PHYSICIANS FOR SOCIAL RESPONSIBILITY

Drinking Water and Disease

WHAT HEALTH CARE PROVIDERS SHOULD KNOW

Why You Need To Know About Drinking Water

- **A FIRST-TIME MOTHER** isn't sure if she is supposed to boil water for her newborn and asks you to explain the pros and cons to her. (See page 16)
- **A PREGNANT LAWYER** asks "Should I be limiting my exposure to those disinfection byproducts I read about in the paper last week?" (See page 18)
- **AN ACCOUNTANT** has just received his Consumer Confidence Report (CCR) from his water utility and wants you to tell him whether or not he could be getting cancer from chemicals in his water. (See page 9)

DO YOU HAVE THE ANSWERS?

Your patients trust you to have up-to-date information on waterborne disease and a good understanding of the problem. A recent national survey revealed that consumers are concerned about the quality of their tap water, and that they trust their health care providers to give them reliable information. This survey of 2000 adults, conducted by National Environmental Education & Training Foundation/Roper,[1] found the following:

- **THREE OUT OF FOUR** adults expressed concern about the quality and safety of their drinking water, with more than one third saying they are "very concerned."
- **ALMOST A QUARTER** of the people surveyed do not drink water straight from the tap because of aesthetic or health concerns.
- **FOUR IN 10 AMERICANS** are dissatisfied with the information they currently receive about the quality and safety of their tap water. (Most of the information they receive comes from TV, radio, and news media).
- **HEALTH CARE PROVIDERS** are the most trusted, but the least used source of information on drinking water quality and safety.

With the new CCRs being distributed by water utilities, your patients will have more information, and probably more questions about drinking water and their health. **This primer will help you provide the answers.**

This document addresses the following key questions about drinking water and health:

How Big is the Problem?

Estimates of the true magnitude of water-associated disease in this country are quite crude. It has been estimated that up to 900,000 people fall ill and up to 900 die annually from waterborne infectious diseases,[2] but the basis of this estimate is not clear. Estimates using extrapolation of intervention studies (see box on page 3) range as high as 40-50 million cases of disease per year. What is clear is that cases of waterborne disease that are officially recorded represent only the tip of the iceberg. The significant barriers to conducting effective surveillance for waterborne microbial disease (see discussion below) make accurate assessment nearly impossible. Assessing the health burden due to waterborne chemicals is similarly daunting, due to multiple routes of exposure for most people, mobility of the population, and long latency between exposure and health effects, among other reasons.

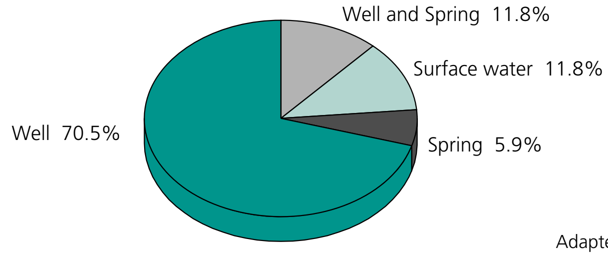
Compounding the problem of inadequate surveillance is a regulatory system that can be slow to respond to advances in knowledge. Only a fraction of chemical water contaminants are regulated, and in some cases, such as arsenic, the current standards are acknowledged to be insufficient in protecting public health. Other chemicals, such as radon and a variety of pesticides, are known to pose health threats yet they are not regulated in drinking water. New requirements for detailed cost-benefit analysis may further erode the Environmental Protection Agency's (EPA's) ability to set standards that guarantee a conservative margin of safety.

For the latest available reporting period (1997-1998), 13 states reported 17 outbreaks associated with drinking water and 18 states reported 32 outbreaks from recreational water.[3] In total, more than 4,000 people fell ill from these reported outbreaks. While drinking water outbreaks associated with surface water decreased by 20% since the last reporting period (1995-1996), the proportion of outbreaks associated with groundwater sources increased almost 30%.

The largest outbreak during that period was caused by *Cryptosporidium parvum*, affecting 1400 people drinking water from municipal wells that became contaminated by a spill of raw sewage. No deficiencies in water treatment were found. In fact, chlorine disinfection was in use, but apparently did not inactivate all *Cryptosporidium* introduced by the sewage contamination. Other etiologic agents associated with drinking water outbreaks included *E. coli* O157:H7, *Giardia lamblia*, and *Shigella sonnei*. Two of the 17 drinking water outbreaks involved copper poisoning.

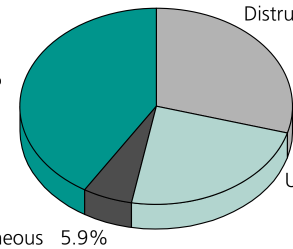
As shown in Figure 1, almost three-fourths of all reported outbreaks were attributed to consumption of contaminated well water. Approximately 40% of outbreaks were traced to inadequately treated water and another 30% to distribution system contamination (Figure 2).

FIGURE 1. WATERBORNE DISEASE OUTBREAKS ASSOCIATED WITH DRINKING WATER, BY TYPE OF WATER SOURCE (1997-1998)



Adapted from CDC *MMWR*, May 26, 2000.

FIGURE 2. WATERBORNE DISEASE OUTBREAKS ASSOCIATED WITH DRINKING WATER, BY TYPE OF DEFICIENCY (1997-1998)



Adapted from CDC *MMWR*, May 26, 2000

Recognizing and diagnosing waterborne disease from microbial agents is challenging. It can most easily be done when there is a sufficiently large outbreak that is recognized by healthcare providers. In normal situations, cases are sporadic, making etiology and an accurate diagnosis more difficult to determine. Physicians do not routinely test stools for pathogens, particularly given the disincentives for additional testing provided by managed care organizations. Furthermore, many cases of waterborne disease are subclinical. Yet, subclinically infected individuals can transmit the disease to others.

Currently in the U.S., waterborne disease outbreaks are tracked using voluntary, passive surveillance techniques. Since 1971, the Centers for Disease Control and Prevention (CDC) and the EPA have collaborated on a system for collecting and reporting data related to waterborne disease outbreaks from both drinking water and recreational water sources. State and local health departments routinely report the epidemiological data of an outbreak, and though CDC requests it, water quality parameters are not always characterized. When possible, the CDC classifies the outbreaks by source: chemical, viral, parasitic, bacterial, or acute gastroenteritis of unknown origin—the category that describes a significant proportion of recognized outbreaks (30% of drinking water outbreaks occurring in 1997-1998 were of unknown origin).

The CDC estimates that the sensitivity of the current surveillance system is probably very low. Although the 1993 cryptosporidiosis outbreak in Milwaukee was estimated to have affected over 400,000 people, only a fraction of one percent of those people were tested for *Cryptosporidium*, and only about a quarter of those tested were positive for the organism. It is easy to see then how few outbreaks are probably ever recognized.

ESTIMATING WATERBORNE DISEASE

Researchers conducted a randomized intervention trial using 299 households that got reverse osmosis filters that eliminated microbial and chemical contaminants and 307 households that were left with their usual tapwater source.[4] The families kept track of gastrointestinal (GI) symptomology with health diaries for 15 months. Based on the resulting differences in incidence rates, the authors concluded that 35% of the GI diseases in tapwater drinkers were water related and therefore preventable. Similar, but more tightly controlled studies using sham filters in the control households, as well as confirmatory stool sampling, are ongoing in California and Australia.

What are the Microbial Contaminants of Greatest Concern?

