Cryptosporidium and Water:

A Public Health Handbook

1997

WG
WC
Working Group on
Waterborne Cryptosporidiosis

Suggested Citation
Cryptosporidium and Water: A Public Health Handbook. Atlanta, Georgia: Working Group on Waterborne Cryptosporidiosis.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

For additional copies of this handbook, write to:

Centers for Disease Control and Prevention
National Center for Infectious Diseases
Division of Parasitic Diseases
Mailstop F-22
4770 Buford Highway N.E.
Atlanta, GA 30341-3724

CONTENTS

Working Group on Waterborne Cryptosporidiosis (WGWC)

Daniel G. Colley and Dennis D. Juranek, Coordinators, WGWC
Division of Parasitic Diseases (DPD)
National Center for Infectious Diseases
Centers for Disease Control and Prevention

Scott A. Damon, Publications Coordinator, WGWC, Centers for Disease Control and Prevention
Margaret Hurd, Communications Coordinator, WGWC, Centers for Disease Control and Prevention
Mary E. Bartlett, DPD Editor, Centers for Disease Control and Prevention
Leslie S. Parker, Visual Information Specialist, Centers for Disease Control and Prevention

Task Forces and Other Contributors:

The draft materials for this handbook were developed through the work of multiple task forces and individuals whose names appear at the beginning of each chapter/section. The draft documents were then reviewed and revised based on comments from representatives* of the entire "Working Group on Waterborne Cryptosporidiosis". The task force for development of information for state and local health officers** designed the handbook, assembled additional published and unpublished informational materials, and prepared the introductory and transitional chapters needed to produce a cohesive reference document for health departments and the drinking water industry.

*WGWC Review Committee

Chair: Dennis D. Juranek, Centers for Disease Control and Prevention
Chet Anderson, Metropolitan Water District of Southern California
Arthur Ashendorff, New York City Department of Environmental Protection
Paul S. Berger, U.S. Environmental Protection Agency
Kathleen Blair, City of Milwaukee Health Department
Scott A. Damon, Centers for Disease Control and Prevention
Iris L. Long, AIDS Coalition to Unleash Power
Alexis M. Milea, California Department of Health Services
James R. Miller, New York City Departments of Health and Environmental Protection
Michael T. Osterholm, Minnesota Department of Health
Thomas Outlaw, Association of State Drinking Water Administrators
Alan Roberson, American Water Works Association
Peggy A. Ryker, Kentucky Department of Environmental Protection
Faye E. Sorhage, New Jersey Department of Health and Senior Services

**WGWC Task Force on Information for State and Local Public Health Officers

Chair: Faye E. Sorhage, New Jersey Department of Health and Senior Services
David G. Addiss, Centers for Disease Control and Prevention
Kathleen Blair, City of Milwaukee Health Department
Lynn M. Bradley, Association of State and Territorial Public Health Laboratory Directors
Scott A. Damon, Centers for Disease Control and Prevention
Anita K. Highsmith, Centers for Disease Control and Prevention
Dennis D. Juranek, Centers for Disease Control and Prevention
Iris L. Long, AIDS Coalition to Unleash Power
James R. Miller, New York City Departments of Health and Environmental Protection
Michael T. Osterholm, Minnesota Department of Health

Agencies represented on the Working Group on Waterborne Cryptosporidiosis include but are not limited to: Centers for Disease Control and Prevention, U.S. Environmental Protection Agency, Food and Drug Administration, U.S. Department of Agriculture, Council of State and Territorial Epidemiologists, American Water Works Association, American Water Works Research Foundation, Association of State Drinking Water Administrators, Association of Metropolitan Water Agencies, AIDS Coalition to Unleash Power, National Association of People With AIDS, American Public Health Association, Association of State and Territorial Public Health Laboratory Directors, National Association of City and County Health Officials, Milwaukee Health Department, New York City Department of Health, New York City Department of Environmental Protection, St. Louis County Health Department, Seattle-King County Department of Health, California Public Health Department, Kentucky Department of Environmental Protection, Maryland Department of the Environment, Minnesota Department of Health, New Jersey Department of Health, New York Department of Environmental Protection, Massachusetts Water Resources Authority, Metropolitan Water District of Southern California, New York Hospital-Cornell Medical Center, International Bottled Water Association, NSF International.

EXECUTIVE SUMMARY

This public health handbook, *Cryptosporidium* and Water, was developed by the Working Group on Waterborne Cryptosporidiosis (WGWC) -- a multi-disciplinary group composed of representatives from the national Centers for Disease Control and Prevention (CDC), U.S. Environmental Protection Agency (EPA), Food and Drug Administration (FDA), U. S. Department of Agriculture (USDA), state and local health departments, the drinking water industry, and organizations representing the concerns of immunocompromised persons. The handbook was developed to assist local health departments and water utilities in preparing for and responding to reports of *Cryptosporidium* oocysts in tap water or in a community's source of drinking water (river, lake, well). A new, federally mandated water monitoring regulation goes into effect in 1997 that requires water utilities to test drinking water sources once a month for *Cryptosporidium*. *Cryptosporidium* will likely be found in the water supplies of many communities; such findings may result in many unnecessary boil water advisories if test results are not carefully interpreted.

The WGWC encourages health departments and water utilities to work as a team to develop appropriate health risk assessment protocols and public responses to findings of *Cryptosporidium* in drinking water supplies. The common occurrence of *Cryptosporidium* in sources of drinking water throughout the nation, and the lack of reliable water testing methods for determining if a sufficient number of viable oocysts are present in water to cause an outbreak, combine to make this a challenging task. Because cryptosporidia are resistant to the chlorine disinfectants commonly used in water treatment, the WGWC encourages water utilities to optimize their filtration methods to reduce the risk of tap water contamination. It should be recognized, however that *Cryptosporidium* oocysts may occasionally get through even well operated filters. Although the handbook focuses primarily on *Cryptosporidium* in drinking water and, to a lesser extent, recreational water, most of the principles outlined in the handbook can be applied equally well to the prevention and investigation of other waterborne pathogens.

The WGWC recommends the formation of a local *Cryptosporidium* Response Task Force that includes, at a minimum, representatives from the health department, water regulatory authority, and water utility. Guidance is provided in the handbook for organizing such a task force, evaluating the water system's vulnerability to *Cryptosporidium* (e.g., source water protection and water treatment methods) *before* there is public concern about the risk of waterborne cryptosporidiosis. The handbook also provides guidelines on assessing and developing health department capabilities for detecting a *Cryptosporidium* outbreak, and developing a coordinated emergency response plan. Also reviewed are some of the complex issues that should be addressed before issuing or rescinding a boil water advisory.

If *Cryptosporidium* is detected in your drinking water, a significant portion of health department and water utility staff time will be consumed by media and public inquiries. The WGWC encourages you to prepare for such inquiries well in advance of a crisis. One effective approach is to develop a good working relationship with key media health/science writers. Let them know in advance that your community, like most communities in the

United States, can expect to find *Cryptosporidium* occasionally in source water when mandatory *Cryptosporidium* testing is initiated. The health department, water utility, and the public will further benefit if the media are provided with a clear understanding of the many problems surrounding interpretation of water testing results for *Cryptosporidium*. Making the extra effort to work with the media before there is a crisis can reduce the chances of articles being published or broadcast with inaccurate, misleading, or frightening information about cryptosporidiosis and *Cryptosporidium* test results. Practical tips for working with the media as well as informational materials are provided in the handbook.

Guidance is also provided for initiating epidemiologic studies to determine if an outbreak is occurring, for conducting a systematic investigation of the water supply to determine if drinking water is a likely source of a suspected outbreak, as well as for assessing the size of an outbreak, geographic distribution of ill persons, and specific risk factors for infection. A sample data collection form and epidemiologic questionnaire are provided to facilitate this process. Emergency telephone numbers are provided for state health departments, CDC, and EPA, to contact for assistance in interpreting preliminary water quality data or investigating a possible outbreak.

Within the various chapters you will find information on *Cryptosporidium* and cryptosporidiosis that can be used for developing public education materials and preparing news media releases. This includes emergency water treatment guidelines such as *boiling water for 1 minute*. Informational materials for immunosuppressed persons (e.g., those with AIDS) at risk of developing life-threatening cryptosporidiosis are also provided. For immunosuppressed persons who want to try to avoid all municipal tap water and commercial products made with tap water, guidance is given for selecting an effective home-use water filter, bottled water, soft drinks, and juices. For the laboratorian, tables are provided that summarize information about the types and sources of diagnostic *Cryptosporidium* tests for water and stool, along with a discussion of their strengths and weaknesses. An appendix includes selected published articles, a listing of key words and phrases, and an index to make the handbook user-friendly.

We hope you will find this handbook helpful. We are interested in receiving comments or questions and welcome suggestions for improving it. Research on *Cryptosporidium* is growing rapidly, and we anticipate that some sections of this handbook will need to be updated. Please let us know if you would like to receive updated materials by filling out and mailing the postpaid postcard enclosed in the front pocket. We welcome your input.

Dennis D. Juranek
Centers for Disease Control and Prevention
for the Working Group on Waterborne Cryptosporidiosis

INTRODUCTION

Cryptosporidium is a protozoan parasite affecting the gastrointestinal tract of humans and animals. It is shed in the feces in the form of an "oocyst," which has a hard shell to protect it from the environment.

Infections may be asymptomatic or may cause watery diarrhea and abdominal cramps. The organism is transmitted by the fecal-oral route. Outbreaks have most commonly been associated with person-to person (day care center) and waterborne (drinking and recreational water) modes of spread. Foodborne and animal-(especially calves) to-person spread has also been documented.

At this time, there is no specific drug therapy proven to be effective against *Cryptosporidium*, but the immunocompetent person will usually recover from illness within 2 weeks. Immunocompromised individuals, however, may be unable to clear the parasite and suffer chronic and debilitating illness.

Waterborne *Cryptosporidium* outbreaks have occurred in both large and small communities, with the largest outbreak occurring in Milwaukee, Wisconsin in 1993, affecting an estimated 403,000 people. Such outbreaks have caused major disruption to residents, businesses, and government. Infection with the *Cryptosporidium* organism may also have contributed to the premature deaths of immunosuppressed individuals in these outbreaks.

Because of this, the finding of *Cryptosporidium* oocysts in many drinking water sources (rivers, lakes, and reservoirs), and occasionally even in treated water, has been a source of considerable concern to drinking water and public health officials, as well as to the public and the news media.

Ordinary water disinfection methods cannot kill *Cryptosporidium* oocysts, and even the best filtration units may allow a few organisms to pass through in treated water. However, the health risks associated with the consumption of public drinking water supplies contaminated with small numbers of oocysts is unknown.

A new Environmental Protection Agency (EPA) collaborative project study, the Information Collection Rule (ICR), will begin in 1997 and will require municipal water systems serving over 100,000 people to test their source waters for *Cryptosporidium*. If the number of cryptosporidia exceed a specified limit, water systems will be requirred to test their treated water as well. The data obtained through this study will assist the EPA in the development of water quality standards relating to *Cryptosporidium*. Testing results will be available to the public and news media and it is very likely that concern will result from reports of positive findings. Health officials will be looked upon to be knowledgeable and to provide guidance in the event of a real or perceived health threat by this organism. In smaller communities, *Cryptosporidium* has also proven to be an important concern, and health officials in such localities also need to be aware of any *Cryptosporidium* testing, public or private.

This handbook has been developed by the Centers for Disease Control and Prevention (CDC) Working Group on Waterborne Cryptosporidiosis to guide health officials in formulating a response to findings of *Cryptosporidium* in drinking water. Working Group membership represents a wide range of agencies and disciplines, including the CDC, EPA, Food and Drug Administration, U.S. Department of Agriculture, drinking water industry, state and local health officials, laboratory professionals, medical and environmental researchers, and community action groups.

In addition to assisting you in your response to real or perceived threats from waterborne *Cryptosporidium*, it is our intention that this handbook will also prove useful to you in responding to other waterborne disease threats.

CHAPTER 1

Coordination and Preparation

Chapter 1 - Coordination and Preparation

Chair: Faye E. Sorhage, New Jersey Department of Health and Senior Services
David G. Addiss, Centers for Disease Control and Prevention
Kathleen Blair, City of Milwaukee Health Department
Lynn M. Bradley, Association of State and Territorial Public Health Laboratory Directors
Scott A. Damon, Centers for Disease Control and Prevention
Anita K. Highsmith, Centers for Disease Control and Prevention
Dennis D. Juranek, Centers for Disease Control and Prevention
Iris L. Long, AIDS Coalition to Unleash Power
James R. Miller, New York City Department of Environmental Protection
Michael T. Osterholm, Minnesota Department of Health

CHAPTER 1

COORDINATION AND PREPARATION

I. Coordination - Forming a Task Force

Need for a Task Force

In many localities, drinking water issues involve jurisdiction held jointly by several different governmental agencies, as well as nongovernmental groups. Therefore, it is highly recommended that local task forces be formed, with participation by all related groups. Before water testing yields a positive test for *Cryptosporidium*, these task forces should be created to formulate sound and timely responses, as such a finding could cause great public concern and scrutiny. Similar task forces should be established at the state or territorial level.

Benefits of Forming a Task Force:

- All appropriate officials work together and are included in the decision-making process.
- Community groups with related interests can be included in the overall process.
- Standardized, coordinated response tactics are thought out and developed, thereby avoiding unwarranted adverse economic and political impacts.
- A coordinated response and a unified public health message promote public trust.
- Relationships and response strategies developed can be used as a basis to manage other waterborne disease threats.

Task Force Membership

The task force can be composed of an Executive Group and an Advisory Group.

The **Executive Group** can include official agency representatives and technical experts who are immediately responsible for drinking water safety and disease outbreak investigations, as well as a person responsible for public communications. You may already have similar individuals chosen to handle responses to natural disasters.

Before water testing yields a positive test for Cryptosporidium, *joint task forces should be created to formulate sound and timely responses to such a finding.*

We suggest the following:

- Health department representative (e.g., infectious disease epidemiologist, communicable disease specialist, community or public health nurse or other health officer)
- Water regulatory representative (health department and/or environmental protection agency)
- Local or regional drinking water EPA representative
- Water utility representative (public or private water supplier agency)
- Public information officer or other designated spokesperson

The **Advisory Group** might include one or more representatives from as many of the following as is possible and appropriate, meeting with the Executive Group on a regular or periodic basis:

- State or regional health agency representative
- Agricultural representative (if watershed issues are involved)
- Clinical laboratory representative
- Immunosuppressed persons' group representative
- Local community group representative
- Local medical association representative
- Local hospital/HMO association representative
- Representative of local Red Cross chapter or other emergency aid agency
- Member(s) of association(s) representing affected industries (e.g., restaurants, hotels, food and water industries)
- Representatives of local day care and nursing home businesses
- University/research expert

There are various ways in which the Executive Group and the Advisory Group could work together, depending on what is appropriate for a particular situation and locale. The interaction could work as follows.

The Executive Group meets several times to get organized (i.e., go over bylaws, rules and regulations; identify areas of responsibility; identify resources; identify and begin to assess technology issues). The Executive Group could also identify groups and/or individuals to invite to serve on the Advisory Group and identify potential projects for Advisory Group participation (i.e., developing notification lists for immunosuppressed persons' groups or health care providers) The Advisory Group will probably also come up with their own ideas for projects and could split off into committees to work on these.

The Executive Group will most likely meet on a frequent and regular basis, and the Advisory Group will meet with them on a regular, but less frequent basis. Participation by certain Advisory Group members on specific Executive Group projects might dictate their meeting with the Executive Group regularly for a time. During combined Executive and Advisory Group meetings, the Executive Group would report to the Advisory Group on Executive Group project progress, and request input on ideas and plans.

II. Preparation

Task force activities

Executive Group becomes familiar with the local water system's sources of water, treatment methodologies, monitoring tests, and the federal and state standards for drinking water quality.

- Reviews current water treatment methodologies and capabilities with the water utility representative.
- Assesses vulnerability of the local drinking water to contamination of source water and to treatment failure. (See Chapter 4)

- Determines what water testing results will necessitate follow-up and task force response.
- Discusses participation in the Partnership for Safe Water, a joint program developed by the EPA, state water supply agencies, and the water industry to optimize water treatment performance, utilizing existing facilities and staff.

Executive and Advisory Groups assess the status of local epidemiologic surveillance for cryptosporidiosis and other diarrheal diseases, and make improvements if necessary.

- Encourage hospital and other clinical laboratories to screen stool samples for *Cryptosporidium*.
- Educate local physicians about *Cryptosporidium* and encourage them to screen diarrheal cases for *Cryptosporidium*.
- Institute mandatory reporting of cryptosporidiosis cases.
- Develop ongoing epidemiologic surveillance to detect outbreaks of diarrheal disease as soon as possible. (See Chapter 2)
- Determine what epidemiologic findings will necessitate follow-up and response.

Executive and Advisory Groups develop an Action/Response Plan to follow in the event that water utility and/or epidemiologic data indicate that drinking water may be a potential health risk. This plan should be sufficiently detailed to ensure notification of all involved groups and agencies, as well as the media. Section III provides assistance on how to develop such a plan.

Executive Group identifies a governmental chain of command to be notified and gain approval from if a water-related emergency occurs. A suggested form for facilitating this process is provided in the appendix, as Figure A. This chain of command may include:

- Immediate supervisors of Executive Group members (first level)
- Department and agency heads/commissioners
- Mayor, other municipal officials
- Governor, state officials
- Others, as appropriate for locale
- Other municipal or county officials

Executive and Advisory Groups determine who will be the spokesperson for communications if a public announcement is needed. Scientific experts on the Executive or Advisory Groups in the areas of health and water quality should also be selected to provide technical backup for the main media spokesperson and to do interviews if necessary. An agency public information office or equivalent can be used to direct questions to appropriate experts. These experts should be aware of which types of questions they should not answer, but rather should refer back to the information office. Back-up spokespersons who have been equally trained should be designated.

Executive and Advisory Groups develop and have available public education materials on cryptosporidiosis. (See Chapter 6)

Executive and Advisory Groups identify the major water users in your locale that would be affected by a waterborne emergency and list, with fax, telephone numbers, and e-mail addresses the contact persons to notify in the event of such an emergency. A suggested form to facilitate this process is provided in the appendix, as Figure B. Some types of major users are listed below.

- Hospitals, nursing homes, day care centers, residential care facilities
- Food processing plants
- Restaurants, hotels
- Correctional facilities
- Bottling facilities
- Schools
- Airports
- Stadia and arenas
- Facilities using automatic ice-making equipment

Executive and Advisory Groups determine back-up or alternate sources of drinking water for use in case of an emergency.

- Communicate with state or local emergency response management coordinators to see if they have already developed emergency drinking water supply plans.
- Contact nearby military and national guard installations about their emergency water treatment capabilities.
- Identify bottled water suppliers and determine their capabilities to serve as a substitute water source in the event of an emergency.
- Encourage institutions (hospitals, schools, long-term care facilities) to have plans for alternative water sources.

Prepare for public and media use educational materials on effective water filters and suitable types of bottled waters. (See Chapter 6)

III. Cryptosporidium action/response plan

The development of a comprehensive *Cryptosporidium* action/response plan will help to organize, standardize, and streamline your response to a possible finding of *Cryptosporidium*, as well as to ensure that all the proper groups, agencies, and the public are notified and kept informed of events and decisions. An example of a sequential plan of action is outlined below and in a flow chart on page 7. The narrative describing this plan corresponds with the flow chart.

1. Water supplier or health department detects cryptosporidiosis "trigger event."

- A "trigger event" is any situation that may stimulate discussion of the need for a boil water advisory. This may include: violation of the total coliform rule or the surface water treatment rule turbidity standard, a water filtration breakdown or other such water treatment problem, an unusual number of customer complaints about water quality, a laboratory finding of pathogens in finished water, significant interruption in key water treatment or monitoring, or an increased reporting of diarrheal illness or cryptosporidiosis cases to the local health department that indicates a possible drinking water source.

2. Event reported by water supplier or health department to Executive Group for further evaluation.

- Executive Group members immediately alert first level of governmental chain of command (i.e., their immediate supervisors), that a trigger event has been reported.

3. Executive Group evaluates trigger event.

- Discusses the incident/findings reported and all relevant information.
- Determines if further information is needed to analyze event thoroughly.

4. Executive Group recommends a response.

- Reviews possible responses with appropriate members of Advisory Group.
- Selects appropriate action (See #6 below).
- Summarizes data in a clear and concise manner and explains why the plan of action was chosen.

5. Executive Group sends concise summary to immediate supervisors for notification and approval.

6. Executive Group carries out action/response plan - four possible responses:

A. Health risk no longer suspected
Event determined to be false alarm — no further action necessary.

B. Health risk indeterminate at current time
Continue heightened monitoring or surveillance for agreed-upon period and report information back to Executive Group members for further evaluation. Executive Group will terminate trigger event response if there are no significant further findings, or recommend an increased level of action/response if findings warrant. Some groups may want to issue a Level I notice (described below) at this point.

C. Health risk suspected—notifications released. (This is only a presentation of options—health risks are rarely defined clearly, and local realities should be the deciding factor.)

Level I—health risk possible for immunocompromised persons

- Issue notice directed to immunocompromised persons that an increased level of suspicion exists regarding the possible presence of parasites in the water supply. Refer to Chapters 4 and 6 for specific educational information you can provide.
- Activate communications systems developed with Advisory Group members to provide notification to immunosuppressed individuals.
- Do not issue general public precautions, because no risk for the general public is suspected at this time.
- Increase epidemiologic surveillance; request that health care providers, staff at clinical laboratories and hospitals, and pharmacists be on the alert for evidence of any increase in diarrheal disease. Test for *Cryptosporidium* and other suspected pathogens when appropriate.

Level II—health risk possible for general population

- Strongly recommend water use precautions for immunocompromised individuals; utilize communications systems developed with Advisory Group to reach these populations with disease prevention information.
- Advise the public that they may also wish to take these precautions.
- Institute more active epidemiologic surveillance — telephone physicians, pharmacists, clinical laboratories, hospitals, and nursing homes to inquire about any evidence of increase in diarrheal disease and/or *Cryptosporidium* findings.

Become familiar with your local water system's sources of water, treatment methodologies, monitoring tests, and the federal and state standards for drinking water quality.

D. Health risk strongly suspected—issue boil water advisory

- Announce that all persons should boil water before consumption.
- Issue specialized informational materials for restaurants, hospitals, dental offices, establishments that sell fountain drinks, etc. (See Chapter 5)
- Institute active surveillance of hospitals, clinical laboratories, physicians' offices, pharmacies, and nursing homes for any evidence of increase in diarrheal disease and cryptosporidiosis. (See Chapters 2 and 4)
- Strongly recommend *Cryptosporidium* testing for all diarrheal illnesses— make health department laboratory available for testing at no cost if possible.
- Set up temporary telephone "hotline" for the public, businesses, and health professionals, if possible. (See Chapter 5)
- Issue media release regarding boil water advisory. (See Chapter 5) Ensure that materials for special audiences (see Chapter 5) are also given to the media for distribution.

7. Executive Group re-evaluates situation frequently.

8. Executive Group makes decision to change status of action/response plan.

- Reviews recommended change with appropriate members of Advisory Group.
- Upgrades action/response to higher level.
- Downgrades warning or terminates boil water advisory.
- Summarizes data in a clear and concise manner and explains why changes in status were made.

9. Executive Group sends summary to immediate supervisors for notification and approval.

10. Executive Group notifies the public and media about any changes in recommendations.

Flow Chart for Action/Response Plan

1. Water system or health department detects trigger event

2. Event reported to Executive Group for further evaluation

Exec. Group members advise their immediate superiors of reported trigger event

3. Exec. Group evaluates event

4. Exec. Group makes final decision on recommended response

Review with appropriate Advisory Group members

5. Exec. Group sends summary to supervisiors for notification and approval

6. Exec. Group carries out action/response

A. Health risk no longer suspected–no further action necessary

B. Health risk indeterminate–continue to monitor and investigate

C. Health risk suspected–notifications released

D. Health risk strongly suspected or ascertained–issue boil water advisory

7. Exec. Group re-evaluates situation frequently

8. Exec. Group makes decision to change status (upgrade or downgrade/terminate)

9. Exec. Group sends summary to immediate supervisors

10. Exec. Group notifies public and media

IV. Preparing a News Media Response

If *Cryptosporidium* is found in your drinking water supply and/or you have an outbreak of cryptosporidiosis in your community, your task force will need to work with the local media to educate the public about cryptosporidiosis without causing undue concern. The experience of other communities in this regard has taught a number of important lessons.

Be Prepared:

The best time to prepare for managing the media and the public in a cryptosporidiosis outbreak or a finding of oocysts in your drinking water is *before* a crisis occurs. Do *not* wait to prepare your response until there is an outbreak. In preplanning, you should take these steps, working with the other agencies that will be involved.

- Set your goals and objectives. Be very clear about what you want the outcome of your interaction with the media to be—what message you want the media to convey to the public.
- Identify your personnel resources.
- Identify a spokesperson(s) for managing the media, and plan how to restrict media access. You may wish to funnel all media inquiries through your office of public affairs, or equivalent, to different spokespersons with expertise in different areas. If you do this, each spokesperson should be aware of which type of questions he or she should answer and which types should be referred to the office of public affairs or to other spokespersons. Designate back-up spokespersons who have been equally trained.
- Bear in mind that, particularly in more competitive media markets, reporters will try to find other sources besides your spokesperson(s) and media releases. Reporters may seek comments from advocacy groups representing the HIV-positive community or similar stakeholders. These stakeholders may have their own, different political agenda to pursue with the media. It is *not* realistic to expect the news media to reproduce your institution's comments or news release verbatim and without comment.
- Plan a joint information center. At this one locale, public information officers and spokespersons from the different agencies can work together to coordinate a response to the media. Any agency that would be involved in issuing a boil water advisory should be represented in this center. If technical questions specifically on the water in question are deferred to the water utility, answers to these questions should be coordinated with the overall message coming from your joint group. *Keep everyone involved in handling any aspect of your crisis "in the loop."*
- Think about the questions you would face from the media in a "cryptosporidiosis event" before called upon to answer them. You may want to write up answers to sample questions; writing such questions and answers will help you focus your responses before you have to give them. An example is provided in Chapter 5. You might also wish to prepare some "fill in the blank" responses for media questions that will occur in different waterborne disease contexts. These statements can be pre-approved, then used immediately in the first moments of a crisis.
- Get to know the reporters and editorial boards who would be involved in coverage of such an event. If they are sophisticated regarding cryptosporidiosis and trust you, they will be far more likely to report on cryptosporidiosis in a calm and accurate manner. You may want to keep a record of helpful and responsible reporters and how to contact them. An example of how to do this is provided in the appendix, as Figure C.

Have a Plan:

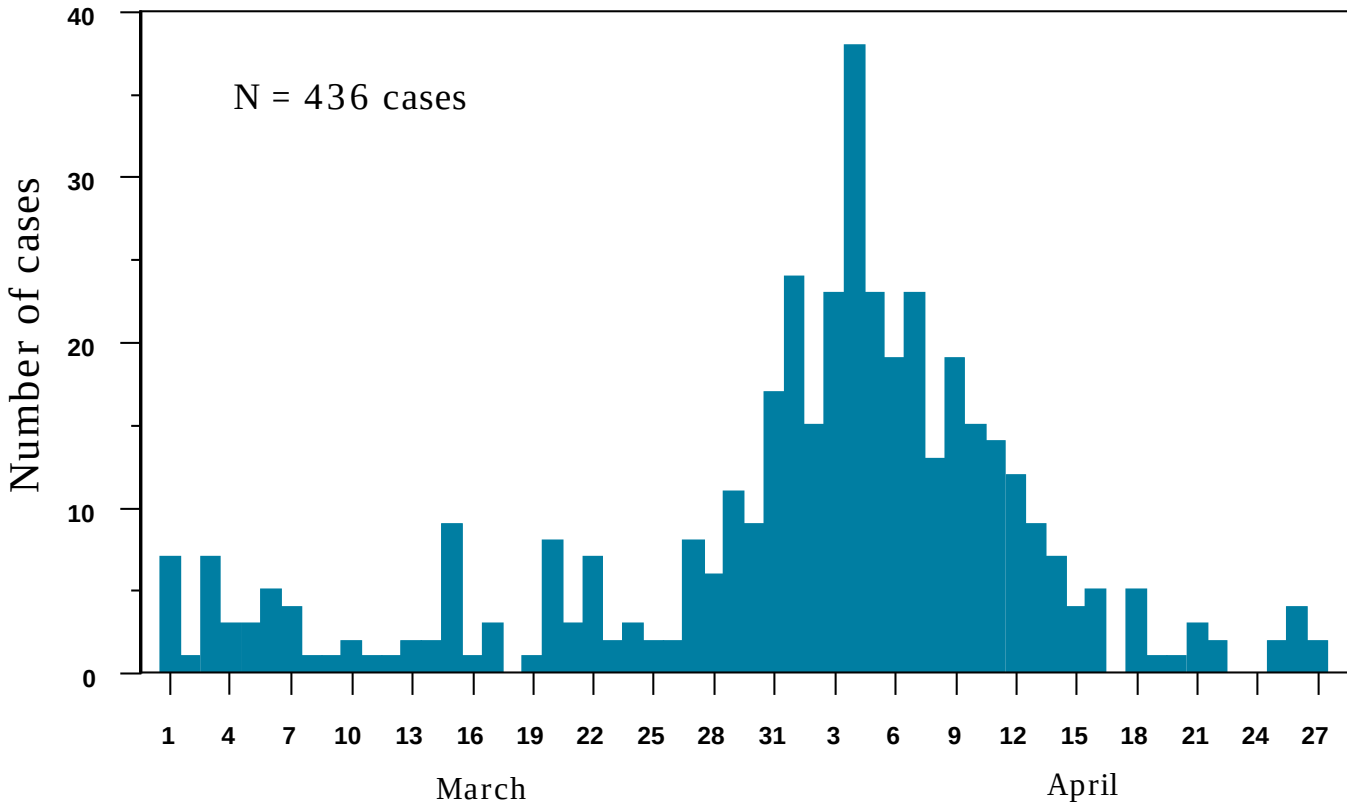
- Identify the target audiences you must reach in the event of a waterborne disease outbreak. Material for specific audiences and contingencies is included in Chapter 4.
- Write a set of key communication points with the cooperation of the other agencies that all of your spokespersons will use. Try to limit this to as few points as possible.
- "Exercise" your plan. Like any other emergency plan, your media plan can benefit, and be utilized better, if you practice it with mock emergencies.
- Build in an evaluation component. Be ready, when your crisis has passed, to review how you handled it and how you could improve your performance.

General Tips for Spokespersons:

- You should be well-informed, apolitical, good at working with the media and direct and nontechnical in answering questions. Spokesperson(s) must be accessible. If the media cannot reach you they will turn to someone else for answers to their questions.
- If appropriate and possible, have a prepared statement to read or to issue.
- Always reply truthfully, simply, and directly to the media but answer only the question asked. "Yes" or "no" answers may need qualification. Unless you have a specific point to make that a reporter did not bring up, limit your comments to direct answers. Prepare and practice for the most difficult questions you are likely to be asked. You will need to be able to respond quickly and with authority to any question the media might ask. It may help to note that *Cryptosporidium* is a pathogen that has been in water for many years and is only now becoming better understood and detected.
- Be concise. Establish your key message at the beginning of your interview or press encounter. Do not overload the media with excessive or overly complex information. Simply state and reinforce one or two important points.
- Admit it when you don't know the answer or don't have conclusive data on the subject. If you are asked hypothetical questions by the media, defer them, answering only fact-based inquiries. Do not try to hedge by using phrases such as "I think," "maybe," or "probably not."
- Be sure to present your data in context. For instance, if oocysts are found in your finished water at a level that is normal and consistent with national findings, be sure to say it is consistent with national findings and therefore not a cause for alarm. Only advise boiling water when your Executive Group, in consultation with appropriate Advisory Group members, has already decided to do so and informed political leaders of this decision.
- Avoid overly downplaying the effect of cryptosporidiosis on people with healthy immune systems. While not life-threatening for the general public, cryptosporidiosis can still be a very unpleasant experience and your credibility could be hurt if you are seen as dismissing their concerns.
- For the media's own use and/or for inclusion in their stories, provide the phone number for CDC's Voice Information System (404-330-1242) and the Internet address for CDC's cryptosporidiosis page (www.cdc.gov/ncidod/diseases/crypto/crypto.htm).

CHAPTER 2

Epidemiologic Surveillance



Chapter 2 - Epidemiologic Surveillance

Dennis D. Juranek, Centers for Disease Control and Prevention and
1994 participants in a CDC/EPA sponsored workshop "Prevention and Control of Waterborne Cryptosporidiosis: an Emerging Health Threat"

(Reference: Juranek DD, Addiss DG, Bartlett ME, Arrowood MJ, Colley DG, Kaplan JK, Perciasepe R, Elder JR, Regli SE, and Berger PS. Cryptosporidiosis and public health: Workshop report. *Journal of the American Water Works Association.* 1995; 87:54-68.)

CHAPTER 2

EPIDEMIOLOGIC SURVEILLANCE

Surveillance Systems

Local public health officials should consider developing one or more surveillance systems to establish baseline data on the occurrence of cryptosporidiosis among residents of their community and, where possible, obtain sufficient epidemiologic data to identify potential sources of infection. These baseline indices will be helpful in assessing whether oocysts that are found in drinking water are associated with any increases in the number of *Cryptosporidium* infections in the community. Such surveillance should be considered by all communities whose water utility provides service to 100,000 persons and whose water supply is derived from surface water. Communities with populations of 10,000-99,999 persons will not be required by the ICR to monitor their source water for *Cryptosporidium*. Small communities with unfiltered surface water or with water quality indices that suggest their filters are not adequately removing oocysts should also consider conducting surveillance for cryptosporidiosis.

No single surveillance strategy can be recommended or would be feasible for all locations; therefore, communities should select a method that meets local needs and is most compatible with existing disease surveillance systems or ongoing special studies. Neither increased incidence of diarrhea nor *Cryptosporidium* infection in a community establishes water as the cause of infection. Any increased occurrence of either diarrhea or laboratory-confirmed *Cryptosporidium* infection detected by surveillance requires further epidemiologic investigation to identify the source(s) of infection. The following six approaches to surveillance are presented hierarchically by increasing order of the perceived effort and cost.

Surveillance should be considered by all communities whose water utility provides service to at least 100,000 persons, and whose water supply is derived from surface water.

Monitor sales of antidiarrheal medications.

Local pharmacies often have computerized data bases that contain the number of medications sold daily. The development of an information exchange between local pharmacists and state or local public health officials is a cost-effective and timely way to detect increases in diarrheal illness in some communities. In addition, these data bases can provide historical data that can serve as an indicator of baseline sales rates for antidiarrheal medication.

Monitor logs maintained by Health Maintenance Organizations (HMOs) and hospitals for complaints of diarrheal illness.

HMOs and hospitals often have computerized systems for logging telephone calls regarding patient illnesses. Information entered promptly into a computerized data base can effectively monitor both complaints of diarrhea and severity of gastrointestinal disease in a community. These data are particularly useful if your local medical-care facility records zip code numbers for persons who are ill, because waterborne illness associated with inadequate water treatment affects persons residing throughout the water distribution area.

Monitor incidence of diarrhea in nursing homes.

During outbreak investigations, data from nursing homes have implicated drinking water as the source of community infection. Diarrheal illness rates in residents of nursing homes that use municipal drinking water can be compared with illness rates in residents of other nursing homes in the same community that use a different water source (e.g., well water). Because nursing staff usually record the frequency and characteristics of bowel movements for each resident, such data also can be used for other surveillance purposes. Substantial efforts by your local or state health department might be needed to review and extract the relevant data from patient records, which could differ in format by nursing home. If this measure is employed, health departments also should establish a baseline for the population comprising nursing home residents, which usually experiences more gastrointestinal problems than the general population.

Monitor laboratory data for *Cryptosporidium*.

Most laboratories do not look for *Cryptosporidium* in stool specimens submitted for routine parasitologic examination. To obtain this information, health-care providers usually must request specifically that stool specimens be examined for *Cryptosporidium*. Because health-care providers who treat patients who have AIDS are more likely to suspect cryptosporidiosis as a diagnosis in such patients who have diarrhea, they are more likely than other health-care providers to request specific testing for *Cryptosporidium*. Thus, current laboratory-based surveillance for cryptosporidiosis would more likely detect an increased number of *Cryptosporidium* infections in patients who have AIDS than in immunocompetent patients in the general population.

To determine more accurately the occurrence of *Cryptosporidium* infection in the general population, health-care providers should be aware of the public health importance of obtaining data on the occurrence of cryptosporidiosis. Further, they should be encouraged to submit stool specimens for *Cryptosporidium* testing in persons who have symptoms compatible with the disease. However, the cost of the additional laboratory testing for cryptosporidiosis in immunocompetent patients may present an obstacle, especially because specific therapy will not necessarily be implemented as a result of a confirmed diagnosis. Some HMOs and laboratories might be able to provide computerized reports of all *Cryptosporidium* diagnoses. You must also be aware that substantial delays can occur between the completion of the test and the entry of data into a computer.

