

Commentaries

Water Quality Laws and Waterborne Diseases: *Cryptosporidium* and Other Emerging Pathogens

ABSTRACT

Waterborne diseases, such as cryptosporidiosis, cause many cases of serious illness in the United States annually. Water quality is regulated by a complex system of federal and state legal provisions and agencies, which has been poorly studied.

The authors surveyed state and territorial agencies responsible for water quality about their laws, regulations, policies, and practices related to water quality and surveillance of cryptosporidiosis related to drinking water. In this commentary they review the development and current status of federal drinking water regulations, identify conflicts or gaps in legal authority between federal agencies and state and territorial agencies, and describe court-imposed limitations on federal authority with regard to regulation of water quality.

Recommendations are made for government actions that would increase the efficiency of efforts to ensure water quality; protect watersheds; strengthen waterborne disease surveillance; and protect the health of vulnerable populations. (*Am J Public Health*. 2000;90: 847–853)

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In 1993, national attention focused on the waterborne risks of *Cryptosporidium parvum*,¹ a relatively new human pathogen that is capable of causing life-threatening illness in persons with HIV/AIDS.^{2,3} Major outbreaks of cryptosporidiosis associated with drinking water in that year sickened more than 400 000 persons in Milwaukee, Wis, and thousands more in Las Vegas, Nev.^{4,5} In 1993 and 1994 the Centers for Disease Control and Prevention (CDC) linked 71% of waterborne disease outbreaks in those years to 2 pathogens, *Giardia lamblia* and *Cryptosporidium*.⁶

As an emerging pathogen,⁷ *Cryptosporidium* posed significant challenges to public health and water authorities. *Cryptosporidium* was highly prevalent in untreated source water,⁸ it caused substantial outbreaks of serious illness,⁶ and existing water testing and treatment methods failed to reliably detect¹ or remove it.⁹ Additionally, responding to cryptosporidiosis outbreaks strained the existing public health infrastructure, requiring both effective surveillance and case investigations, since cryptosporidiosis had been linked to drinking water,⁶ recreational water,^{10–12} food,^{13–15} person-to-person contact,¹⁶ and contact with farm animals.^{17,18} Researchers now know much more about *Cryptosporidium* than they did in 1993 and 1994. At that time, little consensus existed on the magnitude of risk posed by very low concentrations.¹⁸ More recent data, however, suggest that even low doses can lead to infection and illness in healthy volunteers.^{19,20}

Although *Cryptosporidium* is only one among many pathogens annually causing outbreaks of drinking water-associated disease and serious illness, its emergence has influenced federal and state policy-making since the mid-1990s. Public anxiety over *Cryptosporidium* motivated significant federal and state activity to learn more about the

pathogen and examine the adequacy of current water quality regulations, even as the number of drinking water-associated outbreaks attributable to *Cryptosporidium* decreased in 1995 and 1996,²¹ the most recent years for which complete data are available, and the risk to persons with HIV/AIDS declined with the increased use of highly active antiretroviral therapy.^{22,23}

Although major outbreaks of illness, such as occurred in Milwaukee, draw significant public and scientific attention to the problem of waterborne disease, traditional disease reporting greatly underestimates the burden of epidemic and endemic diarrheal disease caused by food,²⁴ drinking water, and recreational water.²⁵ Cases of gastrointestinal illnesses, from mild to severe, may number

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more than 300 million per year in the United States.²⁶ The need for law and policy reform is surpassed only by the need for resources to improve the safety of the nation's drinking water. The Environmental Protection Agency (EPA) estimates that \$12.1 billion is required immediately to meet health-based standards for water systems, primarily to protect water supplies from microbiological contaminants. The agency estimates that over the next 20 years, \$138.4 billion will be needed to replace or upgrade the drinking water infrastructure.²⁷ In this commentary we examine the overall status of state water quality regulation, using *Cryptosporidium* to illustrate the difficulties posed by emerging and reemerging pathogens.

