# Volume 2: What causes the problem? A What to do for Water Suppliers following Diarrhoea Incidents

TT 297/07

### OTHER REPORTS IN THIS SERIES

This guide forms part of a series which is aimed at water supply agencies, water resources managers, workers in health-related fields as well as communities throughout South Africa. The guide is intended to provide awareness-building information to keep water supplies clean of microbial contaminations and thus reduce the incidence of water-related diseases.

The publication on this report emanates from WRC project no 1028: Guide on water-related microbial diseases.

The following documents form part of this series of Guides on the Management of Water-related Microbial Diseases:

- Vol 1 What is the problem? Disease Characteristics.
- Vol 2 What causes the problem? A What to do for Water Suppliers following Diarrhoea Incidents.
- Vol 3 How great is the problem? Health Impact Assessment.
- Vol 4 How dangerous is the problem? Communicating the Risk.
- Vol 5 What we and our children need to know Health & Hygiene Awareness.

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### **FOREWORD**

The water supplier is responsible for protecting the health of the public by providing safe water to the consumer. There is a growing concern about the general failure of authorities to understand the public health impact of waterborne and related infectious diseases. This handbook provides guidelines on how to determine that the water is safe as far as diarrhoea-related diseases are concerned.

The methods and materials in this handbook are not original, and can all be found in the many books and publications that abound in the fields of water management and epidemiology. No attempt is made in this handbook to discuss all the issues surrounding the recommended procedures – the relevant literature will provide far greater insight. What does set this handbook apart is the fact that it pulls together the relevant methodology from traditionally remote disciplines, the methodology that is required to find out whether cases of diarrhoea could be due to water consumption. To the best of our knowledge, no such handbook is currently available in South Africa.

# **PROJECT TEAM**

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To all those who took the time to send in their comments on the draft of this handbook distributed in early 2002, thank you.

Special Thanks to Bettina Genthe and Natasha Potgieter for supplying the cover pictures and Shereno printers for the outlay and inside pictures.

# STRUCTURE OF THE GUIDE

This guide consists of twelve parts

Part 1

Provides general information on the handbook.

Part 2

Discusses water-related diarrhoea diseases.

Part 3

Provides overview on the recommended approach to follow.

Part 4

Discusses data to be gathered on cases of diarrhoea.

Part 5

Assessing water quality failure in the distribution system.

Part 6

Investigating water treatment problems.

Part 7

Gathering evidence to link water quality and cases.

Part 8

Conducting epidemiological studies to investigate linkages.

Part 9

Determining whether the water is responsible for the diarrhoea cases.

Part 10

Determining actions to be taken.

Part 11

Providing guidelines how to communicate with the public.

Part 12

Assisting the water supplier on procedures to follow with help of flowcharts.

**Appendices:** 

Provide tables, graphs, checklists and procedures to document process.

List laboratories, major water suppliers, water quality related documents, epidemiological resources, water quality related laws, water-related diseases and questionnaires.



Par	t 1: INTRODUCTION	1
•	Purpose of this handbook	2
•	International concern	2
•	Target audience	2
•	Routine data and special investigations	2
•	Expertise required	2
•	Note to the water supplier manager	2
	·· · · · · · · · · · · · · · · · · · ·	
Par	t 2: WATER AND DIARRHOEAL DISEASE	3
•	Severity of the problem	4
•	Causes of diarrhoea	4
•	Tap water as a risk for diarrhoea	5
•	Water and outbreaks of diarrhoea	5
Dar	t 3: OVERVIEW OF THE RECOMMENDED APPROACH	7
•	They are blaming our water for the diarrhoea! What now?	8
•	Assess the situation	8
•	Gather evidence about the water	8
•	Gather evidence linking cases and water	8
•	Draw conclusions	8
•	Communicate the findings	8
•	Flowchart to assist the water supplier	9
Par	t 4: ARE THERE MORE CASES OF DIARRHOEA THAN USUAL?	11
•	Purpose	12
•	Responsibility	12
•	Epidemiological assistance	12
•	Background information	12
•	What must be done	14
•	Decide on source of data	14
•	Collect the data	15
•	Obtain standard reports of routinely collected data	15
•	Record details of diarrhoea-related complaints	15
•	Use daily tally sheets for recording non-routine health data	15
•	Obtain data from general practitioners or pathology laboratories	15
	Record data on summary sheet	18
	Different sources of water – implications for analysis	18
	Summarise historic data	18
	Compare current data with historic data	19
	Provide feedback to participants	19

Par	t 5: HAS THERE BEEN A WATER QUALITY FAILURE?	23
•	Purpose	24
•	Responsibility	24
•	Background information	24
•	What must be done	24
	Test for routine parameters	24
	Who should sample	25
	Guidelines on where to take samples	25
	Guidelines on how to sample	25
	<ul> <li>Guidelines on how often to sample and how many samples to take</li> </ul>	25
	Interpret the results	26
	Record the results	26
	Monitor results over time	27
	Compare water quality at different sites	28
Par	t 6: HAS THERE BEEN A WATER TREATMENT PROBLEM?	31
•	Purpose	32
•	Responsibility	32
•	Background information	32
•	What must be done	32
	Inspect water treatment process daily	32
	Record all problems in detail in log books	33
	Complete checklist daily	33
	Evaluate checklist	33
	Priority factors to check	33
Par	t 7: HAS THE PATHOGEN IDENTIFIED IN CLINICAL CASES ALSO BEEN FOUND	27
	IN THE WATER?	37
•	Purpose	38
•	Responsibility	38
•	What must be done	39
	Find out which pathogen has been isolated from clinical cases of diarrhoea	39
	Test the water for the same pathogen found in clinical cases	39
	What if no pathogen has been isolated from clinical cases?	40
	What if no pathogen has been isolated from the water?	40
	So what is the point in testing water for pathogens?	40

