

Review



Environmental Contaminants and Human Health: The Health Effects of Persistent Toxic Substances

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ABSTRACT

Chemical contaminants are widespread in our environment, and we all carry some of many different chemicals in our bodies. What these chemicals do to our health is a very important question. While many chemicals can cause harm to humans, we know much about two categories of persistent toxic substances, metals such as lead and mercury and organohalogens, such as polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs). These substances are very persistent in the environment and in the human body, and can increase risk of a variety of diseases. It is imperative that we find ways of removing these dangerous chemicals from the environment and ways of reducing human exposure. ©2005, Fırat University, Medical School

Key words: *Persistent environmental contaminants and human health*

ÖZET

Çevresel Kirleticiler ve İnsan Sağlığı: Kalıcı Toksik Maddelerin Sağlığa Zararları

Doğada yaygın biçimde bulunan çok sayıda kimyasal kirleticilerden bazılarını vücudumuzda da taşırız. Bu kimyasal maddelerin sağlığımızı ne şekilde etkiledikleri çok önemli bir sorudur. Birçok kimyasal madde insan sağlığına zarar verebiliyorken, bizler kalıcı özellik arz eden iki grup kirleticinin hakkında daha fazla bilgiye sahibiz: kurşun ve cıva gibi metaller ve poli klorlu bifeniller (PCBs) ve poli bromlu difenil eterler (PBDEs) gibi organohalojenlerdir. Bu maddeler doğada ve insan vücudunda çok uzun süre kalabilir ve birçok hastalığın riskini arttırabilirler. Çevrenin bu tehlikeli kimyasal maddelerden arındırılması ve insan maruziyetinin azaltılması için çözümler bulmak zorundayız. ©2005, Fırat Üniversitesi, Tıp Fakültesi

Anahtar kelimeler: *Kalıcı çevresel kirleticiler ve insan sağlığı*

In our bodies we each carry a mixture of environmental contaminants. Even at birth every infant is already contaminated from chemicals derived from his or her mother's body. Our body fat (and mothers = breast milk) contains fat soluble contaminants such as dioxin, polychlorinated biphenyls (PCBs) and a large number of different pesticides, such as DDT. Many of these compounds are no longer manufactured in developed countries, and the Stockholm Convention, which went into effect this year, was designed to stop the production and use of 12 of these persistent organic pollutants (POPs) throughout the world. These 12 substances include dioxins/furans, which are products of combustion, PCBs, which were manufactured oily substances that had many uses, and a number of chlorinated pesticides such as DDT, which while they were effective in pest control were also found to be persistent and to have adverse human health effects. These persistent chemicals which are found in many bodies of water and hazardous waste sites and are present in the blood of almost every living human being. Because they are fat soluble, the major route of exposure to people is from consumption of animal fats, particularly from fish caught from contaminated waters. In addition these POPs are somewhat volatile, and when in the vapor phase are transported to the polar regions of the earth, where they come out of the vapor phase and bioconcentrate in the food chain. These compounds pose particularly significant problems in cold climates, and especi-

ally in indigenous populations whose diet contains a lot of animal fats. Body fats also contain less persistent chemicals, such as perchloroethylene (PERC), which is dry cleaning fluid, and other volatile organics. While these compounds do not remain in the body for a prolonged period of time, they can cause disease, particularly in individuals with chronic exposure.

There are other persistent contaminants of great concern. We have lead in our bones and teeth, and mercury compounds in our organs and muscles. The half life of lead in bones can be several decades, and recently we have begun to use the term "persistent toxic substances" to include both the POPs and the persistent metals.

There are a number of diseases that are caused by exposure to these chemicals, some recognized for a long time and some newly understood (Table 1). Of the 12 substances specifically identified in the Stockholm Convention, all but one (the pesticide, endrin) are listed as probable human carcinogens by the US Environmental Protection Agency. The most potent dioxin congener, 2,3,7,8-tetrachlorodibenzo-p-dioxin is rated by the World Health Organization as a known human carcinogen, and other dioxin congeners and congeners of related substance such as furans and PCBs act via a common mechanism through binding to the aryl hydrocarbon receptor. Most evidence indicates that dioxin-like chemicals

are non-genotoxic carcinogens, which would be expected to function as promoters, not initiators of cancer. A recent meta-analysis of occupational cohorts indicated that dioxin increases risk of all cancers (1), although the evidence is stronger for some relatively rare cancers, such as soft-tissue sarcomas (2). Dioxin has many other actions, some mediated via the Ah receptor but others by different mechanisms.

Table 1. Possible human health effects of environmental contaminants.

Cancer
Birth Defects
Immune System Defects
Reduced IQ
Behavioral Abnormalities
Cardiovascular Disease
Diabetes
Altered Metabolism
Decreased Fertility
Altered Sex Hormone Balance
Specific Organ Dysfunctions

Dioxins are immunosuppressive agents, and the immune system appears to be one of the organ systems most sensitive to the effects of dioxin (3). Dutch children perinatally exposed to dioxin showed decreased allergies, but altered lymphocytes and thrombocytes (4). Highly exposed residents of Seveso showed a significant and dose-dependent reduction of plasma IgG levels (5).

A number of these substances have particularly important actions on the developing fetus. Lead, methyl mercury and PCBs all cause a reduction in cognitive function, and a shortened attention span. The loss of IQ appears to be irregardless of when one would otherwise fall on the IQ distribution curve, with children that are exposed in the perinatal period being 5-7 IQ lower than they would have been otherwise. The degree to which these exposures contribute to diseases such as attention deficit hyperactivity disorder is an important research question. PCBs and methyl mercury both bioconcentrate in fish, and consumption of fish from contaminated waters is a major source of exposure. Lead exposure comes from other sources, and is commonly found in dust dating from the days when lead was added to petrol, in white paint in some countries like the US, in pottery glazes, crystal, and from batteries and industrial sources. Dioxin alters behavior in both animals (6) and humans (7), but in both the changes are different in males and females. Perinatally exposed monkeys show decrements in ability to learn discrimination tasks (8), and Ranch Hand Veterans with high exposure also demonstrate reduced memory function (9). An important, but unanswered question, is to what degree these substances interact if one is exposed to more than one? Do the effects add, not add, or even worse are they synergistic?