Monitor tap water in selected cities.

Intensive surveillance in a sample of six to 10 cities known to have *Cryptosporidium* oocysts in their finished water can provide a method for assessing how often a temporally related increase in diarrheal illness or *Cryptosporidium* diagnosis occurs during the first week or first 2 weeks after oocysts are found in drinking water. Health departments and public officials in other cities can use information derived from analysis of the data generated at these sites as a basis for local decision making and for educating the public about the health risks associated with similar levels of oocyst contamination of their water supplies. Health officials in cities participating in this intensive surveillance would need to implement thorough surveillance techniques for recording diarrheal illness and laboratory-confirmed *Cryptosporidium* diagnoses, and they should monitor finished water for *Cryptosporidium* oocysts more frequently than required by the ICR. In addition to identifying small outbreaks, these studies could be used to compare the effectiveness of different surveillance methods (including those described previously) and to identify cases of cryptosporidiosis for possible inclusion in epidemiologic studies that could further define the risks for waterborne cryptosporidiosis.

Make immediate epidemiologic assistance available.

Rapid initiation of epidemiologic investigations might be necessary when disease surveillance or water quality data indicate that the public might be at increased risk for cryptosporidiosis. Although some states and cities could implement such investigations independently, many could not and would need technical and financial assistance. These investigations should emphasize a) assessment of the morbidity and mortality in various immunocompromised populations, b) appropriate and rapid environmental testing for *Cryptosporidium* oocysts, c) rapid identification and evaluation of potential sources of water contamination (e.g., sewage), and d) a thorough engineering assessment of the water utility's equipment and treatment processes.

CHAPTER 3

Clinical Laboratory Testing

Chapter 3 - Clinical Laboratory Testing

Chair: M. Stephen Gradus, City of Milwaukee Health Department
Sandra Bullock-Iacullo, Parasite Diagnostics, Inc.
Lynne S. Garcia, UCLA Medical Center
Raymond L. Kaplan, SmithKline and Beecham Clinical Laboratories
James W. Smith, Indiana University School of Medicine
Tiffany Tran, Massachusetts Water Resources Authority
Ronald Zabransky, U.S. Department of Veterans Affairs

CHAPTER 3

CLINICAL LABORATORY TESTING

Laboratories can play a critical and preemptive role as a community's first line of surveillance in detecting waterborne outbreaks when they are aware of increased numbers of stool specimens, and suspect or identify *Cryptosporidium* as the cause of illness. In addition, strong working relationships between clinical laboratories and state or local public health laboratories or agencies can facilitate a meaningful and rapid response related to potential outbreaks.

Clinical and public health laboratories potentially play a key role in adding to the limited knowledge of the endemicity and ultimately the natural history of *Cryptosporidium*. This chapter addresses the early detection of waterborne outbreaks of cryptosporidiosis and some strategies that could be used to a) determine endemic levels of *Cryptosporidium* infections unrelated to outbreaks, b) detect *Cryptosporidium* outbreaks by causes other than potable waterborne sources (e.g., food, surface or recreational waters, pets or farm animals, or sexual activity), or c) determine outbreak or endemic levels of other infectious diseases.

Laboratorians should educate those using their services as to what is and is not included in routine culture and fecal parasite examinations in their laboratory. Physicians may incorrectly assume certain enteric pathogens are routinely tested for.

External Planning

Potential planning options are suggested below. These steps may or may not apply to all of the wide variety, size, type, and function of laboratories (e.g., state public health, local public health, reference, community hospital, and medical center clinical laboratories). However, each laboratory should determine its own appropriate public health response plan and coordinate it with other agencies *before a crisis*.

External Planning Before A Waterborne Disease Outbreak
Know the name and phone numbers of appropriate officials to call if you suspect a community-wide situation might be developing. For example a) your state or local public health agency or laboratory; b) state or local water utility or regulatory agency; and c) other local clinical microbiology laboratories.
Discuss and plan follow-up steps with appropriate agency(s) when test results suggest a potential outbreak.
Local public health agencies and/or water utilities with knowledge of at-risk water quality conditions should alert laboratories of the potential for waterborne pathogens in stool specimens.

Internal Planning

The goal of an internal planning process is to prevent a delay in the detection of an increase in the number of stool specimens, which can signal an outbreak. Internal planning allows prompt detection of a potential outbreak and implementation of community-wide prevention strategies.

The tasks of assessing increases of diarrheal stool specimens and added testing are not without additional costs. These recommendations should be considered in view of individual budgetary limitations; therefore several options are offered.

Clinical laboratories should have plans in place to alert either state or local public health agencies when increases in the number of diarrheal stool specimens (or all stool specimens when stool consistency is unknown) occur from outpatient, emergency room, or short-term inpatient populations.

Assessment of an Increase

Laboratories are encouraged to monitor the number of diarrheal stool specimens (or total stool specimens) submitted and to note any increases over their established baseline. If the number of specimens exceeds a predesignated threshold number, the laboratory should consider the possibility of an outbreak such as waterborne cryptosporidiosis. Other nonroutine causes of illness should be considered if other increases in laboratory specimens suggest it.

Suggestions for Assessments
Establish a baseline of the number of stool specimens submitted per day or week: for example, the daily or weekly average for the previous month or year, or a rolling 3-month weekly average, or the prior week's total. Compare the number of current cases with the chosen baseline threshold.
When possible, have your LIS activate a "flag" when baseline thresholds are exceeded.
If resources do not allow for routine quantitative monitoring: call your public health authority when a noticeable increase in stools with no apparent explanation occurs, especially diarrheal stools. Several such calls from laboratories could suggest a meaningful pattern.
If a laboratory is unable to test or confirm a positive *Cryptosporidium* finding, then that laboratory should have plans in place with another facility such as a state or local public health or reference laboratory to do such testing.
When a noticeable increase of enteric pathogen-negative diarrheal specimens occurs, your clinical microbiologists should suggest to physicians that testing for *Cryptosporidium* and other enteric pathogens may be appropriate.
Notify public health authorities when any increase in findings of *Cryptosporidium* or other enteric pathogens are confirmed, following the guidelines of your public health response plan (see Chapter 1).

Testing

Complete, accurate, and relevant laboratory testing depends on compliance with recommended guidelines. Specimen collection and transport protocol must be followed that includes placing appropriate information on test requisitions and specimen containers. In addition, communication between the laboratory and clinician should include specimen rejection criteria and test result limitations. Only when proper specimen submission is ensured can a thorough understanding and interpretation of the test result be guaranteed.

Collection Containers, Requisitions, and Report Formats

A description of the physical nature of a stool specimen (formed, soft, watery, and other factors such as blood or mucus) should be noted, especially for stool in collection vials (stored in transport media or with stool preservatives). Once the stool is mixed with the collection vial contents, the original consistency of the specimen cannot be determined. The laboratory request form or the specimen container must therefore be marked accordingly.

Laboratorians should educate those using their services as to what is and is not included in routine culture and fecal parasite examinations in their laboratory. Physicians may incorrectly assume certain enteric pathogens, such as *Cryptosporidium* or *Escherichia coli* 0157:H7, are routinely tested for in enteric examinations. Such organisms may be listed as separate requests on the form if they are not part of the routine workup.

Another way to clarify results for clinicians is to report which enteric pathogens were *not* detected rather than stating that *no* enteric pathogens were detected. For example:

- "No *Salmonella*, *Shigella*, or *Campylobacter* detected. Other pathogens require specific requests."
- "No ova or parasites detected. Some parasites that occasionally cause diarrheal illness, such as *Cryptosporidium*, require a request for a specific test."
- "To discuss further appropriate testing of this specimen, please consult 'Laboratory/ Microbiology Director.'"

Test Options

Before testing a stool specimen for the presence of *Cryptosporidium*, the proper collection and transport of stool samples in fixatives such as 5 to 10% buffered Formalin or Sodium Acetate-Formalin (SAF) are essential to obtain a reliable test result. Polyvinyl-Alcohol (PVA)-preserved specimens are not appropriate for the modified acid-fast staining procedure.

Several alternatives exist for examining stool specimens or their concentrates for *Cryptosporidium*. These options vary in their sensitivity, specificity, and cost. While an experienced microbiologist may be able to detect heavy concentrations of oocysts in a wet mount, generally additional testing will be needed to confirm the identification or detect low numbers of organisms. Additional tests may include a modified acid-fast or fluorescent antibody stain, or an Enzyme-Linked Immunosorbent Assay (ELISA) test. If testing for the presence of *Cryptosporidium* is not available, then contact a state or local public health laboratory for assistance.

Methods (See Tables)

Collection

- Follow collection recommendations and precautions on routine parasitologic examination of stools. For immunodiagnostic assay kits, follow manufacturer's instructions (refer to references on following pages).

Transport

- If immediate examination is not possible, use one of several preservatives such as 5 to 10% buffered Formalin, Merthiolate-Iodine-Formalin (MIF), or SAF.
- Refrigerate unpreserved specimens to delay deterioration. Do not freeze specimens.

Processing

- Unconcentrated, fresh specimens can be examined by wet mount preparations.
- Concentration by the Formalin ethyl acetate method is preferable. Optimal centrifugation time and speed, 10 minutes at 500 X, are critical for concentrating *Cryptosporidium* oocysts.
- PVA-preserved specimens are *not* acceptable for modified acid-fast staining for detection of *Cryptosporidium*.

Testing

- High concentrations of oocysts can be detected in *un*concentrated wet mounts. However, direct wet mounts are insufficient for detecting oocysts in low concentrations; results should be confirmed by a modified acid-fast or antibody-specific test.
- The auramine-rhodamine nonspecific fluorescent stain can be used as a screening test but is usually not as sensitive as other methods. Results should be confirmed by a modified acid-fast or antibody-specific test.
- For modified acid-fast methods use any of several acceptable variations. (Note: Trichrome-stained smears are not recommended for detection of *Cryptosporidium*.)
- Commercial immunodiagnostic methods are available that vary in cost, sensitivity, and specificity (refer to tables).

Table A

Immunodiagnostic Assay Kits

Giardia Kits		*Cryptosporidium* Kits	
ProSpect T *Giardia* EZ Microplate Assay (EIA) Alexon 1190 Borregas Avenue Sunnyvale, CA 94089-1302 (800) 366-0096	**Color Vue (EIA)** Seradyn P.O. Box 1210 Indianapolis, IN 46206 (800) 345-0915	**ProSpecT Microtiter Assay (EIA)** Alexon 1190 Borregas Avenue Sunnyvale, CA 94089-1302 (408) 747-7000	**IDEIA** Dako Corp. 6392 Via Real Carpinteria, CA 93013
Merifluor (DFA) Meridian Diagnostics, Inc. P.O. Box 44216 Cincinnati, OH 45244 (800) 543-1980 (Detects both *Giardia* and *Cryptosporidium*)	***Giardia*-CEL (DFA)** TechLab Corporate Research Center 1861 Pratt Drive Blacksburg VA 24060 (540) 231-3943	**ProSpect TR (EIA)** Alexon 1190 Borregas Avenue Sunnyvale, CA 94089-1302 (408) 747-7000	**Premier *Cryptosporidium* (EIA)** Meridian Diagnostics, Inc. P.O. Box 44216 Cincinnati, OH 45244 (800) 543-1980
Premier *Giardia lamblia* (EIA) Meridian Diagnostics, Inc. P.O. Box 44216 Cincinnati, OH 45244 (800) 543-1980		**Color Vue (EIA)** Seradyn P.O. Box 1210 Indianapolis, IN 46206 (800) 345-0915	**Crypto IF Kit** TechLab Corporate Research Center 1861 Pratt Drive Blacksburg, VA 24060 (540) 231-3943
		Merifluor (DFA) Meridian Diagnostics, Inc P.O. Box 44216 Cincinnati, OH 45244 (800) 543-1980	***Giardia*/Crypto IF Kit** TechLab Corporate Research Center 1861 Pratt Drive Blacksburg, VA 24060 (540) 231-3943

Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service, the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, or any of the member agencies of the Working Group on Waterborne Cryptosporidiosis.

Table B

Advantages and Disadvantages of EIA and FA Kits Compared with Traditional Methods

The following parameters need to be reviewed before selecting a test kit.

EIA Diagnostic Kits

Advantages	Disadvantages
Visual Interpretation. Easy to perform. Good screening technique. Easy to test large numbers of specimens. Can be automated. Increased sensitivity.	Not recommended as replacement for O & P examination. Dilution step may be required. Wash step is critical to avoid false positives. May be difficult to interpret visually. Higher cost.

FA Diagnostic Kits

Advantages	Disadvantages
Short examination time. Recommended stool concentration yields more accurate results. Some reagents detect *Giardia* cysts and *Cryptosporidium* oocysts at the same time. Can batch test. Fluorescence is bright; slides very easy to read under low magnification Can be read quickly.	Recommended concentration is time consuming. Requires fluorescence microscope. Higher cost.

Note:

1) Comments on the advantages and disadvantages for each test product are extracted from the literature.

2) The selection of a particular method is the responsibility of an individual laboratory. These selections are based on a number of factors, including cost, anticipated workload, ease of kit use, number of trained staff, single vs. batch testing, physician clients, patient base, size of laboratory, availability of equipment, compatibility of method with laboratory work flow, and training needs.

3) External controls in addition to kit controls offer an extra measure of quality control.

4) Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service, the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, or any of the member agencies of the Working Group on Waterborne Cryptosporidiosis.

Table C

Traditional Assays for *Cryptosporidium*

Name	Specificity	Sensitivity	Advantages	Disadvantages
*Modified acid-fast stain.	Not specific for *Cryptosporidium*.	Not as sensitive as immunodiagnostic methods.	Inexpensive. Allows detection of other parasites such as *Isospora* or *Cyclospora* that would be missed by specific immunodiagnostic kits.	May be less sensitive than some specific immunodiagnostic kits.
Auramine-rhodamine stain.	Not specific for *Cryptosporidium*.	Not as sensitive as immunodiagnostic methods.	Inexpensive. Rapid screening possible at lower power magnification.	May be less sensitive than some specific immunodiagnostic kits. Fluorescent microscope required. Should be confirmed by a more specific method such as EIA or IFA.
Observation of direct wet mount with or without iodine.	Not specific for *Cryptosporidium*.	Not as sensitive as immunodiagnostic methods.	Does not require concentration. Inexpensive. Can provide rapid detection of oocysts without concentration, especially in heavy infections or in early outbreak situations.	Should be confirmed by a modified acid-fast stain or more specific methods such as EIA or IFA. Concentration with Formalin ethyl acetate is recommended. Direct wet mount is not sufficient to detect oocysts in light infections usually seen in follow-up, test-of-cure, and examinations of stool from patients shedding oocysts.

* *The modified acid-fast stain, as used for* Nocardia, *does not use acid alcohol but uses 1 to 3% sulfuric acid as the decolorizer.*

Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service, the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, or any of the member agencies of the Working Group on Waterborne Cryptosporidiosis.

References

Current W L , Garcia LS. Cryptosporidiosis. *Clin Microbiol Rev* 1991; 3:325-358.

Garcia LS, Bruckner DA. *Diagnostic Medical Parasitology* 2nd ed. 1993, The American Society for Microbiology, Washington, D.C.

Isenberg HD, ed. *Clinical Microbiology Procedures Handbook.* (Vols. 1 & 2) 1992, American Society for Microbiology, Washington, D.C.

Markell EK, Voge M, John T. *Medical Parasitology* 8th ed. 1994, W. B. Saunders Co., Philadelphia.

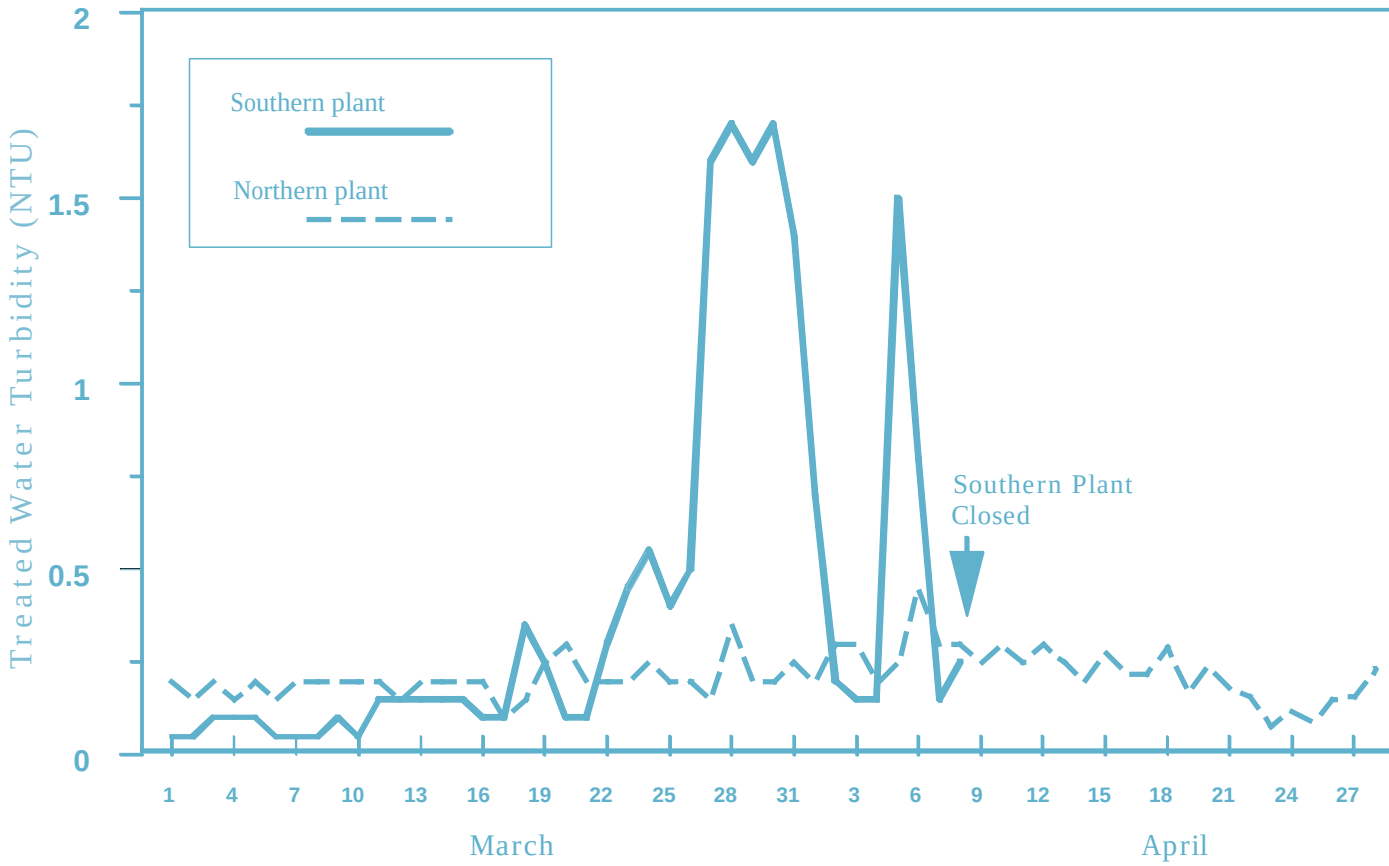
Melvin DM, Brooke MM. Laboratory procedures for the diagnosis of intestinal parasites, pp. 163-189. In: U.S. Dept. of Health, Education and Welfare publication No. (CDC) 85-8282, 1985. U.S. Government Printing Office, Washington, D.C.

Murray PR, Baron EJ, Pfaller MA, Tenover FC, Yolken RH, eds. *Manual of Clinical Microbiology*, 6th ed. 1995, American Society for Microbiology, Washington, D.C.

National Committee for Clinical Laboratory Standards, *Procedures for the recovery and identification of parasites from the intestinal tract: Proposed Guidelines*, M28-P, 1993, National Committee for Clinical Laboratory Standards, Wayne, PA.

CHAPTER 4

Evaluating Water Test Results



Chapter 4- Evaluating Water Test Results

Drinking Water Sources, Treatment, and Testing

Chair: Dennis D. Juranek, Centers for Disease Control and Prevention
Chet Anderson, Metropolitan Water District of Southern California
Paul S. Berger, U.S. Environmental Protection Agency
Anita K. Highsmith, Centers for Disease Control and Prevention

Environmental Sampling Methods

Chair: Walter Jakubowski, U.S. Environmental Protection Agency
Susan Boutros, Environmental Associates, Ltd.
Walter W. Faber Jr., New York City Department of Environmental Protection
Ronald Fayer, U.S. Department of Agriculture
William C. Ghiorse, Cornell University
Mark W. LeChevallier, American Water Works Service Co., Inc.
Joan Rose, University of South Florida
Stephen Schaub, U.S. Environmental Protection Agency
Ajaib Singh, City of Milwaukee Health Department
Mic Stewart, Metropolitan Water District of Southern California

Issuing and Rescinding a Boil Water Advisory

Chair: Kathleen Blair, City of Milwaukee Health Department
Paul S. Berger, U.S. Environmental Protection Agency
Susan Boutros, Environmental Associates Ltd.
Scott A. Damon, Centers for Disease Control and Prevention
Kim R. Fox, U.S. Environmental Protection Agency
Dennis D. Juranek, Centers for Disease Control and Prevention
Vanessa M. Leiby, Association of State Drinking Water Administrators
Carrie Lewis, Milwaukee Water Works
Thomas Outlaw, Association of State Drinking Water Administrators
William F. Parrish, Maryland Department of the Environment

CHAPTER 4

EVALUATING WATER TEST RESULTS

I. Drinking Water Sources, Treatment, and Testing

Drinking water is obtained from one of two types of sources:
Ground water, or water from underneath the surface of the earth, which is pumped up and out for use (e.g., well water) or flows naturally to the surface (e.g., spring water).
Surface water, or water from above ground sources, such as rivers, lakes and reservoirs.

Untreated surface water is more likely than ground water to contain *Cryptosporidium* and other pathogenic microorganisms because of the possibility of direct contamination with animal feces, treated and untreated human sewage, or fecal run-off from adjacent land after heavy rain or snow melt. Ground water is less likely to be contaminated with *Cryptosporidium* because water carrying this size pathogen must usually seep through layers of soil and sand which in essence "filters" out the organism before the water reaches the well. The few ground water-associated outbreaks of cryptosporidiosis that have occurred have been attributed to wells that were either poorly located, constructed, or damaged. An example of a poorly located well is one that may be contaminated by a nearby sewage or septic system. A poorly constructed well or a well with ruptured casings or pipes may also become contaminated.

Water Treatment

Chemical Disinfection
Chemical disinfection is the most common way to make water safe to consume. Chemical disinfection kills many of the harmful microorganisms that might be in raw, or untreated, water. Chlorine is the disinfectant most commonly used by water utilities to treat drinking water; other disinfectants used include chloramine, chlorine dioxide, and ozone. Unfortunately, chlorine-based formulations commonly used by the water treatment industry are not effective against *Cryptosporidium*. Additional research is needed to determine the optimal dose of ozone and resolve other technical and practical issues that may limit its routine use.

Filtration
The conventional filtration process used by most surface water treatment plants usually includes several steps: coagulation-flocculation, sedimentation, and filtration. During the first step in the process, a chemical (coagulant) is added to the water that causes small suspended particles to stick together (flocculation) to form larger particles that either settle to the bottom (sedimentation) or are more easily removed by a water treatment filter that principally relies on fine sand. The coagulation-flocculation step is critical for successful removal of chlorine-resistant protozoa (1-20 microns in size) which could easily slip through the 50-70 micron spaces between grains of sand in a water treatment filter. Poor mixing of coagulants with water and failing to add the appropriate amounts of coagulants are common causes for inadequate filtration. Because the dose of coagulant needed may frequently vary with changes in raw water pH, temperature, or turbidity, successful filtration relies strongly on the training and experience of the filter operator.

Conventional water filtration should trap nearly all protozoan parasites, including *Giardia* and *Cryptosporidium*, if the water is properly processed with adequate equipment and optimal procedures (coagulation-flocculation) are conducted by well-trained operators. However, a small number of *Cryptosporidium* oocysts may occasionally get through the treatment process to the finished drinking water. The health risk associated with drinking filtered or unfiltered water containing *small numbers* of *Cryptosporidium* oocysts is unknown. Oocysts found in drinking water may not be infectious if they are dead, damaged by the treatment process, or of a species of *Cryptosporidium* not infectious to humans. Large numbers of oocysts, or high turbidity or "cloudiness," in finished water indicates inadequate filtration, filter failure, or a filter malfunction that may lead to an outbreak.

Drinking Water Testing

Coliform Bacteria Tests

Coliform bacteria are common in the environment and are generally not harmful. The presence of these bacteria in drinking water, however, generally is the result of a problem with water treatment or distribution pipes, and indicates that the water may be contaminated with organisms that can cause disease. A total coliform test measures the presence or number of living aerobic coliform bacteria in a water sample.

If the total coliform test on a sample of drinking water is positive (1 or more coliforms per 100 ml of water), either a fecal coliform test or an *Escherichia coli* test must be performed to determine if any coliform bacteria found are of fecal origin. Water utilities usually collect additional water samples for this purpose within 24 hours of notification of a positive total coliform test. If a fecal coliform or *E. coli* test is positive, this is a strong indication that the water in question may be contaminated with fecal material. The *E. coli* test is more specific for bacteria of fecal origin than the fecal coliform test. A positive fecal coliform test is possible without recent fecal contamination. When tests for fecal bacteria are positive, follow-up investigations of the water treatment plant and water distribution system are usually initiated and issuance of a boil water advisory may be considered.

Turbidity Tests

Turbidity tests measure the level of suspended particles or “cloudiness” in water. Turbidity is measured in nephelometric turbidity units, or NTUs. High turbidity in finished water can be an indicator of possible water contamination, inadequate filtration, or other water system problems. A single spike exceeding 5 NTUs violates current EPA standards for drinking water. Ninety-five percent of all monthly post-filtration readings must be less than or equal to 0.5 NTUs to meet EPA standards for the most commonly used type of water filter. Recent research, however, indicates that *Cryptosporidium* is most reliably removed when water turbidity is consistently maintained at 0.1 NTU or lower. The American Water Works Association encourages its membership to strive for the 0.1 NTU goal to reduce the risk of waterborne cryptosporidiosis.

Environmental Sampling Methods

Environmental sampling methods for detecting and quantifying *Cryptosporidium* oocysts were adapted from those for *Giardia* cysts. The methods were originally developed to assist in the investigation of suspected waterborne outbreaks. They were subsequently applied to studies seeking to determine the occurrence and distribution of protozoa in water and to assess drinking water treatment effectiveness. Since *Giardia* and *Cryptosporidium* do not reproduce outside the host, the number of organisms per unit volume of water decreases with distance from the point of contamination. Methods for detecting *Cryptosporidium* in environmental water samples usually involve a procedure for concentrating the organisms from large-volume water samples. These methods are designed for detecting *Giardia* cysts as well. Sample volumes generally recommended are 100 liters for source water and 1000 liters or more for finished water.

The usual procedure for collecting oocysts from a sample of water is filtration through nominal 1 micron porosity yarn-wound polypropylene filter cartridges. These are widely used because they are effective with high or low turbidity waters containing a variety of suspended material, and they are relatively inexpensive. Other types of filter cartridges used for concentrating cysts and oocysts are fiberglass-resin cartridge tubes and membrane filters.

Next, filters are eluted in a laboratory with detergent solutions and the recovered particulates are concentrated by centrifugation. Water samples may contain a variety of viable and nonviable organisms, as well as inorganic materials. Detection methods therefore include a purification step to separate the target *Giardia* cysts and *Cryptosporidium* oocysts from the rest of the particulates. This has usually been accomplished by flotation on density gradients consisting of sucrose, Percoll (an organically coated colloidal silica compound), Percoll-sucrose mixtures, or various salt solutions.

The method most widely used in the United States for examining purified material for protozoa is an antibody-based immunofluorescence assay. After staining the purified material with fluorescence antibody reagents, the sample is examined by microscope with an ultraviolet light source. Tentative identification of oocysts is based on the fluorescence reaction, size, and shape of any oocyst-like object. Positive identification requires observing one or more sporozoites within the oocysts by visible light microscopy (phase-contrast or differential interference microscopy).

Antibody-based microscopic methods have several limitations, including the lack of information on the infectivity or viability of cysts or oocysts; the lack of indication of the host species of origin of the organisms; the chance of false identification of algal or other protozoal species as *Cryptosporidium* or *Giardia*; poor recovery efficiency; poor precision; the time-consuming nature of the process; and the need for an experienced and skilled microscopist.

These limitations notwithstanding, existing methods have been useful in outbreak investigations, in identifying possible sources of contamination and in controlled experiments for determining the effectiveness of different treatment processes in removing protozoa. The Milwaukee cryptosporidiosis outbreak in 1993, together with EPA regulatory activities, have stimulated interest and research on better and more cost-effective methods.

Almost all of the following methods address *Giardia* as well as *Cryptosporidium*. Complete methods, assays, and processing techniques, and viability determinations are presented in the following series of tables. Table A summarizes methods characteristics. Since most of the methods use assays that are antibody-based, relevant information on available antibodies is presented in Table B.

More detailed information may be found in: Jakubowski W, Boutros S, Faber W, Fayer R, Ghiorse W, LeChevallier M, Rose J, Schaub S, Singh A, Stewart M. Environmental Methods for *Cryptosporidium*. *Journal of the American Water Works Association*. 1996. 88:107-121.

Table A

Environmental Methods for *Cryptosporidium* Detection

Complete Methods	Sample Collection/Processing	Assay Type	Target	Viability (Y/N)	Species ID (Y/N)	Status[a]
Immunofluorescence Assay-Cartridge American Society for Testing and Materials/ Information Collection Rule[b]	yarn-wound filter/ centrifugation; flotation	microscopic; antibody-based	oocyst	N	N	1
IFA-Membrane[c]	membrane filter/squeegee or acetone; flotation	microscopic; antibody-based	oocyst	N	N	1
Flow Cytometry[c]	filter or grab/$CaCO_3$ ppt; centrifugation; cell sorting	microscopic; antibody-based	oocyst	N	N	1/2B
Electrorotation Assay[c]	foam filter/immunomagnetic separation	microscopic; electric field; antibody-based	oocyst	?	N	2C
Assays						
Fluorescence In Situ Hybridization/ Confocal Laser Scanning Microscopy		microscopic; oligo-nucleotide probes; fluorochromes	oocyst/sporozoite	?	Y	2A
UV-Vis		spectrophotometer	oocyst	?	Y	2A
Enzyme Linked Immunosorbent Assay		plate reader; antibody-based	antigens	N	N	?
Culture		tissue culture cells; various assays	infective sporozoites	Y	?	2A
Polymerase Chain Reaction		gel analysis	DNA/RNA	?	Y	2B
Processing Method						
Immunomagnetic Separation			oocyst			2B

[a] Status: 1 = In Use 2 = Developmental (stage designation is arbitrary) A = early stage B =mid stage C = late stage

[b] 100 L or > Sample volume [c] 20 L Sample volume

Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service, the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, or any of the member agencies of the Working Group on Waterborne Cryptosporidiosis.

Table B

Antibody Products for Detecting *Cryptosporidium*

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Products Used Primarily for Environmental Samples					
Anti-*Cryptosporidium* Antibody Biovir Laboratories, Inc. 685 Stone Road Benicia, CA 94510 Phone: (800) 442-7342	• Direct IFA Monoclonal, mouse IgM • Conjugate: FITC, others on request. • Counterstain: none	Environmental samples	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+) *C. meleagridis* (NT) *C. baileyi* (+) *C. serpentis* (NT)	Not known	None
Hydrofluor Combo EnSys, Inc.[a] P.O. Box 14063 Research Triangle Park, NC 27709 Phone: (919) 941-5509	• Indirect IFA Kit • Primary: Monoclonal, mouse IgM • Secondary: Goat anti-mouse IgM (with BSA) • Conjugate: FITC • Counterstain: none	Environmental samples	*C. parvum* (+) *C. wrairi* (+) *C. muris* (+) *C. meleagridis* (+) *C. baileyi* (-) *C. serpentis* (+) *C.* sp. (lizard) (+) *C.* sp. (turtle) (+)	**Protozoa:** *Entamoeba coli, E. histolytica, E. hartmanni, Endolimax nana, Iodamoeba buetschlii, Giardia lamblia, Chilomastix mesnili, Dientamoeba fragilis, Trichomonas hominis, Balantidium coli, Blastocystis hominis, Isospora belli.* **Helminth eggs and larvae:** *Ascaris lumbricoides, Trichuris trichiura,* Hookworm, *Strongyloides stercoralis, Taenia* sp., *Hymenolepis nana, Hymenolepis diminuta, Diphyllobothrium latum, Clonorchis sinensis, Paragonimus westermani, Fasciola/ Fasciolopsis, Schistosoma mansoni.* **Bacteria:** *Shigella flexneri, Salmonella* Groups B and D, *Campylobacter jejuni, Mycobacterium avium, M. intracellulare.* **Yeast and yeast-like fungi:** *Candida albicans, C. guilliermondii, C. tropicalis, C. krusei, C. pseudotropicalis, C. parapsilosis, C. (Torulopsis) glabrata, Cryptococcus neoformans, C. laurentii, Saccharomyces cerevisiae, Geotrichum* sp., *Trichosporon cutaneum, Rhodotorula rubra*	2, 4, 7, 8, 10, 11

[a] Manufactured by Meridian Diagnostics, Inc., P.O. Box 44216, 3471 River Hills Dr., Cincinnati, OH, 45244 Phone: (800) 543-1980. Positive reactions that may be lessened by using goat serum as a blocking agent have been reported for this antibody when used with some algae (see reference 10). Anecdotal reports exist of positive reactions of this antibody with unidentified yeasts.

Note: This information was current as of January, 1996. Testing for antibody reactivity is not uniform, nor are standard protocols available for testing the reactivity of oocysts with antibodies. Consequently, procedures used in the references for determining reactivity vary among laboratories.

Use of trade names and commercial sources is for identification only and does not imply endorsement by the Public Health Service, the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, or any of the member agencies of the Working Group on Waterborne Cryptosporidiosis.