	: DOES AN EPIDEMIOLOGICAL STUDY SUGGEST A LINK BETWEEN /ATER AND THE DIARRHOEA?	42
		43
	irpose	44
	esponsibility	44
	oidemiological assistance	44
	ackground information	44
	hat must be done	45
•	Descriptive study of the cases	45
•	Develop a case definition  Find all cases in the outbreak	45
•		45 46
•	Develop a questionnaire  Conduct interviews to obtain the information	46 48
•		
•	Analyse the data	48 49
•	Develop hypotheses  Draw conclusions	49
•		49
• D	Analytic (case-control) study	49
	evelop a case definition and define a control	49
	entify cases according to the revised case definition nd controls	50
		50 50
	evelop a questionnaire nalyse the data	51
	raw conclusions	51
• Di	aw Conclusions	31
Part 9	: IS THE WATER RESPONSIBLE FOR THE DIARRHOEA?	53
• Pu	ırpose	54
• Re	esponsibility	54
• Ba	nckground information	54
• W	hat must be done	55
•	Summarize the evidence obtained during the investigation	55
•	Determine the likelihood that the water is responsible for the diarrhoea	56
•	Draw conclusions	58
Dart 1	0: WHAT ACTION(S) SHOULD YOU TAKE?	61
	• •	
	irpose	62
	esponsibility	62
	ackground information	62
	hat must be done	62
•	If there is no water treatment/quality problem and no epidemiological link	62
•	If there is no water treatment/quality problem but there is an epidemiological link	63
•	If there is a water treatment/quality problem regardless of whether there is also an	
	epidemiological link or not	63
•	Emergency response procedures	64

Part 11: KEEP THE PUBLIC INFORMED	67
• Purpose	68
• Responsibility	68
Background information	68
What must be done	68
Appoint a public relations person	68
<ul> <li>Make information easily available to the public</li> </ul>	68
Implement a consumer complaint procedure	68
Communication during a crisis	69
Part 12: FLOWCHART TO ASSIST THE WATER SUPPLIER	71
REFERENCES	77
APPENDICES	78
Appendix A • Glossary of terms	78
Appendix B • Form and tally sheets for recording and monitoring	81
Appendix C • Table and graphs recording test results of water samples	85
Appendix D • Routine checklists for monitoring water treatment	95
Appendix E • Example of a documented emergency response procedure	103
Appendix F • List of major/bulk water suppliers in South Africa	105
Appendix G • List of laboratories in South Africa that test water quality	106
Appendix H • Water-related documents and literature	107
Appendix I • Epidemiological resources	108
Appendix J • Acts and laws related to water quality monitoring in S.A.	109
Appendix K • Water-related diseases	111
Appendix L • Water quality guidelines	112
Appendix M • Assessing domestic water quality	115
Appendix N • The principle of indicator organisms as an assessment	116
Appendix O • Chronic diarrhoea of unknown origin	118

# **List of tables**

Table	4.1	Example of a form to be used for recording each diarrhoea-related complaint received by the water supplier	16
Table	4.2	Example of a tally sheet for recording number of diarrhoea-related reports/complaints per suburb	17
Table	4.3	Example of a summary sheet for recording number of diarrhoea-related reports/complaints per suburb	19
Table	4.4	Example of a summary sheet for historic data of number of diarrhoea-related reports/complaints per suburb	20
Table	5.1	General recommendations for number of samples and sampling frequency	26
Table	5.2	Recommended guidelines for selected parameters	27
Table	5.3	Sample table for recording test results of water samples at a specific site	27
Table	6.1	Sample filtration checklist	34
Table	8.1	Sample questionnaire for descriptive epidemiological study of cases of diarrhoea in Somewhere with onset since 1 January 2001	46
Table	8.2	Sample results of a descriptive study of 50 cases	48
Table	8.3	Sample results of a case-control study with 30 cases and 30 controls	51
Table	9.1	Questions to be answered when determining whether water could be responsible for an outbreak of diarrhoea	55
Table	9.2	Classification scheme for assessing the likelihood that the water is responsible for the cases of diarrhoea	56
Table	9.3	Guidelines for concluding whether the water could be responsible for the diarrhoea cases	58
Table	11.1	Sample consumer complaint procedure	69

# List of figures

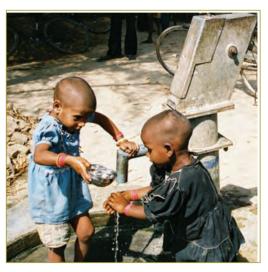
Figure 5.1	Sample graph of levels of turbidity by date for a specific sample site	28
Figure 5.2	Sample graph comparing levels of turbidity at different sample sites	28
List of ap	<u>pendices</u>	
Appendix A	A Glossary of terms	78
Appendix	B Form and tally sheets for recording and monitoring diarrhoea-related complaints	81
Appendix (	C Table and graphs for recording test results of water samples	85
Appendix	D Routine checklists for monitoring water treatment	95
Appendix	E Example of a documented emergency response procedure	103
Appendix	F List of major/bulk water suppliers in South Africa	105
Appendix (	G List of laboratories in South Africa that test water quality	106
Appendix	H Water-related documents and literature	107
Appendix	I Epidemiological resources	108
Appendix J	Acts and laws related to water quality monitoring in South Africa	109
Appendix	K Water-related diseases	111
Appendix	L Water quality guidelines	112
Appendix	M Assessing domestic water quality	115
Appendix	N The principle of indicator organisms as an assessment of water quality	116
Appendix (	O Chronic diarrhoea of unknown origin	118

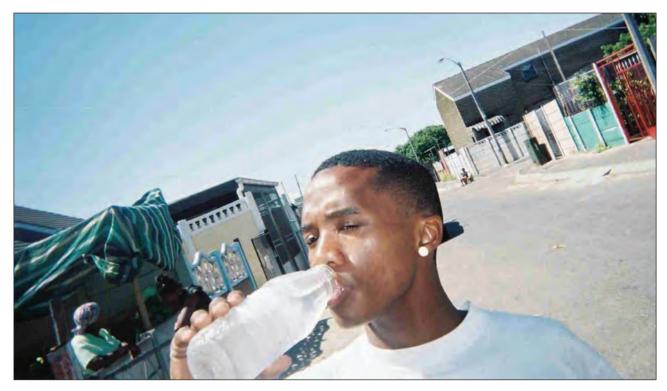


# PART 1

# Introduction







# Purpose of this handbook

When cases of diarrhoea occur in the community, the public is often very quick to blame the water. Confidence in the quality of the water can then only be restored if the allegation has been investigated to the satisfaction of the public. This handbook provides practical guidelines on how to conduct such an investigation.