Detecting levels of microbial pathogens in water is made difficult by the fact that pathogens enter source waters intermittently and at varying concentrations. Therefore, unlike chemicals that cannot exceed specified levels in periodic measurements, microbial pathogens are generally regulated by dictating performance standards for water treatment using relatively resistant organisms as water quality indicators. Thus, water utilities must currently document that their treatment of surface water reduces the levels of enteric viruses by 99.99% and *Giardia lamblia* by 99.9%. The assumption that this level of treatment is adequate to control other microbial pathogens is being revisited for those that are difficult to treat, such as *Cryptosporidium* and *Mycobacterium*.

The bacteria, viruses, and protozoa that are of major concern in drinking water (refer to Table 1) are usually of fecal origin. However, there are serious pathogens that are not transmitted through a fecal-oral route, such as *Mycobacterium avium* complex (MAC) and *Legionella pneumophila*. Generally, enteric viruses and protozoa have low infectious doses—as few as one to 10 infectious units or (oo)cysts. In healthy adults, enteric bacteria tend to require higher doses—ranging from $10^2 – 10^8$ CFU (colony forming units).

BACTERIA

Bacterial waterborne pathogens, once the scourge of human urban existence, are now well controlled by modern water treatment systems. Bacteria such as *Vibrio cholerae*, *Salmonella* spp., and *Shigella* spp., responsible for a large proportion of deaths in the 1800s, are highly sensitive to chlorine, and thus they are not a major threat in areas where chlorinated water is consumed. In this country, waterborne disease in general, and bacterial disease in particular, usually occurs when water treatment systems fail or when untreated water is consumed.

Our understanding of waterborne disease due to bacterial pathogens is greater than that due to viruses or protozoa. This is because they are easier to detect, enumerate, and study. In the U.S., recent (1985-1992) drinking water disease outbreaks due to bacterial agents have been due predominantly to *Shigella* spp. and *Campylobacter* spp.[5] The majority of recreational water outbreaks (which are more commonly reported than drinking water outbreaks) have been dermatitis from *Pseudomonas* spp., shigellosis, and *Legionella* infections.

Waterborne enteric bacteria include both human-associated and zoonotic species. *Campylobacter* and *Salmonella* are found in the intestinal tracts of do-

TABLE 1. KEY MICROBIAL CONTAMINANTS IN U.S. DRINKING WATER

BACTERIA	VIRUSES	ENTERIC PROTOZOA
Shigella spp.	Norwalk-like virus	*Giardia lamblia*
Campylobacter spp.	Rotavirus	*Cryptosporidium parvum*
E. coli 0157:H7	Caliciviruses	Microsporidium
Mycobacterium avium complex	Adenoviruses	
Legionella pneumophila	Hepatitis A	

mestic and wild animals. This means control of contamination of our water supplies by these organisms will require a combination of sophisticated wastewater treatment plants for human sewage and watershed protection to limit agricultural runoff.

VIRUSES

The enteric viruses are more recently recognized waterborne pathogens. Unlike bacteria, the source of enteric viruses is generally human rather than animal feces. Over 120 types of pathogenic viruses can be excreted by humans, and can make their way into the water system through sewage.[6] Their small size and persistence allow them to move widely through the environment, though they cannot multiply outside of a human host. Norwalk and Norwalk-like viruses, rotavirus, caliciviruses, adenoviruses, and hepatitis A are viruses that have all been transmitted by water.[7]

Little is known about the occurrence in water or the endemic rates of infection of the viral pathogens that cause gastroenteritis, such as caliciviruses, Norwalk-like viruses, or adenovirus types 40 and 41. Inadequate detection technology (e.g., inability to culture) has limited the measurement of many enteric viruses in both clinical and environmental samples. Consequently, enteric viruses have not been frequently identified as the etiologic agents of waterborne disease outbreaks. However, many of the outbreaks currently reported as "acute gastroenteritis of unknown etiology" are likely due to viruses.

ENTERIC PROTOZOA

Since 1981, enteric protozoa have been the leading cause of waterborne disease outbreaks. Before *Cryptosporidia*, *Giardia lamblia* was considered the primary waterborne protozoa, and even though the attention it receives has diminished, the CDC estimates that the number of illnesses related to *Giardia* is one order of magnitude greater than that from *Cryptosporidia*.[8] However, the percentage of people who are hospitalized or die is substantially higher in cryptosporidiosis cases. Cryptosporidiosis was first described in 1976, and the first waterborne outbreak was recognized in 1984. Protozoan cysts and oocysts are

UNDERSTANDING CRYPTOSPORIDIOSIS

Cryptosporidium parvum has been recognized as a human pathogen since 1976. Before 1982, the disease was rarely reported, but as the AIDS epidemic increased, so did the number of cryptosporidiosis cases. Initially, infection was recognized only in immunocompromised people, but as diagnostic methods improved, outbreaks and other incidences have appeared in the healthy population. *Cryptosporidium* is considered a major threat to the U.S. water supply because it is highly infectious, resistant to chlorine, and because of its small size, difficult to filter.

Previously healthy patients with cryptosporidiosis exhibit lower gastrointestinal symptoms including watery, non-bloody diarrhea lasting seven to 20 days. Other symptoms include nausea, abdominal cramping, loss of appetite, headache, and fever. Patients who are immunocompromised may become chronic sufferers of cryptosporidiosis.

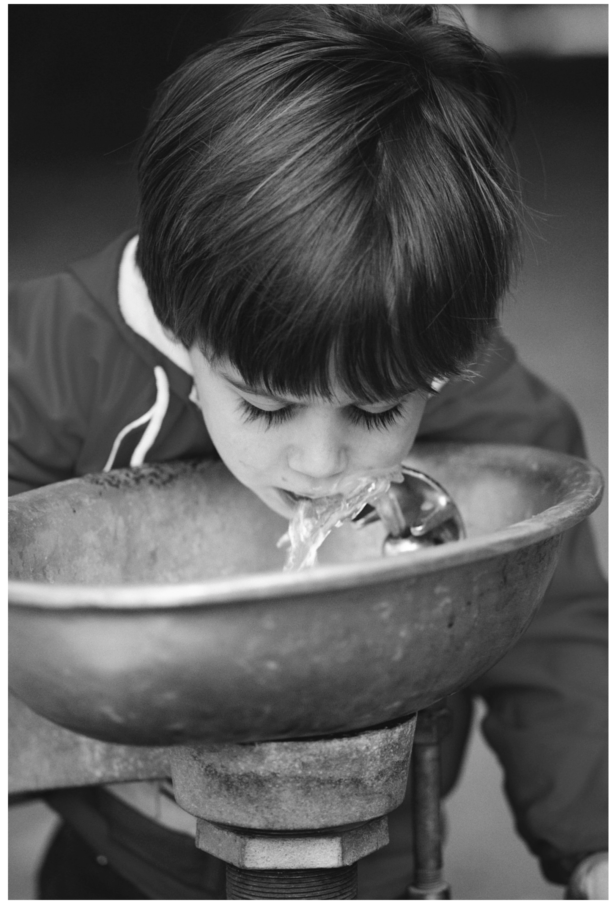
Even a well-operated, modern water treatment system cannot ensure that its drinking water will be completely free of these protozoa. One study reported that up to 80% of surface water samples were positive for *Cryptosporidium* oocysts.[9] The EPA now requires any municipal utility treating surface water for over 100,000 people or groundwater for over 50,000 people to monitor their supplies for *Cryptosporidium* oocysts, which will allow better characterization of the occurrence of this pathogen.

very persistent in the environment and can live a long time in water—especially under the right conditions.