Methods

A national survey of drinking water quality laws and regulations was conducted between 1995 and 1997, with an update in 1998. Members of the Council of State and Territorial Epidemiologists were the original respondents; they identified the appropriate state agencies responsible for water quality, and the survey instrument was forwarded to these agencies. The survey instrument asked for written responses, as well as original documentation or citation for the legal provisions. The state and territorial epidemiologists often provided information about reportable diseases (cryptosporidiosis) directly.

We report results from all 50 states, the District of Columbia, Puerto Rico, and 5 territories. (A table showing the full results is available at http://www.commed.uchc.edu/medicalhumanities/lazzarini/crypto_table1.htm or from the corresponding author.) Here we analyze the results of the survey for apparent conflicts and gaps in legal authority relevant to public health practice, identify legal limitations imposed by courts, and suggest areas for state or federal action. Owing to space constraints, we consider only issues related to waterborne infectious diseases and not those posed by most chemical contaminants.

Results

Federal Regulation of Public Drinking Water Quality

In 1974, Congress enacted the Safe Drinking Water Act (SDWA),²⁸ which authorizes the EPA to promulgate health-based drinking water standards.²⁹ Under the SDWA, tap water from public water systems must meet national primary drinking water regula-

tions that prescribe maximum contaminant levels (MCLs) for physical, chemical, biological, and radiological substances in drinking water supplies. States must use the best available technology and treatment techniques that are economically and technologically feasible.

The SDWA has been both influential and insufficient.³⁰ The EPA was slow to implement its provisions. By the time the SDWA was amended in 1986, the EPA had set MCLs for only 23 contaminants and had failed to prescribe any treatment techniques. In addition, many states received variances and exemptions under the SDWA, which delayed compliance with the national standards. As a result, a majority of public water systems did not meet minimal national standards.³¹

In an effort to facilitate implementation and improve national compliance, Congress amended the SDWA in 1986 and again in 1996. The 1996 amendments repealed an earlier mandate that the EPA regulate 25 contaminants every 3 years because it did not permit scientific judgment to separate real from perceived risks. Instead, the EPA is now required to consult with the scientific community, periodically publish a list of potentially hazardous contaminants, and create a contaminant occurrence database. In addition, the EPA must, every 5 years, select no fewer than 5 contaminants from the list and, after notice and public comment, decide whether to regulate them.³² Regulatory decisions must rely on the best available scientific practices, peer-reviewed studies, and the nature and extent of the public health risk.

The EPA faced a dilemma in promulgating regulations under the SDWA to reduce microbial contaminants in treated water, because many of the chemical disinfectants used to inactivate microbes also carry potential cancer risks associated with long-term consumption.^{33,34} Thus, there is often a trade-off between risks posed by the contaminants and those posed by the disinfectants. The following EPA rules sought a balanced resolution of these issues.

The Surface Water Treatment Rule,³⁵ promulgated in 1989, set disinfection requirements, filtration criteria, and new MCL goals for many organisms that cause waterborne diseases (including *Giardia lamblia*, *Legionella*, viruses, and heterotrophic bacteria). It also set limits on water turbidity (a measure of suspended particles in water) as part of the criteria for filtration and measurement of filtration performance. The Total Coliform Rule (TCR),³⁶ issued the same year, set MCLs for coliforms (common bacteria traditionally used by health and water officials as indicators of contamination).

The Information Collection Rule (ICR)³⁷ mandated collection of data on water quality, specific microbiologic contaminants, disinfectants, and disinfection byproducts from 1996 through 1998.³⁸ For the first time, the ICR specifically required the testing of source water—and under some circumstances, finished water—for *Cryptosporidium*. Scientists have questioned the value of ICR data on *Cryptosporidium*, owing to technical problems and unreliable testing methods.¹