#### International concern

Internationally there is growing concern about the general failure of authorities to understand the public health impact of water-borne and related infectious diseases. This was the subject of discussion at an international colloquium, representing 12 countries, held in Ecuador in 1995.

# Target audience

The target audience for this handbook includes both the water supplier and the district health services, for example the water quality officer and the Environmental Health Practitioner. The successful implementation of the recommended procedures depends on the involvement of both sectors.

All water suppliers, however large or small, should take note of the guidelines provided in this handbook.

# Routine data and special investigations

The water quality and water treatment data routinely collected by the water supplier form an important starting point in finding out whether the water could be responsible for cases of diarrhoea. This handbook shows how to record and interpret such routine data appropriately so that they facilitate the investigation. Special investigations, such as an outbreak response investigation, may be required in addition to the routine monitoring of water quality and water treatment. A flowchart to help the water supplier decide on the necessary steps in the investigation is presented in part 12.

# **Expertise required**

Some of the recommended procedures in this handbook can be done with little or no special training. Literacy and an enquiring mind are essential characteristics! However, when special investigations such as an outbreak response investigation are required, it will be necessary to call upon the assistance of an epidemiologist. Appendix I provides some guidelines on where to find epidemiologists. The flowchart in part 12 should help in determining when to involve assistance from outside the organisation.

# Note to the water supplier manager

The contents of this handbook may look formidable at first glance. The temptation to put this handbook on a shelf without taking proper note of its contents may be very strong. It is suggested that a person in the organisation is made responsible for studying the methods and recommendations outlined in the handbook. This person should feel comfortable – even enjoy - working with numbers. He or she can then make suggestions as to how the methods and recommendations can be implemented in the organisation.

# PART 2

# Water and diarrhoeal disease







# Severity of the problem

It is estimated that, at any one time, people with water-related disease occupy half the hospital beds in the world (2). Worldwide, more than 18 million people die each year as a result of waterrelated diseases (3). Although the mortality of many water-borne diseases is generally low, their socio-economic impact in both the developed and developing world is severe.

In South Africa in 1995, 43 000 people died from diarrhoeal disease (4). The financial implications are enormous. Diarrhoeal disease costs South Africans an estimated R3.4 billion every year (5). This estimate is based on the direct costs of the 3 million cases of diarrhoea that need treatment every year, out of the total of 24 million diarrhoeal cases per annum estimated for South Africa. Diarrhoeal disease is the leading cause of death for children aged 1 to 5 years in South Africa, accounting for one-fifth of all deaths in this age group (4).

Whether these estimates are accurate or not, the impact of water related and diarrhoeal disease remains indisputable. Improvements in wastewater disposal, protection of water sources and the treatment of water supplies have reduced the incidence of water related diseases in many developed countries. In South Africa, with its mix of developed and developing areas, the problem still remains.

#### Causes of diarrhoea

Numerous micro-organisms (bacteria, viruses, parasites) that can cause diarrhoea may be found in faecally polluted water. A list of such pathogens is presented in appendix K. It is impossible to analyse the water on a routine basis for all the potential pathogens that could cause a health problem as a result of exposure to the water.

Many of these water-related pathogens can also be transmitted via food, contaminated utensils and soil, or through person-toperson contact. This complicates the investigation into finding out whether a specific water source could be responsible for an outbreak of diarrhoea.



# Tap water as a risk factor for diarrhoea

Several large-scale epidemiological studies have recently investigated tap water as a risk factor for gastroenteritis.

In two separate prospective studies conducted between 1989 and 1997, researchers in Montreal, Canada found that between 14% and 40% of gastroenteritis cases were due to tap water meeting the drinking water quality guidelines! (6,7). This has resulted in questioning the notion that coliform-free drinking water is pathogen-free. In addition, the value of current drinking water quality indicators is questioned.

As a result of the Canadian studies, the Australians conducted a similar type of study in Melbourne (8). They found no association between drinking water and diarrhoeal disease.



The Americans have also started a study to investigate the incidence of diarrhoea associated with drinking tap water (9), based on the notion that "water utility managers may find it worth a couple of million dollars to do such a study in your area to either confirm or refute claims that your water is making them ill". This study will form part of a much larger initiative, one that is geared towards estimating the occurrence of water-borne disease due to drinking water across the US as a whole. A study such as the one being undertaken in a city in Iowa costs in the order of 3.5 million dollars!

### Water and outbreaks of diarrhoea

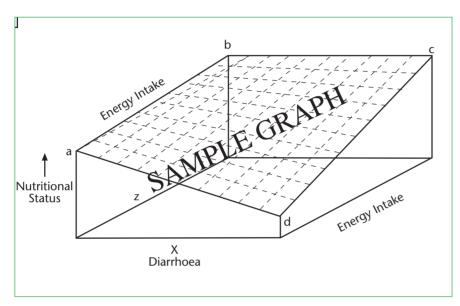
The intervention studies mentioned in the previous section were designed to examine the issue of endemic disease, where water may be suspected of causing a low proportion of community illness on a continuous or semi-continuous basis. The size and cost of these studies is large because they are trying to detect a relatively low level of risk and because they involve long-term follow-up of study participants. Such studies fall outside the realm of this handbook.

