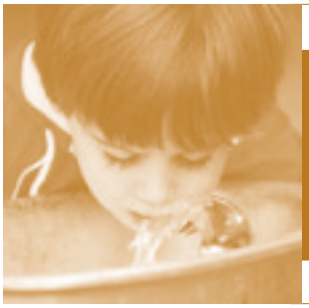

PHYSICIANS FOR SOCIAL RESPONSIBILITY

MATERNAL AND CHILD HEALTH

What Health Care Providers Should Know

DRINKING WATER FACT SHEET #12

Why Are Pregnant Women and Children More Susceptible to Contaminants in Drinking Water?

Industrial chemicals, pesticides, fertilizers, lead from water supply pipes, water disinfection by-products, and pathogens from human and animal waste can all end up in drinking water, with adverse health outcomes ranging from acute diarrheal disease to long-term effects including neurological, developmental, and reproductive effects and even cancer. The interaction of unique physiologic, pharmacokinetic, and exposure factors for pregnant women, fetuses, infants, and children make these populations especially susceptible to certain waterborne contaminants.

Pregnant Women and Fetuses

Pregnant women can transmit some waterborne microbes, such as enteroviruses, to their unborn children. Transplacental spread may occur at different times during gestation, with manifestations present at birth or delayed for months or years. Transmission of infection from mother to infant may take place *in utero*, just before birth, or during delivery.

Other contaminants found in drinking water, including lead, readily cross the placenta. The specific chemical, dose, route of exposure, and genotype of the mother or fetus are all determinants of the effects on fetal health. Timing of exposure is thought to be especially important, with the fetus particularly vulnerable to chemicals that disrupt critical developmental processes at certain times. For instance, exposure to some chemicals during organogenesis can lead to dramatic structural abnormalities depending on the target organ (e.g., thalidomide's effect on developing limbs in the first trimester). During the second and third trimesters, exposure to substances such as lead primarily affects the differentiation of the central nervous system and overall fetal growth (*1,2*).

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Infants and Children

Compared with adults, neonates and infants have a greater surface area-to-body mass ratio, a higher proportion of body water to body fat, different metabolic functioning and capacity, and different dietary consumption patterns (*2,3*). In the first six months after birth, children drink more water per pound of body weight than the average adult. Thus, children can ingest more waterborne contaminants, in proportion to their body weight, than adults (*2,4*). Infants fed formula reconstituted with tap water may be at risk of exposure to a number of drinking water contaminants, including lead, nitrate, and pesticides.

Children's immature enzymatic, metabolic, and immune systems may also provide less natural protection than those of an adult, and their ability to rid their bodies of toxic substances changes as they grow (*2,3*). Many of their organ systems, including the immune, reproductive, digestive, and central nervous systems, continue to develop after birth. Damage to an organ or organ system prior to full maturation could permanently hinder normal functioning (*2,3,5*). Furthermore, exposure to toxics that prevent normal physical development may permanently alter behavioral development (*2*).

Which Drinking Water Contaminants are of Most Concern for Maternal and Child Health?

Pesticides

Pesticides are a major health concern in the U.S., both because of their toxicity and because of their widespread use. In 1997 an estimated 4.63 billion pounds of pesticides were used in the U.S. (*6*). A variety of herbicides and pesticides are routinely found in drinking water sources at low concentrations. The herbicide atrazine has been detected in up to 97% of surface water supplied drinking water systems

in midwestern states (*7*). Children living in rural areas where large quantities of pesticides are used in agriculture are likely to be most heavily exposed. However, children everywhere are routinely exposed to pesticides from multiple sources, including home and garden use, pesticide applications in schools, and residues in food, as well as contaminated drinking water.