EMERGING PATHOGENS

There are a number of infectious agents that have been newly linked to outbreaks of waterborne disease or have the potential for waterborne transmission.

- **E. COLI** O157:H7 has been primarily associated with undercooked beef and raw milk, but waterborne outbreaks have been reported, including one in Missouri that sickened 243 people and left four people dead.
- **MAC** is mostly known as an opportunistic infection that strikes late-stage AIDS patients. However, MAC-related chronic respiratory disease exists in other populations—especially the elderly.
- **LEGIONELLA PNEUMOPHILA** is another respiratory bacteria that causes Legionnaire's disease, which has a death rate up to 30%, and Pontiac fever, which is mild and transient.[10] For both MAC and *Legionella*, a common route of exposure is contaminated water distribution systems—especially where hot water is stored in large tanks, as in a hospital or other institution. Water aerosolized by agitation, such as during showering, carries the organisms into the lungs of those exposed. Though outbreaks of Legionnaire's disease have been notable, the majority of illnesses caused by both *Legionella* and MAC are sporadic.
- **HELICOBACTER PYLORI** is the infectious agent that causes the majority of gastric ulcers. Studies in Peru linked the type of water supply to the risk of infection and also isolated the pathogen in the water supply.[11] Researchers in Pennsylvania recently reported detecting *H. pylori* in surface and groundwater drinking water sources in Pennsylvania and Ohio.[12] More data are needed to show a clear link between *H. pylori* and water consumption, particularly in the U.S.



- **CYANOBACTERIA** (blue-green algae) are found in ponds, lakes, and reservoirs. Cyanobacteria can produce toxins—usually either neurotoxins or hepatotoxins. There is good evidence that certain hepatotoxins are potent liver tumor promoters.[13] Most of the reports of poisonings by cyanobacterial toxins worldwide have involved animals—livestock, dogs, and waterfowl. Well-documented cases of effects on humans are relatively few, but reports have noted the development of dermatitis, eye irritation, and gastrointestinal symptoms.

What are the Chemical Contaminants of Greatest Concern?

DISINFECTION BYPRODUCTS

The most ubiquitous harmful chemicals found in water are the disinfection byproducts (DBPs) formed by reactions between one- and two-carbon organic molecules and added chlorine in water. Among the dozens of DBPs, trihalomethanes (THMs) are among the best studied and are the only class to have a drinking water standard. Brominated compounds, formed by substitution reactions between chlorinated DBPs and naturally occurring bromine, are also widely found and may be more toxic than solely chlorinated compounds.

DBPs have been implicated in both cancer and non-cancer health effects. Comparisons of populations consuming chlorinated and non-chlorinated water have shown an increased risk of bladder and possibly colon and rectal cancer among those consuming chlorinated water.[14] The EPA has estimated that an upper bound estimate of 2-17% of bladder cancer cases in the U.S. are attributable to DBP exposure (1100-9300 cases/year).[15] More recently, similar comparison studies have demonstrated an increased risk of adverse reproductive and developmental outcomes, including spontaneous abortion and neural tube defects.[16] Under the mandate of the 1996 Safe Drinking Water Act (SDWA) Amendments, the EPA has proposed lowering the current standard for trihalomethanes from 100 μg/L to 80 μg/L. In addition, standards have been proposed for trihaloacetic acids and other disinfectant byproducts. Several large studies are underway to confirm and further explore the early findings of adverse reproductive and developmental effects associated with DBPs.

LEAD

Since the removal of lead from gasoline, drinking water has become a more important route of lead exposure for the general population. Lead generally enters drinking water by leaching from pipes and solder joints. Although the use of lead pipes for plumbing was discontinued in the early part of the 20th century (remember the Latin word for lead, *plumbum*, is the root for the English word *plumbing*), lead was not removed from solder used for sealing joints in drinking water pipes until 1986. Lead soldering is still commonly used in taps, water coolers, and other fixtures placed between building pipes and the consumer. Brass fixtures, such as spigots, may also be made with an alloy that contains lead. The same is true of pumps used for wells. Studies of fixtures in offices and schools have shown a potential for high exposures to lead in first-draw samples of water.[17] The EPA also notes that newly built homes with new fixtures have higher lead levels in first draw samples than homes with fixtures that have aged for several years. Hot water and water with lower mineral content ("soft water") leach more lead out of pipes and solder than cold and hard water. Thus, despite the removal of lead from water pipes and solders, it remains a concern, especially in areas with soft water.

Lead content in water is regulated through a "treatment technique" method. Under this method, water utilities are required to sample taps most likely to have lead contamination. If more than 10% of the samples have lead concentrations over 0.015 mg/L, the utility must add additional treatment steps to lower levels. While this ensures adequate protection for the population served as a whole, individual homes may have higher lead levels.

The health effects of lead at levels most likely to be encountered in drinking water are most severe for children and infants. Lead exposure in early childhood has been associated with loss of intelligence and behavioral deficits, which may persist well into adolescence.[18] Low-level lead exposures have also been associated with hypertension in adults.[19]

OTHER METALS

A variety of other metals, including arsenic, cadmium, and mercury may be found locally in drinking water supplies. Arsenic, in particular, has been found in high levels in community water supplies, usually as the result of high concentrations found in regional geologic formations. Arsenic in drinking water at a level of around 450 μg/L has been associated with bladder, skin, and lung cancers, as well as non-carcinogenic effects such as pigmentation changes and peripheral vascular disease.[20] The current drinking water standard for arsenic, 50 μg/L, dates back to 1943. There is general concern that this standard does not adequately protect public health, and the EPA has recently proposed lowering the standard to 5 μg/L. Outside of rare episodes of gross chemical contamination, drinking water is a less important source of exposure to mercury and cadmium for the general population than other routes, particularly food ingestion.

NITRATES

Nitrates contaminate water supplies as the result of ground applications of fertilizers and seepage from septic tanks. Thus, concentrations tend to be highest in rural, agricultural areas and may vary widely based on seasons. The EPA has estimated that as many as 52% of the community water wells and 57% of the domestic water wells in the U.S. are contaminated by nitrates.[21] In infants under about four months of age, ingestion of high concentrations of nitrates from well water results in methemoglobinemia, which carries a 7-8% fatality rate. The current standard for nitrates in drinking water is 10 mg/L, which is felt to be protective for methemoglobinemia. Concentrations as high as 40 mg/L have been reported in agriculturally contaminated wells, and the U.S. Geological Survey (USGS) has estimated that up to 15% of wells in agricultural and urban areas have nitrate levels exceeding the EPA standard.[22] Information on nitrates is reported in the

Consumer Confidence Report by utilities. Families with private wells, particularly in agricultural areas, need to be particularly concerned and should either measure nitrates in their water or provide bottled water or pre-mixed formula to infants.

RADON

Radon from naturally occurring ground deposits can contaminate water, particularly groundwater, just as it directly contaminates indoor air in houses. Radon in water constitutes a threat to health both from direct ingestion as well as from contribution to indoor air levels and inhalation after water is heated and/or agitated such as during showering. Alpha particles emitted from radon can ultimately cause cancer of the gastrointestinal tract or lung, depending on the route of exposure.

Levels of radon are highest in groundwater and water from private suppliers; they are lowest in water from public utilities using surface water as their source, due in part to the more complete filtering such water undergoes. Radon activity in public utility treated surface waters tends to be around 100 pCi/L (picocuries per liter). In groundwaters, levels have been measured as high as 27,000 pCi/L. Levels also vary by region.