Rather, this handbook focuses on the potential role of water in an outbreak of diarrhoea in the community. The recommended approach for water suppliers is:

- to monitor water treatment problems and water quality routinely, and
- to conduct a small-scale epidemiological investigation when an outbreak of diarrhoea is blamed on the water.

# PART 3

# Overview of the recommended approach







# Part 3 • Overview of the recommended approach

# They are blaming our water for the diarrhoea! What now ...?

The water supplier will want to know whether the water is responsible for the diarrhoea or not. It is not sufficient to know that the quality of the water meets the required standards or not, although this does form part of the answer. A more definitive answer requires epidemiological information, information that links the cases of diarrhoea with the water. Obtaining such epidemiological information requires the involvement of the district health services and the advice of an epidemiologist.

The recommended approach consists of monitoring routine water quality and water treatment data and using appropriate epidemiological techniques, aimed at obtaining relevant information that will enable the water supplier to decide whether the water is at fault or not. Each component of the investigation is briefly described below; more detailed guidelines are provided in the following chapters.

# Assess the situation (Part 4)

Part 4 focuses on epidemiological techniques used to determine whether there is an outbreak of diarrhoea or not. These techniques attempt to answer the question – are there more cases of diarrhoea than usual or not?

# Gather evidence about the water (Part 5 and 6)

The water supplier needs to ensure that there have been no water treatment problems and no consequent water quality failures. Techniques that facilitate the recording and monitoring of the appropriate information are described. Routine monitoring of the water quality and the treatment process is essential in determining whether the water could be responsible for an outbreak of diarrhoea. Even more important, routine monitoring can signal the potential for a problem, enabling the water supplier to take appropriate corrective action and thus prevent the problem from occurring.



#### Gather evidence linking cases and water (Part 7 and 8)

Guidelines for conducting investigations to find out whether the cases of diarrhoea are linked to the water.

## Draw conclusions (Part 9 and 10)

Once all the evidence has been obtained, the water supplier has to assess the likelihood of the water being responsible for the diarrhoea. A classification scheme is presented to facilitate this process. In addition, guidelines on what action(s) should be taken subsequently are described.

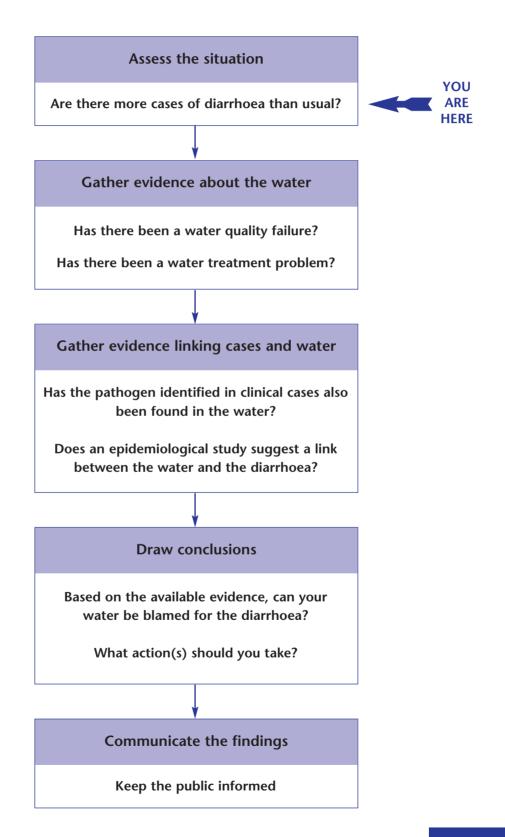
#### Communicate the findings (Part 11)

To maintain the confidence of the public in the quality of the water, it is crucial to be as transparent as possible about the entire investigative process. Suggested procedures for keeping the public informed are provided.



# Flowchart to assist the water supplier (Part 12)

To assist the water supplier in deciding on the appropriate procedures to follow in the investigation of a diarrhoea-related problem, a flowchart is presented in part 12. This flowchart indicates when the water supplier should involve the local Department of Health in the investigation and when to call for the services of an epidemiologist.



# PART 4

# Are there more cases of diarrhoea than usual?







# Part 4 • Are there more cases of diarrhoea than usual?

# **Purpose**

To determine whether there is an outbreak of diarrhoea in the community, i.e. whether there are more cases of diarrhoea than usual.

# Responsibility

This activity falls within the responsibility of the district health services. However, since it may be in the interest of the water supplier to have this information, he/she should initiate the process when appropriate. Depending on the approach used, it may be advisable to include an epidemiologist and a microbiologist on the team.

# **Epidemiological assistance**

This chapter provides some guidelines on how to find out whether there is an outbreak of diarrhoea or not. However, no guidelines can cover all the issues that arise in a specific situation. For this reason, it is recommended that an epidemiologist be consulted to help design the most appropriate methodology for the given circumstances.

# **Background information**

Each and every report of a possibly water-related diarrhoea problem in the community should alert the water supplier to check that all systems for monitoring water quality and water treatment are in place and functioning smoothly (see part 5 and 6).

Epidemiological studies (as described in part 8) are extremely useful in determining whether there is a link between cases of diarrhoea and the water. However, they do require extra resources and it is therefore not advisable to embark on such studies on the basis of an isolated report of a diarrhoea problem. One would want confirmation that there is an outbreak of diarrhoea before initiating an epidemiological investigation.

By definition, an outbreak of diarrhoea exists if there are more cases of diarrhoea than is normal.

What is meant by *normal?* This is generally taken to be the number of cases seen in the past. Since diarrhoea is a seasonal condition, it is important to compare the number of cases currently seen with the number of cases seen in past years during the same month(s).

What constitutes *more cases*? Does an excess of 5 cases represent an outbreak? Or 10? Or 100? There is no easy answer to this question. For the purpose of this handbook, it is recommended that a number double that seen in the past be regarded as an outbreak.

