were still within U.S. "normals". This means that the levels of OP pesticides that appear to have caused the toxic effects in the children of these women can be commonly found in individuals throughout the United States.

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**Prenatal exposure to organophosphates, paraoxonase 1, and cognitive development in childhood.**

Engel SM, Wetmur J, Chen J, Zhu C, et al. *Environ Health Perspect* 2011;119:1182-1188.

**Background:** Prenatal exposure to organophosphate pesticides has been shown to negatively affect child neurobehavioral development. Paraoxonase 1 (PON1) is a key enzyme in the metabolism of organophosphates. **Objective:** We examined the relationship between biomarkers of organophosphate exposure, PON1, and cognitive development at ages 12 and 24 months and 6-9 years. **Methods:** The Mount Sinai Children's Environmental Health Study enrolled a multiethnic prenatal population in New York City between 1998 and 2002 (n = 404). Third-trimester maternal urine samples were collected and analyzed for organophosphate metabolites (n=360). Prenatal maternal blood was analyzed for PON1 activity and genotype. Children returned for neurodevelopment assessments ages 12 months (n=200), 24 months (n=276), and 6-9 (n=169) years of age. **Results:** Prenatal total dialkylphosphate metabolite level was associated with a decrement in mental development at 12 months among blacks and Hispanics. These associations appeared to be enhanced among children of mothers who carried the PON1 Q192R QR/RR genotype. In later childhood, increasing prenatal total dialkyl- and dimethylphosphate metabolites were associated with decrements in perceptual reasoning in the maternal PON1 Q192R QQ genotype, which imparts slow catalytic activity for chlorpyrifos oxon, with a monotonic trend consistent with greater decrements with increasing prenatal exposure. **Conclusion:** Our findings suggest that prenatal exposure to organophosphates is negatively associated with cognitive development, particularly perceptual reasoning, with evidence of effects beginning at 12 months and continuing through early childhood. PON1 may be an important susceptibility factor for these deleterious effects. PMID: 21507778

**Commentary**

In the previous Bouchard et al article on prenatal OP pesticide exposure, the study group was Latino farm workers. Farm workers are exposed to higher levels of OP pesticides because of their employment and their living situations. This study, however, looked at resident of New York City, and correlated not only their OP metabolite (once again using urinary DAP concentrations as a biomarker of OP exposure) level during pregnancy, but also the mothers' genotypes for the PON1 enzyme (see first article commentary in this issue for a brief description of the key role of PON1 activity in OP detoxification). Now that we have moved from farm worker to city dweller, we are looking at a group with an exposure that can be more easily applied to the average U.S. resident. Similar to the children of OP pesticide-exposed farm workers, the children in this study also exhibited cognition problems that were associated with higher prenatal OP exposure. These results were especially strong in children whose mothers had the genotypes linked to low PON1 enzyme activity (so less capable of detoxifying OP pesticides). Fortunately, this group of children did not have the same degree of cognitive difficulties as the prenatally exposed farm worker children.

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**Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide.**

Rauh V, Arunajadai S, Horton M, et al. *Environ Health Perspect* 2011;119:1196-1201.

**Background:** In a longitudinal birth cohort study of inner-city mothers and children (Columbia Center for Children's Environmental Health), we have previously reported that prenatal exposure to chlorpyrifos (CPF) was associated with neurodevelopmental problems at 3 years of age. **Objective:** The goal of the study was to estimate the relationship between prenatal CPF exposure and neurodevelopment among cohort children at 7 years of age. **Methods:** In a sample of 265 children, participants in a prospective study of air pollution, we measured prenatal CPF exposure using umbilical cord blood plasma (picograms/gram plasma) and 7-year neurodevelopment using the Wechsler Intelligence Scale for Children, 4th edition (WISC-IV). Linear regression models were used to estimate associations, with covariate selection based on two alternate approaches. **Results:** On average, for each standard deviation increase in CPF exposure (4.61 pg/g), Full-Scale intelligence quotient (IQ) declined by 1.4% and Working Memory declined by 2.8%. Final covariates included maternal educational level, maternal IQ, and quality of the home environment. We found no significant interactions between CPF and any covariates, including the other chemical exposures measured during the prenatal period (environmental tobacco smoke and polycyclic aromatic hydrocarbons). **Conclusions:** We report evidence of deficits in Working Memory Index and Full-Scale IQ as a function of prenatal CPF exposure at 7 years of age. These findings are important in light of continued widespread use of CPF in agricultural settings and possible longer-term educational implications of early cognitive deficits. PMID: 21507777

**Commentary**

This group of mothers and children was also from New York City (inner-city lower income areas) and so again would be expected to have lower OP pesticide exposure than farm workers. The main difference between this study and the two previously reviewed studies of prenatal exposure is that plasma levels (from cord blood) of a single OP pesticide (chlorpyrifos) were used rather than a biomarker of urinary metabolites that is indicative of exposure from multiple OP pesticides. The results of this study were reminiscent of the farm worker study, in that the children with the highest *in utero* exposure to chlorpyrifos had progressively lower IQs, as well as impairments in memory.

Taken as a whole, these three studies (Bouchard et al, Engel et al, and Rauh et al) on prenatal exposure offer compelling evidence that prenatal exposure to OP pesticides causes neurological and developmental issues in children which appear to persist at least through early childhood (these studies assessed exposed children up to 7 years old). Physicians who believe in preventing illnesses from occurring will recognize the importance of prenatal testing for OP presence along with proper counseling about the simple dietary avoidance measures that can prevent the majority of fetal OP exposures.

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