EXPLORING THE LINK BETWEEN DRINKING WATER AND CANCER

Each year in the U.S., millions of pounds of industrial and agricultural chemicals are released into the environment, either through intentional or uncontrolled discharges. These chemicals include many that are known or suspected carcinogens. Groundwater and surface water bodies that serve as our drinking water sources are vulnerable to contamination by these chemicals as a result of runoff of agricultural and household chemicals, industrial waste discharges, and uncontrolled releases from sources such as landfills and leaking underground storage tanks. According to EPA's 1997 Toxics Release Inventory, industrial sources alone discharged an estimated **28 million pounds of carcinogenic chemicals** directly into surface water or into underground injection wells.[23]

As shown in the following highlights, recent government studies have reported detectable levels of carcinogens in drinking water supplies, some at levels exceeding EPA standards for protection of public health.

- ➤ In a recent EPA survey of drinking water supplies nationwide, **four suspected carcinogens were among the eight contaminants most frequently exceeding drinking water standards** (Maximum Contaminant Levels). These contaminants included the pesticides ethylene dibromide and dibromochloropropane, and the solvents methylene chloride and tetrachloroethylene. [24]
- ➤ A recent study by the USGS found widespread contamination of shallow groundwater by pesticides in the U.S. **Pesticides contaminated over 54% of samples from wells and springs**.[25] Although concentrations were low, and only one pesticide was found to exceed the EPA Maximum Contaminant Level, the researchers caution that these findings may not provide a complete picture of potential health risks. Drinking water standards have been established for only 25 of the 46 pesticides examined in the study, and existing drinking water standards do not take into account potential additive or synergistic toxic effects from exposure to multiple chemicals.
- ➤ In agricultural regions of the U.S., pesticide occurrence is even more widespread. According to EPA's Contaminant Occurrence Database, 97% of surface water systems in the Midwest are contaminated with pesticides.

Conventional water treatment processes do not ensure removal of chemical contaminants, particularly organic compounds that are soluble in water. There is also evidence that the use of disinfectants such as chlorine in drinking water contributes to the formation of potentially toxic byproducts in tap water. Most of these disinfection byproducts have not been adequately characterized as to potential health effects. There is epidemiological and toxicological evidence suggesting an association between long-term consumption of chlorinated water and an increased risk of certain cancers, including bladder cancer (refer to discussion on Disinfection Byproducts on page 7).

Not all chemicals in our drinking water are the result of human activities. Chemicals such as arsenic and radon occur naturally in geologic formations, and are found in groundwater in many regions of the country. Both arsenic and radon are known human carcinogens.

Carcinogenic chemicals in drinking water, when they do occur, are generally found at low concentrations and may not in themselves pose a significant cancer risk. However, in some cases, drinking water can be an important source of contaminant exposure, and can contribute to an individual's overall cancer risk. In assessing individual cancer risk, it is important to examine all potential sources of chemical exposure including occupation, lifestyle (e.g., cigarette smoking), consumption of contaminated food, and use of household chemicals.

Under the National Primary Drinking Water Regulations, EPA currently requires water utilities to routinely monitor for **only 73 chemicals and radionuclides** in treated drinking water. More than two dozen of these agents are regulated in drinking water because of their potential to cause cancer and other chronic health effects. There are literally hundreds of chemicals that can and do occur in drinking water supplies in the U.S. Many of these chemicals are not regulated due to lack of information on potential human health effects. The list of drinking water contaminants regulated by EPA is growing, albeit slowly. Health care providers can play an important role in pressing EPA and Congress for stronger public health protections, including expanded health effects research and more aggressive regulation of potentially harmful contaminants in our water supplies.

Water from New England, the Southeast, and Mountain regions has more radon than other regions.[26]

Because of the importance of inhalation of radon as a route of exposure, radon from water is best removed by filtration upon entry into the house, as opposed to individual tap filters. Granulated activated charcoal filters are effective at reducing radon concentrations in water. The EPA has proposed a drinking water standard of 4000 pCi/L for radon (an amount estimated to contribute about 0.4 pCi/L to indoor air in houses) in states that have programs to reduce radon in indoor air. A more stringent standard of 300 pCi/L has been suggested for states without indoor air radon programs.

PESTICIDES/SYNTHETIC ORGANIC CHEMICALS

A variety of herbicides and pesticides are routinely found in source waters at low concentrations. Many of these pesticides are environmentally persistent organochlorines, such as DDT, aldrin, endrin, alachlor, chlordane, heptachlor, and toxaphene. Herbicides used on lawns, golf courses, and roadsides such as atrazine and simazine are also commonly found. These chemicals, most of which have been banned since the 1970s or 1980s, remain ubiquitous in the environment and drinking water due to their former widespread use and resistance to environmental degradation.

Other synthetic organic chemicals are commonly found as well. Tetrachloroethylene, also known as perchloroethylene or "perc," has been found in high levels in water supplies as the result of leaching from recently installed polyvinyl chloride or PVC water mains. Studies of populations exposed through this route have associated perc exposure with lung cancer and possibly colo-rectal cancer.[27] Migration of fuel-associated chemicals such as benzene and methyl tert-butyl ether (MTBE) from underground gasoline storage tanks has also been reported.[28]

The EPA currently has drinking water standards for 54 organic chemicals or chemical groups. Potential organic chemical contaminants, however, number in the thousands. The SDWA Amendments require EPA to establish a list of contaminants every five years that may require regulation under SDWA. The first Contaminant Candidate List (CCL), finalized in March 1998, included 50 chemicals.

The health effects from low-level drinking water exposures to pesticides, herbicides, and other synthetic organic chemicals are not well characterized for a number of reasons:

- **IDENTIFICATION OF COMPOUNDS** in drinking water is marginal at best; economic and logistical factors prevent testing for the thousands of known potential contaminants in the hundreds of thousands of water systems supplying the population.
- **EVEN IF THE COMPOUNDS COULD BE IDENTIFIED,** the vast majority of them have not been adequately tested for their individual health effects.
- **CURRENT TESTING PROTOCOLS** may not adequately identify effects of combinations of chemicals at low doses. Several studies have suggested possible synergies between chemicals, but our understanding of this phenomenon is presently very poor.[29]

Since volatile chemicals are easily inhaled from heated or aerosolized water, patients whose water supplies have been contaminated by these chemicals must be advised not only to avoid direct use of the water for drinking purposes, but also to avoid using contaminated water for bathing and washing purposes as well.

FLUORIDE

Fluoride may enter water from natural deposits, but is more frequently added to water during the treatment process as a means of controlling dental cavities. Considerable controversy exists over the relative risks and benefits conveyed by fluoridation. Higher than optimal (optimal being approximately 1 mg/L) levels of fluoride in water are associated with increasingly severe dental fluorosis or disruption of tooth enamel. The incidence of fluorosis in children has increased over the past few decades, as the incidence of dental caries has decreased.[30] Conflicting data exist regarding other toxic effects, including cancer and effects on bone.[31] Patients wishing to reduce fluoride in areas with fluoridated water may do so via most filtration methods; physicians should counsel them to maintain topical fluoride applications to prevent dental caries.

How Does Drinking Water Get Contaminated?