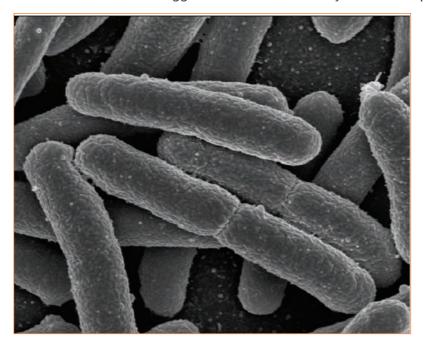
To answer the question whether there are more cases of diarrhoea than normal, one must have historical data on the number of cases as well as know how many cases there are at present. It is crucial that the cases referred to in the past and in the present represent the same type of cases. For example, it would not be valid to compare the number of current self-reported cases with the number of cases of diarrhoea in infants admitted to hospital in the past.

Data on the number of cases of diarrhoea can be obtained from



several sources. No single source provides data on all cases of diarrhoea in the community. Despite this obvious under-count of cases, it is valid to compare the number of cases over time if the same source is used throughout and if the degree of under-count remains constant.

Four sources of data are suggested for consideration by the water supplier:



- The number of diarrhoea-related reports/complaints received by the water supplier. This information is readily available to the water supplier and does not require the assistance of the district health services.
- Routine data collected by the district health services, such as statutorily notifiable medical conditions (e.g. cholera) and number of children presenting with diarrhoea at clinics. Use of this information, which should be easily available, will require the involvement of the district health services.
- The number of cases of diarrhoea seen by general practitioners. Special procedures will have to be initiated in collaboration with the district health services in order to obtain this information. Although this approach requires more resources than the above two approaches, the data obtained is likely to be more useful cases of all ages will be included and relevant clinical details may be obtained.
- The number of diarrhoea-related faecal specimens submitted to pathology laboratories, regardless of whether they test positive or not.
- The number of faecal specimens that test positive for diarrhoea-related organisms from pathology laboratories.

Guidelines for obtaining data from these sources are provided in the next section.

There are two general approaches to collecting the data:

- Prospective collection of data. This implies that the data are collected continuously over time and are therefore readily available when a crisis occurs. This approach allows the water supplier/district health services to monitor the situation on an on-going basis and to detect an outbreak of diarrhoea early in the outbreak. This is the recommended approach.
- Retrospective collection of data. Here the necessary data are collected only when a crisis has arisen and the water supplier needs to know whether the number of cases of diarrhoea is more than normal. One disadvantage of this approach is that it may be difficult to find all the data, particularly the historical data. Another obvious disadvantage is that there may be considerable delay in finding an answer to the question, since the data first have to be obtained.

# Part 4 • Are there more cases of diarrhoea than usual?

### What must be done

This section provides a framework and some ideas on how to determine whether there really is an outbreak of diarrhoea. To develop the most suitable approach for your circumstances, it is advisable to include an epidemiologist on the team.

# Decide on source of data

In order to decide on which data to collect, you will first have to explore the possibility of each option.

- Number of diarrhoea-related reports/complaints. Does your organisation receive such reports? From experience (or looking back in the records), are there more reports/complaints during some months than others? If the answer is yes to both these questions, then this is a viable option.
- Routine data collected by the district health services. The viability of this option needs to be explored in collaboration with your local Department of Health. Are any diarrhoea-related data collected routinely by public sector health facilities? Are these data summarised per month or shorter period? Would your local Department of Health be willing to supply you with the data? A yes to each of these questions means that this is a viable option.
- Number of cases of diarrhoea seen by general practitioners. This option needs to be investigated together with your local Department of Health. Are there any general practitioners willing to supply you with the number of cases of diarrhoea seen per month? To do so means



extra work for the practice - recording and adding up the numbers each month. You are more likely to get their cooperation if you (or the district health service) offer some assistance in reducing the work and/or minimising any associated costs for the practice, e.g. you could offer to phone the practice each month to obtain the information rather than expect the practice to do the phoning. Are there willing practitioners throughout the geographic area supplied by your water? If you cannot find a willing general practitioner in certain suburbs, then you will not be able to detect an outbreak that affects primarily these areas. To answer these two questions, you will have to contact as many general practitioners as possible and find out whether each is willing to participate in such an activity. This is a viable option if the answer is yes to both questions.

• Number of diarrhoea-related faecal specimens submitted to pathology laboratories and/or the number of faecal specimens that test positive for diarrhoea-related organisms. Do you know to which pathology laboratories general practitioners in your supply area send specimens from patients? Are they willing to supply you with the number of specimens tested for diarrhoea-related organisms and the number positive each month?

### Collect the data

# Obtain standard reports of routinely collected data

If you have decided to use data routinely collected by the district health services, such as the number of underfives with diarrhoea, then you need to organise with your local Department of Health to obtain these data each month. The data are probably already summarised on standard forms. Note that it is not essential to get these data from every health facility. One facility per suburb will suffice. Ensure that you receive the data from every participating facility every month, even if a facility has seen zero cases of diarrhoea.

# Record details of diarrhoea-related complaints

If you are going to monitor diarrhoea-related complaints, you should use a standard form to record the details of each complaint. An example of such a form is shown in Table 4.1 and in appendix B. The amount of information recorded on the form should be limited to the essentials. Contact details are important in case it becomes necessary to obtain further information at a later stage.

It is important that copies of such forms be distributed to all staff members who may receive complaints so that they can immediately record the information. Completed forms should be sent immediately to the person responsible for monitoring the complaints.

# Use daily tally sheets for recording non-routine health data

For health data that are normally not routinely collected, such as the number of diarrhoea-related reports/complaints or the number of diarrhoea cases seen by general practitioners, it is useful to draw up a tally sheet that will facilitate the recording and adding up of the required information. A suggested format for such a tally sheet is given in appendix B. Copies will have to be supplied to participating general practitioners and pathology laboratories and training given to the person responsible for recording the information. An example of the use of this tally sheet is shown in Table 4.2.