Table B (Continued)

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Detect IF *Cryptosporidium*[b] Shield Diagnostics, Ltd. The Technology Park Dundee DD1 1 SW Scotland, Great Britain Phone: 44-1382-422000	• Direct IFA • Monoclonal, mouse IgM • Conjugate: FITC • Counterstain: Evans blue	• Environmental samples, feces. • May be used for clinical diagnosis. • U.S. availability for research only.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+) *C. meleagridis* (+) *C. baileyi* (+) *C. serpentis* (+)	*Eimeria tenella* *Toxoplasma gondii*	9
Cryptocel-Cel IF Test Tech Lab[c] 1861 Pratt Drive Blacksburg, VA 24060 Phone: (540) 231-3943 Fax: (540) 231-3942	• Direct IFA Kit • Monoclonal, mouse IgM • Conjugate: FITC • Counterstain: With or without Evans blue	• Research and environmental use only. • Acetone fixed fecal smears air-dried from 10% Formalin fixed stools or water	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+) *C. meleagridis* (NT) *C. baileyi* (+) *C. serpentis* (NT)	*Blastocystis hominis, Entamoeba hartmanni, E. histolytica, Endolimax nana, Giardia intestinalis, Strongyloides stercoralis, Trichuris trichiura, Escherichia coli, Candida* sp., *Streptococcus faecalis*	
Crypt-A-Glo, Aqua Glo, Multi Glo Waterborne, Inc. 6047 Hurst Street New Orleans, LA 70118-6129 Phone/Fax: (504) 895-3338	• Monoclonal, mouse IgM, clone 2-C9 available as direct or indirect IFA. • Eleven products for water testing available. • Conjugate: FITC, Texas red, Biotin, phycoerythrin, or combinations, or not conjugated. Counterstain: none	Water testing	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+ weaker) *C. meleagridis* (NT) *C. baileyi* (+ weaker) *C. serpentis* (NT)	*Giardia lamblia* *Giardia muris* *Giardia microti* *Entamoeba histolytica* *Entamoeba coli* *Blastocystis hominis* *Septata intestinalis* (Helminths, bacteria, yeasts, algae: none specifically tested but no reported reactions.)	None

[b] This antibody was formerly produced and distributed by Northumbria, Northumberland, UK.
[c] Manufactured by Cellabs Party Ltd., Unit 7-27 Dale Street, PO Box 421, Brookvale, NSW 2100 Australia, Phone: 02-905-133, FAX: 02-905-6426

Table B (Continued)

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Products Used Primarily for Clinical Samples					
Clone BEL 0126 BioGenesis[d] 104 Little Mill Road Sandown, NH 03873 Phone: (603) 887-4600 Fax: (603) 887-4800	• Monoclonal, mouse IgG, 3-kappa • Titer: IF>1/100 ELISA>1/2000 • Recognizes specific membrane antigen, protein A purified, in PBS without preservatives.	• Human and bovine feces by IF or ELISA. • For in vitro research and manufacturing use only.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	Not known	6
Clone 2G1 BioGenesis (as preceding)	• Monoclonal, mouse IgM, Ig fraction by selective precipitation, in PBS pH 7.2 without preservatives. • Titer: To be established in end user assay system. • Recognizes unknown antigen present on 17/27 human fecal oocyst preparations tested. • Used in combination with Clone 3E8 recognizes 27/27 preparations tested.	• Human and bovine feces. • Smears air dried and fixed in 3% methanol. • For in vitro research and manufacturing use only.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	Not known	None

[d] Manufactured by BioGenesis, Ltd., New Fields, Stinsford Road, Poole, England BH17 0N, Phone: (0202) 660006, FAX: (0202) 660020

Table B (Continued)

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Clone 3E8 BioGenesis (as preceeding)	• Monoclonal, mouse IgM (see Clone 2G1), recognizes unknown antigen present on 23/27 human fecal oocyst preparations tested. • In combination with Clone 2G1 or Clone 4H5, recognizes 27/27 preparations tested.	Human and bovine feces. For in vitro research and manufacturing use only.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	Not known	None
Clone 4H5 BioGenesis (as preceeding)	•Monoclonal, mouse IgA (see Clone 2G1), recognizes unknown antigen present on 16/27 human fecal oocyst preparations tested. •In combination with Clone 3E8 recognizes 27/27 preparations tested.	Human and bovine feces. For in vitro research and manufacturing use only.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	Not known	None

Table B (Continued)

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Anti-*Cryptosporidium* Antibody Chemicon 28835 Single Oak Drive Tennecula, CA 92590 Phone: (800) 437-7500 Fax: (909) 676-9209	• Monoclonal, mouse IgM, ascites fluid, not conjugated. • Recognizes 40 Kda antigen on *C. parvum* oocyst and binds to exterior. • Does not bind to sporozoites.	Not for use as a diagnostic. For research use only. ELISA, IF, and Western blotting.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	*Eimeria auburnensis, E. bovis, E. ellipsoidalis, E. zuernii*	1
Merifluor *Crypto-sporidium/Giardia* Meridian Diagnostics, Inc. P.O. Box 44216 3471 River Hills Drive Cincinnati, OH 45244 Phone: (800) 543-1980	• Monoclonal, mouse IgG. • Direct IFA kit. • Conjugate: FITC • Counterstain: Eriochrome black	Clinical fecal speci-mens, unfixed or fixed in 10% Formalin or PVA.	*C. parvum* (+) *C. wrairi* (+) *C. muris* (+) *C. meleagridis* (+) *C. baileyi* (-) *C. serpentis* (+) *C.* sp. (lizard) (+) *C.* sp. (turtle) (+)	Same as Hydrofluor Combo, preceding	2, 5, 7, 11, 12, 15

Table B (Continued)

Product Name, Distributor	Product Description	Manufacturer's Designated Use	Species of *Cryptosporidium* Detected (+/-) NT= not tested	Genera & Species Showing No Cross Reactivity	Bibliographic Reference
Hyperimmune Anti-*Cryptosporidium* Bovine Colostrum NIH AIDS Research & Reference Reagent Program[e] Ogden Bioservices Corp. 685 Lofstrand Lane Rockville, MD 20850 Phone: 301-340-0245 FAX: 301-340-9245 email: obcaids@lx.netcom.com	• Polyclonal, bovine hyperimmune colostrum • Irradiated, high titer, from last milking of a 2-day period	For researchers registered with the program, this reagent is provided as a government service free of charge.	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	Not known	3, 14
Anti-*Cryptosporidium* Antibody VMRD Inc. PO Box 502 NW 115 State Street Pullman, WA 99163 Phone: 800-222-8673 FAX: 509-332-5356	• Monoclonal, mouse IgM • Conjugate: FITC or not conjugated	Not specified	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (NT) *C. meleagridis* (NT) *C. baileyi* (NT) *C. serpentis* (NT)	*Eimeria auburnensis, E. bovis, E. ellipsoidalis, E. zuernii*	1
Crypt-A-Glo Waterborne, Inc. (as preceding)	• Same as above, but direct. • Conjugate: FITC • Counterstain: None	Clinical diagnosis of oocysts in stools	*C. parvum* (+) *C. wrairi* (NT) *C. muris* (+ weaker) *C. meleagridis* (NT) *C. baileyi* (+ weaker) *C. serpentis* (NT)	*Giardia lamblia* *Giardia muris* *Giardia microti* *Entamoeba histolytica* *Entamoeba coli* *Blastocystis hominis* *Septata intestinalis* (Helminths, bacteria, yeasts, algae: none specifically tested but no reported reactions.)	None

[e] Provided by Dr. Beth L.P. Ungar

References

1. Anusz KZ, Mason PH, Riggs MW, Perryman L. Detection of *Cryptosporidium parvum* oocysts in bovine feces by monoclonal antibody capture enzyme-linked immunosorbent assay. *J Cli. Microbiol* 1990; 28:2770-2774.

2. Arrowood MJ, Sterling CR. Comparison of conventional staining methods and monoclonal antibody-based methods for *Cryptosporidium* oocyst detection. *J Clin Microbiol* 1989; 27:1490-1495 .

3. Fayer R, Andrews C, Ungar BLP, Blagburn B. Efficacy of hyperimmune bovine colostrum for prophylaxis of cryptosporidiosis in neonatal calves. 1989; *J Parasitol* 75:393.

4. Garcia LS, Brewer TC, Bruckner DA. Fluorescence detection of *Cryptosporidium* oocysts in human fecal specimens by using monoclonal antibodies. *J Clin Microbiol* 1987; 25:119-121.

5. Garcia LS, Shum AC, Bruckner DA. Evaluation of a new monoclonal antibody combination reagent for direct fluorescence detection of *Giardia* cysts and *Cryptosporidium* oocysts in human fecal specimens. *J Clin Microbiol* 1992; 30:3255-3257.

6. Garcia-Gonzalez M, Bettinger S, Ott S, Oliver P, Kadouche J, Pouletty P. Purification of murine IgG3 and IgM monoclonal antibodies by euglobulin precipitation. *J Immun Meth* 1988; 111:17-23.

7. Graczyk TK, Cranfield MR, Fayer R. Evaluation of commercial enzyme immunoassay (EIA) and immunofluorescent (IFA) test kits for detection of *Cryptosporidium* oocysts of species other than *Cryptosporidium parvum*. *Am J Trop Med Hyg* 1996; 54:3:274.

8. LeChevallier MW, Norton WD, Siegel JE, Abbaszadagan M. Evaluation of the immunofluorescence procedure for detection of *Giardia* cysts and *Cryptosporidium* oocysts in water. *Appl Environ Microbiol* 1995; 61:690-697.

9. McLauchlin J, Casemore DP, Harrison TG, Gerson PJ, Samuel D, Taylor AG. Identification of *Cryptosporidium* oocysts by monoclonal antibody. *Lancet* 1987; 1:1:51.

10. Rodgers MW, Flanigan D, Jakubowski W. Identification of algae which interfere with the detection of *Giardia* cysts and *Cryptosporidium* oocysts and a method for alleviating this interference. *Appl Environ Microbiol* 1995; 61:3759-3763.

11. Rose JB, Landen LK, Riley KR, Gerba CP. Evaluation of immunofluorescence techniques for detection of *Cryptosporidium* oocysts and *Giardia* cysts from environmental samples. *Appl Environ Microbiol* 1989; 55:3189-3196.

12. Rusnak J, Hadfield TL, Rhodes MM, Gaines JK. Detection of *Cryptosporidium* oocysts in human fecal specimens by an indirect immunofluorescence assay with monoclonal antibodies. *J Clin Microbiol* 1989; 27:1135-1136.

13. Sterling CR, Arrowood MJ. Detection of *Cryptosporidium* sp. infections using a direct immunofluorescent assay. *Ped Infect Dis J* 1986; 5:s139-s142.

14. Ungar BLP, Ward DJ, Fayer R, Quinn CA. Cessation of *Cryptosporidium*-associated diarrhea in an acquired immunodeficiency syndrome patient after treatment with hyperimmune bovine colostrum. *Gastroenterology* 1990; 98:486-489.

15. Vesey G, Slade JS, Byrne M, Shepherd K, Dennis PJ, Fricker CR. Routine monitoring of *Cryptosporidium* oocysts in water using flow cytometry. *J Appl Bacteriol* 1993**;** 75:87-90.

16. Xiao L, Herd RP. Quantitation of *Giardia* cysts and *Cryptosporidium* oocysts in fecal samples by direct immunofluorescence assay. *J Clin Microbiol* 1993; 31:2944-2946.

II. Issuing and Rescinding a Boil Water Advisory

Introduction

Issuing a boil water advisory (BWA) for the protection of public health from waterborne pathogens has serious implications for a community and must be done only after careful consideration.

Decisions must frequently be made within relatively short periods of time and with either incomplete or inconclusive information. Therefore, as stated in Chapter 1, the most effective way for a community to make decisions is to establish a local task force well in advance of any potential crisis to discuss issues that are critical to BWA decision making. The task force should consist of representatives from public health and regulatory agencies and the water utility.

The task force has two principal goals: to bring together these representatives to establish local water quality standards, and to establish a review process to be activated when a question about the safety of local drinking water arises. Issues for discussion might include the legal authority for issuance of a BWA, identification of regulatory concerns, critical water processing guidelines, source water factors (ground or surface), and public health implications. By discussing these issues well in advance, the task force can prepare itself to make sound professional judgements in the most informed and expeditious manner.

Boil Water Advisory Guidelines

The following guidelines are divided into three components:

1.) Factors that trigger a meeting of the task force to review data relevant to a BWA;
2.) Factors to be considered in issuing a BWA;
3.) Factors to be considered in rescinding a BWA.

Although the working group that developed this document and most water industry professionals encourage water utilities that filter water to maintain a finished water turbidity level of 0.1 NTU, these guidelines do not set specific turbidity levels, pathogen concentrations, or particle counts that would trigger the issuance of a BWA because of the following current limitations:

- The health risk associated with the consumption of drinking water contaminated with small numbers of *Cryptosporidium* oocysts is unknown.
- For *Cryptosporidium* and other emerging pathogens, the analytical methods for detection in water samples are developmental and may lack the sensitivity and specificity that would permit basing decisions about issuing BWAs on test results alone. Negative results, using currently available tests, do not necessarily indicate the absence of organisms, but only that none were detected in the sample analyzed. Positive results do not necessarily provide an accurate assessment of the number of organisms present nor of their infectivity or viability. Hence, a numerical standard for the number of organisms that should be of concern has not been developed.
- Some measurements, such as turbidity levels or particle counts are site-specific.
- The complex interplay of factors to be considered in making BWA decisions makes it difficult to set criteria on a national level that would be appropriate to all communities.

Factors That Trigger a Meeting of the Boil Water Advisory Task Force

- Evidence of disease in a community in which drinking water is suspected as the source of infection.
- Failure or significant interruption in key water treatment process(es) (e.g., increases in turbidity levels, increased particle counts, mechanical or equipment failure, persistent monitoring deficiencies).
- Positive test results for pathogens (e.g., *Cryptosporidium, Giardia, Shigella*) in water.
- An acute violation of the total coliform rule (TCR) or a violation of the surface water treatment rule (SWTR) turbidity standard.
- A persistent nonacute violation of the TCR.
- Any event (e.g., water main break, cross connection) that compromises the distribution system, coupled with an indication of a health hazard.
- A natural disaster that may adversely affect water quality (e.g., flood, hurricane, earthquake).

Issuing a Boil Water Advisory: Factors to Consider

Source water quality

- **Vulnerability of the source water to contamination**. The following may contaminate source water: recreational use, sewage or sanitary discharges, or livestock operations in the watershed area. Other site-specific factors, circumstances, and criteria should also be considered.
- **Previous monitoring results for pathogens**. Data from past monitoring or studies may be helpful in interpreting current test results.
- **Major changes to source water quality**. Source water quality can be altered by sewage or manure spills, destratification of a reservoir, recent heavy or persistent rainfall, floods, wind, water temperature changes, droughts, chemical changes, or related circumstances. These events may increase the risk of pathogen occurrence and concentration, or decrease the ability of the plant to treat the water effectively.

Treatment effectiveness

- **Plant optimization for pathogen removal**. A treatment plant should have a plan for treatment improvement such as that offered by EPA, water utilities, and states under the Partnership for Safe Water program. Evaluation of plant performance by a third party may also be beneficial.
- **Treatment failure or interruption**. Failure or interruption of key treatment processes can occur even if a system is optimal. Maintenance of all levels of a multiple barrier system (i.e., coagulation, flocculation, sedimentation, filtration, disinfection, or other individual water treatment processes) is critical to the effective removal of pathogens.
- **Finished water quality**. Finished water quality measurements that should be reviewed include turbidity levels, particle counts, disinfection (dosage, residual, and contact time), and the presence of pathogens or indicators at the treatment plant or in the distribution system. National water quality standards may not be adequate to prevent transmission of waterborne *Cryptosporidium*. Site-specific standards may need to be more stringent than current EPA regulations.

When evaluating positive test results for pathogens, consider:

- The experience of the laboratory with environmental samples.
- The appropriateness of sample collection and test methods for water.

- The inherent limitations in the test methods. For *Cryptosporidium*, negative results do not necessarily indicate the absence of organisms and positive results do not necessarily provide an accurate assessment of the number of organisms present, nor of their infectivity or viability.
- The time between collection of the sample and the availability of results. For example, a BWA may not necessarily be advisable if a positive test result was associated with a sample that was collected a month ago vs. a few days ago.

Distribution System Integrity

An assessment of the distribution system includes evaluating any disruption to the system such as:

- low pressure or main breaks
- cross connections
- recent construction that might interrupt pipe flow
- stagnant water
- disinfectant residual
- an inadequate flushing program
- age and condition of the system.

This information may be contained in recent sanitary surveys.

Epidemiologic evidence

Epidemiologic evidence that associates gastrointestinal illness with drinking water in any segment of the population should also be taken into account. Epidemiologic data suggesting waterborne disease should be acted upon even if disease-confirming water quality data are not readily available.

Rescinding a Boil Water Advisory: Factors to Consider

Source water quality

Source water quality indicators have returned to acceptable levels.

Treatment effectiveness

Treatment deficiency has been corrected.

Finished water quality

Finished water quality indicators have returned to acceptable levels and are within regulatory limits. Successive pathogen monitoring shows acceptable results. Sufficient finished water displacement has occurred in the distribution system to eliminate water that was or might have been contaminated. *If the BWA was issued because a pathogen was detected and that pathogen is no longer being detected, then the inadequacies of the pathogen detection methods* must *be considered before rescinding a BWA.*

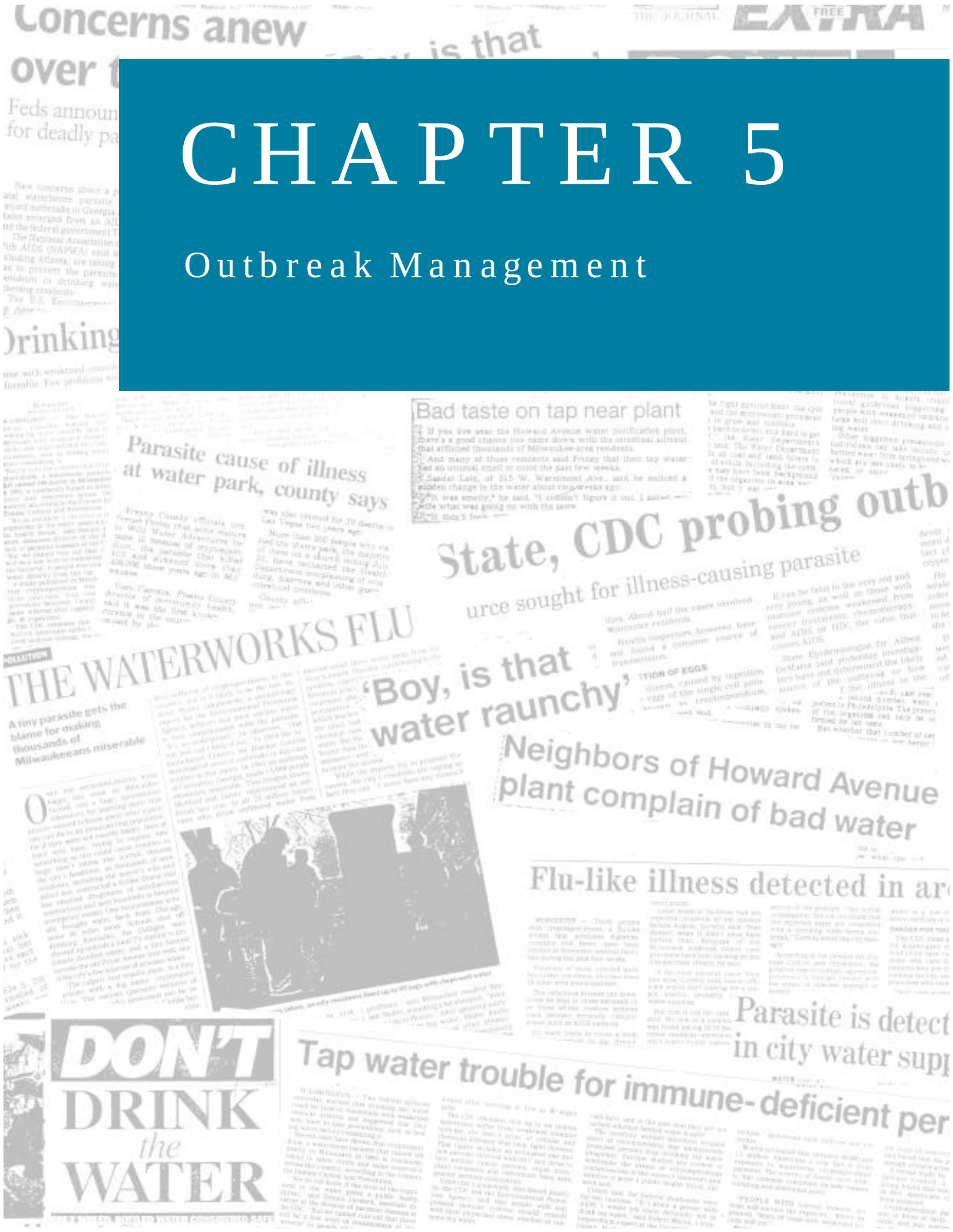
Epidemiologic evidence

Epidemiologic evidence may be valuable. However, epidemiologic data is often not readily available for BWA decision-making.

Additional resources for this decision making are available. Local health and drinking water officials are encouraged to seek advice from their state epidemiologist (see Appendix, Figure F), and their state agency responsible for implementation of the Safe Drinking Water Act. On the federal level, 24-hour assistance is available through the EPA Environmental Response Team at (908) 321-6660 and CDC at (770) 488-7760 (during business hours) and (404) 639-2888 (nights, weekends and holidays).

CHAPTER 5

Outbreak Management



Chapter 5- Outbreak Management

Outbreak Assessment:

Dennis D. Juranek, Centers for Disease Control and Prevention
Deborah A. Levy, Centers for Disease Control and Prevention
Anne C. Moore, Centers for Disease Control and Prevention
Faye Sorhage, New Jersey Department of Health

News Release Information

Scott A. Damon, Centers for Disease Control and Prevention

Frequently Asked Questions

David G. Addiss, Centers for Disease Control and Prevention
Susan Goldstein, Centers for Disease Control and Prevention
Dennis D. Juranek, Centers for Disease Control and Prevention
Thomas Navin, Centers for Disease Control and Prevention

Protocols for Special Audiences and Contingencies

City of Milwaukee Health Department

CHAPTER 5

OUTBREAK MANAGEMENT

I. Epidemiology (checklist for investigating a possible outbreak)

1. Is an outbreak of cryptosporidiosis occurring?

An outbreak can generally be defined as a sudden increase in the incidence of disease in a defined area over a specific period of time. However, even if the number of reported cases of cryptosporidiosis exceeds the expected number, this excess may not necessarily indicate an outbreak. Reporting may increase because of changes in the local reporting procedures, changes in the case definition, increased interest because of local or national awareness, improvements in diagnostic procedures, or changes in laboratory standards or personnel. Similarly, a new physician or infection control nurse seeing referred cases may more consistently report them, when in fact there has been no change in the prevalence of disease.

A general increase in the rate of diarrheal illness in a community does not necessarily mean that a single type of organism or mode of transmission is the cause. One quick way to determine if a specific organism is the predominant cause of diarrhea is to collect stool samples from 10-20 ill people and a similar number from controls (people without diarrhea) and have them tested for a variety of organisms (bacteria, viruses, parasites) by a reliable laboratory. If one organism is commonly found in the stool of ill persons and rarely found in stools from controls, it is likely that this organism is the cause of the outbreak. The finding of two or more different organisms could indicate a) sporadic cases of different diseases are occurring in the same area at the same time; b) multiple outbreaks with different modes of transmission are occurring; or c) a single outbreak is occurring in which multiple organisms are being transmitted in the same way, e.g., sewage-contaminated water may transmit a number of pathogens simultaneously.

An approach for rapidly determining if there is an increase in cases of cryptosporidiosis or diarrhea is outlined below:

- Review data available from ongoing surveillance systems for diarrheal illness or cryptosporidiosis. (See Chapter 2 for information on conducting surveillance)
- Set up a system for recording basic information about people who call the health department or water utility to report laboratory-confirmed infection and clinical illness consistent with cryptosporidiosis. Use a standardized questionnaire or data collection form such as the ones in Figures D and E in the appendix to capture comparable information from all callers. Information collected should include the name and phone number of persons reporting illness, demographic and clinical characteristics of ill persons, suspected source of infection, and name or initials of the person who recorded information on the form. A quick analysis of data collected on these forms may suggest avenues of investigation. For example, if most cases involve toddler-age children a day

care source may be likely. Illness in predominantly older children may indicate a recreational water exposure, or eating at a particular function or food establishment. Instances of disease with no age, sex, or geographic clustering suggest that drinking water or a widely distributed food product may be worthy of more intensive investigation. Data from these forms may also provide a reasonable estimate of the time period when exposure may have occurred.

- Review laboratory practices and laboratory records. Ensure that the cryptosporidiosis diagnosis is correct and that an increase in diagnoses truly represents an outbreak. An apparent outbreak may, in fact, be an artifact of reporting or a laboratory error. The following should be addressed when an increase in the number of cryptosporidiosis diagnoses is being reported by a laboratory:
  - Send a representative sample of specimens reported as positive to an outside reference laboratory (e.g., state health department) for verification.
  - Compare the current weekly or monthly number of cases with a) the number of cases diagnosed in the previous week or month and b) with the number of cases in the same week or month of the previous year.
  - Determine if there has there been a change in the total *number* of stools submitted for *Cryptosporidium* testing that might artificially increase the number of cases. A sudden change in the number of tests requested by physicians may cause an increase in the number of cases detected, but this increase may not signal an outbreak.
  - Determine whether there has there been a change in the *proportion* of stools that test positive for *Cryptosporidium*. An increase in the percentage of stools testing positive (number of stools positive divided by number of stools submitted for *Cryptosporidium* testing) is a more reliable index of a true increase in the occurrence of cases than the total number of stools positive.
  - Determine whether there has been a change in the method(s) used for detection of *Cryptosporidium* or in laboratory personnel that might have caused a greater number of tests to be done or to be read as positive.
  - Determine whether other nearby laboratories have seen similar increases.
  - Determine whether the laboratory reporting most of the cases recently began providing services to a new client, e.g., an AIDS clinic, a day care center, or a large HMO that might explain a sudden increase in the number of specimens testing positive for *Cryptosporidium*.

- Establish a case definition for survey purposes. A case definition is a standard set of criteria for deciding whether an individual should be classified as having a disease. The common elements of a cryptosporidiosis case definition include:
  - laboratory-confirmed infection
  - three or more watery stools per day lasting for 3 or more days in the 2 weeks (or other time period of interest) before the date that the questionnaire is administered.

- Survey health care facilities for evidence of increased numbers of patients with diarrhea or laboratory-confirmed cryptosporidiosis. The survey should be designed to ascertain the number of cases diagnosed within a defined time period (usually several weeks to a month around the time that the outbreak is thought to have occurred). Any impressions

of an increase in the number of cases (case definition to be established by the investigator) identified during this period should be further assessed by comparing the current number of cases with a) the number of cases identified the preceding month and b) the number of cases identified for the corresponding time period in the previous year at these facilities. An increase in cases compared with the previous week or month and compared with the same week or month in the previous year supports the hypothesis that an outbreak may be occurring. Bear in mind, however, that what appears to be an outbreak may be merely the finding or reporting of cases that were not reported previously, but are now being detected or reported as a result of media attention, improved surveillance, or other change in methods for case ascertainment. Sources of information include surveys of hospital and clinic emergency departments and of physicians offices, records of pharmacy sales of anti-diarrheal medications, records of patients with diarrhea at nursing homes (on and off the suspected water supply), and records of school absenteeism.

- Analyze epidemiologic data from all sources including self-reported cases, health care facilities' surveys, questionnaire data from specific epidemiologic surveys, and water and environmental data. The list of activities below is intended to provide a starting point for data analysis. In some outbreaks the preliminary analysis may be adequate to make recommendations; in many other outbreaks preliminary analysis will serve to identify areas that will require more sophisticated statistical analysis or further epidemiologic study to be able to resolve important questions.

Note: *If at any time throughout the entire investigative or analytical process, an ongoing, potentially hazardous source of illness (e.g., food, water) is discovered, recommendations for the community should be decided upon and immediately publicized (see Chapters 1 and 4). Regulatory actions may also need to be taken.*

- Determine whether the outbreak is ongoing. Review line listing and epidemiologic questionnaire data for dates of onset of illness for the most recent cases. The incubation period for cryptosporidiosis is estimated to range from 2 to 10 days. Therefore, if persons are reporting onset of illness in the past 1 to 2 weeks, transmission may still be occurring.
- Chart an epidemic curve. Is it consistent with a common source outbreak, i.e., does it have a steep upward slope with a sharp peak? Does the curve appropriately reflect the effects of a control program, e.g., if a boil water advisory was issued, was there a sharp decline in cases following the advisory?
- Plot cases by location of residence on a map to determine if they are clustered in one area or randomly distributed. Is the distribution of cases consistent with the hypothesized mode of transmission?
- Summarize the age, sex, and ethnic distribution of cases.
- Determine whether drinking tap water is the major risk factor. Were persons with illness more likely to drink tap water without applying home water treatment than were persons who are not ill? Did drinking alternative water, e.g., bottled water, home-filtered water, private well water, or municipal water from another source protect against infection?
- Evaluate other risk factors such as attendance at a day care center, recent travel to a developing country, contaminated food, animal exposures, etc.

2. **Is water a likely source of infection?**

If age, sex, and geographic distribution of cases indicates that only people using a specific water supply are affected, collect additional water data. The objectives are to determine rapidly if drinking water is the probable source of infection and to decide if a boil water advisory should be issued.

- Obtain water quality and treatment data for the community affected by the suspected outbreak. (Chapter 1 discusses how to form a task force to assess the local drinking water supply and treatment before a possible outbreak. Information may already have been collected by the task force for the first three items outlined below.)
  - Identify source(s) and type(s) of water (e.g., surface, spring, well).
  - Determine type(s) of treatment (e.g., filtration type, if any; disinfection type, if any).
  - Determine the number of water supplies serving the community and the parts of the community that each serves. Are cases clustered in one water service area ?
  - Review recent water quality data (e.g., coliform counts, turbidity levels, disinfectant residuals). Graph the peak turbidity levels recorded each day before and during the suspected outbreak period. Were there any recent changes in the water treatment protocol, temporary malfunctions, or treatment failures shortly before cases began to be reported? Have there been chronic water filtration problems, e.g. frequent turbidity spikes in the 0.3 - 1.0 NTU range that may have allowed *Cryptosporidium* to pass through without violating filtration standards?
  - Determine whether there were there any recent repairs to the treatment plant or distribution system. If so, does the distribution of cases correspond to the site of repair?
  - Determine whether system pressure recently fell to less than 5 psi.
  - Determine whether there was vandalism and/or unauthorized access to facilities.
  - Determine whether there have been any recent changes in the watershed (e.g., drought, flood, land use, sewage overflow) that may have increased the chances for *Cryptosporidium* contamination of source water.
  - Discuss water quality and treatment data with the local water treatment plant engineer or the state water-treatment engineer, and/or the EPA engineer that may be assisting in the investigation. This will minimize the risk of misinterpreting data.

- If the outbreak appears to be caused by drinking water:
  - Consider issuing a boil water advisory if there is evidence that a hazard still exists.
  - Consider sampling raw and finished (treated) water for *Cryptosporidium*. This should be done as early in the outbreak as possible in order to increase chances of detecting the organism.
  - Consider sampling filter backwash material for *Cryptosporidium.*
  - Consider locating water for *Cryptosporidium* testing that likely was drawn during the probable period when people were exposed, e.g., stored water such as recently filled swimming pools or water beds, water in dead-end mains, or commercial ice.
  - Contact health departments and water utilities in other communities that could be affected by the same water source, i.e., if a river is the source of drinking water, contact communities upstream and downstream to alert them to a possible problem and ask for information about any recent increases in *Cryptosporidium* diagnoses or diarrhea.

- If recreational water is suspected, sample lake, river, or pool water for *Cryptosporidium*. If pool water is tested, skim off the thin layer of material resting on top of the filter bed and/or gather the filter backwash material for examination for *Cryptosporidium*.

3. **What to do if data indicate an outbreak is occurring.**

A thorough epidemiologic investigation is often desired to better define the size, geographic extent, and cause of an outbreak as well as to identify the specific activities (exposure risk factors) that lead to infection.

Note: *If at any time an outbreak appears to be occurring, it should be reported to your state department of health which can provide both technical and field assistance. Experienced state staff can often improve the study design, provide guidance on interim control strategies, and facilitate more rapid completion of the investigation. Emergency numbers for state personnel are listed in the appendix of this handbook. Ideally an interagency task force will already have been established (see Chapter 1) and a coordinated response plan agreed upon. Task force members should be kept fully apprised of all actions taken when an outbreak appears to be occurring.*

- **Plan the investigation**. Random digit telephone surveys and case-control studies are two types of study design commonly used in outbreak investigations in which drinking water is suspected. Random digit dialing surveys are useful for determining when the outbreak began, the magnitude of the outbreak, geographic distribution of cases, and the demographic profile and symptoms of people reporting illness. Telephone surveys are also useful in determining the impact of control measures (e.g., boil water advisories).

  Case-control studies are used primarily to identify the type(s) of exposure (e.g., water, food, animals, day care, etc) that result in infection. The major objective of the study is to find out what people with *Cryptosporidium* (cases) did to acquire infection that people without the infection (controls) did not do. Case-control studies require that methods be developed to identify cases (e.g., patients who have laboratory-confirmed cryptosporidiosis), and controls (uninfected persons) who are representative of the population from which the cases are drawn. Exposures to infection that are more common among cases than among controls are then identified using an epidemiologic questionnaire. The questionnaire must be developed to ensure critical evaluation of *all* likely sources of infection.

  - Identify a suitable study population(s).
    Investigations can be community-wide or restricted to smaller groups. Early in an investigation, quick studies of small groups such as people in residential care institutions may be helpful. For example, comparing attack rates (number of ill persons divided by total number of persons exposed) for individuals in nursing homes in the same community but with different water supplies can be useful in rapidly assessing the role of drinking water. A high rate of infection in residents of nursing homes using a suspected water source vs. a low rate of infection in a similar facility on another water supply is strong evidence for waterborne transmission because individuals in such institutions have few other exposures to *Cryptosporidium*. For larger case-control studies, consult your state health department for assistance in

determining an appropriate sample size and number of controls to use per case.

- Identify suitable controls.
  This can often be the most important and difficult part of an epidemiologic investigation. Even the experienced epidemiologist will benefit from consultation with another epidemiologist.
- Design a questionnaire.
  Design a standardized questionnaire to use in gathering information on reported or known cases. If a case-control study is planned, develop a similar questionnaire for controls. A sample questionnaire for case-patients is provided in the appendix as Figure E. The sample questionnaire is intended only as a guide; it will require modification to fit the particular circumstances surrounding the outbreak investigated. Below is a brief checklist of important variables to consider when developing a questionnaire:
  - Demographic information:
    Age, sex, ethnicity, home, work, and school addresses. (If the entire address is not available, obtain the zip code to use as a minimum indication of where people live.)
  - Clinical:
    Onset date of illness
    Duration of illness
    Symptoms and severity of illness
    Immune status
    Chronic medications taken
    Medical assistance sought
    Doctor's name
      Diagnosis
      Laboratory test results (if any)
      Hospitalization
  - Exposures:
    Drinking water
      Sources of drinking water at home, work, and school
      Consumption of unpurified lake or river water (e.g., while camping)
      Exclusive or partial use of purified water
      Consumption of water or reconstituted drinks in restaurants, stores, or social settings
      Amount of water consumed daily *before* becoming ill
    Food
      Dining out
      Consumption of unpasteurized beverages or other products
    Children
      Number in diapers
      Number who attend day care
      Number in diapers who attend day care

Other people
    Household contacts with diarrhea
    Visiting ill persons
    Sexual contact
Animals
    Pets
    Farms
    Petting zoos
Travel history

- Collect the data
  - Random digit dialing survey
    Select a sample of names from a residential telephone directory. Depending on the number of people to be sampled, select every 10th, 20th, 30th or other number of persons listed. Seek the telephone company's guidance on how to call residential listings only. Use a computer program to randomly select telephone numbers to call.
  - Case-control study
    Administer your questionnaire to all or a representative sample of persons with illness. For example, if there are a large number of cases, you might want to sample 10-30% of them. Contact your state health department for assistance in determining an appropriate sample size and number of controls per case.

- Other groups to consider studying:
  Consider investigating persons who had time-limited exposures to the water in question (e.g., flight attendants, business travelers, out-of-town attendees at sporting events, weddings, etc). Studies of these groups are useful for determining when the problem began and how long exposure continued. These studies also provide useful information about the incubation period and dose (minimum amount of water consumed that results in infection).

- Draw conclusions and make recommendations. After analysis of epidemiologic and environmental data, conclusions should be summarized in an outbreak report. Special attention should be given to discussing the most likely cause(s) of the outbreak and development of recommendations that would prevent future outbreaks.

II. News Release Information

This is a sample of information to include in a news release to be used if there is a cryptosporidiosis outbreak in your community, or if *Cryptosporidium* is found in your community's water.

Extra precautions for people with weakened immune systems:
In persons with weakened immune systems, cryptosporidiosis can be chronic and life-threatening. Persons with weakened immune systems may wish to take these extra precautions to protect themselves against cryptosporidiosis.

- Drink only water that has been purified by boiling for 1 minute or by distilling.
- Trust only water filters with any of the following information on the label to remove *Cryptosporidium*: reverse osmosis; *absolute* pore size of 1 micron or smaller; tested and certified by NSF Standard 53 for cyst removal; tested and certified by NSF Standard 53 for cyst reduction. Bottled water treated by reverse osmosis or with any of these filters, and distilled water, will also be free of *Cryptosporidium*. Canned or bottled carbonated (bubbly) drinks will also be free of *Cryptosporidium*.
- Wash, with purified water, and/or cook all food.
- Do not swim in lakes, rivers, streams, public pools, or water parks and do not use jacuzzis.
- Avoid any sexual practice that might involve contact with stool.
- Avoid touching young farm animals.
- Avoid touching the stool of animals.

Sources of infection

- Cryptosporidiosis is the disease caused by the parasite *Cryptosporidium parvum*. *Cryptosporidium* infection can be caused by swallowing only a small amount of cryptosporidia. *Cryptosporidium* infection can be contracted by:
  - eating contaminated food or drinking contaminated water;
  - touching the stool of infected persons or animals, then not washing your hands well before touching your mouth;
  - touching anything contaminated with stool, then not washing your hands well before touching your mouth.
- Cryptosporidiosis can be prevented by always washing hands thoroughly, after any contact with animals or soil, after changing diapers, and before eating.

Symptoms

- Symptoms of cryptosporidiosis, the disease caused by *Cryptosporidium*, include diarrhea, stomach cramps, fatigue, nausea, vomiting, or a slight fever.
- Symptoms usually start 2 to 10 days after swallowing *Cryptosporidium*.
- In a healthy person with a normal immune system, symptoms normally will last for 2 weeks or less, although individuals may recover, then get sick again. Some people with cryptosporidiosis may not get sick, but they can still pass the disease to others.
- After infection, an individual can pass cryptosporidia in their stool for up to 2 months, and may give the disease to other people.