Water Definitions Used by State and Federal Water Authorities

- Source water* is the untreated and unfiltered water in rivers, streams, lakes, and aquifers from which water utilities draw water to be treated, filtered, and tested to produce drinking water.
- Finished water* is water leaving the plant and ready to be used by consumers after being collected, treated, and, usually, filtered by a water utility.
- Surface water* includes water from lakes, streams, rivers, and surface springs. It is vulnerable to contamination by a variety of human, animal, and industrial sources and therefore has been subject to some of the most stringent testing and treatment requirements.
- Groundwater* comes from aquifers deep underground and is less susceptible to contamination than surface water.
- Groundwater under the direct influence of surface water* is water in aquifers that may be affected or contaminated by surface water. The EPA mandates more stringent testing, treatment, and filtration requirements for groundwater under the direct influence of surface water than for groundwater alone. The EPA requires water systems to determine whether they are using groundwater under the direct influence of surface water, in part through microscopic examination of water samples for "insect parts, plant debris, rotifers, nematodes, protozoa, and other material associated with the surface or near surface environment" (Interim Enhanced Surface Water Treatment Rule, 63 *Federal Register* 69478–69521, 69491 [December 16, 1998]). (The rule added *Cryptosporidium* oocysts to the specific protozoa included in the examination regimen.)

The interim Enhanced Surface Water Treatment Rule went into effect in February 1999.³⁹ The rule required more stringent standards for general filtration, sanitary surveys for all public water systems using groundwater under the direct influence of surface water, and enhanced record keeping. It also set disinfectant benchmarks, a MCL goal for *Cryptosporidium* of zero, and specific filtration requirements for *Cryptosporidium* oocysts. The Disinfectants and Disinfection Byproducts Rule established MCL goals and maximum residual disinfectant level goals for several common disinfectants and disinfectant byproducts.⁴⁰

Limits on Federal Authority to Regulate Drinking Water Quality

Although federal jurisdiction over drinking water has expanded tremendously since the SDWA was introduced in 1974, federal authority to regulate state actions is not unlimited. The web of regulations based on the SDWA affects water quality and regulatory systems in every state, yet a trend in legal decisions, dubbed “the new federalism,” has challenged the authority of the federal government. Our federalist system grants limited powers to the federal government in areas traditionally governed by state law, including food and water safety.

Several recent cases have overturned federal laws or regulations on Tenth Amendment grounds.^{41–44} One case in particular deserves attention, because it deals with a challenge to federal drinking water regulations, specifically lead-contaminated drinking water in schools. In *Acorn v Edwards*,⁴¹ the Fifth Circuit Court of Appeals held that specific provisions of the SDWA unconstitutionally intruded on the states’ sovereignty under the Tenth Amendment, because they required the state to either implement a federal regulatory program or become subject to civil liability. The importance of *Acorn* extends beyond its impact on drinking water in schools. *Acorn* illustrates the potential limits on federal action to protect drinking water.^{45–47} Without federal drinking water regulations, state provisions would still protect water in most states, but that protection might be short-lived. States adopted existing provisions to meet the minimum federal requirements, and few states have established higher standards. Other cases, which have challenged the EPA’s rule-making authority or processes under the SDWA on other grounds,^{48–50} illustrate both the broad discretion courts grant to regulatory agencies in substantive decision making and the stringent procedural requirements that courts apply to agencies.⁵¹

State Regulation of Public Drinking Water Quality

Regulatory authority. Pursuant to the SDWA, states may qualify for primary enforcement authority (“primacy”) for water quality laws. In states with primacy, state law grants 1 or more state agencies the authority to implement and administer water quality laws. In 15 states and 1 territory,⁵² the state health department has primary authority for water supplies. Environmental protection offices or agencies exercise primary authority over water systems in 20 states and 3 territories.⁵³ Health and environmental departments that are administratively combined or that share power have authority over water supplies in 14 states and 2 territories.⁵⁴

State law may also assign authority to 2 departments, each having primary authority over a different type of drinking water (Kentucky assigns authority to different departments for private and public water supplies). States may vest authority for water quality in local governments or agencies under certain conditions (e.g., Arizona) or for specific types of water systems (e.g., Michigan). In 2 jurisdictions that do not have primacy—the District of Columbia and Wyoming—the EPA directly regulates public water systems.