### Obtain data from general practitioners or pathology laboratories

If you are collecting data from general practitioners or pathology laboratories, you will have to organise collection of the tally sheets each month. Alternatively, if the practice or laboratory is prepared to do all the adding up, then you may organise to phone each month to get the information from the practice or laboratory. Ensure that you receive the data from every participating practice or laboratory every month, even if the number of diarrhoea cases or number of positive specimens is zero.

# Part 4 • Are there more cases of diarrhoea than usual?

# Table 4.1 Example of a form to be used for recording each diarrhoea-related complaint received by the water supplier

Name of person lodging complaint	Mrs C Jones	
Telephone number (home)	011 - 123 1234	
Telephone number (work)	011 - 987 9999	
Address	12 First Avenue, Yellow Suburb	
Capacity of person  Name of media	Professional Media (health)	
Nature of complaint  Specify if 'Other'	Diarrhoea Other	
Details of diarrhoea:		
Number of cases	1	
If more than 1 case	Members of 1 family Different families	
Approximate date when diarrhoea started (in first case)	23 January 2002	
Address of case(s)	As above	
Name of person receiving complaint	Fill Record	
Date complaint received	26 January 2002	

Table 4.2 Example of a tally sheet for recording number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

Day	Suburb		All
	Green	Yellow	suburb
1	1	2	3
2	0	1	1
3	3	0	3
4	1	0	1
5	1	1	2
6	2	3	5
7	8	2	10
8	12	1	13
9	15	0	15
10	14	0	14
11	9	9	18
12	11	14	25
13	6	8	14
14	4	6	10
15	2	9	11
16	3	2	5
17	1	1	2
18	2	3	5
19	0	1	1
20	1	1	2
21	3	2	5
22	0	1	1
23	0	0	0
24	2	1	3
25	1	0	1
26	2	0	2
27	3	2	5
28	0	3	3
29	0	1	1
30	1	0	1
31	•	•	•
Total	108	74	182

# Interpretation of data recorded in Table 4.2

On 7 September, 8 diarrhoea-related complaints were received from Green suburb. This was a noticeable increase over the daily number received in previous days – between 0 and 3. The water supplier should have been alerted to a possible problem by these 8 reports and the numbers reported over the following days.

A similar pattern was noticed in Yellow suburb, but the increase in reported numbers occurred several days after that in Green suburb, namely on 11 September.

By 16 September, the reported number of cases had reduced to the normal expected number, indicating that the problem had resolved itself or had been resolved.

#### Record data on summary sheet

Whatever the source of data being used, the information should be summarised on an annual summary sheet such as the example in Table 4.3. Add up the number of diarrhoea cases seen by all participating practices/facilities for each month of the year and enter it on the summary sheet.

The suggested format for this summary table is provided in appendix B.

#### Different sources of water - implications for analysis

If more than one water supplier serves a particular area, or if there is more than one source of water in an

area, then this has implications for the recording and interpretation of the data. If the source of water is ignored during the recording of complaints (or is unknown), then multiple complaints from a particular area may lead to much effort in tracing problems in one source of water, whilst, in fact, it may be the other source that is at fault. Complainants may not be able to identify the source of water. For this reason, recording exact address will aid the water supplier in identifying the water source. In informal settlements with no exact physical street addresses, some other means of identifying geographical location will have to be used.

### Summarise historic data

Once you have collected the data for a couple of years, you can summarise the data by month across years. It is recommended that the average number of diarrhoea cases per month be calculated across a 3-year period. A sample form that can be used to summarise the historic data is presented in appendix B. Its use is shown in Table 4.4.

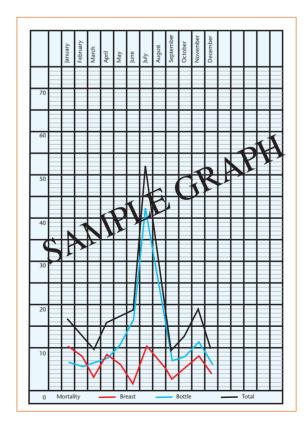


Table 4.3 Example of a summary sheet for recording number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

Number of diarrhoea-related reports received in (year) 2001				
Month	Suburb		All	
MOHUI	Green	Yellow	suburbs	
Jan	38	31	69	
Feb	45	37	82	
Mar	67	62	129	
Apr	89	71	160	
May	51	34	85	
Jun	26	21	47	
Jul	22	16	38	
Aug	49	39	88	
Sep	108	74	182	
Oct	98	65	163	
Nov	81	49	130	
Dec	42	30	72	
Total	716	529	1245	

## Interpretation of information in Table 4.3

Both suburbs Green and Yellow show a similar pattern in the monthly number of complaints received. The numbers increase in March and April, are lowest in June and July, and then increase again during the months September to November.

# Compare current data with historic data

As soon as you have received all the data for the month, compare the number of cases of diarrhoea with the average number seen for the same month in the previous three years. If the current number is twice as high as the historic average number, regard the current situation as an outbreak. Keep in mind the possible influence of public holidays and school holidays, especially if they fall in different months from one year to the next.

# Provide feedback to participants

If you are using data from a source other than within your own organisation, it is only polite to provide the participants with some feedback. Such feedback can take many forms, e.g. a table showing the current number of cases per month for the entire area and the corresponding average number over the past three years. The format of the feedback and the frequency with which it is produced should be part of the agreement with the participating practices/facilities/laboratories. Once agreed upon, it should be provided for the duration of participation by each practice/facility/laboratory.