- Persons with severely weakened immune systems may have cryptosporidiosis for a longer time and should talk with their health care providers to learn how to avoid infection. The CDC AIDS Hotline, 1-800-342-2437, provides more information on cryptosporidiosis.

Information for infected persons

- Persons infected with *Cryptosporidium* should:
  - wash their hands regularly, especially before preparing food and after using the toilet;
  - avoid any sexual contact, especially sexual contact involving exposure to feces;
  - avoid swimming in public bathing areas (swimming pools, lakes, water parks, etc.) while they have diarrhea and for several weeks after it clears up.
- Diarrhea can cause dehydration. Individuals with diarrhea should contact their health care provider, who may prescribe an oral rehydration mix.
- Some drugs, such as paromomycin, may reduce the symptoms of cryptosporidiosis, but no drug now known can cure it. Therefore, prevention of infection is the key.

III. Sample FAQ (Frequently Asked Questions)

Anticipate questions you might be asked by the media and the public during a cryptosporidiosis outbreak and how to answer them. Here are some examples.

Q. What is *Cryptosporidium* and how is it transmitted?

A. *Cryptosporidium* is a microscopic parasite that is found in the feces of infected humans or animals. Humans are infected when they ingest contaminated water or food, or touch contaminated objects, then touch their mouth before washing their hands well. Cryptosporidiosis, the disease caused by *Cryptosporidium*, is one of the most common causes of diarrhea among persons with AIDS in the U.S.

Q. What are the symptoms?

A. Symptoms of *Cryptosporidium* infection in persons with normal immune systems include diarrhea that lasts 1 to 2 weeks, often accompanied by abdominal cramps, fatigue, nausea, vomiting, and low-grade fever. People usually develop symptoms 2 to 10 days after ingesting the parasite.

In persons with weakened immune systems, cryptosporidiosis can be chronic and life-threatening.

Q. Who is at risk for severe cryptosporidiosis?

A. People at risk for severe cryptosporidiosis include people with AIDS, people who have cancer, or organ or bone marrow transplant patients who are taking drugs that suppress the immune system, and people who are born with genetically weakened immune systems.

Q. Why is *Cryptosporidium* a problem in drinking water?

A. *Cryptosporidium* is a problem because most water from lakes, rivers, and streams, contains some of the microscopic parasite. Most communities get their drinking water from these "surface" sources, rather than from underground sources such as wells. *Cryptosporidium* is highly resistant to chlorine and other disinfectants, which are used to kill bacteria and viruses in drinking water. In addition, *Cryptosporidium* is so small that it is not easily removed from water by the type of filters used in conventional municipal water treatment.

Over half of the tested public water supplies that use surface water have been found to have small amounts of *Cryptosporidium* in the water sent to homes and businesses.

Q. How can I tell if there is *Cryptosporidium* in my drinking water?

A. You cannot tell without expensive, special tests. These tests are not very good for home use, and are not always reliable.

Q. Is there a cure for *Cryptosporidium* infection?

A. No. Some drugs, such as paromomycin (PAR-o-mo-my-sin), may reduce the symptoms of cryptosporidiosis, but no drug now known can cure it. Diarrhea can cause dehydration. Persons with diarrhea should contact their health care provider who may recommend an oral rehydration therapy mix.

Q. Should I take extra protective measures?

A. It depends on your health and your drinking water. If you have AIDS, if you have cancer or if you have had an organ or bone marrow transplant and are taking drugs that weaken your immune system, or if you were born with a genetically weakened immune system, you may want to take extra measures. You should talk to your health care provider regarding the level of your risk and on how to reduce it.

If you have a healthy immune system, you are at less risk for cryptosporidiosis, but you may want to consider the quality of your drinking water. Unfortunately, assessing the risk of *Cryptosporidium* infection from your drinking water is not easy. Tests for *Cryptosporidium* in public water supplies are not easy to interpret. A positive test does not necessarily mean there *is* a risk, and a negative test does not necessarily mean there is *no* risk. If your drinking water comes from a surface source (lake, stream, or river) that is unfiltered, or one that is located downstream from a sewage treatment facility or runoff from farming, your water may be at increased risk of containing *Cryptosporidium*.

Q. What can immunosuppressed persons do to avoid infection with *Cryptosporidium*?

A. Avoid sexual practices that may result in exposure to feces.

Avoid drinking water directly from lakes, rivers, ponds, or streams.

Avoid swimming in lakes, rivers, streams, ponds, public swimming pools, or recreational water parks.

Avoid working with diaper-aged children.

Avoid contact with feces of all animals, particularly young farm animals such as calves.

Always wash hands thoroughly:
- after any contact with animals;
- after any contact with soil (e.g., gardening);
- after changing diapers;
- before eating, or preparing food.

Consume only water that has been purified by boiling for 1 minute, or by treatment with certain filters. The CDC AIDS Hotline (1-800-342-2437) has information on filters that remove *Cryptosporidium* from water.

IV. Protocols for Special Audiences and Contingencies

The following pages contain information for various specialized audiences and contingencies for use if a boil water advisory is issued. You may wish to release this information to the appropriate persons individually (i.e., not as a news release). You may also want to set up telephone hotline numbers to handle questions specific to these audiences. These pages are designed, in a camera-ready format, for individual release, by fax or similar methods, to the appropriate persons at the institutions indicated.

Experience has shown that hotlines operate most effectively with a single number (answered automatically or personally) with one consistent message. Callers can be directed to further basic information via audio, fax, Internet, or other means. Callers can also be directed to medical, sanitation, water, or other appropriate personnel. In this way, callers with general questions can be managed at a general level and callers with specific technical questions can be efficiently directed to appropriate personnel. Also, the following protocols can be distributed more appropriately and efficiently on demand if callers are grouped in this manner. Experience has shown that hotlines are especially useful for addressing the needs of commercial establishments and the public.

Hospitals and Clinics

During a boil water advisory

- Patients and employees should not consume water that has not been disinfected, ice or drinks made with water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute 1 micron" filter or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- All employees with diarrheal illness should be regulated by standard rules of exclusion from work.
- Disinfect dishes via dishwashing machines that have a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122°F for 5 minutes or 162°F for 1 minute.
- Use only disinfected water to treat skin wounds.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.
- Backwash pool filters and change media or water.
- Run water softeners through a regeneration cycle.
- Drain and refill hot water heaters set below 113°F.
- Resume usual bathing practices and care for patients with breaks in the skin.

Renal Dialysis Units

During a boil water advisory

- Patients and employees should not consume water that has not been disinfected, ice or drinks made with water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute 1 micron" filter, or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- All employees with diarrheal illness should be regulated by standard rules of exclusion from work.
- Disinfect dishes via dishwashing machines that have a dry cycle or a final rinse that exceeds 113° F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute.
- Use only disinfected water to treat skin wounds.
- Monitor patients closely for signs and symptoms of gastrointestinal illness.

If your water system is treating water chemically beyond normal levels advise dialysis units to

- Sample water for chemical analysis to ensure compliance with AAMI standards.
- Conduct chlorine/chloramine tests to ensure compliance with AAMI standards.
- Monitor water system gauges once per shift.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.
- Backwash pool filters and change media or water.
- Run water softeners through a regeneration cycle.
- Drain and refill hot water heaters set below 113°F.
- Resume usual bathing practices and care for patients with breaks in the skin.

Nursing Homes

During a boil water advisory

- Residents and employees should not consume water that has not been disinfected, ice or drinks made with water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute one micron" filter, or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- All employees with diarrheal illness should be regulated by standard rules of exclusion from work.
- Disinfect dishes by washing in dishwashing machines that have a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.
- Backwash pool filters and change media or water.
- Run water softeners through a regeneration cycle.
- Drain and refill hot water heaters set below 113° F.
- Resume usual bathing practices and care for residents with breaks in the skin.

Day-care Facilities

During a boil water advisory

- Children and employees should not consume water that has not been disinfected, ice or drinks made with water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute one micron" filter, or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- All employees with diarrheal illness should be regulated by standard rules of exclusion from work.
- Disinfect dishes by washing in dishwashing machines that have a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.
- Backwash pool filters and change media or water.
- Run water softeners through a regeneration cycle.
- Drain and refill hot water heaters set below 113°F.

Prevention and Control of Cryptosporidiosis in Day-care Facilities

Effective measures include

- frequent hand washing, by both staff and children;
- clear separation of diapering and food-handling areas and responsibilities;
- the use of overclothes or diapers capable of retaining liquid feces;
- disinfection of diaper areas and toys;
- excluding children with diarrhea;
- use of disposable gloves when changing diapers;
- use of disposable paper to cover diaper-changing areas;
- separation of diaper-changing areas from children's play areas.

No disinfectant is guaranteed to be completely effective against *Cryptosporidium*. However, hydrogen peroxide (3%) is usually effective. Ammonia can also be used but it has a strong odor and, if accidentally mixed with bleach or other chlorine-containing solutions, produces hazardous chlorine gas.

In the event of an outbreak, to reduce the level of potentially infectious *Cryptosporidium*, clean and disinfect toys, table tops, and high chairs more frequently than usual (at least twice daily). Dishwasher-safe toys may be washed in a commercial dishwasher that has a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute. Cloth toys may be washed and heat-dried in a clothes dryer for 30 minutes.

If there is an increase of diarrhea, parents should be informed of the symptoms of cryptosporidiosis, how it is transmitted, the risk of severe illness in immunocompromised persons, and necessary control measures.

Dental Offices

During a boil water advisory

- Reschedule appointments for immunocompromised patients, such as HIV-positive individuals, chemotherapy and transplant patients, and congenitally immunocompromised individuals.
- Warn your patients before treatment that they are at greater risk for cryptosporidiosis if they are immunocompromised, and that they may wish to reschedule their treatment after the boil water advisory is lifted. Explain to all patients the current situation regarding water and indicate what procedures your office is following to protect their health.
- Patients and employees should not consume water that has not been disinfected, or ice or drinks made from water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute one micron" filter or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- All employees with diarrheal illness should be regulated by standard rules of exclusion from work.
- Turn off the water supply to high-speed handpieces. Using disinfected water, flow water out of a bulb syringe when using high-speed handpieces.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.

Commercial Establishments (Restaurants, Hotels, Convenience Stores)

During a boil water advisory

- Do not serve or consume water that has not been disinfected, ice or drinks made with water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a reverse osmosis filter, an "absolute one micron" filter, or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either "cyst removal" or "cyst reduction." Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- Disinfect dishes by washing in dishwashing machines that have a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute.

Upon rescinding a boil water advisory

- Re-start and flush any water-using fixture or piece of equipment in accordance with the manufacturer's specifications. This may vary from fixture to fixture. Consult your facilities engineer and/or the manufacturer when re-starting the equipment.
- Managers of large buildings with water-holding reservoirs should consult with their facility engineer and health department about draining the reservoir.
- Run cold water faucets for 1 minute before using the water.
- Run drinking fountains for 1 minute before using the water.
- Backwash pool filters and change media or water.
- Run water softeners through a regeneration cycle.
- Drain and refill hot water heaters set below 113°F.

Commercial Ice Maker Users

Upon rescinding a boil water advisory

A. Flush the water line to the machine inlet:
   1. Close the valve on the water line behind the machine and disconnect the water line from the machine inlet.
   2. Open the valve, run 5 gallons of water through the valve, and dispose of the water.
   3. Close the valve.
   4. Reconnect the water line to the machine inlet.
   5. Open the valve.

B. Flush the water lines in the machine:
   1. Turn on the machine.
   2. Make ice for 1 hour and dispose of the ice.

C. Clean and disinfect all parts and surfaces that come in contact with water and ice, following the manufacturer’s instructions.

Public Users of Public Water Supplies

During a boil water advisory

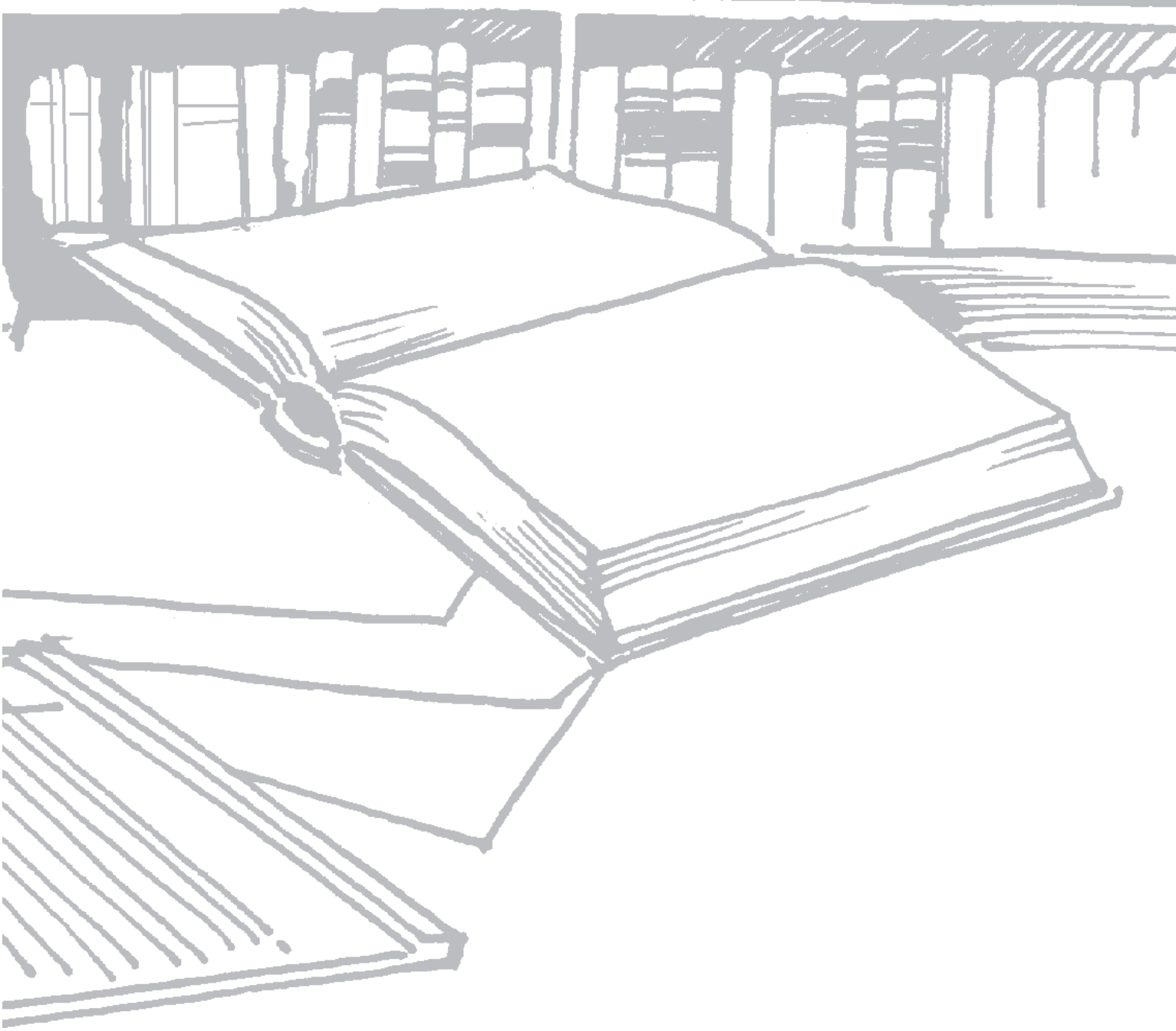
- Do not consume water that has not been disinfected, ice or drinks made from water that has not been disinfected, or raw foods rinsed with water that has not been disinfected.
- Disinfect water of *Cryptosporidium* by
  - boiling at a rolling boil for 1 minute
  - distilling
  - filtering through a “reverse osmosis” filter, an “absolute one micron” filter, or a filter certified to remove *Cryptosporidium* under NSF International Standard #53 for either “cyst removal” or “cyst reduction.” Ultraviolet light treatment of water is *not* effective against *Cryptosporidium*, at normally used levels.
- Disinfect dishes by washing in dishwashing machines that have a dry cycle or a final rinse that exceeds 113°F for 20 minutes or 122° F for 5 minutes or 162° F for 1 minute.

Upon rescinding a boil water advisory

- Flush household pipes/faucets: run *all* cold water faucets for 3 minutes each.
- Flush home automatic ice makers: make three batches of ice cubes and discard all three batches.
- Run water softeners through a regeneration cycle.
- Flush drinking fountains: run continuously for 1 minute.
- Flush water coolers: run coolers with direct water connections for 5 minutes.

CHAPTER 6

Educational Information



Chapter 6- Educational Materials

Preventing Cryptosporidiosis: A Guide for Persons With HIV/AIDS

Chair: Thomas Navin, Centers for Disease Control and Prevention
Chet Anderson, Metropolitan Water District of Southern California
Paul S. Berger, U.S. Environmental Protection Agency
Scott A. Damon, Centers for Disease Control and Prevention
Linda A. Fisher, St. Louis County Health Department
Susan Goldstein, Centers for Disease Control and Prevention
Dennis D. Juranek, Centers for Disease Control and Prevention
Jonathan E. Kaplan, Centers for Disease Control and Prevention
Iris L. Long, AIDS Coalition to Unleash Power
Lisa Ragain, National Association of People With AIDS
Anne Seeley, New York City Department of Environmental Protection
Rosemary Soave, New York Hospital-Cornell Medical Center
Tyrone Wilson, International Bottled Water Association
Robert Wood, Seattle-King County Department of Health

Preventing Cryptosporidiosis: A Guide for the Public

Chair: Kathleen Blair, City of Milwaukee Health Department
Chet Anderson, Metropolitan Water District of Southern California
Scott A. Damon, Centers for Disease Control and Prevention
Alexis M. Milea, California Department of Health Services
Thomas Outlaw, Association of State Drinking Water Administrators
Fred Pontius, American Water Works Association

Preventing Cryptosporidiosis: A Guide to Water Filters and Bottled Water

Chair: Dennis D. Juranek, Centers for Disease Control and Prevention
Chet Anderson, Metropolitan Water District of Southern California
Paul S. Berger, U.S. Environmental Protection Agency
Susan Boutros, Environmental Associates, Ltd.
Nancy Culotta, NSF International
Scott A. Damon, Centers for Disease Control and Prevention
Joseph F. Harris, Water Quality Association
Anita K. Highsmith, Centers for Disease Control and Prevention
George J. Jackson, Food and Drug Administration
Henry Kim, Food and Drug Administration
Iris L. Long, AIDS Coalition to Unleash Power
Michael Miller, NSF International
Michael Redman, National Soft Drink Association
Terry Troxell, Food and Drug Administration
Tyrone Wilson, International Bottled Water Association

The following camera-ready fact sheets can be duplicated or faxed as is. The information for persons with HIV and AIDS is also available in pamphlet form from the CDC National AIDS Hotline at 1-800-342-2437.

PREVENTING CRYPTOSPORIDIOSIS: A GUIDE FOR PERSONS WITH HIV AND AIDS

What is cryptosporidiosis?

Cryptosporidiosis (krip-toe-spo-rid-e-o-sis), often called "crypto," is a disease caused by a one-celled parasite, *Cryptosporidium parvum*, also known as "crypto." Crypto, which cannot be seen without a very powerful microscope, is so small that over 10,000 of them would fit on the period at the end of this sentence.

What are the symptoms of crypto ?

Although sometimes persons infected with crypto do not get sick, when they do get sick they can have watery diarrhea, stomach cramps, an upset stomach, or a slight fever. In some cases, persons infected with crypto can have severe diarrhea and lose weight. The first symptoms of crypto may appear 2 to 10 days after a person becomes infected.

How does crypto affect you if your immune system is severely weakened ?

In people with AIDS and in others whose immune system is weakened, crypto can be serious, long-lasting and sometimes fatal. If your CD4+ cell count is below 200, crypto is more likely to cause diarrhea and other symptoms for a long time. If your CD4+ count is above 200, your illness may not last more than 1 to 3 weeks or slightly longer. However, you could still carry the infection, which means that the crypto parasites are living in your intestines, but are not causing illness. As a carrier of crypto, you could infect other people. If your CD4+ count later drops below 200, your symptoms may reappear.

How is crypto spread?

You can get crypto by putting anything in your mouth that has touched the "stool," (bowel movement) of a person or animal with crypto. You can also get crypto by touching your mouth before washing your hands after touching the stool of infected persons, or touching the stool of infected animals, or touching soil or objects contaminated with stool. Drinking contaminated water or eating contaminated food can also give you crypto. Cryptosporidiosis is *not* spread by contact with blood.

Can crypto be treated ?

Yes, but no drug has been found yet to cure it. Some drugs, such as paromomycin, may reduce the symptoms of crypto and new drugs are being tested. If you think you have crypto, or if you just have diarrhea, talk with your health care provider about testing and treatment. Diarrhea can cause dehydration. You should drink plenty of fluids to prevent dehydration. Oral rehydration powders and sportsade drinks can also help prevent dehydration.

How can I protect myself from crypto?

You can reduce your risk of getting crypto. The more steps you take, the less likely you are to get crypto. These actions will also help protect you against other diseases.

1. **Wash your hands.**

   Washing your hands often with soap and water is probably the single most important step you can take to prevent crypto and other illnesses. Always wash your hands before eating and preparing food. Wash your hands well after touching children in diapers; after

touching clothing, bedding, toilets, or bed pans soiled by someone who has diarrhea; after gardening; any time you touch pets or other animals; and after touching anything that might have had contact with even the smallest amounts of human or animal stool, including dirt in your garden and other places. Even if you wear gloves when you do these activities you should still wash well when you finish. Children should be supervised by adults to make sure they wash their hands well.

2. **Practice safer sex.**
   Infected people may have crypto on their skin in the anal and genital areas, including the thighs and buttocks. However, since you cannot tell if someone has crypto, you may want to take these precautions with any sex partner:
   "Rimming" (kissing or licking the anus) is so likely to spread infection that you should avoid it, even if you and your partner wash well before.
   Always wash your hands well after touching your partner's anus or rectal area.

3. **Avoid touching farm animals.**
   If you touch a farm animal, particularly a calf, lamb, or other young animal, or visit a farm where animals are raised, wash your hands well with soap and water before preparing food or putting anything in your mouth. Do not touch the stool of *any* animal. After you visit a farm or other area with animals, have someone who is not HIV infected clean your shoes, or wear disposable gloves if you clean them yourself. Wash your hands after taking off the gloves.

4. **Avoid touching the stool of pets.**
   Most pets are safe to own. However, someone who is not HIV infected should clean their litter boxes or cages, and dispose of the stool. If you must clean up after a pet, use disposable gloves. Wash your hands afterwards. The risk of getting crypto is greatest from pets that are less than 6 months old, animals that have diarrhea, and stray animals. Older animals can also have crypto, but they are less likely to have it than younger animals. If you get a puppy or kitten that is less than 6 months old, have the animal tested for crypto before bringing it home. If any pet gets diarrhea, have it tested for crypto.

5. **Be careful when swimming in lakes, rivers, or pools, and when using hot tubs.**
   When swimming in lakes, rivers, or pools, and when using hot tubs, avoid swallowing water. Several outbreaks of crypto have been traced to swallowing contaminated water while swimming. Crypto is not killed by the amount of chlorine normally used in swimming pools and water parks. Crypto also can remain alive in salt water for several days, so swimming in polluted ocean water may also be unsafe.

6. **Wash and/or cook your food.**
   Fresh vegetables and fruits may be contaminated with crypto. Therefore, wash well all vegetables or fruit you will eat uncooked. If you take extra steps to make your water safe (see next page for ways to do so), use this safe water to wash your fruits and vegetables. When you can, peel fruit that you will eat raw, after washing it. Do not eat or drink unpasteurized milk or dairy products. Cooking kills crypto. Therefore, cooked food and

heat-processed foods are probably safe if, after cooking or processing, they are not handled by someone infected with crypto, or exposed to possibly contaminated water.

7. **Drink safe water.**
Do not drink water directly from lakes, rivers, streams, or springs. Because you cannot be sure if your tap water contains crypto, you may wish to avoid drinking tap water, including water or ice from a refrigerator ice-maker, which are made with tap water. Because public water quality and treatment vary throughout the United States, always check with the local health department and water utility to see if they have issued any special notices about the use of tap water by HIV-infected persons. You may also wish to take some additional measures: boiling your water, filtering your water with certain home filters, or drinking certain types of bottled water. Processed, carbonated (bubbly) drinks in cans or bottles are probably safe, but drinks made at a fountain might not be because they are made with tap water. If you choose to take these extra measures, use them all the time, not just at home. If the public health department advises boiling the water, do not drink tap water unless you boil it. You could also use one of the bottled waters described below.

Boiling water: Boiling is the best extra measure to ensure that your water is free of crypto and other germs. Heating water at a rolling boil for 1 minute kills crypto, according to CDC and EPA scientists. After the boiled water cools, put it in a clean bottle or pitcher with a lid and store it in the refrigerator. Use the water for drinking, cooking, or making ice. Water bottles and ice trays should be cleaned with soap and water before use. Do not touch the inside of them after cleaning. If you can, clean water bottles and ice trays yourself.

Filtering tap water**:** Not all available home water filters remove crypto. All filters that have the words "reverse osmosis" on the label protect against crypto. Some other types also work, but not all filters that are supposed to remove objects 1 micron or larger from water are the same. Look for the words "**absolute** 1 micron." Some "1 micron" and most **"nominal** 1 micron" filters will *not* work against crypto. Also look for the words "Standard 53" *and* the words "cyst reduction" or "cyst removal" for an NSF-tested filter that works against crypto.

To find out if a particular filter removes crypto, contact NSF International (3475 Plymouth Road, P.O. Box 130140, Ann Arbor, MI 48113-0140, tel: 1-800-673-8010, fax: 1-313-769-0109), an independent testing group. Ask NSF for a list of "Standard 53 Cyst Filters." Check the model number on the filter you intend to buy to make sure it is *exactly* the same as the number on the NSF list. Look for the NSF trademark on filters, but be aware that NSF tests filters for many different things. Because NSF testing is expensive, many filters that may work against crypto have not been tested. Reverse osmosis filters work against crypto whether they have been tested by NSF or not. Many other filters not tested by NSF also work if they have an absolute pore size of 1 micron or smaller.

If you choose to buy a filter, look for this information on the label:

Filters designed to remove crypto (any of the four messages below on a package label indicate that the filter should be able to remove crypto)
Reverse osmosis (with or without NSF testing)
Absolute pore size of 1 micron or smaller (with or without NSF testing)
Tested and certified by NSF Standard 53 for cyst removal
Tested and certified by NSF Standard 53 for cyst reduction

Filters labeled only with these words may not be designed to remove crypto
Nominal pore size of 1 micron or smaller
One micron filter
Effective against *Giardia*
Effective against parasites
Carbon filter
Water purifier
EPA approved - Caution: EPA does not approve or test filters.
EPA registered - Caution: EPA does not register filters for crypto removal.
Activated carbon
Removes chlorine
Ultraviolet light
Pentiodide resins
Water softener

Filters collect germs from your water, so someone who is not HIV infected should change the filter cartridges for you; if you do it yourself, wear gloves and wash your hands afterwards. Filters may not remove crypto as well as boiling does because even good brands of filters may sometimes have manufacturing flaws that allow small numbers of crypto to get past the filter. Also, poor filter maintenance or failure to replace filter cartridges as recommended by the manufacturer can cause your filter to fail.

***Bottled water*:** If you drink bottled water, read the label and look for this information:

Water labeled as follows was processed by method effective against crypto
Reverse osmosis treated
Distilled
Filtered through an *absolute* 1 micron or smaller filter
"1 micron absolute"

Water labeled as follows may not have been processed by method effective against crypto
Filtered
Micro-filtered
Carbon-filtered
Particle-filtered
Multimedia-filtered
Ozonated
Ozone-treated
Ultraviolet light-treated
Activated carbon-treated
Carbon dioxide-treated
Ion exchange-treated
Deionized
Purified
Chlorinated

Bottled water labels reading "well water," "artesian well water," "spring water," or "mineral water" do not guarantee that the water does not contain crypto. However, water that comes from protected well or protected spring water sources is less likely to contain crypto than bottled water or tap water from less protected sources, such as rivers and lakes.

***Home distillers*:** You can remove crypto and other germs from your water with a home distiller. If you use one, you need to carefully store your water as recommended for storing boiled water.

***Other drinks*:** Soft drinks and other beverages may or may not contain crypto. You need to know how they were prepared to know if they might contain crypto.

If you drink prepared drinks, look for drinks prepared to remove crypto:

Crypto killed or removed in preparation	Crypto may not be killed or removed in preparation
Canned or bottled soda, seltzer, and fruit drinks	Fountain drinks
Steaming hot (175° F or hotter) tea or coffee	Fruit drinks you mix with tap water from frozen concentrate
Pasteurized drinks	Iced tea or coffee

Information on Prepared Drinks

Juices made from fresh fruit can also be contaminated with crypto. Several people became ill after drinking apple cider made from apples contaminated with crypto. You may wish to avoid unpasteurized juices or fresh juices if you do not know how they were prepared.

Take extra care when traveling.

If you travel to developing nations, you may be at a greater risk for crypto because of poorer water treatment and food sanitation. Warnings about food, drinks, and swimming are even more important when visiting developing countries. Avoid foods and drinks, in particular raw fruits and vegetables, tap water, or ice made from tap water, unpasteurized milk or dairy products, and items purchased from street vendors. These items may be contaminated with crypto. Steaming-hot foods, fruits you peel yourself, bottled and canned processed drinks, and hot coffee or tea are probably safe. Talk with your health care provider about other guidelines for travel abroad.

For more information on crypto, call the CDC National AIDS Hotline at 1-800-342-AIDS.

This material was prepared by the inter-agency Working Group on Waterborne Cryptosporidiosis, which includes representatives from the Centers for Disease Control and Prevention, Environmental Protection Agency, Food and Drug Administration, U.S. Department of Agriculture, National Association of People With AIDS, AIDS Coalition to Unleash Power, and representatives of state and local health departments and water utilities.

PREVENTING CRYPTOSPORIDIOSIS: A GUIDE FOR THE PUBLIC

What is *Cryptosporidium*?

Cryptosporidium (pronounced krip-toe-spo-rid-ee-um) is a parasite that can live in the intestines of humans, farm animals, wild animals, and household pets. Although there are several species of *Cryptosporidium*, only one species, *Cryptosporidium parvum*, is known to cause infection in humans. The parasite, which is too small to be seen without a microscope, is protected by an outer shell called an oocyst (oh-oh-cist). This protective shell allows it to survive outside the body for long periods of time. When a person or animal swallows *Cryptosporidium* oocysts, the parasite comes out of its shell and can cause infection. More *Cryptosporidium* oocysts are then produced and passed in the feces (bowel movements) of the infected person or animal.

Where is *Cryptosporidium* Found?

Animal droppings and human feces are the most common sources of *Cryptosporidium*. Therefore, soil, drinking water, recreational water, food, hands, and other surfaces contaminated by such wastes can contain *Cryptosporidium* as well.

How Can *Cryptosporidium* Affect My Health?

If you swallow *Cryptosporidium* oocysts, 2 to 10 days later you may get a disease called cryptosporidiosis. Symptoms may include diarrhea, which could be watery, stomach cramps, upset stomach, and a slight fever.

If you are healthy and have a normal immune system, your symptoms usually will last for 2 weeks or less, although during that time your condition may improve and then worsen. People who recover from their initial illness may continue to pass *Cryptosporidium* in their feces for up to two months. *During this 2-month period they may spread the disease to others.* Although some people who swallow *Cryptosporidium* will not get sick, they can still pass the organism in their feces.

If you have a severely weakened immune system, you may have cryptosporidiosis for a longer period of time, and it could lead to serious or life-threatening illness. You should talk with your health care provider to learn how to avoid cryptosporidiosis. Examples of people with weakened immune systems include those with HIV/AIDS, cancer and transplant patients taking certain immunosuppressive drugs, and people with inherited diseases that effect the immune system.

How Would I Know if I Have Cryptosporidiosis?

The only way to tell if you have cryptosporidiosis is to have your feces analyzed in a laboratory. Because most people recover from the infection without visiting a doctor, they may never know if *Cryptosporidium* was the cause of their illness.

Is There a Treatment for Cryptosporidiosis?

Presently, there is no drug that can cure cryptosporidiosis. Most people with a healthy immune system will recover on their own. Young children and persons with a weakened immune system may need special treatment from a doctor to replace fluids lost during the

illness. If you have diarrhea, you should drink plenty of fluids and may also wish to take over-the-counter anti-diarrheal medication.

How is Cryptosporidiosis Spread ?

You can become infected by swallowing *Cryptosporidium*. Even a small amount may cause infection. Some sources of the disease are:

Feces

- People infected with *Cryptosporidium* can pass the infection to others through soiled diapers, clothing, bedding, or other items. You should always wash your hands after touching items that may be contaminated.
- Infected persons may have small amounts of feces containing *Cryptosporidium* on their skin throughout the genital area, including the thighs and buttocks. Sex that may involve contact with feces, including oral and anal sex, can lead to infection with *Cryptosporidium*.
- The feces of animals, especially animals less than 6 months old or animals with diarrhea, can contain *Cryptosporidium*. You should always wash your hands after touching animals, cleaning up their feces, cleaning their cages or stalls, or visiting barns or other areas where these animals live.

Food

- Food that is grown in or has fallen upon soil contaminated with feces.
- Unpasteurized milk and dairy products that may have been contaminated with feces.
- Food contaminated by being handled by someone who is infected and does not wash their hands carefully, or food that is washed with *Cryptosporidium*-contaminated water.

Water

- Water in lakes, rivers, streams, ocean bays, swimming pools, hot tubs, jacuzzis, and recreational water parks can be contaminated with *Cryptosporidium*. When swimming, if you drink this water or accidentally swallow it, you may get cryptosporidiosis. Neither the chlorine used to disinfect swimming pools nor the types of filters used in most swimming pools can be depended upon to kill or remove *Cryptosporidium*.
- Contaminated drinking water or ice may be a source of *Cryptosporidium* infection. Unlike most germs, *Cryptosporidium* is not completely removed or killed by treatment methods most commonly used to disinfect drinking water.

How Can I Protect Myself ?

1. Always Wash Your Hands Thoroughly with Soap and Hot Water.

- Any time you may have touched human or animal feces. Always wash your hands after using the bathroom, changing diapers, having sex, or handling animals. You can also become infected by touching objects that are contaminated with feces such as faucet handles, diaper changing tables, or bed pans.
- After working in soil. Soil can become contaminated when an animal with cryptosporidiosis leaves its droppings there.
- Before eating.

2. Avoid Sexual Activity that May Involve Contact with Feces.

3. Avoid Contaminated Food.

- Food that will be eaten uncooked should be washed with purified (boiled or filtered) water before serving.
- Do not drink or eat unpasteurized milk, dairy products, or juices and ciders.

4. Know the Source of Your Water.

- Do not drink or swallow water directly from rivers, lakes, streams, the ocean, swimming pools, hot tubs, or jacuzzis.
- If you travel to a less developed region, you may want to avoid drinking water that has not been boiled or filtered to remove *Cryptosporidium*.

5. Extra Precautions for People with Severely Weakened Immune Systems.

If you have a severely weakened immune system, consult your health care provider for additional guidance. You can also call the CDC AIDS Hotline toll-free at 1-800-342-2437 and ask for more information on cryptosporidiosis, or use the WWW site www.cdc.gov/ncidod/diseases/crypto/crypto.htm.

Should I Have My Water at Home Tested for *Cryptosporidium*?

Home tests for *Cryptosporidium* are generally not recommended because they are expensive and impractical. This is especially true if you are served by a municipal water system that is already providing this service. The test requires a large amount of water (about 100-400 gallons) and many hours of analysis by a specially trained microbiologist. For more information on *Cryptosporidium* testing in your local water system, contact your water provider or the state agency that sets rules for water systems. If you have a private drinking water source, routine maintenance should include annual testing for bacterial contamination. This may provide an indication of possible contamination.

What Should I do if My Water Utility Reports *Cryptosporidium* in My Drinking Water?

Current water treatment practices may not remove all *Cryptosporidium* from drinking water. Drinking water systems that routinely test for *Cryptosporidium* are likely to find it occasionally. If *Cryptosporidium* is found in your drinking water, public health and water supply officials will look at many measures of water quality and alert the public about any additional precautions that might be necessary. If you are advised to boil your water, don't drink tap water or eat uncooked products prepared with tap water such as food or ice, unless you boil the water for 1 full minute, or filter the water first.

What About Boiling, Home Filters, and Bottled Water?

Boiling your drinking water for 1 minute is the best way to get rid of *Cryptosporidium*. When boiling is not possible, there are many different types of home water filters and bottled water that you can use, although not all of them can protect you against cryptosporidiosis.