In epidemiological studies, children's exposure to pesticides in the home (not in drinking water) has been associated with increased risk for a number of childhood cancers, including leukemia, non-Hodgkin's lymphoma, and neuroblastoma (*8*). The endocrine disruption that is associated with many pesticides is a great concern, as effects to this system could result in abnormal behavior, motor and sensory dysfunction, and cognitive deficits (*1*). Maternal exposure to certain herbicides, including atrazine, in drinking water was associated with intrauterine growth retardation in an Iowa population (*9*). Also, pregnant women exposed to pesticides in a farm community had a higher rate of spontaneous abortion (*10*). *See PSR's drinking water fact sheets on pesticides and atrazine for more information.*

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Nitrate

The main source of nitrate in drinking water is fertilizers, but contamination may also result from animal waste run-off, the leaching of waste systems, or the erosion of natural deposits. Thus, concentrations in drinking water tend to be highest in rural, agricultural areas and may vary widely from season to season. People who use shallow or poorly constructed wells in agricultural areas are at the greatest risk (*2*). Infants are exposed to nitrate primarily through infant formula prepared with contaminated water from nitrate-contaminated wells (*11*). Though nitrate itself is not toxic to humans, it is converted to nitrites in the intestines. Nitrites react with hemoglobin, forming methemoglobin, which has less oxygen-carrying capacity.

Neonates are especially susceptible to nitrate in water, because the body's system to reduce methemoglobin back into an oxygen-carrying state is only half as active in infants under six months as in adults (*2*). The gut flora in infants is also more likely to convert nitrate to nitrite. A build-up of methemoglobin in an infant's blood results in methemoglobinemia, or "blue baby syndrome." Signs of methemoglobinemia include shortness of breath and bluish skin, with lips and mucous membranes appearing brownish (*2*). Other symptoms include central nervous system depression (headache, dizziness, fatigue and lethargy), comas, convulsions, abnormal heart rhythms, circulation failure, and hemolytic anemia (*12*). Methemoglobinemia can be life threatening if medical attention is not sought immediately. Additional health effects that may be associated with chronic nitrate exposure include cancer, thyroid disease, diabetes, and adverse birth outcomes (*11*). *See PSR's drinking water fact sheet on nitrate for more information.*

Escherichia coli O157:H7

One infection to which small children are susceptible is enterohemorrhagic *Escherichia coli*. While there are many harmless *E. coli* strains, food- and waterborne *E. coli* O157:H7 can cause illness. The bacterium is shed in animal and human fecal matter, and drinking water sources may be contaminated by malfunctioning septic systems, leaking sewer lines, and heavy rain or snowmelts that wash *E. coli* contaminated wastes into surface and groundwater. Three of four bacterial drinking water outbreaks reported to the Centers for Disease Control and Prevention (CDC) in 1997 and 1998 were caused by *E. coli* O157:H7 (*13*).

For children, symptoms of an *E. coli* O157:H7 infection include abdominal cramps, low-grade fever, and watery or bloody diarrhea. Recovery without treatment usually occurs within five to ten days (*14*). However, some infections, particularly those in children under the age of five, result in hemolytic-uremic syndrome (HUS). This potentially fatal condition causes red blood cell destruction and kidney failure, often requiring renal dialysis and blood transfusions. Fifteen percent of infected children will progress to HUS, which is the chief cause of acute renal failure in children (*15,16*). With intensive care, the death rate is between 3% and 5%, and survivors can suffer long-term effects. About one-third of children with HUS will experience abnormal renal function years later, and others may suffer blindness, paralysis, high blood pressure, or seizures (*14*). *See PSR's drinking water fact sheet on E. coli for more information.*

Lead

Lead generally enters drinking water by leaching from pipes and solder joints in household plumbing. The use of lead pipes for new plumbing was discontinued in the early part

of the 20th century, but approximately 20% of all public water distribution systems contain some lead components (*17*). Many older homes also contain lead plumbing, and even new "lead-free" brass fixtures contain and leach some lead. Drinking water may add to children's overall lead exposure, but it is not the major source of exposure for most children. Deteriorating lead paint remains the leading source of children's lead exposure, particularly for children living in older housing.

Lead readily crosses the placenta, exposing the fetus. Fetal exposure can result in premature birth and reduced birth weight. Evidence also suggests that women exposed to lead during pregnancy have an increased frequency of miscarriages and stillbirths (*18,19*). This appears to be true even when maternal blood lead levels are low to moderate, although it is not clear whether levels of lead found in drinking water may lead to such effects (18). Because the blood/brain barrier is not fully developed until the age of three, young children's nervous systems are particularly susceptible to lead penetration. Children also absorb more lead into their bodies than adults, and suffer adverse health effects at lower levels of exposure than adults (*20*). Lead exposure in early childhood has been associated with loss of intelligence as measured by IQ, mental development, and behavioral deficits, which may persist beyond childhood (*2,4,21,22*). Nearly 900,000 American children under the age of six still have blood lead levels high enough to be of concern under guidelines from the CDC (*2*). *See PSR's drinking water fact sheet on lead for more information.*

Disinfection Byproducts

Disinfection byproducts (DBPs) include a variety of chemicals that form when drinking water disinfectants—most commonly chlorine—react with organic material naturally found in water. There is now evidence linking some DBPs to cancer and adverse reproductive effects in humans.