Testing and filtration in excess of federal standards. With one exception, states and territories do not require testing or monitoring that exceeds the federal Surface Water Treatment Rule.⁵⁵ No state reported plans to test for *Cryptosporidium* (except as required by the ICR). Similarly, only one state’s filtration regulations are more stringent than the federal rule.⁵⁶ Under the federal rule, public water systems that meet specific requirements, such as watershed protection, may be exempt from filtering their treated water.⁵⁷ States have the option of adopting or excluding the federal rule’s list of conditions necessary to avoid filtration, called “filter avoidance standards.” Thirty-one states, the District of Columbia, and 1 territory⁵⁸ have adopted the federal standards or have promulgated similar filter avoidance standards.

Reporting requirements. Most jurisdictions have laws or regulations requiring water suppliers to notify the public or the department that regulates the water supply in specific instances: when contamination or treatment failures occur⁵⁹ or when the supplier suspects a waterborne disease outbreak.⁶⁰ Other jurisdictions may achieve the same results with more general legislation.⁶¹

Mandatory reporting of cryptosporidiosis. In addition to requiring reporting by water suppliers, 49 states⁶² and Puerto Rico require physicians or laboratories to report

cases of cryptosporidiosis, usually naming the patient, to the state health department.

Watershed protection. Many states and territories have instituted programs to protect watershed areas, but the programs vary substantially. Nine states have comprehensive watershed protection plans.⁶³ These states safeguard the watershed through a systematic plan that includes land use restrictions, site-specific requirements, detailed reporting, and inspections. Eleven states, the District of Columbia, and 2 territories⁶⁴ require counties and localities to develop watershed control programs. Nine states and 1 territory⁶⁵ protect the watershed through a series of land use restrictions in areas affecting watersheds. Watershed protection commonly focuses on household waste disposal, for example, by regulating septic systems, cesspools, and seepage pits. Some states combine regulation of human waste with protection of water supplies from contaminants particular to the state. Alaska’s provisions address both human waste and contamination by petroleum lines.

Boil water advisories. Health or water officials who suspect contamination of drinking water rely on boil water advisories (BWAs) as one of their key tools. Entities with the authority to issue and terminate BWAs vary by jurisdiction. In 19 states,⁶⁶ state or local health departments have the sole authority to issue an advisory. In 17 states and 1 territory,⁶⁷ an environmental protection office has sole authority to issue an advisory. Twelve states and 2 territories⁶⁸ grant authority to both health departments and environmental protection offices. Where the authority to issue a BWA is held by more than one department or agency, some states require the entities to issue a cooperative BWA; other states grant each department independent authority.

The law usually specifies which entity may terminate a BWA. In at least 1 state, however, the entity with the authority to initiate an advisory lacks the power to terminate it.⁶⁹ Ten states and 1 territory⁷⁰ report some method, formal or informal, for resolving disagreements or conflicts of authority over termination of a BWA.

Criteria for issuing and terminating a BWA are not uniform. In 32 states, the District of Columbia, and 4 territories,⁷¹ the entities responsible for water quality exercise broad discretion in determining the standards for issuing a BWA. In 10 states and 1 territory,⁷² departmental policy or guidelines specify criteria for issuing a BWA. Finally, in 9 states and 3 territories,⁷³ policymakers use formal legislative or regulatory procedures to establish criteria for issuing a BWA. Regardless of how these criteria are set, their nature and specificity vary from jurisdiction to jurisdiction. For example, North

Carolina has no written criteria or procedures for issuing a BWA; in contrast, Maryland has detailed standards, particularly relating to cryptosporidiosis (Maryland formulated a Cryptosporidiosis Action Plan in 1996).

Other emergency measures. In 15 states and 2 territories,⁷⁴ the heads of the departments charged with regulating the state or territorial water supply are expressly authorized to grant injunctions against water suppliers in cases of emergency or in situations that threaten the public health. In 42 states, the District of Columbia, and 4 territories,⁷⁵ officials are authorized to take other measures when faced with noncompliance, general health threats, or disease outbreaks.

