PHYSICIANS FOR SOCIAL RESPONSIBILITY

DBPs

DISINFECTION BYPRODUCTS

What Health Care Providers Should Know

DRINKING WATER FACT SHEET #10

What are DBPs and Why is there Concern About their Presence in Drinking Water?

Disinfection byproducts (DBPs) form when chlorine or other disinfectants react with organic material (from the decomposition of leaves and other vegetation) naturally found in drinking water sources. The use of chlorine to disinfect drinking water has been hailed as one of the major public health breakthroughs in the 20th century, resulting in a large decrease in mortality from waterborne infectious disease. However, in 1976 the National Cancer Institute published data showing that chloroform, a chlorination byproduct, caused cancer in rodents (*1*). There is now evidence that disinfection—though pivotal in fighting infectious disease—may also result in cancer and other health risks for humans.

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The two classes of DBPs usually measured in drinking water are trihalomethanes (THMs) and haloacetic acids. THMs, particularly chloroform, are common in U.S. drinking water supplies. Other byproducts also exist but are not regularly measured. Recently, it has been estimated that much of the mutagenicity of DBPs is related to the compound 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX) (*2*). Recent tap water monitoring studies in Massachusetts suggest that levels of MX may be considerably higher than previously reported in the U.S. or Europe (up to 80 ng/L) (*3*).

Difficulties arise in balancing microbial risks from contaminated drinking water with the chemical risks posed by DBPs. Many DBPs have been shown to cause cancer and reproductive and developmental effects in animal studies; however, animal toxicity studies generally focus on one chemical byproduct delivered in high doses. Epidemiological studies, too, have suggested a weak association between DBPs and cancer and reproductive effects in humans. Such studies offer a crude measurement of what is likely a small yet prevalent risk. More than 200 million people in the U.S. drink chemically disinfected water, so even a relatively small risk may be significant (*4*).

What Affects the Production of DBPs?

Various characteristics of local water sources and treatment methods contribute to the production of DBPs. The amount of organic precursors in the source water (i.e., the water coming into the treatment plant from lakes, rivers, or wells), water temperature and pH, the amount and type of chemical disinfectants, and the stage in the process that disinfection occurs all affect DBP levels (*5*).

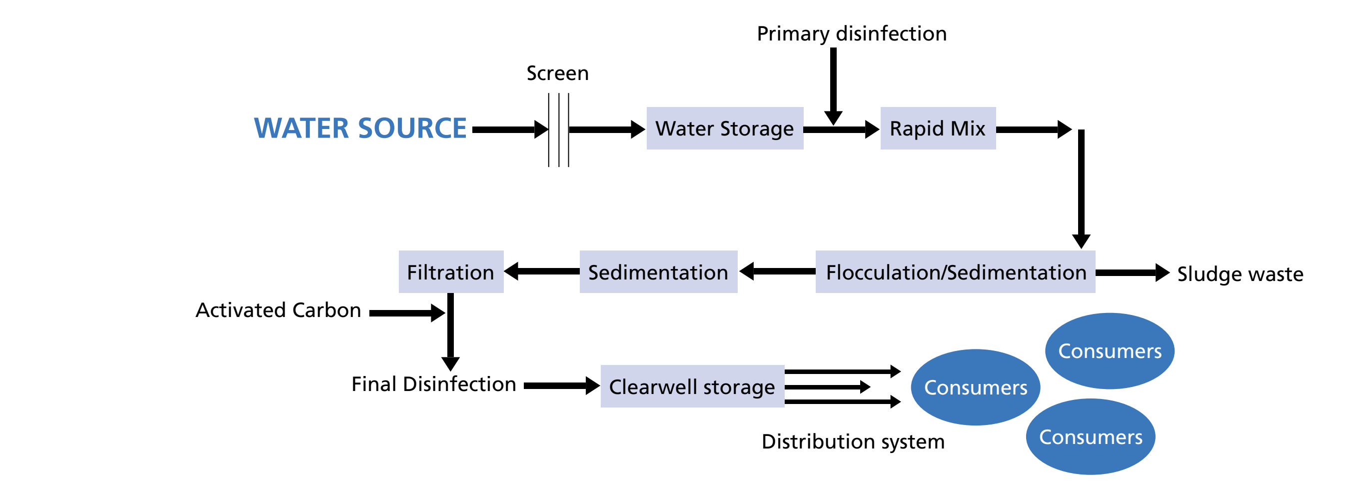
When chlorine has more time to react with organic matter in the water, levels of THMs and other DBPs increase. For this reason, homes at the outskirts of the distribution system tend to have higher levels of THMs than homes closer to the treatment plant (*6*). THM levels also vary by season because the amount of organic matter in the surface water tends to be greater in the summer and fall. Water systems supplied by groundwater will usually have low levels of THMs and other DBPs, because groundwater contains much less organic matter.

Several strategies can help reduce the production of DBPs in drinking water; for example, activated carbon helps to remove organic compounds, and using alternative primary or secondary disinfectants can reduce byproducts (see figure of conventional water treatment). As water purveyors turn toward methods of disinfection other than chlorination (e.g., ozonation, chloramination, chlorine dioxide, UV), more data will be needed on the production and health effects of their byproducts as well (*7*).