If you are interested in a specific brand of filter and want to find out if it removes *Cryptosporidium* you can contact NSF International, 3475 Plymouth Road, P.O. Box 130140, Ann Arbor, MI 48113-0140, 1-800-673-8010, or by fax at 1-313-769-0109. NSF International is an independent testing group that some filter manufacturers use to certify their products. In addition, any process that uses reverse osmosis or a filter with a pore size of 1 micron **absolute** or smaller should remove *Cryptosporidium*. Remember that all filters must be properly maintained as recommended by the manufacturer.

If you choose to buy a filter, look for the following information on the label:

Filters Designed to Remove *Cryptosporidium* (any of the four messages below on a package label indicate that the filter should be able to remove *Cryptosporidium*)
Reverse osmosis (with or without NSF testing)
Absolute pore size of 1 micron or smaller (with or without NSF testing)
Tested and certified by NSF Standard 53 for cyst removal
Tested and certified by NSF Standard 53 for cyst reduction

All types of bottled water are not equally safe. Bottled water labels that say "well water," "artesian well water," "spring water," or "mineral water," do *not* guarantee water free of *Cryptosporidium*. If you want to buy bottled water with a low risk of *Cryptosporidium*, read the label and look for the following information:

Water Processed by a Method Effective Against *Cryptosporidium*
Reverse osmosis treated
Distilled
Filtered through an *absolute* 1 micron or smaller filter
1 micron *absolute*

PREVENTING CRYPTOSPORIDIOSIS: A GUIDE TO WATER FILTERS AND BOTTLED WATER

Filtering tap water: Not all available home water filters remove crypto. All filters that have the words "reverse osmosis" on the label protect against crypto. Some other types also work, but not all filters that remove objects 1 micron or larger from water are the same. Look for the words "absolute 1 micron." Some "1 micron" and most "nominal 1 micron" filters will not work against crypto. To find out if a particular filter removes crypto, contact NSF International (3475 Plymouth Road, P.O. Box 130140, Ann Arbor, MI 48113-0140, 1-800-673-8010, 1-313-769-0109 [fax]), an independent testing group. Ask NSF for a list of "Standard 53 Cyst Filters." Check the model number on the filter you intend to buy to make sure it is *exactly* the same as the number on the NSF list. Look for the NSF trademark on filters, but be aware that NSF tests filters for many different things. Also look for the words "Standard 53" and the words "cyst reduction" or "cyst removal" for an NSF-tested filter that works against crypto. Because NSF testing is expensive, many filters that may work against crypto have not been tested. Reverse osmosis filters work against crypto whether they have been tested by NSF or not. Many other filters not tested by NSF also work if they have an absolute pore size of 1 micron or smaller.

If you choose to buy a filter, look for this information on the label:

Filters designed to remove crypto (any of the four messages below on a package label indicate that the filter should be able to remove crypto)	**Filters labeled only with these words may not be designed to remove crypto**
Reverse osmosis (with or without NSF testing)	*Nominal* pore size of 1 micron or smaller
Absolute pore size of 1 micron or smaller (with or without NSF testing)	One micron filter
Tested and certified by NSF Standard 53 for cyst removal	Effective against *Giardia*
Tested and certified by NSF Standard 53 for cyst reduction	Effective against parasites
	Carbon filter
	Water purifier
	EPA approved - Caution: EPA does not approve or test filters.
	EPA registered - Caution: EPA does not register filters for crypto removal
	Activated carbon
	Removes chlorine
	Ultraviolet light
	Pentiodide resins
	Water softener

Filters collect germs from water, so someone who is not HIV infected should change the filter cartridges; anyone changing cartridges should wear gloves and wash their hands afterwards. Filters may not remove crypto as well as boiling does because even good brands of filters may sometimes have manufacturing flaws that allow small numbers of crypto to get past the filter. Also, poor filter maintenance or failure to replace filter cartridges as recommended by the manufacturer can cause a filter to fail.

If you drink bottled water, read the label and look for this information:

Water labeled as follows was processed by method effective against crypto	**Water labeled as follows may not have been processed by method effective against crypto**
Reverse osmosis treated	Filtered
Distilled	Micro-filtered
Filtered through an *absolute* 1 micron or smaller filter	Carbon-filtered
"1 micron absolute"	Particle-filtered
	Multimedia-filtered
	Ozonated
	Ozone-treated
	Ultraviolet light-treated
	Activated carbon-treated
	Carbon dioxide-treated
	Ion exchange-treated
	Deionized
	Purified
	Chlorinated

Bottled water labels reading "well water," "artesian well water," "spring water," or "mineral water"do not guarantee that the water does not contain crypto. However, water that comes from protected well or protected spring water sources is less likely to contain crypto than bottled water or tap water from less protected sources, such as rivers and lakes.

Home distillers: You can remove crypto and other germs from your water with a home distiller. If you use one you need to carefully store your water as recommended for storing purified water.

Other drinks: Soft drinks and other beverages may or may not contain crypto. You need to know how they were prepared to know if they might contain crypto.

If you consume prepared beverages, look for drinks from which crypto has been removed:

Crypto killed or removed in preparation	Crypto may not be killed or removed in preparation
Canned or bottled soda, seltzer, and fruit drinks	Fountain drinks
Steaming hot (175° F. or hotter) tea or coffee	Fruit drinks you mix with tap water from frozen concentrate
Pasteurized drinks	Iced tea or coffee

Juices made from fresh fruit can also be contaminated with crypto. Several people became ill after drinking apple cider made from apples contaminated with crypto. You may wish to avoid unpasteurized juices or fresh juices if you do not know how they were prepared.

CHAPTER 7

Recreational Water

Chapter 7 - Recreational Water

David G. Addiss, Centers for Disease Control and Prevention

RECREATIONAL WATER

Waterborne cryptosporidiosis associated with recreational water exposure is an emerging public health problem. *Cryptosporidium* oocysts are resistant to disinfection by chlorine at levels generally used in swimming pools, and recreational water filtration units that use sand filter media are not effective in removing oocysts. Furthermore, few recreational water facilities enforce measures that might reduce the potential for contamination. The low infective dose of this organism and the intermittent nature of diarrhea experienced by many persons with cryptosporidiosis adds to the difficulty of preventing swimming-associated cryptosporidiosis.

The first reported U.S. outbreak of cryptosporidiosis associated with recreational water exposure occurred in 1988 in Los Angeles County, Calif. Forty-four (73% of the total) persons from five separate swimming groups reported diarrhea after using the same swimming pool in July and August. Unlike most outbreaks subsequently reported, a fecal accident was noted the week before onset of illness.

Since then, nine additional recreational waterborne outbreaks of cryptosporidiosis have been reported in the United States; these have occurred in California, Kansas, Idaho, Oregon, Wisconsin, New Jersey, and Georgia. Attack rates among pool users have ranged from 15 to 100%; typically, the highest attack rates are reported among children. The number of ill persons per outbreak has ranged from 26 to more than 2,000. Although some outbreaks have occurred in the presence of inadequate chlorination or malfunctioning filter systems, no such irregularities have been identified in other outbreaks.

Outbreaks have occurred in a variety of recreational water settings, including a lake at a state park in New Jersey, a large recreational water park in Georgia, a wave pool in Oregon, a water slide in Idaho, and community or hotel pools in Wisconsin and Kansas. The occurrence of recreational waterborne cryptosporidiosis appears to be increasing, and these outbreaks are most certainly underrecognized and underreported. Outbreaks in Wisconsin and Oregon followed large drinking water-associated outbreaks in nearby cities, suggesting that increased awareness and enhanced surveillance may have played a role in the detection and investigation of these outbreaks.

As noted previously in this handbook, *Cryptosporidium* oocysts are resistant to disinfection by chlorine at levels generally used in swimming pools. Because *Cryptosporidium* oocysts are only 4-6 microns, most recreational water filtration units that use sand filter media are not effective in removing them. In a typical case of diarrhea, one bowel movement can contain enough oocysts to contaminate 100 million gallons of water, to the extent that swallowing a single mouthful of this water can cause illness. Because persons infected with *Cryptosporidium* will excrete oocysts for several weeks after they have stopped having diarrhea, contamination of recreational water is possible long after symptoms are no longer present.

Few recreational water facilities enforce measures that might reduce risk of exposure, such as showering before entering the pool, excluding persons with diarrhea or incontinence, or restricting diaper-age children to certain pools. Children in diapers and those being toilet trained are more apt to have fecal accidents. This, coupled with younger children's tendency to swallow pool water, increases their chance of becoming ill. In addition, younger children are more likely to suffer from dehydration as a result of diarrhea. Restricting access to certain pools can reduce the risk of spreading contamination to an entire recreational facility.

Cryptosporidium *oocysts are resistant to disinfection by chlorine at levels generally used in swimming pools, and recreational water filtration units that use sand filter media are not effective in removing oocysts.*

Data on effective prevention strategies are extremely limited. Behavioral changes will require education of swimmers and facility management alike. Improved pool filtration, and separate filtration and/or circulation systems for adult and children's pools may reduce risk, but such changes can be costly, and the degree to which they reduce risk is unknown. Development and enforcement of clear and effective policies regarding fecal accidents in recreational water facilities is needed, but the effectiveness of stringent policies is unclear. For example, one recommendation might be to treat all observed fecal accidents as potentially involving *Cryptosporidium*, in which case all swimmers should immediately leave the pools and the water should be effectively treated for *Cryptosporidium*. Unfortunately, fecal accidents are often not reported and can be difficult to detect when stools are watery.

In light of these uncertainties, much work is needed to educate the public and the recreational water industry, and to evaluate potential intervention strategies. In the meantime, immunosuppressed persons should be counseled regarding the potential risk of *Cryptosporidium* infection associated with recreational water.

References

Beach MJ, McNeil M, Arrowood M, et al. *Cryptosporidium* in a water park: largest U.S. recreational waterborne outbreak [abstract]. 45th Annual EIS Conference, CDC, Atlanta, April 22-26, 1996.

Centers for Disease Control and Prevention. Surveillance for waterborne disease outbreaks — United States, 1991-1992. *MMWR* 1993;42 (No. SS-5):1-22.

Centers for Disease Control and Prevention. *Cryptosporidium* infections associated with swimming pools — Dane County, Wisconsin, 1993. *MMWR* 1994; 43:561-563.

Centers for Disease Control and Prevention. Assessing the public health threat associated with waterborne cryptosporidiosis: report of a workshop. *MMWR* 1995; 44 (No. RR-6):1-19.

Kramer MH, Sorhage F, Dalley E, Wahlquist S, Goldstein S, Herwaldt B. Outbreak of cryptosporidiosis associated with recreational exposure to lake water, New Jersey [abstract]. 44th Annual EIS Conference, CDC, Atlanta, March 27-31, 1995.

MacKenzie WR, Schell WL, Blair KA, et al. Massive waterborne outbreak of cryptosporidiosis, Milwaukee, Wisconsin: recurrence of illness and risk of secondary transmission. *Clin Infect Dis* 1995; 21:57-62.

Mac Kenzie WR, Kazmierczak JJ, Davis JP. An outbreak of cryptosporidiosis associated with a resort swimming pool. *Epidemiol Infect* 1995; 115:545-553.

McAnulty JM, Fleming DW, Gonzalez AH. A community-wide outbreak of cryptosporidiosis associated with swimming at a wave pool. *JAMA* 1994; 272:1597-1600.

Sorvillo F, Fujioka K, Nahlen B, Tormey MP, Kebabjian R, Mascola L. Swimming-associated cryptosporidiosis. *Am J Public Health* 1992; 82:742-744.

Wilberscheid L. A swimming-pool-associated outbreak of cryptosporidiosis. *Kansas Medicine* 1995; 96:67-68.

Appendix

Selected Articles

Cryptosporidiosis: Sources of Infection and Guidelines for Prevention*

by Dennis D. Juranek
Division of Parasitic Diseases,
Centers for Disease Control and Prevention,
Atlanta, Georgia

Cryptosporidium parvum is an important emerging pathogen in the United States and a cause of severe, life-threatening disease in patients with AIDS. No safe and effective form of specific treatment for cryptosporidiosis has been identified to date. The parasite is transmitted by ingestion of oocysts excreted in the feces of infected humans or animals. The infection can therefore be transmitted from person-to-person, through ingestion of contaminated water (drinking water and water used for recreational purposes) or food, from animal to person, or by contact with fecally contaminated environmental surfaces.

Outbreaks associated with all of these modes of transmission have been documented. Patients with human immunodeficiency virus infection should be made more aware of the many ways that *Cryptosporidium* species are transmitted, and they should be given guidance on how to reduce their risk of exposure. This article summarizes existing data on the various modes of transmission. It includes an in-depth look at waterborne transmission because as more research data are made available to the public, physicians will increasingly be asked by patients about the importance of this source of infection compared with other sources of infection.

Cryptosporidium parvum has been recognized as a human pathogen since 1976. From 1976 to 1982 the disease was rarely reported and primarily occurred in immunocompromised persons. In 1982, the number of reported cases began to increase dramatically as part of the AIDS epidemic. Initially the increase was limited to immunocompromised persons; however, with the aid of newly developed laboratory diagnostic techniques, outbreaks in immunocompetent persons began to be recognized. In immunocompetent persons, cryptosporidiosis is manifested as an acute, self-limiting diarrheal illness lasting 7 to 14 days and it is often accompanied by nausea, abdominal cramps, and low-grade fever. In patients with AIDS, cryptosporidiosis is generally chronic and more severe than in immunocompetent persons; the voluminous watery diarrhea is often debilitating and may be accompanied by severe abdominal cramps, weight loss, anorexia, malaise, and low-grade fever [1].

No safe and effective form of treatment for Cryptosporidiosis has been identified to date. On the basis of initial human treatmenttrials, several drugs have been reported to decrease the frequency or volume of stool production in some patients. However, to date, none of these initially “promising” drugs have lived up to expectations when subjected to larger, controlled studies or to widespread use by physicians in clinical practice.

Incidence of Cryptosporidiosis

Cryptosporidiosis is among the most common causes of diarrhea in patients with AIDS in the United States. About 2.2% of all patients whose cases of AIDS are reported to Centers for Disease Control and Prevention (CDC) have cryptosporidiosis as their AIDS-defining illness; 3.5% of children whose cases of AIDS are reported to the CDC have cryptosporidiosis. Hospital-based studies indicate that Cryptosporidiosis is diagnosed in 10%-20%
of patients with AIDS who have diarrhea [2-6]. Because diarrhea occurs in about half of all patients with AIDS each year [2, 7], it is estimated that the annual rate of cryptosporidial infection among all patients with AIDS may approach 5%-10%.

Cryptosporidiosis can occur at any time in the course of HIV infection. However, severe and persistent disease correlates well with CD4 counts of less than 180 cells/mm3. In one study, only 5 (13%) of 39 patients infected

***This article originally appeared in *Clinical Infectious Diseases* 1995;21(Suppl 1)S57-61.**

with *C. parvum* and with CD4 counts of less than 180 cells/mm3 had self-limiting disease, whereas all 8 patients with CD4 counts of greater than 180 cells/mm3 had infections that cleared and did not relapse during a follow-up period of 1-24 months [8].

Source of Infection and Risk Factors
Cryptosporidium species are transmitted by ingestion of oocysts excreted in the feces of infected humans or animals. Cryptosporidial infection can therefore be transmitted from person-to-person, through ingestion of fecally contaminated water or food, from animal to person, or by contact with fecally contaminated environmental surfaces.

Transmission via Water and Food
Six well-documented outbreaks of cryptosporidiosis attributed to drinking water have been recognized in the United States, including an outbreak in Milwaukee in 1993 that affected over 400,000 persons [9-15]. The source of drinking water used by utilities in these outbreaks included surface water (lakes, rivers, streams), well water, and spring water. Several outbreaks have also been associated with swimming pools and amusement park wave pools or water slides [12, 16-19].

There is considerable circumstantial evidence that low level (nonepidemic) transmission of *Cryptosporidium* species through drinking water may be occurring throughout the United States. Recent studies indicate that *Cryptosporidium* oocysts are present in 65% - 97% of surface waters (rivers, lakes etc.) tested throughout the country [20-23]. Because *Cryptosporidium* species are highly resistant to chemical disinfectants used in the treatment of drinking water, physical removal of the parasite from contaminated water by filtration is an important component of the water treatment process. However, a filtration system, especially one that is not well maintained and operated, may not afford absolute protection. All waterborne outbreaks of cryptosporidiosis detected to date have occurred in communities where water utilities met state and federal standards for acceptable quality of drinking water, and in all three of the outbreaks that involved surface water supplies, a filtration system had been used. Data from the outbreaks suggest that compliance of utility companies with state and federal standards for water treatment may not be adequate to protect citizens from waterborne cryptosporidiosis. Moreover, recent surveys for the occurrence of *Cryptosporidium* oocysts in fully treated (disinfected and filtered) municipal water demonstrate that small numbers of oocysts were able to breach filters and were present in tap water in 27%-54% of communities evaluated [23, 24].

Twenty-three million Americans reside in communities that do not filter municipal drinking water that comes from surface sources [25]. These communities include some of America's largest cities, which have substantial numbers of patients with HIV infection or AIDS, (e.g. New York, Boston, Seattle, Portland, and San Francisco). Small numbers of *Cryptosporidium* oocysts have also been intermittently found in the drinking water in these cities.

However, none of the cities with filtered water or with unfiltered drinking water where small numbers of oocysts have been detected have had a recognizable outbreak of cryptosporidiosis. While low level transmission could be occurring as a result of such low concentrations of oocysts, there are no data to date that document such an event. The absence of a treatment barrier for *Cryptosporidium* species in communities that do not use a filtration system could result in significant transmission if the source of the drinking water were to become heavily contaminated with this organism.

The health risk (especially for immunocompromised persons) associated with consumption of (filtered or unfiltered) public drinking water contaminated with small numbers of *C. parvum* oocysts is unknown. Although researchers are able to recover small numbers of oocysts from treated drinking water, current laboratory methods do not enable them to determine if these oocysts are viable or infectious. Moreover, it is not known if the number of oocysts present in drinking water constitutes a sufficient dose to cause illness in humans, whether immunosuppressed persons are more susceptible to lower doses of oocysts than are immunocompetent persons, or if there are strains of *C. parvum* that vary in infectious dose and virulence. Dose response data are currently available for only one isolate of *C. parvum* that was evaluated in healthy volunteers. In this study the 50% infectious dose (ID50) was estimated to be 132 oocysts. [26, 26a].

Food contaminated with feces from infected persons or animals has always been considered to be a theoretical risk factor for cryptosporidiosis. A recent outbreak of cryptosporidiosis in children who drank fresh-pressed apple cider contaminated by animal feces at a county fair in Maine provides the first documentation of this mode of transmission [27]. Although oocysts do not survive cooking, infected food handlers may unwittingly transmit the infection by fecal contamination of beverages, green salads, or other foods that are not cooked or heated after handling.

Animal-to-Person Transmission
C. parvum is capable of infecting all species of mammals including humans [28, 29]. In animals, cryptosporidiosis almost exclusively occurs in newborns. There are no data on the national prevalence of cryptosporidial

infection in puppies or kittens in the United States, but in a study in Atlanta, 10% of puppies examined at an animal shelter were found infected and shedding oocysts [30]. To date there have been no confirmed instances of *C. parvum* transmission from infected household pets. Two suspicious episodes have been reported in which an infected cat was found in the house of an immunodeficient person with cryptosporidiosis; in neither instance could the direction of spread be clearly elucidated [31, 32].

Other species of *Cryptosporidium* that infect birds (*C. meleagridis* and *C. baileyi*), rodents (*C. muris*), reptiles (*C. serpentis*), and fish (*C. nasorum*) are not generally considered to be infectious for humans [33]. To date, only one case of human infection with any of these species has been reported [34]; this case occurred in an HIV-infected patient from whom a parasite resembling *C. baileyi* was isolated, but who did not have a pet bird or other specific exposures to birds.

In strong contrast to the weak epidemiological data implicating household pets as sources of cryptosporidiosis in humans, the evidence for *C. parvum* transmission from calves to humans is unequivocal [35-40]. It is estimated that 50% of dairy calves shed oocysts and that the parasite is present on more than 90% of dairy farms [41-43]. While relatively few patients with AIDS are directly exposed to calves or to premises where calves are raised, the high prevalence of infected calves, especially on dairy farms, raises additional questions about the prudence of drinking unpasteurized milk.

Person-to-Person Transmission

Person-to-person spread of *C. parvum* is believed to be one of the most common modes of transmission. Children still wearing diapers who attend day care centers are at especially high risk for this form of transmission either through intimate play or because of careless diaper changing practices. Infections acquired by children in the day care setting are often transmitted to care-givers at the facility and to older children and adults who come in contact with the infected child at home [44]. Any sexual practice that brings a person into oral contact with the feces of an infected person is also considered a high-risk for exposure to *Cryptosporidium* species. It is not known how many patients with HIV infection or AIDS acquire cryptosporidiosis by this route of transmission. For patients with HIV infection or AIDS who follow "safer sex" practices, including avoidance of feces, this mode of transmission should be minimal.

Several other types of high-risk exposures include direct contact with feces while caring for an infected person (e. g. bathing, changing soiled bedding, or emptying a bed pan) at home or in a medical facility. Nosocomial infections involving both medical care staff and patients have been reported [45- 50]. Hospital staff should observe proper precautions for preventing fecally transmitted disease while caring for patients with cryptosporidiosis.

Prevention of Exposure

The proportion of cases of cryptosporidiosis in HIV-infected persons that can be attributed to each mode of transmission is unknown. Identification of the most common route(s) of transmission and a better understanding of the specific risk factors for exposure that lead to infection would greatly facilitate development of a more targeted prevention strategy. Until such data become available, doing what one can to avoid each of the commonly recognized modes of transmission should reduce the risk of infection. As with many other opportunistic infections for which effective treatment is not available, prevention of infection is the most effective approach to disease control.

It is clear that HIV-infected persons should not drink water directly from lakes or rivers. This includes accidental ingestion of lake or river water while swimming or engaging in other types of recreational water activity. The amount of chlorine and types of filters used in public swimming pools are not adequate to prevent transmission from swimmers infected with *Cryptosporidium* species who can shed oocysts for weeks after symptoms resolve. Patients should be advised that these activities may expose them to *Cryptosporidium* species, especially if the pool is used by young children who might accidentally defecate in the pool.

Because HIV-infected patients who have a cryptosporidial infection can reinfect themselves and infect others, they should not use swimming pools that will be used by others. Swimming pools can be disinfected by using high concentrations of chlorine for long periods (e.g. 3 mg/l water for 53 hours or 8 mg/l for 20 hours). While several municipal waterborne outbreaks of cryptosporidiosis have occurred in the U.S., the magnitude of risk for acquiring cryptosporidiosis by drinking municipally treated water in the non-outbreak setting is presently unknown. The risk is likely to vary from city to city depending on the quality of the city's source of water and the quality of water treatment provided. Current risk data are not adequate to recommend that all immunocompromised persons in the U.S. boil or avoid drinking tap water. However, persons with severely weakened immune systems should be advised that the risk is not zero. Until the health risk associated with small numbers of oocysts commonly found in drinking water is more clearly defined, HIV-infected persons who want to take independent precautions to reduce the risk of waterborne cryptosporidiosis can do so by boiling for 1 minute all water intended for drinking [51, 51a].

As an alternative to boiling water, certain types of individual or household filters or a high-quality bottled water may provide nearly the same level of protection. While several portable and household filters are capable of removing *Cryptosporidium* oocysts from drinking water, bacterial overgrowth on these filters may pose an additional health risk [52]. Therefore, patients should be advised to carefully follow the manufacturer's instructions for the use and replacement of filters. In addition, since *Cryptosporidium* oocysts are likely to concentrate on the outside of a filter cartridge that has been in use, patients should have someone else change dirty cartridges or they should use gloves if they do it themselves.

When selecting an effective filter one must pay careful attention to label information in order to avoid purchasing one of numerous filters on the market that are not effective against *Cryptosporidium* species. Only microstraining filters that can remove particles 0.1 to 1 micron in size should be considered. Filters in this category that provide the greatest assurance of removal of *Cryptosporidium* species include those that filter water by reverse osmosis, those that have "absolute" 1 micron filters, and those that meet NSF standard #53 for "cyst removal." The "nominal" 1 micron filter rating is not standardized and many filters in this category may not be capable of removing greater than 99% of oocysts. Filters that only employ ultra-violet light, activated carbon, or pentiodide impregnated resins are not effective against *Cryptosporidium* species. It should not be assumed that all filters advertised as effective against *Giardia* species are effective against *Cryptosporidium* species.

Many, but not all, brands of bottled water may provide a reasonable alternative to tap water. Patients should be advised that the origin, the microbial quality, and microbial treatment of water before it is bottled vary considerably among companies and even among brands of water produced by the same company. Information on the labels of water bottles has not been standardized and often does not provide the consumer with the type of information needed to identify the product with the lowest risk for cryptosporidiosis. As with filters, individuals who want to use bottled water as an alternative to tap water must research and pick their supplier very carefully. In general, bottled water derived from springs or wells is safer than water obtained from rivers and lakes. Bottled water that originates from well-protected underground sources (a well or a spring), that are not subject to intermittent contamination from surface water, and that have been consistently shown to be free of coliform bacteria will not contain oocysts. Since there is no industry labeling standard that reflects this information, patients may have to question vendors directly to obtain information about these points.

Just as in the case of municipal water supplies, the absence of coliform bacteria in the final bottled water product does not provide assurance that the water came from an uncontaminated source or that it has been treated adequately to remove *Cryptosporidium* species. Treatment of water prior to bottling by distillation or reverse osmosis filtration, regardless of the source (well, spring, river, lake), ensures the remove of oocysts if they are present. In addition, water that has been passaged through an "absolute" 1 micron or smaller filter, or through a filter labeled as meeting NSF standard #53 for "cyst removal" prior to bottling will provide nearly the same level of protection. Bottlers using "nominal" 1 micron filters as the only treatment barrier for *Cryptosporidium* species may not be capable of removing >99% of oocysts. Companies that use the word "micro-filtration" on the label may or may not be using filters that are effective against *Cryptosporidium* species.

Although ozonation of water has also been shown to kill *Cryptosporidium* oocysts, the appropriate amounts of ozone needed to disinfect water at various temperatures and pHs have not been clearly defined. Bottlers are currently restricted to no more than 0.4 mg of ozone per liter in the final product. This may or may not be an adequate amount to kill *Cryptosporidium* species, depending on the contact time and other water conditions. In general, the amount of ozone needed to kill *Cryptosporidium* species is hundreds of times greater than that needed to kill bacterial contaminants [33]. Treatment of municipal tap water with charcoal to remove the chlorine taste or with short-term exposure to ultra-violet light before bottling offers no additional protection against *Cryptosporidium* species.

The risk of cryptosporidiosis associated with pet ownership is probably small, but it is reasonable to suggest that HIV-infected persons avoid contact with feces of animals. In situations where it is not possible to avoid such contact, e.g., cleaning a cat litter box or removing feces from shoes or other items that may have become contaminated, patients should be instructed to wear disposable gloves. The risk from household pets (dogs and cats) is greatest from exposure to animals younger than 6 months of age and to any animal with diarrhea. Physicians should inform patients that pet ownership may entail a small risk for cryptosporidial infection and should discuss how these risks can be further minimized; it should not be recommended that patients destroy or give away healthy pets with whom they have a strong emotional attachment. Immunosuppressed patients contemplating the acquisition of a new pet should avoid bringing any animal with diarrhea into their household, should avoid purchasing a dog or cat younger than 6 months of age, and should not adopt stray animals found roaming the neighborhood. HIV-infected patients who

want to assume the small risk of acquiring a puppy or kitten younger than 6 months of age should be advised to specifically request that their veterinarian examine the animal's stool for *Cryptosporidium* species before the patient has contact with the animal.

Research Priorities

More rapid and sensitive serological and molecular diagnostic techniques for the detection of cryptosporidia in humans and in environmental sources are needed to facilitate epidemiologic studies of cryptosporidiosis. High priority studies include: 1) an assessment of the proportion of cryptosporidial infections attributable to the low numbers of oocysts frequently found in municipal drinking water and 2) the relative risk of acquiring cryptosporidiosis from drinking water versus contact with animals, unsafe sexual practices, and non-sexual household or hospital contacts. Data from such studies would serve to focus the immunocompromised patient's attention on avoidance of the exposures that would put them at greatest risk. Studies are needed to define the asymptomatic carrier rate for *Cryptosporidium* species in HIV-infected patients who recover from a clinical episode of cryptosporidiosis and who have CD4 cell counts of greater than 200/mm3. There is also a need to know if such carriers are likely to develop severe cryptosporidiosis when their CD4 count drops below 200 cells/mm3. Improved laboratory methods are needed to facilitate screening of potential therapeutic agents for infections due to *Cryptosporidium* species. Finally, state and national reporting systems for cases of cryptosporidial infection are needed to better quantify the public health impact of this disease and to identify outbreaks.

References

1. Petersen C. Cryptosporidiosis in patients infected with the human immunodeficiency virus. *Clin Infect Dis* 1992;15:903-9.

2. Weber R, Bryan RT, Thompson S, Rimland D, Kozarsky P, Juranek D. Prospective evaluation of diarrhea and enteric parasitosis in HIV/AIDS. [Abstract, 1527]. In: Program and abstracts of the 32nd Interscience Conference on Antimicrobial Agents and Chemotherapy (Anaheim), Washington D.C.:American Society for Microbiology, 1992:365.

3. Moderator: Smith PD, Discussants: Quinn TC, Strober W, Janoff EN, Masur H. Gastrointestinal infections in AIDS. *Ann Intern Med* 1992;116:63-77.

4. Laughon BE, Druckman DA, Vernon A, et al. Prevalence of enteric pathogens in homosexual men with and without acquired immunodeficiency syndrome. *Gastroenterology* 1988;94:984-93.

5. Soave R, Armstrong D. *Cryptosporidium* and Cryptosporidiosis. *Rev Infect Dis* 1986;8:1012-23.

6. Janoff EN, Limas C, Gebhard RL, Penley KA. Cryptosporidial carriage without symptoms in the acquired immunodeficiency syndrome (AIDS). *Ann Intern Med* 1990;112:75-6.

7. Johanson JF, Sonnenberg A. Efficient management of diarrhea in the acquired immunodeficiency syndrome (AIDS) - a medical decision analysis. *Ann Intern Med* 1990;112:942-8.

8. Flanigan T, Whalen C, Turner J, et al. *Cryptosporidium* infection and CD4 counts. *Ann Intern Med* 1992;116:840-2.

9. D'Antonio RG, Winn RE, Taylor JP, et al. A waterborne outbreak of Cryptosporidiosis in normal hosts. *Ann Intern Med* 1985;103:886-8.

10. Gallaher MM, Herndon JL, Nims LJ, Sterling CR, Grabowski DJ, Hull HF. Cryptosporidiosis and surface water. *Am J Public Health* 1989;79:39-42.

11. Hayes EB, Matte TD, O'Brien TR, et al. Large community outbreak of Cryptosporidiosis due to contamination of a filtered public water supply. *N Engl J Med* 1989; 320(21):1372-6.

12. Levins WC, Stephenson WT, Craun GF. Surveillance for waterborne disease outbreaks—United States, 1986-1988. *MMWR* 1990;39 (No. SS-1):1-21.

13. Herwaldt BL, Craun GF, Stokes SL, Juranek DD. Surveillance for waterborne disease outbreaks—United States, 1989-1990. *MMWR* 1991;40 (No. SS-3):1-21.

14. Herwaldt BL, Craun GF, Calderon RL, Highsmith AR, Juranek DD. Surveillance for waterborne disease outbreaks— 1991-1992. *MMWR* 1993;42 (No. SS-5):1-22.

15. Mac Kenzie WR, Hoxie MS, Proctor ME, et al. A massive outbreak in Milwaukee of *Cryptosporidium* infection transmitted through the public water supply. *N Engl J Med*. 1994; 331:161-7.

16. Sorvillo FJ, Fujioka K, Nahlen B, Tormey MP, Kebabjian R, Mascola L. Swimming-associated Cryptosporidiosis. *Am J Public Health* 1992;82(5):742-4.

17. Joce RE, Bruce J, Kiely D, et al. An outbreak of Cryptosporidiosis associated with a swimming pool. *Epidemiol Infect* 1991;107:497-508.

18. Centers for Disease Control and Prevention. *Cryptosporidium* infections associated with swimming pools —Dane County, Wisconsin, 1993. *MMWR* 1994;43:561-3.

19. Bell A, Guasparini R, Meeds D,Mathias RG, Farley JD. A swimming pool-associated outbreak of Cryptosporidiosis in British Columbia. *Can J Public Health* 1993;84:334-7.

20. Rose, JB. Occurrence and significance of *Cryptosporidium* in water. *J American Water Works Assoc* 1988;80:53-8.

21. Rose, JB, Gerba, CP and W. Jakubowski. Survey of potable water supplies for *Cryptosporidium* and *Giardia*. *Environ Sci Technol* 1991;25:1393-1400.

22. LeChevallier MW, Norton WD, Lee RG. Occurrence of *Giardia* and *Cryptosporidium* spp. in surface water supplies. *Appl Environ Microbiol* 1991;57:2610-6.

23. LeChevallier MW, Moser RH. Occurrence of *Giardia* and *Cryptosporidium* in raw and finished drinking water. *J American Water Works Assoc*. 1995

24. LeChevallier MW, Norton WD, Lee RG. Giardia and *Cryptosporidium* spp. in filtered drinking water supplies. *Appl Environ Microbiol* 1991;57:2617-21.

25. Federal Register (1987) National Primary Drinking Water Regulations: Filtration, Disinfection, Turbidity, *Giardia lamblia*, Viruses, *Legionella* and Heterotrophic Bacteria. Proposed Rule, 40 CFR parts 141 and 142. Fed Reg., 52:212:42718.

26. Dupont HL, Chappell CL, Sterling CR, Okhuysen PC, Rose JB, Jakubowski W. The infectivity of *Cryptosporidium parvum* in healthy volunteers. *N Engl J Med* 1995;332:855-9.

26a. Haas CN, Rose JB. Reconciliation of microbial risk assessment and epidemiololgy: the case of the Milwaukee outbreak. In: Proceedings of the 1994 Conference of the American Water Works Association- water quality. 1994:517-23.

27. Millard PS, Gensheimer KF, Addiss DG, et al. An outbreak of Cryptosporidiosis from fresh-pressed apple cider. *JAMA* 1994;272:1592-96.

28. Fayer R, Ungar BLP. *Cryptosporidium* spp. and Cryptosporidiosis. *Microbiol Rev* 1986;50:458-83.

29. Tzipori S. Cryptosporidiosis in perspective. *Adv Parasitol* 1988;27:63-129.

30. Jafri HS, Reedy T, Moorhead AR, Dickerson JW, Schantz PM, Bryan RT. Detection of pathogenic protozoa in fecal specimens from urban dwelling dogs [abstract no. 361]. Proceedings of the 42nd Annual Meeting of the American Society of Tropical Medicine and Hygiene, Atlanta, GA, 1993.

31. Bennett M, Baxby D, Blundell N, Gaskell CJ, Hart CA, Kelly DF. Cryptosporidiosis in the domestic cat. *Vet Rec* 1985;116:73-4.

32. Koch KL, Shankey TV, Weinstein GS, et al. Cryptosporidiosis in a patient with hemophilia, common variable hypogammaglobulinemia, and the acquired immunodeficiency syndrome. *Ann Intern Med* 1983;99:337-40.

33. Dubey JP, Speer CA, Fayer R, eds.. *Cryptosporidiosis of man and animals*. Boston: CRC Press, 1990:1-199.

34. Ditrich O, Palkovic L, Sterba J, Prokopic J, Loudova J, Giboda M. The first finding of *Cryptosporidium baileyi* in man. *Parasitol Res* 1991;77:44-7.

35. Anderson BC, Donndelinger T, Wilkins RM, Smith J. Cryptosporidiosis in a veterinary student. *J Am Vet Med Assoc* 1982;180:408-9.

36. Current WL, Reese NC, Ernst JV, Bailey WS, Heyman MB, Weinstein WM. Human Cryptosporidiosis in immunocompetent and immunodeficient persons. Studies of an outbreak and experimental transmission. *N Engl J Med* 1983;308:1252-57.

37. Pohjola S, Oksanen H, Jokipii L, Jokipii A. Outbreak of Cryptosporidiosis among veterinary students. *Scand J Infect Dis*1986;18:173-8.

38. Lengerich EJ, Addiss DG, Marx JJ, Ungar BLP, Juranek DD. Increased exposure to cryptosporidia among farmers in Wisconsin. *J Infect Dis* 1993; 167:1252-5.

39. Levine JF, Levy MG, Walker RL, Crittenden S. Cryptosporidiosis in veterinary students. *J Am Vet Med Assoc* 1988;193:1413-14.

40. Miron D, Kenes J, Dagan R. Calves as a source of an outbreak of Cryptosporidiosis among young children in an agricultural closed community. *Pediatr Infect Dis J* 1991;10:438-41.