Discussion

For much of this century, federal efforts have focused on raising national drinking water standards. Since 1974, the EPA, through the SDWA, has crafted a detailed body of federal regulations that water systems must meet, either through compliance with state laws or by direct regulation. Substantial differences remain, however, in state and local implementation of federal requirements. Although our federalist system welcomes state experimentation, the current system may hinder public health efforts to prevent illness caused by drinking water and to control waterborne diseases. Even the EPA and the CDC may be unaware of the proper authority in each state to contact to distribute information or collect data on waterborne disease outbreaks. Some individual states, however, have evolved impressive statutory or regulatory approaches to controlling waterborne diseases, systems that could serve as models for future state or federal action. Here we identify 9 problems with existing drinking water regulation; discuss, where appropriate, possible state models; and make recommendations for future action.

1. Federal provisions can provide uniformity for national water quality provisions, but federal agencies are constrained by federalism and by procedural requirements of the rule-making process.

The federal judiciary can constrain federal agencies' control over national water quality. Recent cases suggest substantive limitations on the power of the federal government and its agencies to set uniform standards. Moreover, procedural requirements impose costs and can delay federal response to emerging problems. To withstand legal challenges in the current climate favoring states' rights, regulators must carefully adhere to constitutional and procedural requirements.

States often perceive federal standards as a ceiling rather than a floor. Because federal law sets minimum standards for water treatment (testing, disinfection, and filtration), states have little incentive to assume further costs by supplementing those federal rules. Many states have failed to attain federal safety levels, and only a handful have exceeded federal requirements. Although individual water utilities may set and maintain higher standards than required by state law, existing laws provide no mechanisms to measure or enforce more stringent conditions or inform consumers of differences in utilities' standards.

By coordinating federal, state, and local identification of and response to waterborne disease threats, the nation can better protect the public health. Ideally, federal regulation would set minimum standards, ensure a harmonized approach, and provide valuable scientific research. States would implement, and exceed, federal standards on the basis of local needs.

Recommendation: In promulgating regulations, the EPA should provide states with alternatives to meeting mandatory federal standards. The EPA should be meticulous in providing states and other interested parties with notice and should adhere to a fair process for rule making. Federal initiatives should include adequate resources and incentives for the states to set and maintain high standards.

2. State laws do not provide clear authority for water quality.

State law often apportions the responsibility for the safety of drinking water to multiple governmental agencies. Where 2 agencies share joint responsibility, federal agencies or other states may not be able to discern the correct agency to contact in case of a waterborne disease emergency. Moreover, authority may be so buried in state administrative structure that divided authority leads to intrastate confusion or conflict. The law may not clearly state which agency should take the lead in response to an outbreak or how disagreements between agency personnel should be decided.

Recommendation: States should clarify which entities have authority over water quality and ensure that an explicit method exists for resolving conflicts of authority. In particular, states should specify which agencies have the authority to issue BWAs and which have the power to terminate BWAs, and they should fully articulate plans to resolve any differences.

3. State provisions lack clear criteria for public health responses such as BWAs.

State provisions for issuing and terminating BWAs may vest broad discretion in health or water officials, describe criteria in

considerable detail, or adopt an intermediate position. Some discretion permits flexibility, quick response, and utilization of the newest scientific and epidemiologic methods and evidence. Discretionary power without specific guidance, however, can lead to inconsistent decision making, reaction to media or public pressure without scientific support, and poor decisions by newly hired health or water officials who have not gained sufficient experience. Avoiding misuse of discretionary power requires a regulatory scheme that establishes a framework for applying good scientific and epidemiologic practices and permits authorities to evaluate and respond to both known and new threats to the public water supply.⁷⁶

The state of Illinois has developed an excellent system of issuing BWAs that allows for quick response to water emergencies as well as adequate supervision over the decision making. The Illinois EPA has the main authority to issue BWAs. To mitigate the health effects of water contamination, water suppliers in Illinois must give the public notice of a health threat. In addition, the regulations require local health departments to inform all food service facilities what measures they must take to remain open whenever a BWA is issued.

Recommendation: To guide health officials without unduly limiting their ability to respond to emerging pathogens, states should set clear criteria for issuing BWAs.

4. Health and water officials lack sufficient scientific knowledge about the prevalence of Cryptosporidium and other pathogens in source and finished water, as well as the risks attributable to pathogens and those attributable to disinfectants and disinfection byproducts.