SURFACE WATER CONTAMINATION

Most drinking water in the U.S. is obtained from surface or ground water sources. Surface water comprises rivers, streams, lakes, and ponds, and it is constantly under threat from environmental contamination. Some of this contamination may be "natural," as from animal fecal waste, algal growth, or geologic formations. Surface water is also particularly vulnerable to anthropogenic contamination, both from point sources (such as industrial or wastewater treatment plant discharges) and non-point sources (such as runoff from urban streets, agricultural runoff, etc.). With the reduction in point source contamination that has resulted from the Clean Water Act, non-point sources have become the dominant cause of water pollution in this country. Because of this degree of contamination, surface water usually requires aggressive and sophisticated treatment prior to consumption.

GROUNDWATER CONTAMINATION

Groundwater is sometimes called "fossil water," because it is water that has been impounded deep under the earth's surface for many years. Groundwaters tend to be replaced much more slowly than surface waters, and thus are less renewable as a resource than surface waters. Due to the ability of soils to adsorb chemicals and larger microbes (bacteria and protozoans more than viruses), groundwaters tend to be purer, less under the influence of surface contamination, and in less need of treatment. Groundwaters may be subject to natural contamination from substances such as arsenic and radon due to local hydrogeology. In addition, severe contamination of the soil, such as that from hazardous waste dumps and leaking underground storage tanks, can result in locally severe groundwater contamination. Because of its slow replenishment, contamination of groundwater tends to be far longer lasting and more difficult to remediate. Groundwater supplies are derived primarily from wells, but not all well water is truly "groundwater." Water from shallow wells is usually under the influence of surface water via runoff and infiltration.

DISTRIBUTION SYSTEM CONTAMINATION

Properly treated water may become contaminated again after it leaves the treatment plant and enters the distribution system. Outbreaks have been associated with contamination of water within distribution systems when sewage from wastewater pipes has entered drinking water pipes through leaks or improper connections. Certain pathogens, such as *Legionella* and MAC, are capable of growing within distribution systems in biofilms attached to water pipes. MAC and *Legionella*'s predisposition for warm stagnant water has led to numerous nosocomial infections in hospitals.[32] In addition to growth of microbes within the distribution system, disinfection byproducts continue to form within the distribution system as residual chlorine interacts with organic matter in the water. This leads to higher levels of DBPs in houses near the end of the distribution line compared to those closer to the source.

How Is Drinking Water Treated?

"Standard" drinking water treatment includes coagulation/flocculation, sedimentation, filtration, and disinfection. In the first step, the addition of chemicals, mostly alum, to raw water results in floc that attracts and adsorbs particulate matter. This then sinks during the sedimentation phase. The resulting effluent is then filtered to remove smaller particles, including protozoa and many other pathogens. The filter can be made of sand, gravel, charcoal, or a combination of the three. Following filtration, a disinfectant, usually chlorine, is added to inactivate remaining microbes. The amount of chlorine added is titrated to allow for residual chlorine to remain in the water as it passes through the distribution system and emerges from the tap. This "finished" water is stored in a closed tank or reservoir, and then pumped to the community.

The amount of treatment provided by the water utility is dependent on the nature and degree of source water contamination. Most urban utilities obtaining water from local rivers require intensive water treatment. It is not uncommon for water utilities to draw raw water from a variety of sources, and to co-mingle the water during treatment. Since groundwater is naturally filtered, it may not go through all of the treatment steps described above. Some large surface water systems (e.g., those serving San Francisco, New York City, and Seattle) obtain their water from distant, relatively pristine watersheds, and so they do not filter their drinking water. It is also worth noting that large municipal areas are often served by more than one treatment plant.

The majority of bacterial pathogens are removed or inactivated by standard water treatment practices. Most of the recent outbreaks associated with bacterial pathogens in drinking water have been due to the consumption of untreated groundwater.[33] Inactivation and removal of enteric viruses by water treatment processes vary by virus type and treatment conditions. For example, poliovirus and rotavirus are susceptible to chlorine, while some data suggest that Norwalk virus is resistant to chlorine.

Protozoal cysts are highly resistant to chlorine, so these organisms must be removed by coagulation-flocculation, sedimentation, and filtration. Concerns about the adequacy of standard water treatment practices have led the EPA to develop new surface water treatment rules that will use enhanced techniques to more effectively clear the water of protozoans. The majority of drinking water outbreaks attributed to enteric protozoa have been associated with surface water supplies that were either unfiltered or not otherwise adequately treated.

Measurement and reporting of microbial contaminants in water is incomplete at best. A group of bacteria called fecal coliforms is one indicator of microbiological water quality. Coliforms adequately

HAVING TAP WATER TESTED FOR SAFETY

If a patient is interested in having his or her tap water tested, the appropriate test depends on the water source, treatment, and geography.

For example:

- A well located in an agricultural area is susceptible to nitrate and pesticide contamination.
- Groundwater taken from places like New England or the Midwest may be contaminated by radon.
- If the water source is in an industrial area, test for petroleum products and volatile organic compounds.

EPA's Drinking Water Hotline (800-426-4791) or the local health department can recommend what contaminants to test for and also direct your patient to a qualified laboratory.

predict the presence of fecal material and some bacterial pathogens in the water, particularly source waters. Because coliforms are killed during disinfection processes, however, they are not adequate predictors of viral and protozoal contamination, especially in finished waters.

Water turbidity, gauged by the scattering of light by particles in the water, is the other most common indicator of water quality. Turbidity is measured in nephelometric turbidity units (NTUs) and increases with increasing concentration of fine particulates in water. It is used as a crude indicator of contamination with organisms such as *Cryptosporidia*, as rapid and accurate techniques for detecting the tiny oocysts have not yet been developed. For many organisms, adequate or practical methods of detection in water are not available.

ALTERNATIVES TO CHLORINE

Because of the potential carcinogenic and other health effects of chlorination, other disinfectants are under consideration. Ozone, chlorine dioxide, and chloramines are all considered viable alternatives to chlorine; however, risks associated with byproducts of alternatives to chlorination are even less well studied than chlorination. Furthermore, these alternative disinfectants vary in their biocidal effectiveness, are more expensive, and may require application that is more sophisticated. Any disinfectant replacing chlorine needs to match its effectiveness in initial application to the water and also provide comparable residual disinfection as water passes through distribution systems. If alternatives are not applied and controlled correctly, the public may be less protected.[34]

All disinfecting chemicals appear to be capable of forming mutagenic chemicals during water treatment. However, the levels of mutagens formed by ozone, chlorine dioxide, and monochloramines have typically been lower than that of chlorine, and particularly with ozone, have been highly dependent on the quality of the source water.[35]

How Should You Counsel Patients, And Which Patients Are Most Susceptible?

In advising patients about their drinking water, it is important for the health care provider to consider a patient's individual susceptibilities and the relative risks from microbial pathogens and chemicals. For example, boiling water for an infant may provide more thorough disinfection, but may also inadvertently concentrate lead or nitrates in that water. Decisions need to be based on knowledge of likely contaminants in a specific source of water, an understanding of the risks and benefits of the various alternatives to tap water, and understanding of the individual's susceptibility. Table 2 summarizes susceptibilities of various populations to selected chemical and microbial agents.

While ingestion of tap water is the primary way people are exposed, the variety of uses of tap water means that patients can be exposed inadvertently and must be vigilant. For example, immunocompromised patients should boil not only the water they drink, but also the water they use for brushing teeth, making ice cubes, washing fruits and vegetables, and perhaps bathing.[36] Vulnerable patients should also be informed that fountain beverages and ice served in commercial establishments are usually made from tap water and may pose risks.