41. Anderson BC, Hall RF. Cryptosporidial infection in Idaho dairy calves. *J Am Vet Med Assoc* 1982;181:484-5.

42. Aurich JE, Dobrinski I, Grunert E. Intestinal Cryptosporidiosis in calves on a dairy farm. *Vet Rec* 1990;127:380-1.

43. Ongerth JE, Stibbs H. Prevalence of *Cryptosporidium* infection in dairy calves in western Washington. *Am J Vet Res* 1989;50:1069-70.

44. Cordell RL and Addiss DG. Cryptosporidiosis in child care settings: a review of the literature and recommendations for prevention and control. *Pediatr Infect Dis J* 1994;13:310-317.

45. Baxby D, Hart CA, Taylor C. Human Cryptosporidiosis: a possible case of hospital cross infection. *Br Med J* 1983;287:1760-1.

46. Koch KL, Phillips DJ, Aber RC, Current WL. Cryptosporidiosis in hospital personnel. Evidence for person-to-person transmission. *Ann Intern Med* 1985;102:593-6.

47. Roncoroni AJ, Gomez MA, Mera J, Cagnoni P, Michel MD. *Cryptosporidium* infection in renal transplant patients [letter]. *J Infect Dis* 1989;160:559.

48. Wittenberg DF, Miller NM, van den Ende J. Spiramycin is not effective in treating *Cryptosporidium* diarrhea in infants: results of a double-blind randomized trial. *J Infect Dis* 1989;159:131-2.

49. Martino P, Gentile G, Caprioli A, et al. Hospital-acquired Cryptosporidiosis in a bone marrow transplantation unit. *J Infect Dis* 1988;158:647-8.

50. Ravn P, Lundgren JD, Kjaeldgaard P, et al. Nosocomial outbreak of Cryptosporidiosis in AIDS patients. *BMJ* 1991;302:277-80.

51. Fayer R. Effect of high temperature on infectivity of *Cryptosporidium parvum* oocysts in water. *Appl Environ Microbiol* 1994;60:2732-35.

51a. Centers for Disease Control and Prevention. Assessment of inadequately filtered public drinking water—Washington D.C., December 1993. *MMWR* 1994;43(no. 36):661-3.

52. Payment P, Franco E, Richardson L, Siemiatycki J. Gastrointestinal health effects associated with the consumption of drinking water produced by point-of-use domestic reverse-osmosis filtration units. *Appl Env Microbiol* 1991;57:945.

Giardia and *Cryptosporidium* in raw and finished drinking water*

Mark W. LeChevallier
William D. Norton

The American Water System has conducted extensive monitoring of its operations since 1988. Analysis of 347 surface water samples collected between 1988 and 1993 showed that the prevalence rate of *Giardia* and *Cryptosporidium* was 53.9 percent and 60.2 percent, respectively. But because the parasite assay does not indicate viability or virulence, these results do not necessarily indicate that these water systems were at risk from waterborne pathogens. To supplement coagulation and filtration, the average system will have to apply sufficient disinfection to reduce viable *Giardia* levels by 3.1 $\log_{10}$. An analysis of existing disinfection practices shows that most systems are already applying disinfectant at a level sufficient to reduce *Giardia* levels. However, the proposed Disinfectants/Disinfection By-product (D/DBP) Rule may hamper the ability of water utilities to apply sufficient disinfection under current operating conditions. Careful integration of the D/DBP and the Enhanced Surface Water Treatment rule is encouraged.

The analogy of the water purveyor as a juggler of sometimes conflicting federal and state regulations has never been more true. The challenge is to keep all of the regulated parameters successfully flying through the air while new regulations are constantly being added. What makes this prestidigation even more impressive is that pending regulations, which will have enormous impact, are constantly changing shape during the performance. In the middle of this magic show the ring master attempts to interpret the meaning of the performance and its impact on the audience. This article will try to play the role of the ring master in attempting to discuss the application and interpretation of *Giardia* and *Cryptosporidium* monitoring results but the reader should be aware that this description is based on the proposed regulations, and the final program may be subject to change.

The Information Collection Requirements (ICR) will be an administrative order that will require utilities to monitor and provide the United States Environmental Protection Agency (USEPA) with information that will assist the agency in establishing new regulations (1). Systems will have to provide a variety of technical, chemical, and operational data. For microbiological testing, systems serving populations between 10,000 and 100,000 people will be required to monitor for *Giardia*, *Cryptosporidium*, andtotal and fecal coliforms (or *Escherichia coli*) in raw water samples. Large systems (those serving >100,000 people) will additionally monitor for coliphage and *Clostridium* spp. in raw water and be required to examine filtered water if raw water values exceed 1/L.

Through the process of regulatory negotiations the USEPA has developed a two-tiered Disinfectants/Disinfection By-Product (D/DBP) Rule (2). Stage 1 regulations will specify maximum contaminant levels (MCLs) and MCL Goals (MCLG) for DBPs; maximum residual disinfectant levels (MRDLs) and MDRL Goals (MRDLG) for disinfectants; best available technology for achieving compliance with the MCLs; a treatment technique for DBP precursor removal; analytical and monitoring requirements, and reporting and record-keeping requirements. Under stage 1, the MCL for five haloacetic acids and total trihalomethanes will be 60 and 80 g/L, respectively. Stage 2 requirements will be developed using data generated under the ICR (1). In addition, the D/DBP Rule will specify that all public water systems using chlorine disinfection and conventional treatment must operate with enhanced coagulation for removal of DBP precursors if the total organic carbon (TOC) concentration prior to the first application of continuous disinfection exceeds 2.0 mg/L. Enhanced coagulation is defined as achieving a specified percent removal of TOC between the raw water and the point prior to continuous disinfection. The specified removals are based upon source water alkalinity and TOC concentrations. Credit for chlorine disinfection will not be given until the appropriate TOC removal levels have been achieved.

With the development of the D/DBP Rule, USEPA recognized the possibility that in an effort to reduce DBP levels, utilities could inadvertently increase the risk from microbial agents. Utilizing the DBP regulatory analysis model (DBPRAM), USEPA was able to examine the health and economic implications of various approaches to DBP regulation. In a direct comparison of microbial risk from *Giardia* infection with cancer risk for several DBP control scenarios, the predicted increases in *Giardia* infection were orders of magnitude higher than decreases in cancer rates. To ensure that implementation of the D/DBP Rule did not increase microbial risk, USEPA considered it necessary to review the adequacy of the existing Surface Water Treatment Rule (SWTR). This revised rule, which may also include regulation of *Cryptosporidium*, is called the Enhanced SWTR (ESWTR) (3).

***This article originally appeared in *Journal of the American Water Works Association*, 1995; 87(9): 54-68.**

USEPA intends to use the microbial data generated by the ICR to help formulate the final draft of the ESWTR and it is very likely that the final rule will be subject to many modifications. The four principal treatment options outlined in the draft ESWTR are summarized in Table 1.

AWS began *Giardia, Cryptosporidium* testing in 1984

The American Water System (AWS) first began to test for *Giardia* in 1984 at several locations of its Pennsylvania operations. Analysts were trained by Dr. Charles Hibler of Colorado State University to perform the zinc sulfate/Lugol's iodine test. Nearly 60 percent of 49 river samples and 36 percent of 79 reservoir samples were positive for *Giardia* cysts. In 1987 the commercial availability of monoclonal antibodies to *Giardia* and *Cryptosporidium* allowed the development of an immunofluorescence method for simultaneous detection of cysts and oocysts in water (4). Comparison of the immunofluorescence antibody (IFA) method with the zinc sulfate (light microscopy) technique showed that the IFA method detected approximately 12 times more *Giardia* cysts in water than did the zinc sulfate technique (5). IFA also allowed for the simultaneous detection of *Cryptosporidium* oocysts.

With the development of the IFA method, a survey was conducted to determine the level of *Giardia* and *Cryptosporidium* in surface water supplies. A total of 66 surface water treatment plants in 14 states and 1 Canadian province were examined (6). The results showed that cysts and oocysts were widely distributed in the aquatic environment. *Giardia* were detected in 81 percent of the raw water samples, and *Cryptosporidium* were found in 87 percent. Either *Giardia*, *Cryptosporidium*, or both, were detected in 98 percent of the raw water samples. Significant correlations were found between *Giardia* and *Cryptosporidium* densities and raw water quality parameters such as turbidity, and total and fecal coliform levels. Higher cyst and oocyst densities were associated with source waters receiving industrial or sewage effluents. The geometric mean for *Giardia* in raw water was 2.8 cysts/L (range=0.04-66 cysts/L), whereas the geometric mean for *Cryptosporidium* was 2.7 oocysts/L (range=0.07-484 oocysts/L). Application of a model predicting the 10^{-4} annual risk of *Giardia* infection to these raw water data indicated that the average treatment plant would have to provide 5.0 $\log_{10}$ removal, inactivation or both.

Examination of filtered drinking water showed that *Giardia* were detected in 17 percent of the 83 water samples (7). *Cryptosporidium* oocysts were observed in 27 percent of the drinking water samples. Overall, cysts or oocysts were found in 39 percent of the treated effluent samples. Despite the frequent detection of parasites in drinking water, microscopic observations of the cysts and oocysts suggested that nearly all the organisms were nonviable and there were no reported outbreaks of water-related illness in any of the systems examined.

Compliance with the filtration criteria outlined by the Surface Water Treatment Rule (SWTR) did not ensure that treated water was free of cysts or oocysts. The average plant effluent turbidity for sites that were parasite positive was 0.19 ntu. Seventy-eight percent of the sites that were positive for *Giardia* and *Cryptosporidium* met the 0.5-ntu turbidity requirement of the SWTR. No correlation could be found between a particular treatment process, coagulation scheme, or operational practice and the occurrence of cysts or oocysts in filtered effluents. Plants with high source water parasite levels had a high probability of detection

Table 1

Summary of the Proposed Enhanced Surface Water Treatment Rule

Parameter	Action
Definitions:	
Groundwater under the direct influence of surface water	Includes *Cryptosporidium*
MCLG	
Cryptosporidium	MCLG = 0
Criteria to Avoid Filtration:	
Watershed control program for *Giardia*, *Cryptosporidium* and viruses.	Tightens requirements to avoid filtration
Analytical & Monitoring	
Sanitary Survey	All public water systems Frequency: 3-5 years Conducted by State, agent, or system
Treatment Requirements	
Treatment based on *Giardia*	3-6 log treatment requirement based on raw water levels
Treatment based on *Cryptosporidium*	3-6 log treatment requirement based on raw water levels
Minimum treatment	Specifies minimum treatment of 2-log removal of *Cryptosporidium* in addition to existing SWTR requirements for *Giardia* and viruses.
No change	Does not modify existing SWTR levels for removal-inactivation

of cysts or oocysts in treated effluents. Examination of disinfection practices showed that nearly all systems applied more than the minimum 0.5 $\log_{10}$ disinfection level specified by the SWTR. More than 75 percent of the systems applied sufficient disinfection to reduce the annual risk of *Giardia* infection to $<10^{-4}$.

Detailed analysis of five systems showed variation in the performance of individual filters within a treatment plant for *Giardia* and *Cryptosporidium* removal (8,9). Although the turbidity of the combined filter effluent was low (<0.5 NTU), variation in particle counts between individual filters could exceed 1,000 fold. Significant correlations were shown between the removal of turbidity or particle counts and the reduction in cyst and oocyst levels (9). Particle counts >5 m were shown to be a sensitive indicator of filter performance. Small changes in effluent turbidity could be associated with dramatic increases in particle count levels. Although higher cyst and oocyst levels were associated with the filter ripening period, organisms were also observed in the filter effluents of "mid-run" samples.

Database allows evaluation of regs, issues

The current study was conducted to develop a database of *Giardia* and *Cryptosporidium* results to determine treatment plant performance goals, aid in long-term planning for treatment modifications, and help in determining the impact of future regulations. The project analyzed cyst and oocyst levels from raw and plant effluent water for 72 surface water treatment plants. Analysis using risk assessment techniques developed for *Giardia* and *Cryptosporidium* permitted a theoretical evaluation of the health impact of the data.

Because this database is the most comprehensive collection of results for *Giardia* and *Cryptosporidium* available to the water industry, it was of interest to evaluate the pending regulations and determine the feasibility of balancing the reduced DBP requirements with the enhanced treatment levels. This analysis also permits evaluation of issues related to interpretation of data collected by the ICR.

Samples collected from 72 plants

Samples were collected from 72 surface water treatment plants located in 15 states and 2 Canadian provinces. Sixty-seven surface water locations were examined. Raw water samples were typically collected from pressurized taps at the intake to the treatment process. Samples were filtered through 10-in. (25.4 cm) wound polypropylene cartridge filters having a nominal porosity of 1 m (Cat. #U1A10U, Memtek Corp., Timonium, MD). Flow rates averaged 0.99 gpm (gallons per minute) and ranged from 0.04 to 4.1 gpm. The total volume collected averaged 132 gal (499 L) and ranged from 22.9 (86.6 L) to 898 gal (3,394 L).

Separate sampling systems were used to collect plant effluent water. Chlorine residuals were neutralized prior to filtration through injection of a sodium thiosulfate solution using an in-line injector (Dema Engineering Co., St. Louis, MO). Flow rates averaged 0.99 gpm and ranged from 0.13 to 2.45 gpm. The total volume collected averaged 1,022 gal (3,863 L) and ranged from 100 (378 L) to 2,080 gal (7,862 L).

After collection, the filter along with the filter housing water was placed in a bag (Whirl-Pac, Nasco, Fort Atkison, WI) containing 10 mL of 37 percent formalin. Filters were double-bagged and shipped to the laboratory via overnight delivery. After delivery, the samples were stored at 2-5°C and usually processed within 24 to 72 hours.

IFA used to detect pathogens

The procedure for detection of *Giardia* and *Cryptosporidium* in water samples has been described (4,8). This method is essentially the same as the American Society for Testing and Materials procedure P229, (10) with minor modifications. For example, a single step centrifugation procedure was used to concentrate the filter extract because it has been shown that *Cryptosporidium* can be lost through repeated centrifugation (11). Neither Evan's blue nor bovine serum albumin was used because the authors' experience shows that these procedures did not enhance cyst or oocyst detection.

The recovery efficiency of the procedure was evaluated by spiking 40 gal (151 L) samples with known concentrations of cysts and oocysts. To simulate raw water samples, filter concentrates were added to tap water to achieve a 150 NTU solution.

Table 2

Summary of Observable Internal Structure for *Giardia* Cysts

Observed Structure*	Number of Cysts
Nuclei, median bodies, axoneme	24
Nuclei, median bodies	12
Nuclei, axoneme	12
Median bodies, axoneme	2

*Two or more observed internal structures is considered characteristic of *Giardia* cysts.

Densities of cysts and oocysts were reported as the number per liter for surface water and number per 100 L for plant effluent water. When parasites were not detected, the parasite level was reported as less than the detection limit. Unless stated differently, total cyst and oocyst counts are given, and values are not adjusted to reflect recovery efficiencies.

Data were combined with a previous data set
The data from the two-year biannual monitoring (from March 1991 to January 1993) was combined with a previous dataset (October 1988 to June 1990) collected from most of the same systems (6,7). Therefore, five or more analyses were performed on both raw and plant effluent samples for most systems (94 percent).

Physical and operational data were collected
Data characteristic of each site collected from each plant included source type, level of watershed protection, total and fecal coliform counts, heterotrophic plate counts, and turbidity levels for the day of sampling as well as the average level for the previous month. Physical factors included temperature, pH, ammonia, nitrate, phosphate, and total dissolved solids (TDS). Operational data included peak turbidity level, treatment characterization, type of filter media, average filter run time, surface wash, filter-to-waste capability, coagulant type and dosage, polymer type and dosage, pre- and postoxidant levels, and contact times.

Estimates of the level of *Giardia* disinfection were obtained by determining the average pH (7.5), temperature (15°C) and free chlorine residual (1.4 mg/L) for the data set analyzed. Previously published tables (12) indicate 1.0 $\log_{10}$ *Giardia* inactivation will require 31 mg.min/L under these conditions. No *Giardia* disinfection credit was given for treatment with chloramines. Because most systems had not performed tracer studies at the time data were collected, theoretical detention times were adjusted (by a factor of 0.6 for sedimentation basins, and 0.1 for clearwells) to account for short circuiting. The adjusted detention times were divided by 31 to estimate the level of log-fold *Giardia* reduction by free chlorine disinfection. This level of inactivation will change seasonally and under different operating conditions, but for the purposes of this study it provided an estimate of treatment efficacy.

To calculate the level of treatment needed to achieve a theoretical 10^{-4} annual risk goal, the logarithmic difference between source water data collected from this study was compared to previously published risk assessment values for *Giardia* and *Cryptosporidium* (13,14). The theoretical 10^{-4} annual risk level is 7×10^{-6} cysts/L for *Giardia* and 3×10^{-5} oocysts/L for *Cryptosporidium*, and include an assumption of 2 L per person per day consumption of drinking water. For these calculations, the authors followed USEPA's procedure of assuming that the method recovery efficiency equaled the level of source water cyst and oocyst viability so that these two variables cancelled each other in the risk calculations. Although there are no data to support this assumption, the authors believe that the calculation results in a conservative measure of risk (e.g. that recovery efficiencies are higher than protozoa viability).

Recovery efficiencies evaluated
During the past five years a large set of recovery efficiency data has been accumulated for the IFA test. Although minor details of the methodology have changed (e.g., a stomacher homogenizer is used instead of hand washing the filters), however, these alterations did not substantially change recovery efficiencies. For tap water samples (turbidity <1 NTU), the geometric mean for recovery of *Giardia* cysts was 42.4 percent (range=18.2 - 118.3 percent; *n*=58) and the geometric mean for recovery of *Cryptosporidium* oocysts was 23.6 percent (range=8.7 - 74.7 percent; *n*=57). More than 90 percent of the variation in *Cryptosporidium* recovery efficiencies were within a factor of 2 from the mean, whereas 89 percent of the variation in *Giardia* recovery efficiencies were within a factor of 2 from the mean. It is possible that if the identical method had been used for all the recovery experiments the variation may have been less, but other studies have concluded that there are still unidentified sources of variation within the procedure (11). Although there has been considerable concern related to the reproducibility of monitoring results from various laboratories (15), this study shows that values from one lab can vary by logarithmic factor of 0.31. This variation does not unduly affect the interpretation of treatment goals for surface water plants.

To simulate raw water samples, sample concentrates were added to tap water to achieve a 150 ntu solution. The geometric mean for recovery of *Giardia* cysts from the high turbidity solution was 50.1 percent (range=36.7 - 75.3 percent; *n*=5) and the geometric mean for recovery of *Cryptosporidium* oocysts was 40.9 percent (range=34.5 - 59.3 percent; *n*=6). These values are not statistically different from the low turbidity experiments and may illustrate the beneficial impacts of turbidity on sample concentration (11).

When parasites were not detected, the parasite level was reported as less than the detection limit. The geometric mean of the detection limit was 0.99 organisms/L (range=0.004 - 42 cysts/L) for raw water, and 1.79 organisms/100 L (range=0.02 - 52 organisms/100 L) for plant effluent water. The relatively high detection limit is probably due to the nature of the Midwestern waters examined and the fact that emphasis was not placed on achieving absolutely the highest sensitivity possible (e.g. multiple membranes were not processed for samples with

high limits of detection). Despite this approach, cysts or oocysts were detected in a majority of samples. However, the proposed ICR would require water utilities to sample filtered drinking water whenever the limit of detection for source water samples exceeds 1 organism/L. More than 90 percent of the systems examined would have exceeded this level at one time or another. The impact of this low threshold level would be to nearly double the testing requirements for large systems and to stress limited laboratory capabilities. Additionally, the presence of high levels of cysts or oocysts in the raw water did not automatically indicate that the organisms would be found in filtered supplies. A total of 9.4 percent of the plant effluent samples were positive for cysts or oocysts when the raw water detection levels were ‑1 organism/L compared to an 8.8 percent positive plant effluent rate for raw waters with detection levels >1 organism/L.

Raw water results compiled

Giardia cysts were detected in 118 (45.0 percent) of the 262 raw water samples collected between March 1991 and January 1993. The geometric mean of (detectable) *Giardia* was 2.0 cysts/L with levels ranging from 0.02 to 43.8 cysts/L. Microscopic examination of 343 cysts detected in the raw water samples showed that 50 (14.6 percent) of the organisms had two or more observable internal structures (e.g., axoneme, median bodies, nuclei). Frequently, when the cysts were observed to contain internal structures, all three characteristic structures (axoneme, median bodies and nuclei) were present (Table 2). *Giardia* cysts averaged 8.6 m in width (range 6.6 - 11.9 m) and 12.3 m in length (range 8.6 - 16.5 pm).

Cryptosporidium were detected in 135 (51.5 percent) of the 262 raw water samples collected between March 1991 and January 1993. The geometric mean of (detectable) *Cryptosporidium* was 2.4 oocysts/L with levels ranging from 0.065 to 65.1 oocysts/L. Microscopic examination of 364 oocysts detected in the raw water samples showed that 124 (34.2 percent) of the organisms had no observable internal structures (e.g. sporozoite or residuum). Nearly 54 percent (183 oocysts) of the isolates contained observable sporozoite (40 additional isolates were labeled “full,” but sporozoite could not be distinguished). A total of 183 samples (69.8 percent) was positive for either *Giardia* (47), *Cryptosporidium* (65), or both (71).

The occurrence of *Giardia* and *Cryptosporidium* for surface water in this study was lower than the rates previous reported for the same sites (6). Earlier the authors reported that *Giardia* cysts were found in 81 percent of the samples tested, and *Cryptosporidium* in 87 percent. This discrepancy suggests four possible explanations:

- The original study counted organisms that were not *Giardia* or *Cryptosporidium*.
- The current study was less efficient in detecting *Giardia* and *Cryptosporidium*.
- Occurrence levels fluctuate as a result of unknown causes. The “true” level of occurrence is the average of the two studies.
- *Giardia* and *Cryptosporidium* levels in raw water have declined over the past four years.

The first possibility—that the previous study detected organisms other than *Giardia* and *Cryptosporidium*—can be discounted because the characteristics of the organisms (the number of internal structures observed in cysts and oocysts) were similar between the two studies. In the previous study, 12.8 percent of the cysts contained two or more structures, compared with 14.6 percent in this study. Oocysts with sporozoite comprised 32 percent of 242 isolates in the previous study compared with 54 percent in this study.

The second possibility is also dismissed because neither the methodology nor the recovery efficiencies have changed substantially. The recovery efficiency in the first study for *Cryptosporidium* was 25.3 percent (*n*=16) compared to 23.6 percent (*n*=57) for this study. Although *Giardia* recoveries in the first study averaged 68.6 percent (*n*=16), some of the values were unrealistically high (i.e., >100%). When these high values were eliminated from the recovery calculation from the first study, the value averaged 44.4 percent, which is similar to the 42.4 recovery (n=58) reported for this study.

When the data from this study (*n*=262) are combined with the previous investigation (6,7) (*n*=85), the occurrence of *Giardia* and *Cryptosporidium* in 347 samples was 53.9 percent and 60.2 percent, respectively. These values are consistent with the findings of other investigators (16-21). Ongerth (16) reported detecting *Giardia* cysts in 43 percent of 222 samples collected from 17 sampling stations on three Pacific Northwest rivers. Rose et al (21) recovered *Cryptosporidium* oocysts in 51.4 percent of 111 surface water samples collected in 13 states.

Poulton et al (17) reported that *Cryptosporidium* levels have declined in three of four watersheds monitored by the Thames Water Company in the United Kingdom. Levels decreased over a three year period (1989-1991) with the geometric mean for oocyst levels declining an average 78 percent. Peak levels in oocyst occurrence declined 10- to 20-fold. One watershed, however, showed a 73 percent increase in the geometric mean for oocysts, and a four fold increase in peak concentrations. Combined data from this and the previous study also showed a decline in the occurrence of *Giardia* and *Cryptosporidium* from 1989 to 1992 (Table 3). When the

Table 3

Frequency of Occurrence for *Giardia* and *Cryptosporidium*—1988 - 1992*

		Giardia		*Cryptosporidium*	
Year	**Number of Samples**	**Number Positive**	**Percent Positive**	**Number Positive**	**Percent Positive**
1989	47	38	80.9	42	89.4
1990	38	31	81.6	32	84.2
1991	110	56	50.9	69	62.7
1992	133	55	41.4	60	45.1

*1989 and 1990 data from LeChevallier et al (6).

Table 4

Frequency Distribution of *Giardia* and *Cryptosporidium* in Raw Water

Detection Frequency (percent)	**Percent Distribution of**	
	Giardia	***Cryptosporidium***
0	9.1	3.0
1 - 21	10.6	6.1
21 - 40	24.2	27.7
41 - 60	27.3	27.3
61 - 80	16.7	27.3
81 - 100	12.1	13.6

1991-92 data are tabulated by quarters a generalized trend towards lower frequencies of detection is shown throughout this time period. Although it is unclear whether this trend is due to the sampling frequency or some methodological difference, it is possible that there are cyclic variations in environmental cyst and oocyst concentrations. Such multiyear variations are well known for many pathogens (e.g., *Vibrio cholerae*, influenza, etc.) (18). This cyclic phenomena should be considered in the development and interpretation of sampling programs such as that proposed in the ICR. It is possible that intense sampling over a short time span may result in an inaccurate estimation of cyst or oocyst occurrence. Rather, systems should strive to develop a database of cyst and oocyst occurrence over a prolonged period of time.

Analysis of the data according to the raw water sites provides another means to evaluate the accuracy and reliability of the results. This analysis showed that for the 67 raw water sites (serving 72 treatment plants) examined, only five were consistently negative for *Giardia*, and only two were negative for *Cryptosporidium*. All negative sites were examined between four and six times. Nearly 79 percent of the sites (53 of 67) were positive for *Giardia* on multiple occasions, while 86.6 percent of the sites were multiple-positive for *Cryptosporidium*. Only one site (a protected watershed in Connecticut) was consistently negative for both *Giardia* and *Cryptosporidium* (n=5). It is highly likely, therefore, that if a utility performs a sufficient number of samples, *Giardia*, *Cryptosporidium* or both will eventually be detected.

The large number of systems with multiple-positive samples shows that the results of the initial survey (6) could be duplicated in subsequent tests. Tabulation of sites that were positive on only one occasion (n=18 for either *Giardia* or *Cryptosporidium*) showed that six sites were uniquely positive in the first study (1988-90) while 12 sites were uniquely positive in the second study (1991-93). Therefore, when the data were weighted for the number of samples processed, there was no tendency to find more sites positive for cysts or oocysts in either study.

Table 4 shows that the majority of sites were positive for *Giardia* cysts 40-60 percent of the time (e.g., two to three times based on five analyses). Most sites were positive for *Cryptosporidium* oocysts 60-80 percent of the time. This range of parasite occurrence is consistent with the results of other investigators (19-23). Ongerth and Stibbs (23) found *Cryptosporidium* oocysts in all of the samples from the six rivers (four in the state of Washington, two in California) they examined. The occurrence of *Giardia* ranged from 20 to 80 percent, and *Cryptosporidium* ranged from 70 to 100 percent, in three watersheds examined by LeChevallier et al. (9). Variations in parasite occurrence were noted during an extensive survey of three watersheds in the United Kingdom where *Cryptosporidium* oocysts were infrequently detected in two of the rivers (1 to 7 percent); in the third river system oocysts were observed in an average of 52 percent of the samples (24). When *Cryptosporidium* oocysts were detected, the range of oocyst levels in the rivers was similar and the arithmetic average of positive results was actually higher in the watersheds with infrequent detection.

Variation in raw water levels important

From a water supply perspective, the variation in source water pathogen levels is important. For example, a water purveyor drawing from a watershed with a low frequency of cyst or oocyst detection might become complacent because of the infrequent detection of waterborne protozoa. However, during episodes of peak cyst or oocyst densities, these systems may need to provide roughly the same amount of treatment as

watersheds with a higher frequency occurrence of parasites. Because a single peak event can overwhelm treatment barriers and result in waterborne illness, treatment plants should be designed and operated in a manner that can handle such events and ensure a consistently low level of microbial risk.

USEPA has proposed (1) four possible approaches for analyzing data collected through the ICR: (1) use the arithmetic mean for the data; (2) use the geometric mean for the data; (3) use the 90th percentile of the highest value based on a distribution of the results; or (4) use the maximum count.

In all cases the USEPA has proposed to count the limit of detection when cysts or oocysts are not found (e.g., a value of <1.0 cyst/L becomes a calculated value of 1.0 cyst/L).

Analysis of the combined data from the 1988-90 and 1991-93 studies allowed the four methods for tabulating *Giardia* and *Cryptosporidium* data to be evaluated (Table 5). In addition, a fifth method (termed maximum detected level) was added which provides an alternative calculation when the maximum count was based on a nondetect value (e.g., limit of detection). The logarithmic difference between these calculated values and the estimated level for a 10^{-4} annual risk of infection for *Giardia* and *Cryptosporidium* (0.0007 cysts/100 L and 0.003 oocysts/100 L respectively) permits a theoretical evaluation of the level of treatment required for each organism.

The average treatment requirement for *Giardia* based on the geometric mean, the arithmetic average and maximum level was 5.38, 5.52, and 5.85 $\log_{10}$, respectively (Figure 1). The average treatment requirement for *Cryptosporidium* based on the geometric mean, the arithmetic average and maximum level was 4.49, 4.68, and 5.05 $\log_{10}$, respectively (Figure 2). All plants required more than the minimum 3.0 $\log_{10}$ level of treatment as outlined in the SWTR (25). Overall, the difference between treatment requirements based on the geometric mean (the lowest value) and the maximum level observed (the highest value) averaged 0.47 $\log_{10}$ for *Giardia* (range=0.1 - 1.2 $\log_{10}$) and 0.56 for *Cryptosporidium* (range=0.01 - 1.59 $\log_{10}$).

The intent of establishing treatment goals based on the monitoring data is to aid the plant supervisor and the design engineer in the routine operations and design of the treatment facility. Once a database of results was established, routine operations could be based on achieving a particular level of treatment without the need for constant parasite monitoring. Using the geometric or arithmetic mean for determining this routine level of treatment is problematic because the parasite levels are frequently higher than the mean.

The 90th percentile or the maximum level observed is a more appropriate parameter for setting treatment goals. The 90th percentile is an arbitrary standard, but does account for unusual circumstances (e.g., flooding, turbidity peaks, spills) when the utility would normally perform additional treatment. The 90th percentile would encompass the normal variation in parasite levels during routine operations. The relationship between the samples where cysts were not detected (nondetect values) and the samples where cysts were observed is noticeable. This consistency between actual counts and nondetect values permits an estimation of the 90th percentile, even when cysts or oocysts are infrequently detected. Another advantage of the 90th percentile approach is the possibility of estimating a confidence interval around the linear fit of the data. In the authors' experience, as more data are collected, the linear fit is improved, and the 95 percent confidence interval is reduced. With this analytical approach, there is an incentive for utilities to perform increased raw water monitoring because the highest values can be eliminated from consideration.

At least 10 samples are required to determine the 90th percentile. Within the database examined, only seven systems were examined 10 or more times (Figure 3).

Figure 1

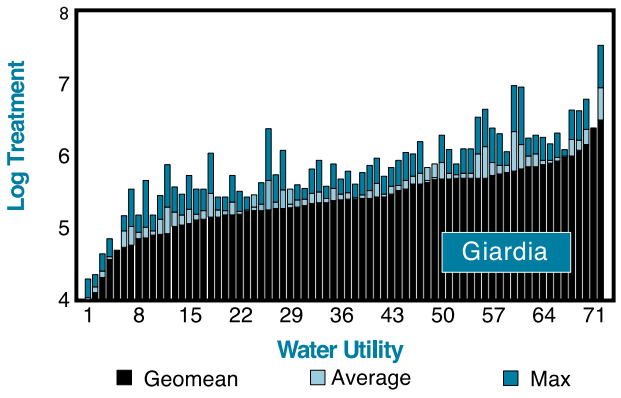


Figure 2

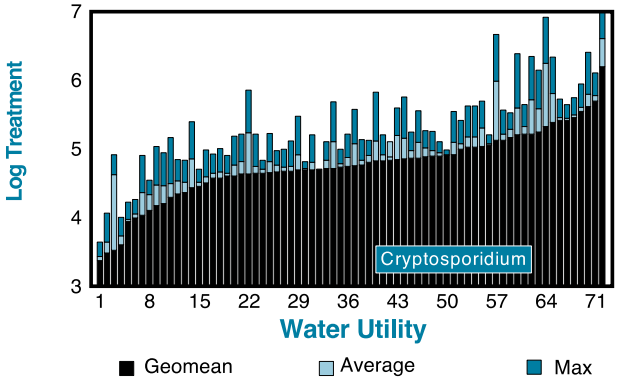


Table 5

Tabulation of *Giardia* and *Cryptosporidium* Data for each surface water treatment plant

Table 6

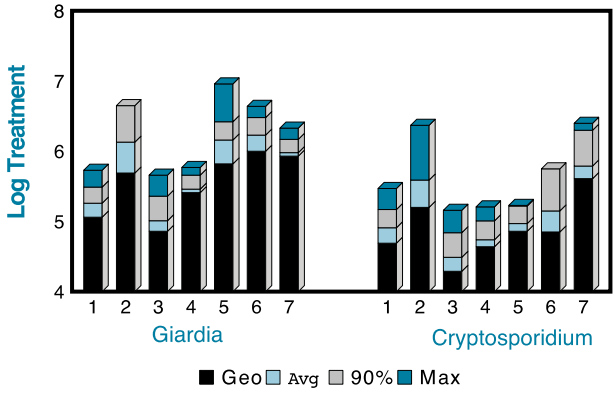
Giardia and *Cryptosporidium* Data for Site 72

Date	*Giardia*/L	*Cryptosporidium* oocysts/L
June 27, 1989	<242	484
July 8, 1991	11	39
December 2, 1991	<12	24
May 11, 1992	<4	12
August 3, 1992	<42	42

Comparison of treatment goals for the geometric means, arithmetic average, 90th percentile, and maximum count showed that the difference between the different calculations averaged 0.71 $\log_{10}$ for *Giardia* (range 0.36 to 1.1 $\log_{10}$) and 0.78 $\log_{10}$ for *Cryptosporidium* (range 0.37 to 1.2 $\log_{10}$).

When data are limited (e.g., <10 samples) the maximum level observed would provide protection against possible peak occurrences of pathogens. One limitation with the maximum level guideline occurs when the maximum count is a nondetect value. For the *Giardia* data presented in Table 5 the maximum count was a nondetect value for 17 (23.6 percent) of the 72 systems. For six of these systems, all values were nondetect (i.e., *Giardia* cysts were not found in any samples). For nine of the systems, the maximum nondetect value was <0.5 $\log_{10}$ higher than a value where an actual cyst had been detected. For three systems, the maximum nondetected value ranged between 1 and 2 $\log_{10}$ higher than an actual observed value. For *Cryptosporidium*, the maximum count was a nondetect value in 10 of the 72 systems (13.9 percent). The difference between the maximum count and the maximum detected level value (i.e., the next highest value when the maximum level is a nondetect) for *Cryptosporidium* averaged 0.24 $\log_{10}$ (range 0.006 to 0.52).

Figure 3



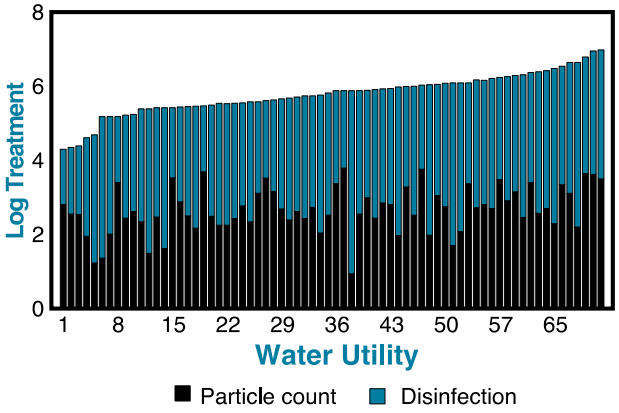
An example of the impact of a nondetect value on the calculated level of *Giardia* is illustrated by the data from site 72 (Table 6). *Giardia* cysts were detected only once among the five samples collected. The sample collected on June 27, 1989, was during flood stage of the river and raw water turbidity levels were estimated at 3,000 NTU. The large amount of debris in the sample clogged the filter after 3 gal (11.3L) was collected and resulted in a concentrated pellet of 55 mL. Because the analytical methodology limits the size of the pellet processed to 1 mL, the sample would have required processing 55 times (approximately 3 months of work) to analyze all 3 gal. Because the assay also requires a monolayer of material to be placed on the filter, only a small fraction of the processed sample was analyzed. The net result was that an equivalent volume of 0.004 L was analyzed. No cysts were detected in the sample, but two oocysts were. The statistical reliability of a value based on no observed organisms (or for *Cryptosporidium*, a count of two oocysts) is extremely large (greater than 10 fold). Additional testing during 1991 to 1992 failed to produce such high results. The impact, however, of this nondetect value results in a maximum observed count treatment goal of 7.5 $\log_{10}$ for *Giardia* and 7.2 $\log_{10}$ for *Cryptosporidium* removal, inactivation or both. A more realistic treatment goal would be the next highest value, which in this case was 42 cysts/L, or a treatment goal of 6.8 $\log_{10}$. Providing routine treatment at this level ensures ample protection for the situation in which *Giardia* was observed (11 cysts/L requires 6.2 $\log_{10}$ treatment to achieve 10^{-4} annual risk of *Giardia* infection) and is more comparable to the arithmetic or geometric mean treatment goals for *Cryptosporidium* (6.6 and 6.2 $\log_{10}$, respectively).