Effective water regulation is manifestly complex and exists within a milieu of imperfect scientific knowledge. Regulators rely on filtration and chemical disinfectants in sufficient concentrations to kill or inactivate disease-causing organisms. Some disinfectants and disinfection byproducts, however, are toxic and possibly carcinogenic. Data on the carcinogenic effects are conflicting. A number of studies have found an association between disinfection byproducts and specific cancers, including cancers of the colon and bladder.^{33,77,78} Not all studies have found the same associations, however,^{79,80} and methodological constraints may limit their generalizability.³³

The history of the SDWA and its repeated amendments demonstrates the difficulty of designing and implementing ongoing prioritization of contaminants and disinfectants for study and regulation. The Enhanced Surface Water Treatment Rule and the Disinfectant and Disinfection Byproduct Rule represent the next step in a national effort to analyze and balance disparate risks.

Establishing the appropriate risk trade-off requires careful scrutiny of scientific data and consensus among different interests. Collecting and analyzing information to clarify specific risks demands resources that exceed those currently available to water and public health authorities.

As other waterborne pathogens emerge to cause human disease, water and public health authorities will face similar problems—identifying the pathogen, documenting its spread through drinking water, developing accurate monitoring systems, establishing effective disinfection or filtration methods, and weighing trade-offs among competing health risks.

Recommendation: The ICR seeks to provide scientific data on risks, but federal and state health officials must engage in, and fund, research to provide a stronger scientific foundation for drinking water regulation. This will require resources dedicated for these purposes. The EPA and the states should immediately begin providing resources to support monitoring; conducting heightened disease surveillance and appropriate epidemiologic studies; evaluating standards; and researching effective prevention, treatment, and control of microbial contaminants capable of causing significant illness or death. The EPA should also support continued research on, and regulation of, disinfectants and disinfection byproducts.

5. *Improved monitoring capacity and subsequent detection of contaminants, including waterborne pathogens, may lead to inordinate public concern and increased social and economic costs.*

The ICR produced extensive data on contaminants in drinking water with the potential to cause human illness.³⁸ However, the significance of these data and the actual level of risk posed by many contaminants remain unknown. In the absence of clear scientific data, regulators must balance competing risks. A decision to aggressively prevent and respond to low levels of *Cryptosporidium* oocysts in drinking water may lead to heightened public concern, unnecessary BWAs, and substantial social, economic, and human costs.^{9,81}

Recommendation: The EPA and states should carefully analyze the data from monitoring and surveillance systems to determine their public health significance. Until laboratory detection methods improve significantly, states should avoid issuing BWAs based on detection of *Cryptosporidium* oocysts alone, absent a demonstrable health threat or other indicators of risk.

6. *States lack adequate surveillance systems.*

Disease surveillance and investigation provide a crucial link in prevention of water-

borne diseases. Surveillance permits timely investigation to identify the agent of disease, endemic cases, outbreaks, and treatment deficiencies. National systems of tracking existing and emerging diseases largely depend on voluntary state reporting of cases to the CDC. States usually require reporting through their communicable disease control laws or disease-specific statutes. The majority now mandate reporting of cryptosporidiosis. However, until health officials identify a pathogen as posing a potential public health threat, state provisions do not require reporting. Consequently, reporting of emerging diseases, including cryptosporidiosis, usually lags behind their actual occurrence. This lag may cause delays in identifying outbreaks, and it hampers national efforts to estimate the disease burden of emerging pathogens and limits coordinated actions to prevent future outbreaks and reduce endemic cases. Even where reporting is mandated, many states lack adequate resources to conduct even basic effective surveillance, investigation, and identification of waterborne or foodborne illnesses.^{82,83}

Some states have adopted other means of surveillance to enhance health officials' ability to identify outbreaks of waterborne disease, including cryptosporidiosis.⁸⁴ Maryland includes reporting of outbreaks in nursing homes and communities with significant populations of immunosuppressed individuals. Others have experimented with monitoring sales of anti-diarrheal medications.