It should also be emphasized that the major route of exposure to certain chemicals in water, particularly volatile organic chemicals, is not necessarily

WHAT IS A CONSUMER CONFIDENCE REPORT?

By now, many of your patients should have received a Consumer Confidence Report (CCR) from their drinking water utility. Under the SDWA Amendments of 1996, water utilities are required to issue these reports, which disclose results of monitoring for regulated contaminants. It is important to recognize what information is and is not reported in the CCRs. The CCRs are a good tool, but they do not give the consumer the full picture on drinking water quality.

According to the regulation, CCRs must include the following information:

- ➤ The source of the drinking water.
- ➤ Whether the water meets federal standards.
- ➤ Potential health effects if the standards are violated.
- ➤ Potential sources of any contamination found.
- ➤ Where consumers can go for more information on water quality.
- ➤ Educational information for susceptible people on avoiding *Cryptosporidium*.

The CCR represents an important step in providing communities with information about their possible waterborne exposures. But these federally mandated reports have important limitations:

- ➤ They only provide information to bill-paying customers of community water supplies. People drinking private well water will not receive these reports, since EPA does not regulate wells. It is estimated that 9% of people in the U.S. (about 24 million) get their drinking water from wells or other individual systems. Moreover, renters and others who don't directly pay their own water bills may not receive information regarding their water, despite the existence of the CCR.
- ➤ Utilities are only required to report levels of contaminants that are regulated. Some important contaminants are not regulated, including radon and a number of pesticides. These may be in your drinking water but not reported.
- ➤ CCRs report data from the previous calendar year. The data do not reflect current drinking water conditions.
- ➤ With the exceptions of nitrate, arsenic, lead, and trihalomethanes, the EPA rules don't require disclosure of the health effects of contaminants, unless the system violated EPA's enforceable standard (Maximum Contaminant Level, or MCL) for that contaminant.
- ➤ The quality and completeness of information contained in CCRs varies from utility to utility and may not comply fully with EPA's reporting requirements.

CCRs list both the range and the average level of each contaminant found. Contaminant levels in tap water can vary over time, depending on seasonal uses and precipitation patterns. For example, some pesticides like atrazine may run off farm fields and contaminate water at high levels during the spring, but despite these seasonal "spikes," the year-round average may be much lower. The health effects of many chemical contaminants, such as arsenic, nitrates, and organophosphate pesticides, may be more related to short-term high-level exposures than to cumulative averaged exposures. Thus, attention should be given to the range as well as to the average levels.

TABLE 2. SELECTED PATIENT SUSCEPTIBILITIES

CONTAMINANT	NEONATES	INFANTS – CHILDREN	PREGNANT WOMEN*	IMMUNO-COMPROMISED	ELDERLY
Lead	XXX	XXX	XXX		
Nitrates	XXX		XX		
DBPs			X?		
E.coli O157:H7		XXX			XX
Enteroviruses	XXX				
Cryptosporidia				XXX	XX
Hepatitis E			XXX		
Adenovirus				XXX	
MAC				XXX	XX

Table 2: Summary table of categories of patients at higher risk than the general population for specific exposures. The number of X's is a qualitative judgment by the authors of the relative degree of susceptibility, weighing both frequency and severity of adverse health effects.

*With the exception of hepatitis E, all of the susceptibilities listed are for the fetus.

the ingestion of water. Since inhalation provides a more direct route to the bloodstream than other routes of exposure, chemicals that leave water, particularly when water is heated or aerosolized, may be readily absorbed. Inhalational exposure during showering or bathing has been shown to result in greater absorption of volatile organic chemicals than ingestion of a day's worth of water.[37] Inhalation is also the primary route of exposure from drinking water to MAC and *Legionella*.

Health care providers should also be sure to address other routes of exposure besides drinking water when counseling patients. It would be a mistake, for example, to give instructions to a patient to filter their water for lead without also inquiring about lead paint within the house, since lead paint is currently the main source of severe lead poisoning in children. Similarly, an infant in day care will be exposed to enteric viruses through contact with other children, caretakers, surfaces, and food in addition to any ingestion from drinking water. The effectiveness of drinking water interventions depends on how important drinking water is as a route of exposure for that particular contaminant or pathogen.

NEONATES

Neonates are usually afforded some protection from microbial risk through passive immunity from their mothers. However, enteroviruses, such as echoviruses and coxsackieviruses, are especially dangerous to neonates. The most serious complications associated with enteroviral infections in neonates are hepatitis and myocarditis, with a resulting fatality rate reported as high as 83%.[38] It should be noted that exposure of the neonate is primarily through the mother, either transplacentally or through direct contact, rather than through neonates ingesting water themselves.

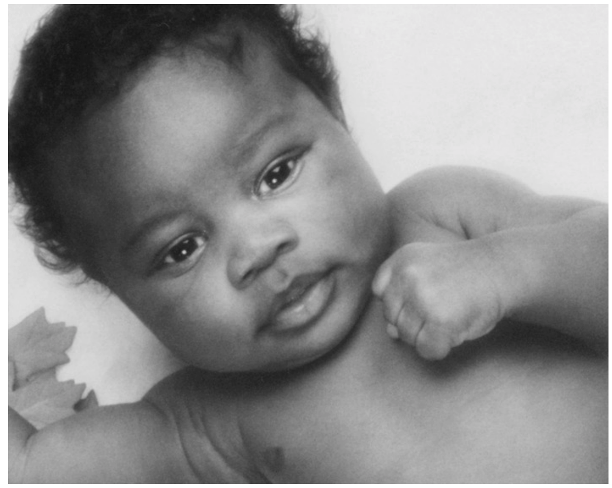
Lead and mercury are of particular concern for neonates because of the synergy between increased gastrointestinal absorption, immaturity of the blood-brain barrier, and incomplete neuronal development within the brain. As mentioned above, nitrates also have special toxicity for neonates. This is because of their low levels of NADH-dependent methemoglobin reductase, high levels of hemoglobin F, and higher gastrointestinal pH. Elevated gastrointestinal pH leads to greater bacterial proliferation, and hence greater bacterial conversion of dietary nitrates into more potent nitrites. Gastrointestinal disease in infants may accentuate this problem and lead to greater risk of methemoglobinemia. All of these factors tend to reach adult levels by the age of four months.

Parents of newborns are no longer instructed to boil water for one minute before using it, to inactivate any microbial pathogens that may be present in the water. Parents living in homes at risk for high lead, nitrates, or other chemical contaminants should have their water tested for these contaminants. Alternatively, they can filter their water (generally more effective for lead than for nitrates), obtain a reputable brand of bottled water for their newborn, or use pre-mixed formula. Parents of newborns should also be cautious about giving their children unpasteurized juices due to the risk of bacterial contamination.

INFANTS/CHILDREN

The rate of waterborne infection and the effects of those infections are age related. With some pathogens, such as coxsackie and echovirus, the rate of developing clinical disease can be low in children under five years and high in adults. Many enterovirus outbreaks in infants result in asymptomatic infections.[39] Also, hepatitis A and E are less serious diseases in children than adults. On the other hand, children are more likely to develop significant disease due to rotavirus infection than adults, and children under five years are more susceptible to serious outcomes from *E. coli* O157:H7, including hemolytic uremic syndrome, which is the most common cause of kidney failure in children.[40]

Children can also be at greater risk because of their differential exposure. Recreational water outbreaks are more commonly reported than drinking



water outbreaks in the U.S., and children are most likely to be swimming in lakes, ponds, streams, or pools. In one study that measured enteroviral levels in community swimming pools, 100% of the wading pools that were tested contained measurable enterovirus.[41] This should be no surprise considering that wading pools are usually very warm and frequented by toddlers in diapers.