Treatment objectives can be optimized

Once the raw water monitoring has been completed and the treatment goals for a particular plant established, the utility can focus options to routinely achieve these goals and balance them with other water quality objectives. For most systems, this means optimizing particle removals through coagulation, sedimentation and filtration, and balancing disinfection so that adequate microbial inactivation is achieved along with minimal DBP formation. Improving particulate removal obviously lessens reliance on disinfection.

For this study, particle counting (total particles > 3 m) was used to evaluate the removal of parasites through the treatment process. Previous studies have shown correlations between removals of *Giardia* and *Cryptosporidium* and particle counts (9,26). In this study, the systems achieved an average 2.7-$\log_{10}$ removal of particles >3 m (range=0.94 - 3.8 $\log_{10}$). The difference between the average level of particle removal for each system and the treatment goal (based on the geometric mean of raw water parasite counts) estimates the level of disinfection

Figure 4



that will be required under the ESWTR. For *Giardia*, the average system would need to supplement sedimentation and filtration treatment with and additional 2.7 log_{10} of disinfection (Figure 4). All systems examined required more than the minimum 0.5 log_{10} disinfection as outlined in the SWTR (25). However, when the level of *Giardia* inactivation was estimated at each facility, the average system applied sufficient *CxT* to achieve 5.1-log_{10} disinfection. This estimate was based on the average pH (7.5), temperature (15°C), and free chlorine residual (1.4 mg/L) for the samples analyzed (contact times were adjusted for short circuiting in the basins) (12), and will obviously change for different seasonal conditions. However, when this estimate was compared to the level of disinfection necessary to achieve the 10^{-4} annual risk of infection, 64.3 percent of the systems exceeded the amount of disinfection necessary to control *Giardia* and an additional 15.7 percent were within 1 log_{10} of the treatment goal. An estimated 20 percent of the systems would need to increase disinfection levels (2 - 3 log_{10}), whereas another 20 percent could reduce the level of disinfection used by 10 log_{10} or more.

The importance of these estimates is to show that many systems are currently meeting or exceeding the required level of treatment—even for the ESWTR guidelines for *Giardia*—and that a substantial number of systems could reduce disinfection practices without impacting microbial protection. This finding is similar to previous results showing that 76 percent of the systems examined exceeded the 10^{-4} risk level for *Giardia* (7). Additionally, approximately 80 percent of these systems currently meet the stage 1 D/DBP levels of 80 g/L for THMs and 60 g/L for haloacetonitriles despite the wide use of prechlorination (27). In these studies, however, approximately 80 percent of the *CxT* credit for *Giardia* inactivation came from prechlorination, usually because of the long contact times in the sedimentation basins. Elimination of prechlorination *CxT* credit under the D/DBP Rule would jeopardize the ability of utilities to provide adequate *Giardia* disinfection. Moreover, reliance on only postfilter disinfection removes one of the elements of the multiple barrier protection by not providing options for backup disinfection should postfiltration disinfection fail. Because most systems would probably still apply some prechlorination (even if no disinfection credit is applied) to control algal growths and to improve filter performance and oxidation for iron, manganese, and taste and odor compounds, DBP levels could actually increase because the water would have to be rechlorinated for postfiltration *CxT* credit. It is important that USEPA more carefully study the integration of the ESWTR and D/DBP rules and cautiously approach the issue of changing predisinfection practices before these regulations are promulgated.

Plant optimization, chlorination have prevented cryptosporidiosis recurrences

Comparing the difference between particle count removals and treatment goals for *Cryptosporidium* reveals that the average system will need to provide 2.0-log_{10} disinfection (range=0.5 - 2.6 log_{10}) to meet a 10^{-4} annual risk of infection. Although there is not a large database of disinfection data for *Cryptosporidium*, recent studies have shown that a combination of free chlorine (1 mg/L for 60 min) and chloramines (2 mg/L for 240 min) resulted in 1.6-log_{10} of oocyst inactivation (28). Other studies have suggested that multiple stresses could increase oocyst inactivation under field conditions (29-31). Although much more disinfection data are needed, especially under field conditions, the reassuring message is that the combination of effective turbidity and particle count reductions with chlorination may already be achieving risk assessment goals for *Cryptosporidium*. Indeed, plant optimization and chlorine disinfection has been sufficient to prevent reoccurrences of cryptosporidiosis outbreaks in the Carrollton Ga., Talent Ore., and Milwaukee Wis. systems. Because multiple application of disinfection may be important for *Cryptosporidium* inactivation, again, it is critical that USEPA move cautiously regarding the elimination of predisinfection practices.

Plant effluent results examined

For the 1991-93 study, *Giardia* cysts were detected in filtered plant effluent water on 12 occasions (4.6 percent of 262 samples). When detected, *Giardia* levels averaged 2.6 cysts/100 L (range=0.98 - 9.0 cysts/100 L). Microscopic examination of the cysts suggested that the majority of the organisms were dead. More than 86 percent of the 22 cysts found in the water samples lacked observable internal morphological structures, while only one isolate had a peritrophic space (a potential indicator of viability). Because microscopic indicators of viability are very broad and probably greatly over estimate the potential to cause illness, there is little reason to believe that any community was at risk for an outbreak of giardiasis.

Cryptosporidium oocysts were observed in 35 (13.4 percent) of 262 plant effluent samples. When *Cryptosporidium* was detected, levels averaged 3.3 oocysts/100 L (range=0.29 - 57 oocysts/100 L). Microscopic examination of the oocysts showed that 27 (35 percent) of 77 isolates contained sporozoites. It is uncertain whether any of these sporozoites were viable.

Overall, 16.8 percent of the samples (44 of 262) contained *Giardia*, *Cryptosporidium*, or both. These levels are lower than the 39 percent rate for finished water reported in the previous study (7), but probably reflect the lower cyst and oocyst occurrence in the raw water and improved treatment plant performance. The relationship between the levels of parasites in raw water and their detection frequency in filtered water has already been discussed (7,9). In the 1991 study, the average plant effluent turbidity level was 0.19 ntu, and 80.5 percent of the systems had turbidity levels less than 0.5 ntu. In the current study, the average plant effluent turbidity level was 0.14 ntu and 98.9 percent of the plants had turbidity values less than 0.5 ntu. The data suggest that implementation of the SWTR (25) has resulted in improvements in water quality.

A summary of the occurrence data for *Giardia* and *Cryptosporidium* in filtered effluent water for all samples collected between 1988 and 1993 showed that almost 28 percent of the plants (20 of 71) were positive for *Giardia* cysts on one or more sampling occasions. A total of 14 systems (19.7 percent) were positive for cysts on only one occasion, whereas six systems were cyst-positive two or more times. For *Cryptosporidium*, 32 of 71 plants (45 percent) were consistently negative, while 24 plants were positive once and 15 plants were oocyst-positive two or more times. Forty-four of 71 (62 percent) of the plants were positive for *Giardia*, *Cryptosporidium*, or both at one time or another. The results suggest that if sampled often enough, *Giardia* or *Cryptosporidium* will eventually be detected at nearly every plant. Because the parasite assay does not indicate viability or virulence, the results do not necessarily indicate that these systems are at risk from waterborne pathogens. However, the results do suggest that controlling coagulation and filtration procedures for removal of *Cryptosporidium* will be more difficult than control of *Giardia*.

Because conventional filtration will remove 99 to 99.7 percent of cysts and oocysts (25), it is reasonable to expect that detection of cysts and oocysts in the raw water will result in detectable levels in filtered effluents. Because microscopic detection of cysts and oocysts in treated water is an inefficient method for determining plant performance and the confidence interval of individual results is large, the best use of limited analytical resources would be to concentrate on developing a raw water database for *Giardia* and *Cryptosporidium* occurrence and to use other means, such as particle counts, to determine treatment plant performance (9,25).

Acknowledgement
The authors acknowledge the effort of Judith Siegel who helped with the *Giardia* and *Cryptosporidium* analysis, and thank Richard H. Moser and Ramon Lee for their comments. This research was supported by funds from the American Water System.

References

01. **USEPA.** 1994. Monitoring Requirements for Public Drinking Water Supplies; Proposed Rule. *Federal Register* **59(28):** 6332-6444.
02. **USEPA.** 1994. National Primary Drinking Water Regulations; Disinfectants and Disinfection Byproducts; Proposed Rule. *Federal Register* **59(145):** 38668-38829.
03. **USEPA.** 1994. National Primary Drinking Water Regulations; Enhanced Surface Water Treatment Requirements; Proposed Rule. *Federal Register* **59(145):** 38832-38858.
04. **LeChevallier, M. W., W. D. Norton, and R. G. Lee.** 1992. Evaluation of a Method to Detect *Giardia* and *Cryptosporidium* in Water, p.483-498. **In** J. R. Hall and G. D. Glysson (eds.), *Monitoring Water in the 199's: Meeting New Challenges*, ASTM STP 1102, American Society for Testing and Materials, Philadelphia, PA.
05. **LeChevallier, M. W., T. M. Trok, M. O. Burns, and R. G. Lee.** 1990. Comparison of the Zinc Sulfate and immunofluorescent techniques for detecting *Giardia* and *Cryptosporidium* in water. *J. Amer. Water Works Assoc.* **82(9)**:75-82.
06. **LeChevallier, M. W., W. D. Norton, and R. G. Lee.** 1991. Occurrence of *Giardia* and *Cryptosporidium* spp. in surface water supplies. *Appl. Environ. Microbiol.* **57(9)**:2610-2616.
07. **LeChevallier, M. W., W. D. Norton, and R. G. Lee.** 1991. *Giardia* and *Cryptosporidium* spp. in filtered drinking water supplies. *Appl. Environ. Microbiol.* **57(9)**:2617-2621.
08. **LeChevallier, M. W., W. D. Norton, R. G. Lee, and J. B. Rose.** 1991. Giardia *and* Cryptosporidium *in Water*, AWWA Research Foundation, Denver, CO.
09. **LeChevallier, M. W. and W. D. Norton.** 1992. Examining Relationships Between Particle Counts and *Giardia, Cryptosporidium*, and Turbidity. *J. Amer. Water Works Assoc.* **84(12)**:54-60.
10. **ASTM.** 1991. Proposed test method for *Giardia* cysts and *Cryptosporidium* oocysts in low-turbidity water by a fluorescent antibody procedure. *Ann. Book of ASTM Standards* **11.01**:925-935.
11. **LeChevallier, M. W., W. D. Norton, J.E. Siegel and M. Abbaszadegan.** 1995. Evaluation of the Immunofluorescence Procedure for Detection of *Giardia* Cysts and *Cryptosporidium* Oocysts in Water. *Appl. Environ. Microbiol.* **61(2)**: 690-697.
12. **USEPA.** 1989. *Guidance Manual for Compliance*

with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, US Environmental Protection Agency, Washington, D.C..
13. **Rose, J. B., C. N. Haas, and S. Regli.** 1991. Risk Assessment and Control of Waterborne Giardiasis. *Amer. J. Pub. Health* **81(6):** 709-713.
14. **Haas, C. N., and J. B. Rose.** 1994. Reconciliation of Microbial Risk Models and Outbreak Epidemiology: The Case of the Milwaukee Outbreak. *Proceedings AWWA 1994. Annual Conf.* AWWA Denver, CO.
15. **Clancy, J. L., W. D. Gollnitz, and Z. Tabib.** 1994. Commercial Labs: How Accurate are They? *J. Amer. Water Works Assoc.* **86(5)**:89-97.
16. **Ongerth, J. E.** 1989. *Giardia* cyst concentrations in river water. *J. Amer. Water Works Assoc.* **81(9)**:81-86.
17. **Poulton, M. J., J. S. Colbourne, and J. B. Rose.** 1992. *Cryptosporidium* monitoring in the UK and risk assessment, p.589-598. In *Proc. AWWA Water Quality Tech. Conf*, AWWA, Toronto, Ont.
18. **Ballows, A., W.J. Hausler Jr., K. L. Herrmann, H.D. Isenberg, H.J. Shadomy**. 1991. *Manual of Clinical Microbiology, Fifth Edition*. American Society for Microbiology, Washington, DC.
19. **Boutros, S. N.** 1989. *Sampling and Analysis for Cryptosporidium in PA Public Surface Water Supply Sources*, Report to Pennsylvania division of water supply, Harrisburg, PA.
20. **Hansen, J. S. and J. E. Ongerth.** 1991. Effects of time and watershed characteristics on the concentration of *Cryptosporidium* oocysts in river water. *Appl. Environ. Microbiol.* **57(10)**:2790-2795.
21. **Rose, J. B.** 1988. Occurrence and significance of *Cryptosporidium* in water. *J. Amer. Water Works Assoc.* **80(2)**:53-58.
22. **Rose, J. B., C. P. Gerba, and W. Jakubowski.** 1991. Survey of potable water supplies for *Cryptosporidium* and *Giardia*. *Env. Sci. Tech.* **25(8)**:1393-1400.
23. **Ongerth, J. E. and H. H. Stibbs.** 1987. Identification of *Cryptosporidium* oocysts in river water. *Appl. Environ. Microbiol.* **53**:672-676.
24. **The National Cryptosporidium Survey Group,** 1992. A survey of *Cryptosporidium* oocysts in surface and groundwaters in the UK. *J. IWEM* **6(12)**:697-703.
25. **USEPA.** 1989. National primary drinking water regulations: filtration and disinfection; turbidity, *Giardia lamblia*, viruses, *Legionella* and heterotrophic bacteria; proposed rule. *Federal Register* **54(124)**:27486-27541.
26. **LeChevallier, M. W. and W. D. Norton.** 1995. Plant Optimization using Particle Counting for Treatment of *Giardia* and *Cryptosporidium*. Royal Society of Chemistry in press.
27. **Arora, H., M. W. LeChevallier, and R. H. Moser.** 1994. Disinfection By-Products — American System Survey of Occurrence, Control and Fate. Report to the American Water System, Voorhees, NJ.
28. **Finch, G. R., K. Black, and L. L. Gyurek.** 1995. Ozone and Chlorine Inactivation of *Cryptosporidium*. pp. 1303-1318. In *Proc. AWWA Water Quality Tech. Conf*, AWWA, San Francisco, CA.
29. **Robertson, L. J., A. T. Campbell, and H. V. Smith.** 1992. Survival of *Cryptosporidium* under Various Environmental Pressures. *Appl. Environ. Microbiol.* **58(11)**:3493-3500.
30. **Parker, J. F. and H. V. Smith.** 1993. Destruction of Oocysts of *Cryptosporidium* by Sand and Chlorine. *Wat. Res.* 27(4): 729-731.
31. **Carrington, E. G. and M. E. Ransome.** 1994. *Factors Influencing the Survival of Cryptosporidium Oocysts in the Environment. FR 0456.* Crown and Foundation for Water Research, Bucks, UK.

About the authors: *Mark W. LeChevallier is the director of research for the American Water Works Service Company, Inc. (AWWSC), 1025 Laurel Oak Rd., POB 1770, Voorhees, NJ 08043. A member of AWWA, IWSA, IWQA, and the American Society for Microbiology, LeChevallier is the past chairman of the AWWA Organisms in Water Committee. He has had work published previously in* JOURNAL AWWA, Applied and Environmental Microbiology, Microbial Ecology, *and* Journal of Microbiological Methods. *William D. Norton is a research analyst at the AWWCS, Belleville Laboratory, 1115 S. Illinois St., Belleville, IL 62220.*

Abbreviations:

n	The number of samples collected
Avg	Arithmetic average
Geo-X	Geometric mean
90 percent	Calculation of the 90th percentile, for sites with >10 samples
Max	Maximum count observed
Max2	Maximum detected level (when the maximum count was based on a nondetect value) or arithmetic average, which ever was greater

The Public Health Response to an Outbreak*

William R. Mac Kenzie, MD
Richard A. Goodman, MD, MPH
Epidemiology Program Office,
Centers for Disease Control and Prevention, Atlanta, GA

Introduction

The words 'epidemic' and 'outbreak' are synomonous and can be defined as the occurrence of cases of disease that is in excess of what would normally be expected (1). The word 'outbreak' is often preferred because it less likely to be misinterpreted or sensationalized. In the United States, local and state health departments are the front line respondents to outbreaks of disease within their jurisdiction. Outbreaks often represent a crisis situation that concurrently necessitates intense thought, coordinated action, and crisis management by the public health community. The successful management of an outbreak requires that public health officials be able to recognize the occurrence of an outbreak, mobilize and coordinate resources, conduct a thorough investigation, and rapidly institute control measures. An outline of the basic steps to conducting an outbreak investigation are found in Table 1. In this article we provide an overview to the detection and investigation of outbreaks, institution of control measures, and administrative aspects of the public health response.

Detection and Confirmation of an Outbreak

For public health agencies to respond to an outbreak there first must be recognition that an outbreak has occurred. Outbreaks are frequently recognized by health care providers or public health workers who observe an increase in cases of disease or constellations of unusual signs and symptoms. For example, in 1989, physicians who evaluated three patients with eosinophilia and severe myalgia in New Mexico reported these cases to the New Mexico Department of Health. These reports stimulated an investigation that led to the discovery of a nationwide outbreak of the eosinophilia-myalgia syndrome associated with consumption of L-tryptophan produced by a single pharmaceutical company (2). Outbreaks due to some enteropathogens, including unusual *Salmonella* serotypes, are often noted first by state public health laboratorians who recognize an increase in the number of isolates (3). Finally, public health officials may recognize outbreaks of diseases which are reported through routine notifiable disease surveillance when there is an increase in reported cases of a disease.

Once an outbreak is suspected, it is essential to determine if reported cases represent true cases of disease. Misdiagnosis or laboratory error need to be ruled out by examination of cases, review of charts, and repeating laboratory tests when indicated. For example, a pseudo-outbreak of *Mycobacterium xenopi* in a Michigan hospital was uncovered when case-patient charts were reviewed and the majority of those with isolates did not have disease consistent with *M. xenopi* infection (4). Epidemiologic investigation then revealed that cases were associated with undergoing bronchoscopy with a bronchoscope that had been rinsed with contaminated tap water after disinfection. The presence of an outbreak can be confirmed only if there has been a true increase in cases of the disease over a baseline number of expected cases.

Institution of Control Measures

When the occurrence of an outbreak has been confirmed, measures to control the outbreak should be instituted as quickly as possible. For some diseases (e.g., syphilis, tuberculosis, hepatitis A) specific control measures, such as treatment of cases, cohorting, contact investigation, and prophylaxis, are well established and can be initiated simultaneously with the investigation. However, when the source of the outbreak, agent, or both is unknown, an epidemiologic investigation must be conducted before specific control measures can be implemented. The decision to take public health action involves weighing the strength of the epidemiologic data, the likely cost of inaction with regard to morbidity and mortality, the cost of taking action in terms of inconvenience, financial loss, and possible complications of the action (e.g., burn injuries secondary to boil water orders). Public health officials must quickly assess these factors and promptly communicate a balanced picture to decision makers. When epidemiologic data implicates a source or mode of transmission of illness, prompt consideration should be given to immediate intervention. In general, public health officials should not wait for laboratory confirmation of their epidemiologic findings to take action because waiting for requisite laboratory data may substantially delay the institution of control measures.

***This article originally appeared in *Current Issues in Public Health*, 1996; 2:1-4.**

Table 1
Basic steps to an outbreak investigation

1.	Verify the existence of an epidemic
2.	Confirm the diagnosis
3.	Take immediate control measures (if indicated)
4.	Develop a case definition
5.	Institute case-finding and count cases
6.	Collect and orient the data in terms of time, place and person
7.	Develop hypotheses explaining the specific exposure that caused disease
8.	Test hypotheses using appropriate epidemiologic and statistical methods
9.	Plan additional systematic studies
10.	Execute and evaluate control and prevention measures
11.	Continue surveillance
12.	Communicate findings

Adapted from Selected Bibliography references 1 and 2

Administrative Aspects

The public health response to an outbreak is complex and substantially transcends the issues regarding the scientific investigation of the outbreak. Other important considerations include the need to attend to establishing relationships, logistical considerations, resource management, planning, and coordinated communication and action; failure to address these considerations likely will hamper the response to the outbreak.

For example, an important first step is to establish the outbreak investigation team, define its leadership, and specify goals early in the investigation. The leadership must organize the team to assure the assignment of specific roles and an appropriate division of labor. Resources that are needed to conduct the investigation should be assessed early and, if needed, additional resources should be sought immediately. When outbreaks require the involvement of personnel from local, state, and federal agencies, it is essential that collaborative and consultative relationships between health officials be established immediately. Local and state officials generally bear the final responsibility for the response to an outbreak in a specific jurisdiction. Each aspect of the investigation should be prioritized to allow team members to optimize their efficiency, and the team should meet regularly to review the progress of each portion of the investigation and redirect resources to complete the essential tasks. Collected data should be routinely compiled, discussed daily by the investigative team, and used to further direct the investigation.

Because the collection, testing, and reporting of specimens obtained from cases and the environment to the outcome of an outbreak investigation, whenever possible, laboratory scientists should be included in the planning and conducting of the outbreak investigation. Consideration should be given to dedicating personnel to assure proper collection, recording of laboratory data, and transport of laboratory specimens. In addition, outbreak investigations often may require the expertise and cooperation of persons in other disciplines (e.g., engineers, agriculture and industry officials, veterinarians, and entomologists) to conduct the investigation; the roles of these experts should be defined early in the investigation. This type of multi-disciplinary approach adds to the complexity of the overall investigation, often necessitating increased effort and time to communicate findings and coordinate the investigation.

Because outbreaks often garner intense public interest, the news media may seek to report large amounts information about outbreaks in a timely manner, including facts, controversies, and stories of human interest. The needs of public health officials usually are specifically directed toward informing the public of measures to control and prevent disease while avoiding the creation of biases which might affect the scientific investigations. The differing priorites of the news media and public health may create a tension between these two groups. To facilitate the provision of information a single public health spokesperson should be designated as the main communicator with the news media. This person should be in regular and direct contact with the investigation team, should provide the media regularly scheduled updates regarding the outbreak, act as a buffer to allow the outbreak investigation team uninterrupted time to conduct the investigation, and should interpret and communicate important findings using messages that can be readily understood and used by the general public.

Investigational Aspects

Following confirmation of the occurrence of an outbreak, the investigator must enhance surveillance to identify additional cases. Many cases initially may not be recognized because of inadequate testing of patient specimens and underreporting of cases to local public health departments. To enhance surveillance and case-finding, public health officials must inform the medical community about the presence of an outbreak, clinical manifestations, laboratory tests used to confirm the

diagnosis, available treatment, prophylaxis of case contacts, means of preventing secondary spread, and the importance of promptly reporting all suspected cases to the health department. When appropriate, increased laboratory testing should be encouraged and, if necessary, supported logistically and financially. The health department may decide to conduct active surveillance for cases by directly contacting health care providers and laboratorians.

Case definitions have great importance in enhancing case-finding, delineating the study population, and describing criteria for the illness under investigation. The three basic components of a case definition are specification of 1) conditions (e.g., signs and symptoms and laboratory results); 2) the time period of exposure or onset of illness; and 3) relevant geographic factors (e.g., place of residence, employment, or recreational and social activities). For the purpose of reporting of cases by health care providers, case definitions with both high sensitivity and specificity are preferred. However, in some situations a relatively sensitive, but less specific case definition, may be used to enhance case finding and improve characterization of the spectrum of disease.

Information gathered about cases should be evaluated in terms of on the characteristics of person, place, and time, and used to construct epidemic curves, spot maps, and other characteristic profiles shared by case-patients. This information can then be used to formulate hypotheses about the source or spread of the problem. This process also entails extensive interview of case-patients (particularly those who became ill early in the outbreak), determining the order and timing of key events and activities, and inspecting the site or sites suspected to be involved in the outbreak. In addition to formulating hypotheses about the source and the mode of transmission, the investigation can also assess the pathogenic mechanisms, presence of a dose response, risk factors for illness, effectiveness of the control measures utilized, sequelae of disease, and costs engendered.

The identification of hypotheses and other key questions will quide the design of epidemiologic, laboratory, and environmental studies. Choice of study populations, control groups, means of data collection (personal interview, telephone interview, or self-administered questionnaire) and the design of questionnaires must be considered carefully to assure validity and precision of studies. Epidemiologists need to be creative and resourceful when considering study designs to answer specific questions. For example, the use of multiple different control groups during investigations of hantavirus infections in the Southwest was critical in permitting investigators to elucidate different factors associated with exposure to infection (5). During the large cryptosporidiosis outbreak in Milwaukee due to community-wide exposure to a contaminated public water supply, the investigation of special populations such as short-term visitors who had only brief exposure to Milwaukee water was useful to determine the incubation period, duration of community exposure, and the frequency secondary transmission (6). In these examples, restriction of the investigations to single control groups or community members, respectively, would likely have precluded the determination of answers to important questions.

Questionnaires should be designed to allow the testing of identified hypotheses, evaluation for confounding and effect modification, and classification of varying levels of exposure and illness. Collection of data extraneous to testing the identified hypotheses should be avoided. Maintaining a questionnaire as brief, clear, and easy to use as possible results in higher response rates and more timely data collection. To accomplish this, questionnaires should undergo extensive critique by colleagues, be revised as needed, and, when possible, be pre-tested on people representative of those who will ultimately be administered the questionnaire. Designing questionnaires is often a time consuming and difficult process, but is worth the effort since there is no analysis that can overcome collection of poor data. There is great truth in the maxim, “garbage in, garbage out.”

Investigations should be carried to completion. Data collected during the initial investigation should be evaluated promptly and used to direct on-going hypothesis generation. Surveillance should be maintained after the outbreak appears to subside and the efficacy of the control measures assessed. A final report should be written promptly to document the investigation, the findings, and recommendations made. Consideration should be given to the broader implications of the investigation’s findings for public policy, industry, and science. For investigations that make substantial contributions in these areas, the investigators should communicate of their findings in a timely manner to colleagues in public health bulletins, abstracts, presentations, and journal articles.

References

1. In: *A Dictionary of Epidemiology. Second Edition.* Edited by John M. Last. Oxford University Press, c1988

2. Belongia EA, Hedberg CW, Gleich GJ, White KE, Mayeno AN, Loegering DA, Dunnette SL, Pirie PL, MacDonald KL, Osterholm MT.. An investigation of the cause of the eosinphilia-myalgia syndrome associated with tryptophan use. *New Engl J Med*. 1990; 323-357-65

3. CDC. Multistate outbreak of Salmonella poona infection - United States and Canada, 1991. *MMWR* 1991; 40:549-52

4. Bennett SN, Peterson DE, Johnson DR, Hall WN, Robinson-Dunn B, Dietrich S. Bronchscopy-associated Mycobacterium xenopi pseudoinfections. *Am J Respir Crit Care Med*. 1994;150:245-250

5. Zeitz PS, Butler JC, Cheek JE, Samuel MC, Childs JE, Shands LS, Turner RE, Voorhees RE, Sarisky J, Pollin PE, Ksiazek TG, Chapman L, Reef SE, Komatsu KK, Dalton C, Krebs JW, Maupin GO, Gage K, Sewell, CM, Breiman RF, Peters CJ. A case-control study of hantavirus pulmonary syndrome during an outbreak in the southwestern United States. *J Infect Dis* 1995;171:864-70

6. Mac Kenzie WR, Schell WL, Blair KA, Addiss DG, Peterson DE, Hoxie NJ, Kazmeirczak JJ, Davis, JP. Massive outbreak of waterborne *Cryptosporidium* infection in Milwaukee, Wisconsin: Recurrence of illness and risk of secondary transmission. *Clin Infect Dis* 1995;21:57-62

Selected Bibliography

1. Gregg, MB. Conducting a field investigation. In *Field Epidemiology*, pgs. 44-59. Editor, Michael B. Gregg. Oxford University Press. c1996

2. Goodman RA, Buehler JW, Koplan JP. The epidemiologic field investigation: Science and judgment in public health practice. *Am J Epidemiol* 1990; 132:9-16

3. Gregg MD, Parsonnett J. Principles of an epidemic field investigation. In: *Oxford Textbook of Public Health*, Second Edition, vol. 2, pgs. 399-408, Edited by Walter W. Holland, Roger Detels, George Knox. Oxford University Press, c1991

4. Goodman RA, Gregg MB, Gunn RA, Sacks JJ. *Operational aspects of epidemiologic field investigations*. In Field Epidemiology, pgs 35-43. Editor, Michael B. Gregg. Oxford University Press. c1996

5. Investigation. In Maxcy-Rosenau-Last *Public Health & Preventive Medicine*, 13th Edition, pgs. 22-4. Editors, John M. Last, Robert B. Wallace. Appleton & Lange. c1992

Key Words and Phrases

Acid-fast stain: The nonspecific staining procedure used by most medical laboratories for detection of *Cryptosporidium* oocysts in stool specimens.

Action level: A specified concentration of a contaminant in water; if this concentration is reached or exceeded, certain actions (e.g., further treatment and monitoring) must be taken to comply with a drinking-water regulation.

Available chlorine level : See "Free residual chlorine level."

Backflow: A reversal of the normal flow of water or other liquid caused by a negative-pressure gradient (e.g., within a water system). Also known as "siphonage."

Boil water advisory: A statement advising persons to boil tap water before use because of suspected microbial contamination.

Case definition: A standard set of criteria for deciding whether an individual should be classified as having a disease.

Coagulation: The process of adding chemicals to water to gather particles for removal by sedimentation and/or filtration.

Coliforms: Bacteria used as a measure of potential fecal contamination. Elevated coliform levels indicate poor water quality.

Contact time: The length of time water is exposed to a disinfectant (e.g., chlorine contact time).

Cross-connection: Any physical connection between the water pipe(s) delivering water to a customer and a source of contamination (e.g., a wastewater line) that might allow that contamination to enter the water pipe.

Cyst: The infectious stage of *Giardia* and some other protozoan parasites that has a protective wall, which enables it to survive in water and other environments.

DFA test (direct fluorescent antibody test): A test for *Cryptosporidium* that uses fluorescence-labeled antibodies to detect oocysts under a microscope, used by some medical laboratories for the detection of *Cryptosporidium* in stool specimens.

Disinfection: The treatment of water to inactivate, destroy, or remove pathogenic (disease-producing) bacteria, viruses, parasites, and other microorganisms for the purpose of making the water microbiologically safe for human consumption.

Disinfection byproducts: Chemicals formed in water by reactions between organic matter and disinfectants.

Distribution system: System of water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers.

EIA (enzyme immunoassay): A specific antigen or antibody detection test used by some medical laboratories for the detection of *Cryptosporidium* in stool specimens.

Endemic level: The expected or "background" level of a disease or infectious agent within a given area.

Epidemiologically linked case: A case in which the patient has had the same exposure as one or more persons who have/had the disease.

Excystation: The release of the internal contents of cysts or oocysts. The mechanism by which ingested *Cryptosporidium* oocysts cause human and animal infection.

Fecal coliforms: An easily measured subset of the coliform group of bacteria, primarily *Escherichia coli*, that is found mainly in the gut of warm-blooded animals, including humans. Its presence in water indicates that fecal pathogens (e.g., *Cryptosporidium, Giardia*) may also be present.

Fecal-oral route: Transmission involving oral ingestion of *Cryptosporidium* or other organisms that have been excreted through feces.

Filter backwash: Water that contains material obtained by reversing the flow of water through a filter to dislodge particles.

Filtration: The process of removing suspended particles from water by passing it through one or more permeable membranes or media of small diameter (e.g., sand, anthracite, or diatomaceous earth).

Finished water: The fully treated water (i.e., drinking water) which leaves a treatment plant.

Flocculation: The water-treatment process after coagulation that uses gentle stirring to cause suspended particles to form larger, aggregated masses (floc). The aggregates are removed from the water by a separation process (e.g., sedimentation, flotation, or filtration).

Free, residual chlorine level: The concentration of chlorine in water that is not combined with other constituents and thus serves as an effective disinfectant. Also known as "available chlorine level."

Ground water: Water extracted from under the ground (i.e., from a well or spring).

Immunocompromised, immunosuppressed, immunodeficient, immune-suppressed: Terms used to describe a person whose immune system has a reduced ability to protect the body from infection.

Indicator organism: An easily measured microorganism, or group of related organisms, that indicates by its presence or concentration that pathogens may be present.

Information Collection Rule: A U.S. Environmental Protection Agency (EPA) regulation that requires water systems using surface water that serve 100,000 or more people and water systems using ground water that serve 50,000 or more people to conduct monitoring and/or treatment studies. It also requires these water systems to report data to the EPA and to make their findings public if required by the state. This data will be used in developing future regulations for disinfectants/disinfection byproducts and enhanced surface water treatment.

Laboratory-confirmed case: A case that is confirmed by analysis of a stool, blood, or tissue sample in a reliable laboratory (as opposed to a case identified only by a person's symptoms or reported symptoms).

Maximum-contaminant level: The maximum permissible concentration (level) of a contaminant in water supplied to any water consumer.

Multiple barrier system: The use of more than one barrier or protection and treatment in series to ensure the safety of drinking water. Multiple barriers may include wastewater collection and treatment, protection of water sources, disinfection, protection of water quality during storage and distribution, aggressive management, and adequate training.

Nephelometric turbidity units (NTU): Measurement of turbidity (lack of clarity) of a sample of water.

Oocyst: The infectious stage of *Cryptosporidium parvum* and some other coccidian parasites. An oocyst has a protective shell-like wall that facilitates its survival in water and other environments.

Point-of-use filter: Water filter installed at point just before water is drunk. A faucet, for example, is a "point-of-use."

Protozoan: One-celled microscopic organism.

Raw water: Untreated, unfiltered water.

Reverse osmosis: A process that removes dissolved salts, metallic ions, and microbes from water by forcing it through a semipermeable membrane.

Sedimentation: The process of settling out suspended solid particles to the bottom of water.
Shedding: Releasing infective particles; excreting contagious germs.
Siphonage: See "backflow."
Source water: Untreated, unfiltered water (e.g., water in lakes, rivers, and reservoirs) used to produce drinking water. Also known as "raw water."
Spiking: A laboratory research method of adding oocysts to water to determine if filtration systems are functioning properly; intentionally contaminating water with oocysts or other microorganisms.
Stool specimen: A small sample of feces to be tested for the presence of oocysts or other microorganisms.
Submicron: Less than 1 micron (1 millionth of a meter).
Supportive laboratory results: Laboratory results that support a diagnosis but do not prove it.
Surface water: The water in lakes, rivers, reservoirs, ponds, and oceans.
Surface Water Treatment Rule (SWTR): EPA regulation that requires water systems using surface water, and ground water under the direct influence of surface water, to disinfect their waters. It also requires all such systems to filter their water, unless the system can meet certain EPA-specified criteria.
Suspected case: An instance of disease (e.g., cryptosporidiosis) that is suspected but is not laboratory confirmed.
Total chlorine: Free and bound atoms of chlorine in water calculated together.
Total Coliform Rule: EPA regulation that sets a maximum limit and monitoring requirements for total coliforms in drinking water. Total coliforms, which are not generally pathogenic, are a group of closely related bacteria used to indicate contamination problems in the distribution system, and thus the potential presence of waterborne pathogens.
Total coliforms: Nonfecal and fecal coliforms calculated together to measure contamination of a water sample.
Total coliform test: A measure that detects the presence or number of living coliform bacteria in a water sample.
Transmission: Passing of infection from one person or animal to another.
Turbidity: The level of suspended matter (e.g., clay, silt, or plankton) in water, which causes a loss of clarity or transparency.
Watershed: An area from which water drains to a particular body of water.
Watershed-control program: An effort designed to prevent contamination of source water.

Figure A
Governmental Chain of Command Notification Contacts (sample)

An example of how to fill out this form is given below. A reproducible form is provided on the following page.