Recommendation: States should develop and support adequate public health infrastructure for all disease surveillance. The system should permit timely reporting, investigation, and identification of pathogens, and the means to implement effective public health responses to specific threats. Specifically, states should designate as reportable under state law illnesses caused by important waterborne pathogens such as *Cryptosporidium*, Norwalk virus, and other emerging pathogens; develop methods of active, as well as passive, surveillance; educate physicians about stool sample testing; train physicians to consider *Cryptosporidium* as part of differential diagnosis of diarrhea; and evaluate innovative measures to enhance existing surveillance systems, including monitoring of specific health care facilities (e.g., nursing homes, emergency rooms, and health maintenance organizations) for complaints of diarrheal disease, adopting those that show promise.

7. *Local health officials need effective evaluations of possible public health risks.*

Local health and water officials are usually the first to deal with reports of pos-

sible waterborne disease outbreaks, weather emergencies, or treatment failures that may lead to contamination of public drinking water supplies. They may need access to experts who are well versed in the epidemiology of specific waterborne diseases. They also need support in gathering data, investigating cases, and evaluating risks. If the local public health response is well planned, officials save time and resources during an outbreak.⁸⁵

Recommendation: Communities should establish advisory groups, well versed in the risks of *Cryptosporidium* and other waterborne infections, that can be quickly activated to evaluate data on potential public health risks. States, through law or regulation, should establish and support local advisory groups or task forces specifically charged with preventing and responding to waterborne disease outbreaks.⁸¹

8. *Regulations often neglect watershed protection.*

Ideally, drinking water protection should focus on raising the quality of source water, rather than increasing the sophistication of treatment and testing techniques for finished water.⁸⁶ Many states lack comprehensive watershed control programs that account for both human and wildlife-related contamination. New Hampshire, in contrast, exemplifies a well-developed program. To maximize protection of the water supply, New Hampshire has identified more than 50 specific geographic areas of the state and has developed watershed control measures for each area. Although it is time-consuming to formulate such detailed and specific regulations, they can have long-term benefits. Area-specific characteristics of a watershed tend to go undetected or unnoticed in a more general watershed control program. However, even watershed protection cannot eliminate waterborne pathogens from source water, since recent data suggest that wildlife may contribute to waterborne disease outbreaks.

Recommendation: States should design and adopt comprehensive watershed protection plans. Such plans would account for land use, construction limitations, and industrial provisions. These plans should take full advantage of federal funding programs to protect groundwater and foster other measures to facilitate compliance by small systems.

9. *Vulnerable populations may be at heightened risk even in nonoutbreak settings.*

Current scientific data suggest that vulnerable populations are at increased risk of becoming seriously ill from cryptosporidiosis and other waterborne diseases,^{87,88} although the precise risk remains difficult to

estimate. The traditional public health response to possible outbreaks, however, often does not distinguish between immune-competent and vulnerable populations—BWAs are issued, if at all, for all consumers of the water supply. In the case of *Cryptosporidium*, however, health authorities and water officials have worked together to develop educational materials specifically for immunocompromised persons and physicians to address additional protective measures they might take.⁸¹

Recommendation: Health departments should educate physicians and patients about potential risks and instruct them in measures to prevent infection from water and foodborne pathogens.^{18,81} Moreover, health officials should issue special health warnings to specific populations when epidemiologic or water quality data suggest heightened risk.

Conclusion

The drinking water supply in the United States cannot be taken for granted. Waterborne disease outbreaks have occurred in major American cities. Epidemiologic reports demonstrate the large burden on health of waterborne diseases.²⁶ Improved science and surveillance, systematic regulation based on the best scientific evidence, and adequate resources are sorely needed to build and maintain a safe drinking water infrastructure in the 21st century.⁸⁹ □