# Part 4 • Are there more cases of diarrhoea than usual?

Table 4.4 Example of a summary sheet for historic data of number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

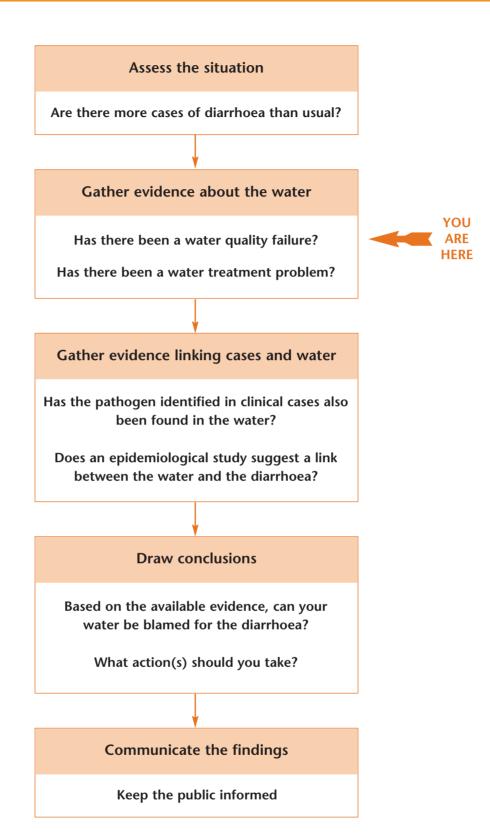
Average number of diarrhoea-related reports received from (year) 1998 to year 2000

Month	Suburb		All
WOILLI	Green	Yellow	suburbs
Jan	28	23	51
Feb	32	25	57
Mar	49	45	94
Apr	61	54	115
May	37	31	68
Jun	24	17	41
Jul	17	12	29
Aug	37	27	64
Sep	50	40	90
Oct	43	38	81
Nov	47	31	78
Dec	33	23	56
Total	458	366	824

Interpretation of monthly number of complaints in 2001 (Table 4.3) compared with historic data for 1998-2000 (Table 4.4)

The number of reports received during 2001 each month is less than twice the corresponding historic monthly average, except for the months September and October. For example, in August 2001, 88 complaints were received; this is slightly higher than the historic average of 64. In September 2001, 182 complaints were received; this is more than double the historic average of 90 complaints and could therefore indicate an outbreak of diarrhoeal disease.

# Are there more cases of diarrhoea than usual? • Part 4



# PART 5

Has there been a water quality failure?







# Part 5 • Has there been a water quality failure?

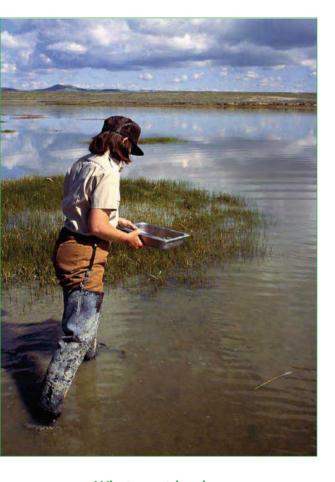
# **Purpose**

To find out whether there has been a water quality failure that could have resulted in cases of diarrhoea.

# Responsibility

This is the responsibility of the water supplier, in accordance with the Water Services Act, No. 108 of 1997 (see appendix J).

# **Background information**



Water is often blamed when diarrhoea occurs in the community. The opposite may also be true, where diarrhoea caused by the water, even water that meets the quality guidelines, may occur in the community without being noticed.

A number of tests should be included when analysing domestic water quality. The emphasis here is on those parameters that are relevant to diarrhoea. The parameters discussed are not directly related to the water being able to cause diarrhoea - such tests are too costly to do on a regular basis (see part 7) - but they give an indication of the general water quality. For example, the presence of faecal coliforms or E. coli indicates that faecal pollution may have occurred whilst the CI2 concentrations give an indication of whether disinfection has been effective or not.

A few other parameters, not dealt with here, may also be related to diarrhoea. For instance, magnesium and sulphate in high doses are both known to cause diarrhoea, as do some toxins. However, it is the exception that these parameters are the cause of an outbreak of diarrhoea.

A handy table, specifying which parameters must be included when assessing domestic water quality at different points in the supply system and from different sources, is reproduced in appendix M.

# What must be done

### Test for routine parameters

Test the water for the following parameters on a routine basis:

- E. coli or faecal coliforms (since faecal coliforms can be derived from non-faecal sources, E. coli should be the preferred parameter)
- Free available chlorine
- Turbidity (NTU)
- Electrical conductivity (EC).

Immediately investigate these parameters if any complaints are received.

#### Who should sample

For routine monitoring purposes, the water supplier is required to sample at all points under his/her responsibility at a required frequency, in accordance with the Water Services Act, No. 108 of 1997. The water supplier is also required to report annually to the Minister of Water Affairs and Forestry.

When there is a problem which requires investigation, all stakeholders – the water supplier, the Department of Health and the Department of Water Affairs and Forestry – should jointly decide on a sampling strategy to ensure consistency.

#### Guidelines on where to take samples

Where samples are taken depends on what you are trying to assess. For instance, you need to sample the raw water source to find out what the starting quality of the water is. Sampling a point after treatment will show whether the treatment process is working or not.

It is very important that the water quality be assessed at different points in the distribution system. This ensures that the results reflect the true quality of the water received by consumers and not just that at one particular site. A map of the distribution system is essential in selecting sampling sites. It is also important to include areas where the water quality might deteriorate. For instance, dead-ends where the water does not flow much and has a chance to deteriorate should be included. Places within the distribution system where sensitive people are exposed must also be included e.g. hospitals, crèches and old-age homes.

#### Guidelines on how to sample

The test results of samples are only as good as the samples themselves. However good a laboratory is, if the sample is of poor quality then the results cannot be reliable. It is therefore critical to follow correct sampling procedures. These are described in Quality of Domestic Water Supplies Volume 2 Sampling Guide (10).

# Guidelines on how often to sample and how many samples to take

The number of samples and how often to sample depends on the type of water source (ground water or surface water) and how many people are supplied with the water. Table 5.1 provides general recommendations.