Young children remain especially susceptible to the neurotoxic effects of lead. Parents of young children should determine whether their drinking water is at risk of lead contamination, and take the proper precautions if lead is found.

IMMUNOSUPPRESSED

The immunosuppressed population includes not only people with AIDS, but also transplant patients, persons undergoing chemotherapy, and those suffering from less common congenital or acquired immune system dysfunction. Cryptosporidiosis is deadly for the immunocompromised. During the Milwaukee outbreak in 1993, almost all of the deaths occurred in those with AIDS. As water is the most likely source of cryptosporidiosis, patients with AIDS and other immune system disorders need careful counseling regarding their drinking water practices.

Disseminated MAC is another common infection in AIDS patients who have CD4 counts less

ARE YOU REQUESTING THE RIGHT TEST FOR CRYPTOSPORIDIUM OOCYSTS?

In an effort to learn what physicians know about cryptosporidiosis, researchers at the Connecticut Department of Public Health surveyed a stratified random sample of Connecticut internists, gastroenterologists, pediatricians, and those with a focus on infectious disease and family or general practice. The results were published in the *Archives of Internal Medicine*.[42] Most (67-98%) physicians knew cryptosporidiosis causes watery diarrhea, especially in AIDS patients, but many failed to identify other groups at increased risk. Nor did many of these physicians test for the parasite. More than three-quarters of gastroenterologists, general or family practitioners, internists, and pediatricians rarely or never ordered diagnostic testing, and more than 30% of physicians assumed that standard ova and parasite examination included *Cryptosporidium* testing. **It does not.** The authors concluded that unless *Cryptosporidium* testing increases, it will be difficult to characterize and reduce the public health impact of cryptosporidiosis.

than 100/mm^3, and it can also occur in other immunocompromised patients without AIDS. In this country, about 20 to 40% of AIDS patients develop MAC over the course of their diseases, though with the advent of effective antiretroviral drug protocols, that percentage may be lessening.[43]

Transplant patients are especially susceptible to developing disseminated adenovirus infections; one report noted an incidence of 11% in transplant patients overall with a case fatality rate of 60% in bone marrow transplant patients particularly.[44] Sometimes, the immunocompromised are not any more likely to suffer an increased rate of infection or significant disease from a microbial pathogen. This is the case with Norwalk virus and *H. pylori*, and the enteric adenoviruses (40/41) are not commonly found in the immunocompromised patient, though they are a significant cause of diarrheal disease in children.

Immunocompromised people should take careful precautions to avoid ingesting microbial pathogens from water. They should be aware of the various unapparent routes of exposure to drinking water mentioned above, and ensure a safe water supply both at home and out of the house. Within the house, the immunocompromised may use a water filter that removes particles one micrometer or less in diameter. Such filters either use reverse osmosis, are labeled as "absolute" one micrometer pore size filters, or are labeled as tested and certified by NSF International under standard 53 for "cyst removal." (For more information, call the CDC AIDS Hotline at 800-342-2437.) Patients must be reminded to change filters regularly as advised by the manufacturer to avoid microbial contamination of the filters. Alternatively, boiling water for one minute provides effective protection from pathogens as well.

PREGNANT WOMEN

In most cases, waterborne diseases do not seriously threaten the health of pregnant women; rather, the risk is borne by their children. One notable exception is hepatitis E. With this virus, the case fatality rate for pregnant women is extremely high—possibly up to 40%.[45] Although outbreaks of hepatitis E have not been reported in this country, waterborne outbreaks affecting thousands of people have been reported mainly in developing countries, and travelers have introduced cases to the U.S.[46]

Other notable waterborne infections during later pregnancy include coxsackie and echoviruses, which may result in stillbirths, spontaneous abortions, and birth defects. Since infection from these viruses may be acquired by multiple routes (in addition to water), physicians may advise pregnant patients to take general precautions, such as careful handwashing, in addition to any measures aimed at reducing waterborne exposures.

The association between trihalomethanes or other DBPs and miscarriage or neural tube defects is currently under study by the EPA and other agencies. Concerned patients can reduce levels of THMs by either using carbon filtration or boiling for one minute followed by letting water sit for several hours before consumption. Pregnant women should be reminded that adequate water consumption is also essential to their health and the health of their child.

ELDERLY

The elderly are at increased risk of infection and disease from microbial contamination because of many factors: reduced immunity; a high incidence of frailty from malnutrition or existing chronic illness; and institutional exposure (e.g., hospitals and nursing homes). They are also at increased risk of dying from waterborne infections. The case fatality rates in nursing homes for certain waterborne pathogens, such as rotavirus and *E. coli* O157:H7, can be two orders of magnitude greater than that in the general population.[47]

A study of diarrheal deaths in this country showed that the greatest risk factors were being older than 74, being female, and residing in a long-term care facility.[48] Outbreaks of Norwalk virus and other caliciviruses have been frequently reported in nursing homes. There is also evidence to suggest that the elderly are more susceptible to the effects of cryptosporidiosis.[49]

Both pulmonary MAC (P-MAC) disease and Legionnaire's disease have been opportunistic diseases affecting mostly elderly people with a predisposing lung condition, such as emphysema. Reports show that though early studies of P-MAC found it to be more common in men with a history of tobacco use or lung disease, recently older women without any evidence of preexisting conditions have been reported as infected with P-MAC. Among P-MAC patients without recognized predisposing conditions (including smoking) the overwhelming majority are older females.[50]

What Are The Alternatives To Tap Water?

There are three alternatives to plain tap water for patients in vulnerable populations and for anyone during a waterborne outbreak alert: boiled water, bottled water, and filtered water.

BOILED WATER

Boiling water for one minute kills most harmful microbes but does not remove chemical contaminants. In fact, if water is boiled for longer than one minute, it can concentrate some chemicals, like nitrates. Boiling water within the house also raises the risk of serious burns. A countertop distiller that boils water and condenses the vapor is equally effective and has the added benefit of eliminating most minerals and metals, such as arsenic.[51]

BOTTLED WATER

While bottled water is generally of good quality, a study by the Natural Resources Defense Council (NRDC) found that some bottled water contains harmful bacteria, synthetic organic chemicals, such as solvents, chemicals from plastics, chlorination byproducts such as trihalomethanes, and inorganic contaminants, such as arsenic.[52]

NRDC sampled 1000 bottles from 103 brands and found that one-third of the brands had at least one bottle that violated state or industry limits for contaminants. In at least one sample, nearly 20% of the water brands tested (18/103) contained indicator bacteria at levels that exceeded state and industry guidelines. The same amount contained synthetic organic chemicals or chemicals used in plastics manufacturing. The NRDC tested only about half of the drinking water contaminants regulated by the Food and Drug Administration (FDA) and EPA, so the number of bottles containing contaminants may in fact be much higher.

The regulatory oversight of bottled waters is far more lax than that of community water systems. An estimated 60-70% of bottled water escapes FDA oversight because it is bottled and sold in the same state, and many states do not have a bottled water regulatory program. Many bottled waters also escape FDA-required testing and contamination standards because FDA exempts carbonated water, seltzer, etc. Even those brands that are tested do not have to undergo the same number and frequency of tests that public water purveyors must perform.