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52. Arkansas, California, Connecticut, Hawaii, Louisiana, Maine, Minnesota, Mississippi, Nebraska, New York, North Dakota, Oregon, Virginia, Washington, West Virginia, and Palau.
53. Alabama, Alaska, Arizona, Georgia, Idaho, Indiana, Iowa, Maryland, Michigan, Missouri, New Hampshire, New Jersey, New Mexico, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Vermont, Wisconsin, Guam, the Northern Mariana Islands, and the US Virgin Islands.
54. Colorado, Delaware, Florida, Illinois, Kansas, Kentucky, Massachusetts, Montana, Nevada, North Carolina, Ohio, Rhode Island, South Carolina, Utah, Puerto Rico, and the Marshall Islands.
55. Connecticut monitors turbidity more closely than required by federal standards [Conn PHC §19-13-B102(e)(7)(K)].
56. Louisiana prohibits the use of pressure filters for water supplies using surface water (La San Code, SWTR §5.01, §12.006).
57. CFR §141.71.
58. Alabama, Alaska, Delaware, Florida, Idaho, Illinois, Indiana, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Vermont, Wisconsin, West Virginia, Washington, Wyoming, and Palau.
59. Thirty-three states and 1 territory (Alabama, Alaska, Arizona, Arkansas, Connecticut, Colorado, Florida, Georgia, Hawaii, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Virginia, West Virginia, and Puerto Rico) require water suppliers to report any compliance failure (e.g., failure to perform tests, failure to disinfect, nonmaintenance of filter avoidance standards) or violation (e.g., elevated MCLs, including MCLs for total or fecal coliforms).
60. Most states (e.g., Arizona, Hawaii, Idaho, Indiana, Montana, Virginia) expressly require water suppliers to report to the state an outbreak of waterborne disease that may be linked to the drinking water supply.
61. Massachusetts law requires immediate reports of “any violations of standards and regulations regulating the quality of water used for drinking, domestic, or culinary purposes to the department of public health” (Mass Gen Laws, ch 111 §160B).
62. The exception is Virginia. The District of Columbia also lacks such a requirement.
63. California, Hawaii, Maryland, Massachusetts, Nebraska, New Hampshire, Oklahoma, Vermont, and Washington.
64. Colorado, Connecticut, Georgia, Illinois, New Mexico, New York, Rhode Island, Tennessee, Texas, West Virginia, Wyoming, Guam, and the Northern Mariana Islands.
65. Alabama, Alaska, Arizona, Arkansas, Connecticut, Iowa, Louisiana, New Hampshire, New Mexico, and the Marshall Islands.
66. Alabama, Arkansas, California, Connecticut, Delaware, Hawaii, Louisiana, Maine, Minnesota, Mississippi, Nebraska, New York, North Dakota, Oregon, Rhode Island, Virginia, Washington, West Virginia, and Wyoming.
67. Alaska, Arizona, Georgia, Kentucky, Maryland, Massachusetts, Missouri, New Hampshire, New Mexico, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Vermont, Wisconsin, and the Northern Mariana Islands.
68. Colorado, Idaho, Florida, Illinois, Indiana, Iowa, Michigan, Montana, New Jersey, North Carolina, Texas, Utah, the Marshall Islands, and the US Virgin Islands.
69. In Alabama the Department of Public Health usually issues the BWA, but only the Department of Environmental Management has the authority to discontinue it.
70. Arizona, Idaho, Indiana, Iowa, Kentucky, Massachusetts, Montana, Nebraska, New Hampshire, Wyoming, and the Marshall Islands.
71. Alaska, Arkansas, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Michigan, Mississippi, Montana, Nebraska, New Hampshire, New Jersey, North Carolina, Ohio, Oklahoma, Oregon, South Dakota, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, West Virginia, Wyoming, Guam, the Northern Mariana Islands, Palau, and the US Virgin Islands.
72. Alabama, Arizona, Florida, Kentucky, Maryland, Massachusetts, Minnesota, Missouri, Rhode Island, South Carolina, and the Marshall Islands.
73. California, Hawaii, Idaho, Illinois, Missouri, New Mexico, North Dakota, Pennsylvania, Tennessee, Palau, the Marshall Islands, and the US Virgin Islands.
74. Alabama, Arizona, Georgia, Hawaii, Kansas, Louisiana, Massachusetts, Mississippi, Missouri, Nevada, New Mexico, North Carolina, Oregon, Vermont, Virginia, Puerto Rico, and the Marshall Islands.
75. Arizona, Arkansas, California, Colorado, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington, Wisconsin, West Virginia, Wyoming, Palau, Puerto Rico, the Marshall Islands, and the US Virgin Islands.
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