Many of these compounds also interfere with several hormonal systems (10,11). Thyroid hormone regulates our metabolism and level of energy. PCBs and dioxins and perhaps some of pesticides are known to reduce thyroid function. These compounds have some structural similarity to thyroid hormone, and this is likely why they have these actions. A number of contaminants interfere with sex hormones. Those

that have estrogenic (female hormone)-like activity may feminize little boys during development, cause birth defects such as hypospadias and undescended testes, and may contribute to reproductive disorders in both males and females. Alternatively, some act as anti-estrogens, and tend to masculinize females. Compounds as different as lead, PCBs and dioxins are all known to inhibit the synthesis of the male sex hormone, testosterone. Since male reproductive function is dependent upon testosterone levels, the makers of Viagra and other drugs for erectile dysfunction probably owe much of their profits to the contaminant loads that many men carry in their bodies. Dioxin alters other endocrine functions, causing endometriosis in monkeys (12) and possibly in humans (13). Dioxin is an anti-estrogen, and as such impairs prostate development (14), spermatogenesis and reproductive capability in rodents (15). In human studies Vreugdenhil et al. (7) showed that higher prenatal dioxin levels were associated with more feminized play behavior in both boys and girls. High paternal exposure to dioxin has found to alter the sex ratio of offspring, with significantly more girls than boys being born. (16,17). Thus, while most of the attention has been focused on cancer as an end point of dioxin exposure, there are a number of other diseases of equal or perhaps greater public health importance.

A number of diseases not commonly associated with environmental exposures are also increased in people exposed to environmental contaminants. For example, dioxin increases risk of cardiovascular disease, most likely secondary to causing an elevation of serum lipids (18). Dioxin exposure has also been shown to be associated with an increased risk of diabetes in both Vietnam Ranch Hands (19) and among individuals living near to a dioxin-contaminated Superfund site (20).

In 1998 Health Canada investigated the diseases that people were hospitalized with, the cancers they got and the number of birth defects reported in communities around the Great Lakes that were designated as areas of concern by the International Joint Commission (IJC), the body that advises the US and Canadian governments on issues related to the boundary waters between the two countries, much of which is the Great Lakes. In a series of reports on 17 different AOCs they found a large number of diseases to occur more commonly among the AOCs than in the rest of Ontario. As a member of the Science Advisory Board of the IJC, I was asked to see whether we could obtain similar kinds of information on the US side of the border. New York has good data on a number of health indicators, and also an excellent system for identification of sites with environmental contamination to a degree as to pose a threat to human health. We have a complete birth registry, which records information on mother, father and infants for every child born in New York, including the zip code of residence of the mother. We have matched this dataset information with a registry which identifies nearly 900 hazardous waste sites in New York. We identified those sites which contain PCBs from those that contain other wastes and identified the zip code(s) than contain or abut the PCB-containing hazardous waste sites. It has been known for some time that women with elevated PCBs are more at risk of giving birth to a child of low birth weight than unexposed women, and that this risk is greater for male than female infants (21). Much of the evidence for this relationship comes from studies of people who eat Baltic Sea fish (22). Even after adjustment for other known risk factors for low birth weight (maternal race, age, weight, smoking among others) we found a 6%

statistically significant elevated risk of giving birth to a low-birth weight male infant if the mother simply lives in a zip code with a PCB site (23).

We have also used the hospitalization dataset to investigate frequency of hospitalization for several diseases in relation to residence near to these hazardous waste sites. In a recent paper (24) we investigated respiratory infections, both acute infections such as pneumonia and chronic infections, such as chronic bronchitis. We found statistically significant excess hospitalization diagnosis of respiratory infections in zip codes containing or abutting hazardous waste sites containing PCBs or other persistent organochlorine compounds. The excess rates were greater for the chronic than the acute infections. In a subset of PCB-contaminated zip codes along the 200 miles of the Hudson River, where average income is higher than in the rest of the state, where there is less smoking, better diet and more frequent exercise, there was about a 20% elevated rate of hospitalization for chronic bronchitis as compared to either clean zip codes or zip codes with a hazardous waste site that did not contain PCBs or other organochlorines. Since smoking and SES are known as the major risk factors for bronchitis, these factors do not appear to explain the elevated incidence of disease. We interpret these observations to indicate that simply living near to a PCB-

contaminated site poses a risk of exposure, and a consequent elevated risk of infectious disease, probably secondary to suppression of the immune system. While ingestion of these contaminants is widely viewed as the major route of exposure, living near to a contaminated site would not be expected to alter dietary patterns. We hypothesize that the route of exposure to the PCBs is through inhalation.

The challenge we face is to find ways of removing these hazardous contaminants from our food, our water, our air and our environment. Our results and those of many others indicate that the food, water and air will not be clean until we get these compounds out of the environment. To do that we not only have to prevent new pollution, but have to find cost-effective ways of removing the old chemicals that have widely distributed throughout our world. To accomplish this is expensive, and will require new technologies in everything from agriculture to engineering. But the cost of not cleaning up the environment will be a reduced intelligence of our children, perturbation of their sexual and reproductive development and increased diseases such as cancer and infections. The societal cost of not dealing with the problem is much greater than the cost of reducing the levels of contaminants in all of these various media.

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