Epidemiological studies show that some DBPs, including trihalomethanes (THMs) and chloroform, pose particular risks for the developing fetus. One such study found that neonates were more likely to have a smaller body length and cranial circumference if their mothers had consumed chlorinated water during pregnancy (*23*). A study in Iowa showed a relationship between chloroform levels in drinking water and intrauterine growth retardation (*24*). Studies have also shown a link between THMs in chlorinated drinking water and an increased frequency of stillbirths (*25*). One of the best-conducted studies of reproductive effects and THMs found a strong association with spontaneous abortions (*26*). DBPs in drinking water have also been related to birth defects such as neural tube defects, oral cleft defects, and urinary tract defects (*27,28*). A recent review of the literature on DBPs and adverse pregnancy outcomes showed the strongest evidence of association with small for gestational age at birth, neural tube defects, and spontaneous abortions (*28*). *See PSR's drinking water fact sheet on DBPs for more information.*

What Can Health Care Providers Do to Reduce the Threat of Waterborne Contaminants to their Susceptible Patients?

- Encourage patients, especially pregnant women and parents of young children, to read the Consumer Confidence Reports distributed by their local water facility and be aware of the contaminants in their water.
- Urge families whose drinking water may contain contaminants harmful to children to install home treatment units. When specifically designed for the contaminant in question, these can be effective at removing lead, pesticides, some pathogens, and other contaminants. Letting tap water sit in an open container for one hour will also reduce DBP concentrations.
- Advise parents who bottle-feed their infants—especially those in agricultural areas at risk of pesticide and nitrate contamination—to test water used for reconstituting formula, or to choose premixed formula.
- Hot water and prolonged contact with lead plumbing can increase the lead content of tap water. Advise families in older housing where this may be an issue to "flush" pipes for 30 to 60 seconds before drinking tap water or using it for cooking, and to use only cold water. Parents living in older homes should also be advised about protecting children from other exposures to lead, such as paint chips and dust.
- Encourage patients with private wells to have their wells tested regularly. The local health department can help determine which tests may be needed. Sloping the area around wells can protect them from surface runoff contaminated with pesticides, *E. coli*, and other pollutants.
- Discourage parents from boiling water for more than one minute to kill pathogens. Concentrations of other contaminants, such as nitrate and lead, can increase if water is boiled longer.
- Health care providers can be a significant force in the prevention of waterborne disease by becoming involved in local efforts to prevent contamination of drinking water sources. See PSR's *From Knowledge to Action: A Safe Drinking Water Advocacy Kit* for strategies on how to become involved in these advocacy efforts.

Sources of Additional Information and Guidance

- Physicians for Social Responsibility: (202) 667-4260 or www.psr.org.
- PSR/ACPM online CME course, "Drinking Water and Disease": www.acpm.org/ehealth/sdw_intro.htm.
- NSF International (regarding water filtration systems): (800) 673-6275 or www.nsf.com.
- Campaign for Safe and Affordable Drinking Water: www.safe-drinking-water.org.
- EPA's Office of Ground Water and Drinking Water: (202) 260-5543 or www.epa/gov/ogwdw.
- EPA's Safe Drinking Water Hotline: (800) 426-4791 or www.epa.gov/safewater/dwinfo.htm.
- Farm*A*Syst/Home*A*Syst Program: (608) 262-0024.

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This document is one in a series of Drinking Water Fact Sheets developed specifically for health care providers by Physicians for Social Responsibility. These fact sheets provide practical and concise information to assist health care providers in recognition and prevention of disease caused by exposure to drinking water contaminants.

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Physicians for Social Responsibility
1875 Connecticut Avenue, NW • Suite 1012 • Washington, DC 20009