What are the Health Effects of DBPs in Drinking Water?

In laboratory studies using rats and mice, THMs have been linked to cancers of the colon and kidney, and haloacetic acids have been linked to liver tumors (*7*). The risk of cancer

CONVENTIONAL WATER TREATMENT, Surface Water



from DBPs in humans, especially cancers of the colon, rectum, and bladder, has been documented by several epidemiological studies (*8-11*). In addition, DBPs are potentially harmful to fetuses, which is demonstrated in the following summary of epidemiological studies:

- Italian neonates were more likely to have a shorter body length and cranial circumference if their mothers had consumed chlorinated water during pregnancy (*12*).
- A study in Iowa associated intrauterine growth retardation with chloroform levels in drinking water consumed by pregnant women (*13*).
- Studies have linked THMs in chlorinated drinking water with an increased frequency of stillbirths (*14*, reviewed in *17*).
- One of the best-conducted studies of reproductive effects found a strong association between spontaneous abortions and THMs, especially bromodichloromethane (*15*).
- THMs in drinking water have also been linked to birth defects such as neural tube defects (*16,17*).
- A review of the epidemiological 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 (*17*). Associations between DBPs and oral cleft defects and urinary tract defects were also seen (*17*).

The National Center for Birth Defects and Developmental Disabilities (part of the Centers for Disease Control and Prevention) is supporting a number of birth defects surveillance projects, including the largest study of the causes of birth defects ever undertaken (*18*). These researchers are taking steps to better assess the exposure of mothers to drinking water during their pregnancies, including polling the mothers about water consumption habits and linking water utility monitoring data to maternal address during the first trimester (a period particularly subject to recall bias) (*17*).

In order to control DBP concentrations, methods are under development to reduce concentrations of organic materials in water, DBP precursors, and DBPs themselves.

Ingestion of contaminated drinking water may not be the only significant route of exposure to DBPs. DBPs have been shown to be absorbed through dermal and inhalational exposures; recent data indicate that the act of showering increases the levels of DBPs in the bloodstream, consistent with the type of DBPs present in the tap water (*19*).

How are DBPs in Drinking Water Regulated?

In order to control DBP concentrations, methods are under development to reduce concentrations of organic materials in water, DBP precursors, and DBPs themselves (*5*). The EPA has encouraged these methods and has implemented several rules designed to protect against microbial contaminants while minimizing levels of DBPs in drinking water.

In its the first regulation regarding DBPs in 1979, EPA set a maximum contaminant level for total THMs as an

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annual average of 0.10 mg/L (*4*). In 1998, EPA strengthened existing rules with its Stage 1 Disinfectants and Disinfection Byproducts Rule. This rule reduced the maximum contaminant level for total THMs (comprising four contaminants) to 0.080 mg/L (*4*), set maximum contaminant levels for five haloacetic acids at 0.060 mg/L, and set maximum contaminant levels for chlorite and bromate. EPA estimates that up to 140 million people will receive more protection because of this rule, and that levels of THMs will be reduced by 24% nationwide (*20*). Large surface water systems were required to abide by this rule by January 2002, while the compliance deadline for groundwater systems and small surface water systems is January 2004. More stringent limitations are also under consideration. The Interim Enhanced Surface Water Treatment rule requires utilities to identify sources of contamination through assessing source waters and profiling their disinfection byproducts. These assessments look at the factors, such as the organic matter in the source water, that influence the amount and types of DBPs in each drinking water system.

What Can Health Professionals Do to Reduce the Public Health Threat from DBPs?

Health professionals can play an important role in reducing the risks from DBPs. Following are some practical steps that health care providers can take with their patients and communities:

- Join others in your community who are working to keep source waters free from contamination from farms, factories, and other human activity.
- Become familiar with the water treatment processes used in your community and ask your local water utility about disinfection methods. Ask if the utility has done a source water assessment or any other review of DBPs. If none has been done, urge the utility to complete these studies as soon as possible.
- Identify patients in your practice who may be especially susceptible to DBPs. Vulnerable groups include pregnant women, infants, and young children. Advise these patients to consider consuming filtered water. Letting tap water sit in an open container for an hour will also reduce DBPs.
- Encourage higher risk patients, such as children and pregnant women, to reduce time in the shower and other activities that involve prolonged skin contact or inhalation of steam.
- Join local efforts to educate the public and other health care providers about the health effects of DBPs. Also, consider becoming involved in safe drinking water advocacy. See PSR's *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 http://www.psr.org.
- Campaign for Safe and Affordable Drinking Water: http://www.safe-drinking-water.org.
- U.S. EPA Office of Ground Water and Drinking Water: (202) 260-5543 or http://www.epa.gov/ogwdw.
- National Drinking Water Advisory Council: http://www.epa.gov/safewater/ndwac/council.html.
- National Resources Defense Council: http://www.nrdc.org/.

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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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