Name (alphabetical)	Agency	Title	Office Phone Phone or Beeper	After-hours	Fax Number	E-mail Address
Aaronson, Aaron	*Water Control Center*	*Assistant Director*	*555-1234*	*555-4321*	*555-5678*	*aaronson@water.com*
Grimm, Benjamin	*Water Utility*	*Assistant Director*	*555-2345*	*555-5423*	*555-6789*	*grimm4@water.com*
Masterson, Eric	*EPA Regional Office*	*Asst. Region. Director*	*555-2344*	*555-7809*	*555-1092*	*masterson@epa.com*
Pym, Janet	*Mayor's Office*	*Executive Assistant*	*555-4667*	*555-7654*	*555-8901*	*pym@cityhall.gov*
Richards, Susan	*Public Affairs Office*	*Public Affairs Officer*	*555-5551*	*555-1111*	*555-5556*	*richards@cityhall.gov*
Stark, Anthony	*Dept. of Environ. Quality*	*Water Quality Assistant*	*555-2349*	*555-6543*	*555-0912*	*stark@deq.gov*

Governmental Chain of Command Notification Contacts

Name (alphabetical)	Agency	Title	Office Phone Phone or Beeper	After-hours	Fax Number	E-mail Address

Figure B
Major Water Users Notification Contacts (sample)

An example of how to fill out this form is given below. A reproducible form is provided on the following page.

Name (alphabetical)	Agency or Company	Title	Office Phone Phone or Beeper	After-hours	Fax Number	E-mail Address
Baggins, William	*City Airport*	*Manager*	*555-1834*	*555-4321*	*555-5678*	*baggins@air.gov*
Harfoot, Hubert	*Restaurant Association*	*Chair*	*555-2345*	*555-5493*	*555-6709*	*none*
Malory, Thomas	*Superintendent of Schools*	*Superintendent*	*555-2356*	*555-7849*	*555-1692*	*malory@schools*
Stewart, Marilyn	*Good Water Inc.*	*Plant Manager*	*555-4567*	*555-7567*	*555--5469*	*Stwart@cave.com*

Major Water Users Notification Contacts

Name (alphabetical)	Agency	Title	Office Phone Phone or Beeper	After-hours	Fax Number	E-mail Address

Figure C
Media Contact Form

Name (alphabetical)	Media Affiliation	Phone	FAX	E-Mail	Comments

Figure D
Information About Self-reported Or Physician-reported Cases

Name of person who is ill
(Last, First) _____

Today's date |__|__|-|__|__|-|__|__|
MM DD YY

Address_____
_____

Telephone No._____(home)
_____(work)

Sex_____ Age_____

Symptoms onset date |__|__|-|__|__|-|__|__|
MM DD YY

Still having symptoms now? Y N

Total duration of symptoms _____

Seen a physician? Y N

If yes, name and number_____
_____

If yes, diagnosis _____

Any laboratory work done? Y N

If yes, what type (probe for blood and stool)
_____

If yes, results (probe for *Cryptosporidium*, *Giardia*, *Cyclospora*) _____

Any of the following symptoms?

Diarrhea	Y	N
Nausea	Y	N
Vomiting	Y	N
Fever	Y	N
Weight loss	Y	N
Cramping	Y	N

Comments
_____
_____
_____
_____
_____
_____

Immune compromised in any way (HIV, cancer chemotherapy, organ transplant recipient)?
Y N If yes, specify _____

Are other family members ill with similar symptoms? Y N If yes, how many?_____
If yes, specify
_____

Relation	Sex	Age	Date became ill

Caller believes potential vehicle or source of the infection is_____

Report completed by _____

Figure E

Note: Text in regular type is to be read to the respondent.
Text in CAPITALS is an instruction for the interviewer and should not be read to the respondent.
Text in *italic* is a suggestion for modification of the questionnaire to tailor the document to the ongoing investigation.

CASE QUESTIONNAIRE FOR CASE-CONTROL STUDY

ID: |__|__|__|__|__| Interviewer: _____

Date of Interview: |__|__|-|__|__|-|__|__|
MM DD YY

Interview Outcome Code: |__|__|

TITLE OF YOUR SURVEY/CASE-CONTROL STUDY

WHEN YOU MEET THE SUBJECT:
Hello, my name is (YOUR NAME). I am from (STATE YOUR AFFILIATION). We are conducting a study designed to examine factors associated with the development of *state the disease you are studying*. I am here to speak with you about this study.

ARRANGE PRIVATE SETTING FOR INTERVIEW IF NOT DONE BY PHONE.
As I just mentioned, the purpose of this study is to *state specifically what the primary goal of the interview is, i.e., to collect information on exposure factors for acquiring* Cryptosporidium. Your help in this study is very important. Your participation is voluntary and all information you give will be kept confidential to the extent legally possible. Some of the questions may be sensitive. You may refuse to answer any question at any time. Neither your name nor any identifying information will appear on any report of the study.

ADMINISTER CONSENT FORM.

BEGIN INTERVIEW.

SECTION A: BACKGROUND INFORMATION

CIRCLE CODE FOR PARTICIPANTS GENDER
MALE..... 1
FEMALE..... 2

I would like to begin by asking you some basic questions about yourself.

A1. What is your full name? (LAST, FIRST, MI)_____

A2. What is your home address? (IF RESPONDENT REFUSES, ATTEMPT TO OBTAIN HIS/HER ZIP CODE, EXPLAINING THAT INFORMATION ON THE GENERAL AREA WHERE HE/SHE LIVES IS VERY IMPORTANT FOR EXPOSURE ASSESSMENT.)

_____

A3. What is your work address? (IF RESPONDENT REFUSES, ATTEMPT TO OBTAIN HIS/HER ZIP CODE, EXPLAINING THAT INFORMATION ON THE GENERAL AREA WHERE HE/SHE WORKS IS VERY IMPORTANT FOR EXPOSURE ASSESSMENT.)

_____

A4. What are your home and work phone numbers? (IF SUBJECT REFUSES FILL IN 8s IN THE BOXES. IF NONE, FILL IN 9s.)
|__|__|__|-|__|__|__|-|__|__|__|__| |__|__|__|-|__|__|__|-|__|__|__|__|
HOME WORK

A5. What is your date of birth? |___|___|-|___|___|
MONTH YEAR

A6. What racial or ethnic group do you consider yourself part of?
WHITE, NON-HISPANIC..... 1
BLACK, NON-HISPANIC..... 2
WHITE, HISPANIC..... 3
BLACK, HISPANIC..... 4
AMERICAN INDIAN/ALASKA NATIVE..... 5
ASIAN/PACIFIC ISLANDER..... 6
OTHER (SPECIFY)_____ 7
REFUSED..... 8
UNKNOWN..... 9

A7. What type of residence are you living in now? (*List the appropriate possibilities with codes for your population such as a private home, apartment, condominium, a group residence, a homeless shelter etc.... Codes should include 7 for other, 8 for refused, and 9 for unknown or blank responses.*)

A8. How many individuals currently live in your household? |__|__|

SECTION B: CLINICAL INFORMATION

(*The questions in this section relate to symptoms experienced by the case patient. Modify and/or delete as appropriate if the questionnaire is being used to interview a control patient.*)

Now I would like to ask you some questions about your illness.

B1. What was the approximate date your symptoms began? |__|__|-|__|__|-|__|__|
MM DD YY

B2. Do you currently have these symptoms?
YES..... 1
NO..... 2
REFUSED..... 8
UNKNOWN..... 9

B3. How long have you had these symptoms? (RECORD AS NUMBER OF DAYS. CROSS CHECK THE RESPONSE BY SUBTRACTING THE DATE OF THE INTERVIEW FROM THE DATE OF ONSET OF SYMPTOMS.) |__|__|__|

B4. Have you had any of the following symptoms? (READ AND CIRCLE ALL THAT APPLY. CLARIFY THAT THE DEFINITION FOR DIARRHEA IS THREE OR MORE LOOSE OR WATERY STOOLS IN A 24-HOUR PERIOD.)
Diarrhea..... 01
Nausea..... 02
Vomiting..... 03
Fever..... 04
Loss of weight or appetite..... 05
Cramping..... 06
Gas..... 07

Headache..... 08
Other (SPECIFY)_____ 77
REFUSED..... 88
UNKNOWN..... 99
NO SYMPTOMS..... 00 (GO TO B12)

B5. Have you consulted a health care provider for your symptoms?
YES..... 1
NO..... 2 (GO TO B8)
REFUSED..... 8 (GO TO B8)
UNKNOWN..... 9 (GO TO B8)

B6. What was his or her name, address, and telephone number?
_____
_____

B7. What was the diagnosis? (RECORD THE RESPONDENT'S ANSWER VERBATIM AND CODE LATER.)_____
_____ |__|__|

B8. Has any laboratory work been done, such as a blood test and/or a stool examination?
YES..... 1
NO..... 2 (GO TO B10)
REFUSED..... 8 (GO TO B10)
UNKNOWN..... 9 (GO TO B10)

B9. What were the results of the test(s)? (RECORD THE RESPONDENT'S ANSWER VERBATIM, AND VERIFY WITH THE LAB AND CODE LATER.)
BLOOD_____ |__|__|
STOOL_____ |__|__|

B10. Were you hospitalized as a result of your symptoms?
YES..... 1
NO..... 2 (GO TO B12)
REFUSED..... 8 (GO TO B12)
UNKNOWN..... 9 (GO TO B12)

B11. How many days were you hospitalized? |__|__|

B12. Do you have a weakened immune system ? In other words, are you HIV positive, receiving cancer chemotherapy, or an organ transplant recipient?
YES..... 1
NO..... 2
REFUSED..... 8
UNKNOWN..... 9

B13. Had you regularly been taking any medication before your symptoms began?
YES..... 1
NO..... 2 (GO TO LINE BEFORE B15)
REFUSED..... 8 (GO TO LINE BEFORE B15)
UNKNOWN..... 9 (GO TO LINE BEFORE B15)

B14. Tell me the name of this (these) medications. (RECORD THE RESPONDENT'S ANSWER VERBATIM AND CODE LATER.)
_____|__|__| _____|__|__|
_____|__|__| _____|__|__|

IF RESPONDENT LIVES ALONE, GO TO SECTION C.

B15. Are other members of your household ill with similar symptoms?

YES.....	1
NO.....	2 (GO TO SECTION C)
REFUSED.....	8 (GO TO SECTION C)
UNKNOWN.....	9 (GO TO SECTION C)

B16. How many members are ill? (CODE 88 FOR REFUSAL, 99 FOR UNKNOWN.) |__|__|

B17. What is his (her, their) relationship to you, and his (her, their) age and gender?

RELATION_____|__|__|	AGE |__|__|	GENDER (M=1, F=2) |__|
RELATION_____|__|__|	AGE |__|__|	GENDER (M=1, F=2) |__|
RELATION_____|__|__|	AGE |__|__|	GENDER (M=1, F=2) |__|

SECTION C: EXPOSURE INFORMATION

(*Questions in this section should be added, deleted, and/or tailored to the specific situation being investigated, and to whether the respondent is a case or control patient. The time of reference should be between 2 and 4 weeks before the onset of the illness.*)

I would like to move on to some questions about how you might have acquired your illness. First, I would like to concentrate on your exposure to water during the 2 weeks <u>before</u> you became ill. (EMPHASIZE THE TIME FRAME OF INTEREST.)

C1. What were your sources of drinking water at home? (READ AND CIRCLE ALL THAT APPLY.)

Municipal water from the tap.....	1 (GO TO C4)
Municipal water processed with a home filter.....	2
Well water.....	3 (GO TO C4)
Commercially bottled water.....	4 (GO TO C4)
(SPECIFY NAME)_____	
Other (SPECIFY)_____	7 (GO TO C4)
REFUSED.....	8 (GO TO C4)
UNKNOWN.....	9 (GO TO C4)

C2. Which brand(s) and model(s) of water filter have you been using? (CODE 8 FOR REFUSED AND 9 FOR UNKNOWN.)

Brand(s) _____ |__|

Model(s) _____ |__|

C3. When was the last time you changed the filter element? (CODE 8 FOR REFUSED AND 9 FOR UNKNOWN, E.G. 99-99.) |__|__|-|__|__|
MM YY

C4. What were your sources of drinking water at school or at work? (READ AND CIRCLE ALL THAT APPLY.)

Municipal water from the tap.....	01
Municipal tap water with more filtration at work.....	02
Municipal tap water filtered at home and taken to work...	03
Well water.....	04
Commercially bottled water.....	05
(SPECIFY NAME)_____	
Other (SPECIFY)_____	77

REFUSED..... 88
UNKNOWN..... 99
DOES NOT GO TO SCHOOL OR WORK..... 00

C5. Before you became ill, on average, how many glasses of water did you drink in a day? (RECORD THE NUMBER FOR HOME AND SCHOOL/WORK CONSUMPTION SEPARATELY. FILL IN 8s FOR REFUSED, 9s FOR UNKNOWN, AND 0s FOR NOT APPLICABLE.)

|__|__| |__|__|
HOME SCHOOL/WORK

C6. What was your usual source of ice during the 2 weeks before you became ill? (READ AND CIRCLE ALL THAT APPLY.)

Tap water from your home..... 1
Tap water from your school/work..... 2
Commercially bought ice..... 3
(SPECIFY BRAND AND LOCATION)
_____
_____
Does not use ice..... 4
Other (SPECIFY)_____ 7
REFUSED..... 8
UNKNOWN..... 9

C7. During the 2 weeks before you became ill, did you drink any beverage made with water, such as ice-tea or lemonade, at a restaurant, picnic, fair, or other social event?

YES..... 1
NO.....2 (GO TO C9)
REFUSED.....8 (GO TO C9)
UNKNOWN.....9 (GO TO C9)

C8. What was the name, date, and location of the event(s)?

NAME_____ |__|

LOCATION_____ |__|

DATE |__|__|-|__|__|-|__|__|
MM DD YY

(*Duplicate this information for each restaurant and/or event.*)

C9. During the 2 weeks before you became ill, did you swim in a pool, lake or river?

YES..... 1
NO.....2 (GO TO C15)
REFUSED.....8 (GO TO C15)
UNKNOWN.....9 (GO TO C15)

C10. Where did you swim?

BODY OF WATER_____ |__|

LOCATION_____ |__|

C11. Do you remember if you put your face in the water?

YES..... 1
NO.....2 (GO TO C15)
REFUSED.....8 (GO TO C15)
UNKNOWN.....9 (GO TO C15)

C12. Did you get any of the water in your mouth?
YES..... 1
NO..... 2 (GO TO C15)
REFUSED..... 8 (GO TO C15)
UNKNOWN..... 9 (GO TO C15)

C13. Do you remember accidentally swallowing any of the water?
YES..... 1
NO..... 2 (GO TO C15)
REFUSED..... 8 (GO TO C15)
UNKNOWN..... 9 (GO TO C15)

C14. Please estimate how much water you swallowed. (READ.)
A mouthful..... 1
Several mouthfuls..... 2
The equivalent of a glass..... 3
REFUSED..... 8
UNKNOWN..... 9

C15. During the 2 weeks before you became ill, did you bathe in a hot tub or jacuzzi?
YES..... 1
NO..... 2 (GO TO INTRO BEFORE C17)
REFUSED..... 8 (GO TO INTRO BEFORE C17)
UNKNOWN..... 9 (GO TO INTRO BEFORE C17)

C16. Where did you bathe in this hot tub or jacuzzi?
LOCATION_____ |__|

Now I would like to concentrate on your exposure to food during the 2 weeks <u>before</u> you became ill. (EMPHASIZE THE TIME FRAME OF INTEREST AGAIN.)

C17. During an average week, how many meals did you eat outside your home, including breakfast, lunch, and dinner, and any take out food ordered and brought home? (CODE 00 FOR NONE, 88 FOR REFUSED, AND 99 FOR UNKNOWN. IF NONE, THEN GO TO C19.)
NUMBER OF MEALS |__|__|

C18. How is food served at these restaurants? (READ AND CIRCLE ALL THAT APPLY.)
Take-out or Drive-thru..... 01
Buffet or Salad Bar..... 02
Sit-down restaurant..... 03
Other (SPECIFY)_____ 77
REFUSED..... 88
UNKNOWN..... 99

C19. During the 2 weeks before you became ill, how many times did you eat the following food items? (CODE 0 FOR NONE, 8 FOR REFUSED, AND 9 FOR UNKNOWN.)
Lettuce or garden salad..... |__|
Other cold salads such as coleslaw, potato salad, or pasta salad... |__|
Cold cuts, chicken salad, egg salad, or tuna salad..... |__|
Raw vegetables such as carrots, tomatoes, and cucumbers..... |__|
Raw fruits such as strawberries and raspberries..... |__|

C20. During the 2 weeks before you became ill, did you drink unpasteurized milk, unpasteurized apple juice, and/or eat any unpasteurized products?

YES..... 1
NO..... 2 (GO TO C22)
REFUSED..... 8 (GO TO C22)
UNKNOWN..... 9 (GO TO C22)

C21. What unpasteurized product(s) did you eat?

_____ |__|
A SPECIFY CODE
_____ |__|
B
_____ |__|
C
_____ |__|
D

C22. During the 2 weeks before you became ill, did you begin eating any new health foods or begin using any new dietary supplements?

YES..... 1
NO..... 2 (GO TO C24)
REFUSED..... 8 (GO TO C24)
UNKNOWN..... 9 (GO TO C24)

C23. What were these new products?

_____ |__|
A SPECIFY CODE
_____ |__|
B
_____ |__|
C
_____ |__|
D

C24. During the two weeks before you became ill, did you use any nontraditional or alternative treatments or therapies?

YES..... 1
NO..... 2 (GO TO C26)
REFUSED..... 8 (GO TO C26)
UNKNOWN..... 9 (GO TO C26)

C25. What product(s) did you use?

_____ |__|
A SPECIFY CODE
_____ |__|
B
_____ |__|
C
_____ |__|
D

C26. Before you became ill, where did you do most of your grocery shopping? (READ AND CIRCLE ALL THAT APPLY.)

(*List and code groceries found in the location being investigated. If there are specialty markets or stores, make sure to collect information on what products were bought at each store.*)

C27. During the 2 weeks before you became ill, did you go to any of the following bars, clubs, and/or discos? (READ AND CIRCLE ALL THAT APPLY.)

(*List clubs, bars etc...found in the location being investigated and code.*)

C28. During the 2 weeks before you became ill, did you attend any parties, weddings, receptions, banquets, or other events?

YES..... 1
NO..... 2 (GO TO INTRO BEFORE C30)
REFUSED..... 8 (GO TO INTRO BEFORE C30)
UNKNOWN..... 9 (GO TO INTRO BEFORE C30)

C29. What event(s) did you attend? (RECORD THE TYPE, THE LOCATION, AND THE DATE OF THE EVENT(S).)

EVENT_____ |__|

LOCATION _____ |__|__|-|__|__|-|__|__|
MM DD YY

(*Duplicate this information for each event.*)

I would now like to ask you a few questions about your travel history.

C30. During the 2 weeks before you became ill, did you travel within the state?

YES..... 1
NO..... 2 (GO TO C32)
REFUSED..... 8 (GO TO C32)
UNKNOWN..... 9 (GO TO C32)

C31. Please give me the locations and the number of days you spent at each location.

	_____	|__|__|	|__|__|
A	LOCATION	CODE	DAYS
	_____	|__|__|	|__|__|
B			
	_____	|__|__|	|__|__|
C			
	_____	|__|__|	|__|__|
D			

C32. During the 2 weeks before you became ill, did you travel to another state within the United States?

YES..... 1
NO..... 2 (GO TO C34)
REFUSED..... 8 (GO TO C34)
UNKNOWN..... 9 (GO TO C34)

C33. Please give me the name of the cities and states, and the number of days you spent in each state.

	_____	|__|__|	|__|__|
A	CITY/STATE	CODE	DAYS
	_____	|__|__|	|__|__|
B			
	_____	|__|__|	|__|__|
C			
	_____	|__|__|	|__|__|
D			

C34. During the 2 weeks before you became ill, did you travel to another country?

YES.....1
NO.....2 (GO TO INTRO BEFORE C36)
REFUSED.....8 (GO TO INTRO BEFORE C36)
UNKNOWN.....9 (GO TO INTRO BEFORE C36)

C35. Please tell me which country (ies) and the number of days you spent in each country.

	_____	|__|__|	|__|__|
A	COUNTRY	CODE	DAYS
	_____	|__|__|	|__|__|
B			
	_____	|__|__|	|__|__|
C			
	_____	|__|__|	|__|__|
D			

Next, I would like to ask you some questions about person to person and person to animal exposures.

C36. During the 2 weeks before you became ill, did you work or go to school outside of your home?

YES.....1
NO.....2
REFUSED.....8
UNKNOWN.....9

C37. During the 2 weeks before you became ill, were you involved in any of the following types of activities? (READ AND CIRCLE ALL THAT APPLY.)

Food handling..... 1 (GO TO C38)
Child care..... 2 (GO TO C39)
Animal care outside of household 3 (GO TO C40)
Patient care..... 4 (GO TO C41)
Other (SPECIFY)_____ 7 (GO TO C42)
REFUSED..... 8 (GO TO C42)
UNKNOWN..... 9 (GO TO C42)

C38. What type of food handling or preparation were you involved with? (READ AND CIRCLE ALL THAT APPLY.)

Hot food preparation..... 1
Cold food preparation..... 2
As server or waiter..... 3
As bartender..... 4
As salad bar/buffet organizer..... 5
Other (SPECIFY)_____ 7
REFUSED..... 8
UNKNOWN..... 9

C39. What type of child care work were you involved in? (READ AND CIRCLE ALL THAT APPLY.)

Out of home child care center..... 1
(SPECIFY NAME)_____
In-home child care center..... 2
Out of home babysitter..... 3
In-home babysitter..... 4
Other (SPECIFY)_____ 7
REFUSED..... 8
UNKNOWN..... 9

C40. What type of animal care were you involved in? (READ AND CIRCLE ALL THAT APPLY.)

Work in a pet store	1
Work on a farm	2
Work on a dairy farm	3
Dog walker	4
Dog groomer	5
Veterinarian	6
Other (SPECIFY)_____	7
REFUSED	8
UNKNOWN	9

C41. What type of patient care were you involved in? (READ AND CIRCLE ALL THAT APPLY.)

Physician	1
Nurse	2
Nurse's aid	3
Home health care worker	4
Other (SPECIFY)_____	7
REFUSED	8
UNKNOWN	9

C42. Do you have children in out of home child care?

YES	1
NO	2 (GO TO LINE BEFORE C44)
REFUSED	8 (GO TO LINE BEFORE C44)
UNKNOWN	9 (GO TO LINE BEFORE C44)

C43. Where is the out of home child care located?

NAME/ADDRESS_____ |__|

IF THE CASE PATIENT IS 5 YEARS OLD OR LESS, ASK QUESTION C44. OTHERWISE GO TO QUESTION C46.

C44. Does the child who is ill attend a child care center?

YES	1
NO	2 (GO TO C46)
REFUSED	8 (GO TO C46)
UNKNOWN	9 (GO TO C46)

C45. Where is the child care center located?

NAME/ADDRESS_____ |__|

C46. During the 2 weeks before you became ill, did you come in contact with anyone who had diarrhea, including (READ AND CIRCLE ALL THAT APPLY.)

Teenagers or adults	1
(SPECIFY)_____	
Children	2
(SPECIFY)_____	
Animals	3
(SPECIFY)_____	
REFUSED	8
UNKNOWN	9

C47. During the 2 weeks before you became ill, did you visit a person who was ill with an intestinal problem, e.g., diarrhea, nausea, or vomiting?

YES	1
NO	2 (GO TO C49)
REFUSED	8 (GO TO C49)
UNKNOWN	9 (GO TO C49)

C48. Where did you visit this person? (READ.)

In a hospital	1
In a nursing home	2
In a hospice	3
At their home	4
Other location	7
(SPECIFY)_____	
REFUSED	8
UNKNOWN	9

C49. During the 2 weeks before you became ill, did you visit anyone in a hospital, nursing home, and/or hospice?

YES	1
NO	2 (GO TO C52)
REFUSED	8 (GO TO C52)
UNKNOWN	9 (GO TO C52)

C50. What is this person's relationship to you, and his or her age and gender?
RELATION_____|__|__| AGE |__|__| GENDER (M=1, F=2) |__|

C51. Where was this person located?
LOCATION_____ |__|

C52. During the 2 weeks before you became ill, did you come in contact with children in diapers?

YES	1
(SPECIFY)_____	
NO	2
REFUSED	8
UNKNOWN	9

C53. During the 2 weeks before you became ill, did you come in contact with young animals, that is animals who are less than 6 months of age?

YES	1
NO	2 (GO TO INTRO BEFORE C56)
REFUSED	8 (GO TO INTRO BEFORE C56)
UNKNOWN	9 (GO TO INTRO BEFORE C56)

C54. How did you come in contact with these young animals? For example, were they (READ AND CIRCLE ALL THAT APPLY.)

Pets in a house	1
Animals on a farm	2
Animals in a petting zoo	3
Other (SPECIFY)_____	7
REFUSED	8
UNKNOWN	9

C55. What types of young animals did you come in contact with? (*List appropriate animals for this investigation or leave open ended as needed.*)

Finally, I would like to ask you a few questions about possible sexual exposures. Some of these questions may be very personal. I would like to remind you that you may refuse to answer any question at any time.

(*Design questions C56 and on to collect information on sexual practices that could involve oral exposure to fecal matter.*)

I would like to thank you very much for your time and cooperation in answering my questions.

END OF QUESTIONNAIRE

Figure F

State Contacts for Assistance with Waterborne Disease Outbreaks

State	Agency	Telephone Normal Office Hours	Emergency TelephoneFor After Normal Office Hours, Weekends, or Holidays	Contacts
AK	Division of Public Health	(907) 269-8000	(800) 478-0084	Ask for Elizabeth Funk
	Dept. of Environmental Conservation	(907) 269-7644		Ask for Janice Adair
AL	Dept. of Public Health	(334) 613-5200		General number. The name of a specific contact was not available at the time of publication.
AR	Dept. of Health	(501) 661-2573	(501) 661-2136	Ask for William Teer (recreational and private wells)
	Dept. of Health	(501) 661-2623	(501) 661-2136	Ask for Harold Seifert (coordinate with water officials)
AS	Dept. of Health Services	684-633-4606		General number. The name of a specific contact was not available at the time of publication.
AZ	Dept. of Health Services	(602) 230-5820	(602) 230-5820	State Epidemiologist
	Dept. of Environmental Quality	(602) 207-4619	(800) 234-5677	
CA	Dept. of Health Services	(916) 322-2308	(916) 328-3605	Ask for David Spath
CO	Dept. of Public Health and Environment Division of Water Quality	(303) 692-2000	(303) 756-4455	Ask for Patti Shwayder, Executive Director or Tom Looby, Director Holm, Director or Jerry Biberstine, Director of Drinking Water Section
CT	Dept. of Health	(860) 509-7333	(860) 509-8000	Ask for Gerald Iwan
DC	Office of Emergency Preparedness	(202) 673-7644	(202) 673-7644	
DE	Dept. of Health and Social Services	(302) 739-5410	(302) 335-4415	Ask for Ed Hallock
FL	Dept. of Health, Division of Environmental Health, Bureau of Environmental Health Programs	(904) 487-0004	(904) 487-0864	Ask for Ed Bettinger
FM	Dept. of Human Resources	691- 320-2619		General number. The name of a specific contact was not available at the time of publication.

State Contacts (continued)

GA	Dept. of Human Resources	(404) 657-2588	404-657-6534	Ask for Kathleen Toomey or Jim Drinnon
GM	Guam Environmental Protection Agency Guam Waterworks Authority Dept. of Public Health and Social Services	671-475-1638 671-632-9697 671-735-7205		
HI	Dept. of Health	(808) 586-4586	(808) 247-2191	Ask for Epidemiology Specialist on call
IA	Dept. of Public Health	(800) 362-2736	(515) 281-3561	Center for Acute Disease Epidemiology
ID	Dept. of Health and Welfare	(208) 334-5945		General number. The name of a specific contact was not available at the time of publication.
IL	Division of Public Water Supplies, IL EPA Division of Environmental Health, IL DPH	(217) 785-8653 (217) 782-5830	(800) 782-7860 (800) 782-7860	Ask for Roger Selburg for community water supplies Ask for Clinton Mudgett for all other water supplies
IN	Dept. of Environmental Management Dept. of Health	(800) 451-6027 (317) 233-7665	(317) 383-6144	
KS	Dept. of Health and Environment	(913) 296-0201	(913) 357-5683	Ask for Tim Monroe, Office of Epidemiologic Services
KY	Dept. for Public Health Dept. of Environmental Protection Dept. for Public Health (environmental health)	(502) 564-3261 (502) 564-3410 (502) 564-7398	(502) 223-4607	Ask for Clarkson Palmer Ask for Peggy Ryker Ask for David Nichols
LA	Office of Public Health Office of Public Health	(504) 568-5005 (504) 568-5996	(504) 488-7517 (504) 392-0887	Ask for Louise McFarland Ask for Mason Seals
MA	Dept. of Environmental Protection Dept. of Public Health	(617) 292-5500 (617) 983-6800	(617) 522-3700	
MD	Dept. of Health and Mental Hygiene Dept. of the Environment	(410) 767-6671 (410) 631-3588	(410) 795-2100 (800) 633-6101	Ask for Diane Dwyer or Epidemiology after hours Ask for Saeid Kasrael or Public Water Program after hours
ME	Maine Drinking Water Program	(207) 287-5674	(207) 821-0973	Ask for Paul Kempf; after hours, enter PIN #3563
MH	Majuro Hospital	692-625-3355/3399		General number. The name of a specific contact was not available at the time of publication.
MI	Dept. of Community Health	(517) 335-8024		General number. The name of a specific contact was not available at the time of publication.

State Contacts (continued)

MN	Dept. of Health	(612) 623-5414	(612) 623-5414	
MO	Dept. of Health	(573) 751-6113	(573) 893-7457	Ask for Caryl Collier
MP	Dept. of Public Health	670-234-8950		General number. The name of a specific contact was not available at the time of publication.
MS	Dept. of Health	(601) 960-7634		General number. The name of a specific contact was not available at the time of publication.
MT	Dept. of Public Health and Human Services	(406) 444-3986	(406) 444-4740	Ask for Todd Damrow
NC	Public Water Supply Section Div. of Epidemiology, Dept. of Environment	(919) 733-3232 (919) 733-3419	(919) 733-3419	Call for water supply problems Provides T/A to the Public Water Supply Section
ND	Resources for Water Quality Crisis	(701) 328-5211	(701) 328-2121	Ask for Rex Kern, Municipal Facilities
NE	Dept. of Health	(402) 471-0510	(402) 826-5550	Ask for Jack Daniels
NH	Dept. of Health and Human Services	(603) 271-4496	(603) 271-5300	Ask for Bureau of Disease Prevention and Control
NJ	Dept. of Environmental Protection Dept. of Health and Senior Services	(609) 292-5550 (609) 984-2193	(609) 292-7172 (609) 392-2020	Bureau of Safe Drinking Water Ask for Perry Cohen or Faye Sorhage (609-588-3121)
NM	Dept. of Health	(505) 827-0006	(505) 827-0006	Ask for epidemiologist on call
NV	Health Division	(702) 687-4750	(702) 687-4757	Ask for Richard Reighley or David Hunt
NY	Dept. of Health	(518) 458-6731	(518) 465-9720	Ask for Mike Burke, Center for Environmental Health
OH	Dept. of Health	(614) 466-2253		General number. The name of a specific contact was not available at the time of publication.
OK	Dept. of Health Dept. of Environmental Quality	(405) 271-3266 (405) 271-8062	(405) 630-3870 (800) 522-0206	Ask for Mike Crutcher, State Epidemiologist Ask for Larry Gales
OR	Health Division	(503) 731-4024	(503) 731-4030	
PA	Dept. of Environmental Protection	(717) 787-5027	(717) 787-4343	
PL	Palau Environmental Quality Protection Board	680-488-3600	680-488-1723	

State Contacts (continued)

PR	Dept. of Health	(787) 274-7602	(787) 782-3141	Ask for Carmen Desada
RI	Dept. of Health	(401) 277-2577	(401) 272-5952	
SC	Dept. of Health and Environment	(803) 737-4165	(803) 690-3756	Ask for Jerry Gibson or after hours, page consultant on call
SD	Dept. of Health	(605) 773-3754	(605) 224-8572	Ask for Garland Erbele
TN	Dept. of Health	(615) 532-8482	(615) 776-2028	Ask for Robert Taylor
TX	Natural Resource Conservation Commission	(512) 239-6020	(800) 832-8224	Ask for Steve Walden or Antony Bennett
UT	Dept. of Environmental Quality (Water)	(801) 536-4200	(801) 536-4123	
VA	Dept. of Health	(804) 371-2885	(804) 674-2400	Ask for Allen Hammer
VI	Dept. of Health	(809) 774-0117		General number. The name of a specific contact was not available at the time of publication.
VT	Dept. of Health	(802) 863-7240	(802) 863-6299	Ask for Susan Schoenfeld or epidemiologist on call
WA	Dept. of Health	(206) 361-2914	(206) 361-2914	Ask for John Kobayashi
WI	Division of Health Dept. of Natural Resources Public Water Section	(608) 267-9003 (608) 267-7651 (608) 266-2291	(608) 238-5064 (608) 233-5064 (608) 271-0362 (608) 238-1357	Jeffery Davis, MD, State Epidemiologist or Mary Proctor, Communicable Disease Epidemiology Unit Robert Krill, Bureau Director Robert Baumeister, Chief
WV	Dept. of Health and Human Resources	(304) 558-5358		Ask for Loretta Haddy or Cathy Slemp
WY	Dept. of Health EPA Region VIII - Denver	(307) 777-5596 (303) 312-6262	(307) 777-6186 (303) 312-6262	Ask for Gayle Miller or Bill Letson Ask for Mary Wu

Index

Definitions of many of the following terms can be found in “Key Words and Phrases,” on pages 25 through 27 of the Appendix.

Members of the Working Group on Waterborne Cryptosporidiosis

Larry Adams, David G. Addiss, Susan S. Addiss, Mosies Agosto, John Aldom, Diane Alwine, Chet Anderson, Michael J. Arrowood, Arthur Ashendorff, Anita Barry, Mary E. Bartlett, Michael Beach, Paul S. Berger, Dorena Bertussi, Sue Binder, Wayne Black, Kathleen Blair, Philip Bouton, Susan Boutros, Lance Bowen, Henry B. Bradford, Jr., Lynn M. Bradley, Jackie Bramblett, Michael H. Brodsky, Sandra Bullock-Iacullo, Rebecca L. Calderon, Gergory M. Carmichael, Abdul Chagla, Sim Chandler, Shih-Lieg Chang, Cynthia Chappell, Esther Chernak, Jennifer L. Clancy, Dean O. Cliver, Daniel G. Colley, Reagan Cook, Fred Cox, Gunther F. Craun, Nancy Culotta, Scott A. Damon, Lawrence Davis, Armah De La Cruz, Carmen Deseda, Debbie Dorman, Alfred Dufour, Herbert Dupont, James Elder, Walter W. Faber Jr., William Faber, Alexandra S. Fairfield, Ronald Fayer, Pamela Vossenas Fernandez, Linda A. Fisher, Kim R. Fox, Michael Franchini, Floyd Frost, Lynne S. Garcia, William C. Ghiorse, Susan Goldstein, M. Stephen Gradus, Lee Hall, Paul Hansen, Joseph F. Harrison, Fred Hauchman, Barbara L. Herwaldt, Fred Hicks, Anita K. Highsmith, Ronal Hoffer, Stephen A. Hubbs, Margaret Hurd, Judith Isaac-Renton, George J. Jackson, Walter Jakubowski, Dennis D. Juranek, Eric Juzenas, Jonathan E. Kaplan, Raymond L. Kaplan, Rick Karlin, William E. Keene, Henry Kim, Heidi Klein, Michael Kramer, Cheryl Lackey, Pat Lammie, Emerson Lamontaque, Marcel Layton, Zita Lazzarini, Mark W. LeChevallier, Vanessa M. Leiby, Deborah A. Levy, Carrie Lewis, Iris L. Long, William Lulves, William R. Mac Kenzie, Robin Massengale, James L. Mau, Mark A. McClanahan, Yves B. Mikol, Alexis M. Milea, James R. Miller, Michael Miller, Anne C. Moore, Robert D. Morris, Paul W. Nannis, Thomas Navin, Charles Nelson, Randall S. Nelson, Joseph F. O'Neil, Michael T. Osterholm, Thomas Outlaw, William F. Parrish, Linda Peterson, Fred Pontius, Lisa Ragain, Yvette Rauff, Michael Redman, Judy Rees, Stig Regli, Alan Roberson, Les Roberts, Joan Rose, Peggy A. Ryker, Mohammad Sarai, Tom Schaeffer, Mark Scharfenaker, Stephen Schaub, Neil Schram, Paul M. Schur, Anne Seeley, Michael Shriver, Ajaib Singh, James W. Smith, Rosemary Soave, Faye Sorhage, Jon Standridge, Mic Stewart, John Sullivan, Robert Sullivan, Jeffrey Swertseger, Jean Taylor, Ramon Torres, Tiffany Tran, Terry Troxell, Seema Verma, Eric A. Weiss, Margaret Whittaker, Tyrone Wilson, Robert Wood, Ronald Zabransky