Another problem emerges with deceptive marketing practices. The report notes that some bottled water manufacturers mislead consumers about the source of the water. It gives the example of a label picturing a lake and mountains. The label reads "spring water," but the water actually comes from a well (known to have been periodically contaminated) in an industrial facility's parking lot near a waste dump. Patients who contact bottlers should request data supporting claims of their water's source and treatment.

WATER FILTERS

Patients shopping for a filtering system should look for certification from the NSF International for the reduction of contaminants of concern. Not every filter reduces every contaminant, so the consumer needs to know which contaminants are of concern in their area. NSF operates a certification program for water filter systems based on standards set by the American National Standards Institute (ANSI). This certification guarantees that the claims made by the manufacturer are legitimate—removal of anything from pesticides to protozoan cysts. NSF recommends identifying the contaminants of concern in the system (from the utility, health department, EPA, or from private testing) and choosing a system based on its removal certification. For example, water that is susceptible to *Cryptosporidium* contamination should be certified to ANSI/NSF standard 53 for cyst removal. Information on the current status of water filters can be obtained by contacting NSF at 800-673-8010 or www.nsf.org. Another label to look for is an "absolute" one micrometer filter—a "nominal" rating indicates that the filter may not reliably remove (oo)cysts.[53]

Your patients using water filters will be best protected if they change the filters frequently. *Consumer Reports* tested 14 drinking water filters and carafes. Faucet-mounted filters and three of the freestanding carafes (Brita, Pur, and Pur Plus) filtered out about 90% of lead and reduced chlorine byproducts. Many faucet-mounted filters reduced parasite levels. Generally, package labeling was accurate in terms of what the filter would reduce or eliminate. Among the higher-rated carafes and faucet-mounted models, none claimed to remove chloroform, but *Consumer Reports* testing found that certain brands did. *Consumer Reports* did not test for parasite reduction and also suggested looking for "NSF standard 53 for cyst reduction" on the package.

What Actions Can Health Care Providers Take?

You can be a critical force in your community for preserving or improving the quality of water and the environment in general. Following are some important actions that health professionals can take.

1. **REPORT ALL POSSIBLE CASES** of waterborne disease to your local or state health department to improve efforts at surveillance.
2. **INFORM YOURSELF** about the quality of your local drinking water and potential sources of contamination in your community. Read your water purveyor's CCR and familiarize yourself with the health effects of known or likely contaminants in your area. Stay abreast of current developments in drinking water regulations, scientific and medical studies, and treatment alternatives. Ask questions of your local water company(ies) and become familiar with the water treatment processes being used in communities where your patients live. Contact your water company to find out if they have done a source water assessment, a sanitary survey, or any other review of potential pollution sources. If none have been done, urge your utility to complete these studies as soon as possible.
3. **INFORM YOUR PATIENTS.** Identify all patients in your practice who may be at increased risk from waterborne exposures, and give them appropriate counseling. Let them know where they can go for more information. You may also want to prepare a patient handout with information on risks from water and advice regarding appropriate and safe use of water filters and bottled water.
4. **BECOME A RESOURCE** on drinking water for your community, for patient advocacy, and for professional groups.
5. **TALK TO YOUR PEERS.** Give presentations on drinking water at Grand Rounds, re-certification courses, and continuing education talks.
6. **GET INVOLVED** with consumer, advocacy, and environmental groups working to protect our drinking water sources. Physicians for Social Responsibility can assist those interested in becoming advocates for safer drinking water. Your expertise is a valuable resource to your patients, government decision-makers, and the media.

For Information On Becoming an Advocate for Safer Drinking Water, Contact:

PHYSICIANS FOR SOCIAL RESPONSIBILITY
1101 14TH ST., NW, SUITE 700 • WASHINGTON, DC 20005 • 202-898-0150 • 202-898-0172 (FAX)

To stay current on drinking water issues, be sure to check PSR's website frequently (www.psr.org).

FOR MORE INFORMATION ABOUT DRINKING WATER…

GENERAL INFORMATION

- EPA's Safe Drinking Water Hotline: 800-426-4791
- EPA's Safe Water Web site: www.epa.gov/safewater
- Clean Water Action National Office, Washington, DC: 202-895-0420 or www.cleanwateraction.org

LOCAL AND REGIONAL DRINKING WATER QUALITY

- EPA Regional Offices: www.epa.gov/epahome/locate2.htm
- EPA's "Surf Your Watershed" Database: www.epa.gov/surf
- U.S. Geological Survey district or national offices: see blue pages in your phone book, or check http://www.usgs.gov

WELL WATER

- EPA information on private wells: www.epa.gov/safewater/pwells1.html

WATER FILTERS

- NSF International: 800-673-8010 or www.nsf.org

BOTTLED WATER

- Natural Resources Defense Council: www.nrdc.org

OTHER RESOURCES

- CDC AIDS Hotline: 800-342-2437

Glossary

COMMUNITY/NONCOMMUNITY WATER SYSTEM: a public water system can be classified as community or noncommunity. A community system serves at least 15 connections or 25 residents year-round. A noncommunity system serves the public, but does not serve the same people year-round (e.g., summer camp, trailer park).

CONSUMER CONFIDENCE REPORT (CCR): a document required by law to be sent from water purveyors to customers with information regarding their community's drinking water quality.

CONVENTIONAL TREATMENT OR FILTRATION: a series of processes, including chemical coagulation, flocculation, sedimentation, and filtration.

CROSS-CONNECTION: a connection between a drinking water system and an unapproved water supply or other source of contamination.

DISINFECTION BYPRODUCT: a compound formed by the reaction of a disinfectant, such as chlorine, with organic material in the water supply. Trihalomethanes are disinfection byproducts.

FECAL COLIFORM BACTERIA: found in the intestinal tracts of humans and animals. Their presence indicates fecal contamination, and therefore, potential presence of pathogens.

FINISHED WATER: water that has passed completely through a treatment plant.

GROUNDWATER: fresh water beneath the Earth's surface, usually found in aquifers that supply wells and streams. Groundwater is a major source of drinking water in the U.S. Groundwater can also be under the direct influence of surface water, which makes it susceptible to the same contaminants.

MAXIMUM CONTAMINANT LEVEL (MCL): the maximum permissible level of a contaminant in finished water. The maximum contaminant level goal (MCLG) is the maximum level of a contaminant at which no adverse effect on health is known, plus a margin of safety. MCLGs are unenforceable.

NEPHELOMETRIC TURBIDITY UNIT (NTU): the unit identifying turbidity (the presence of particulate matter) in water. Turbidity is used as an indicator of water quality.

PICOCURIE: Measure of radioactivity equivalent to 0.037 disintegrations per second. The EPA has determined that a level of 4 pCi/L due to radon in indoor air requires action to remediate.

RECREATIONAL WATER: water used for recreation—could be a natural body of water, like a lake or river, or a swimming pool or hot tub.

RESIDUAL CHLORINE: amount of available chlorine remaining after a given contact time under specified conditions. The residual serves to disinfect finished water that becomes contaminated in the distribution system.

REVERSE OSMOSIS: the application of pressure to liquid across a semipermeable membrane, producing demineralized water.

SAFE DRINKING WATER ACT (SDWA): Legislation passed by Congress in 1974 to ensure safe drinking water for consumers. The SDWA amendments of 1996 required, among other things, a greater emphasis on public outreach and information, as with the creation of the CCRs.

SURFACE WATER: all water naturally open to the atmosphere (rivers, lakes, reservoirs, etc.).

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