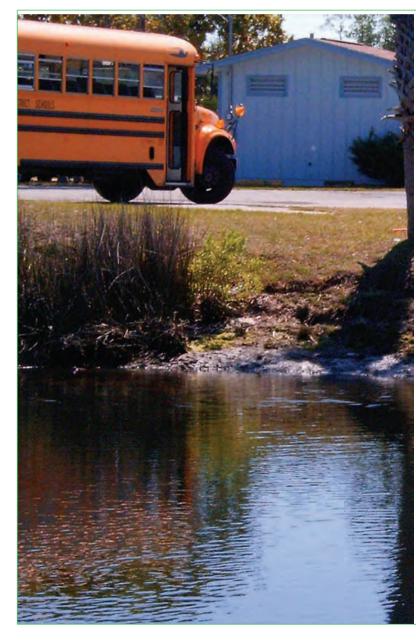


Table 5.1 General recommendations for number of samples and sampling frequency

Sampling point	Sampling point Number of samples per point per year		Sampling frequency per point		
	Recommended	(Minimum)	Recommended	(Minimum)	
S River/stream/ O spring/dug-well	26	(4)	2-weekly	(3-monthly)	
R Dam	12	(2)	monthly	(6-monthly)	
C E Borehole	2	(1)	6-monthly	(-)	
Treatment works	12/52/365	(4)	Monthly/ weekly/daily	(3-monthly)	
Point of use	12/52/365	(4)	Monthly/ weekly/daily	(3-monthly)	

Extracted from Quality of Domestic Water Supplies. Volume 2: Sampling Guide (DWA&F, DoH, WRC, 2000)

#### Interpret the results

Compare the value obtained for each sample with the recommended guidelines for the corresponding parameter (Table 5.2) to determine whether the value falls within the acceptable range.

If the faecal coliform or *E. coli* counts exceed 100 per 100 ml, immediately retest to determine whether a true risk exists and immediately investigate the possible cause for this excess.

If the turbidity results exceed 50 NTU, investigate the possible reasons before carrying out any remedial action.

#### **Record the results**

Record the test results in an easily accessible format. A suggested format is shown in Table 5.3 and appendix C. The test results of water samples taken from a specific site on different dates are recorded in the table. For each substance other than faecal coliforms and E. coli, calculate the maximum and average results over the time period in the table. For faecal coliforms and E. coli counts, calculate only the maximum.



Table 5.2 Recommended guidelines for selected parameters

Damanatan	Description				
Parameter	Ideal	Good	Marginal	Poor	Unacceptable
Faecal coliforms / E. coli (per 100 ml)	0	0 - 1	1 - 10	10 - 100	> 100
Cl <sub>2</sub> (mg/l)	0.3 - 0.6 or	0.2 - 0.3 or 0.6 - 0.8	0.1 - 0.2 or 0.8 - 1.0	0.05 - 0.1 or 1.0 - 1.5	< 0.05 > 1.5
Turbidity (NTU)	< 0.1	0.1 - 1.0	1 - 20	20 - 50	> 50
Electrical conductivity (mS/m)	< 70	70 - 150	150 - 370	370 - 520	> 520

Based on the DWA&F Water Quality Guidelines and the World Health Organisation Guidelines for Drinking Water Quality (1996)

Table 5.3 Sample table for recording test results of water samples at a specific site

Parameter		Calculated				
	01/04/97	07/07/97	10/08/97	05/10/97	Maximum	Average
Faecal coliforms /						
E. coli (per 100 ml)	3	5	20	3	20	-
Cl2 (mg/l)	0.1	0.2	0.4	0.2	0.4	0.22
Turbidity (NTU)	3	5	4	2	5	3.5
Electrical						
conductivity (mS/m)	170	102	94	68	170	109

Extracted from Quality of Domestic Water Supplies. Volume 1: Assessment Guide (DWA&F, DoH, WRC, 1998)

Comparison of the maximum value with the corresponding guidelines in Table 5.2 will immediately show whether the parameter reached unacceptable levels at any time over the period recorded.

#### Monitor results over time

Monitor the results at each site over time by graphing the results as shown in Figure 5.1. This illustrates how often the water at that site failed the quality guidelines over the time period graphed. More important, though, it gives an immediate visual impression of whether there is a trend in the levels. For example, although the levels may be within acceptable range, it may be obvious that the levels are increasing and could well exceed acceptable limits in the near future. Investigation of the problem and subsequent corrective action can abort a potential water quality failure.

Turbidity readings at Location XYZ in Middle-of-Nowhere

| Interpresentation | Interpr

Figure 5.1 Sample graph of levels of turbidity by date for a specific sample site

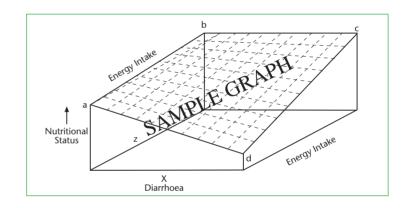
# Interpretation of turbidity readings in Figure 5.1

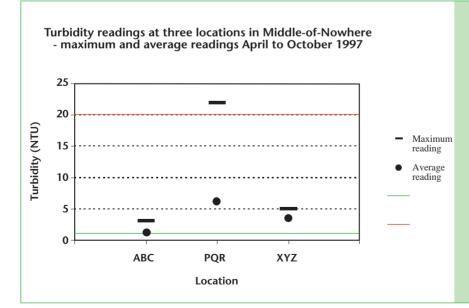
All four readings taken at Location XYZ between April and October fell in the marginal range of 1 – 20 NTU. The maximum recorded reading was 5 NTU on 7 July 97. Subsequent readings indicated decreasing turbidity.

#### Compare water quality at different sites

It is useful to graph the average and maximum results at different sampling sites, such as shown in Figure 5.2. The graph provides a quick overview of the quality of water at different sites over a period of time.

Figure 5.2 Sample graph comparing levels of turbidity at different sample sites

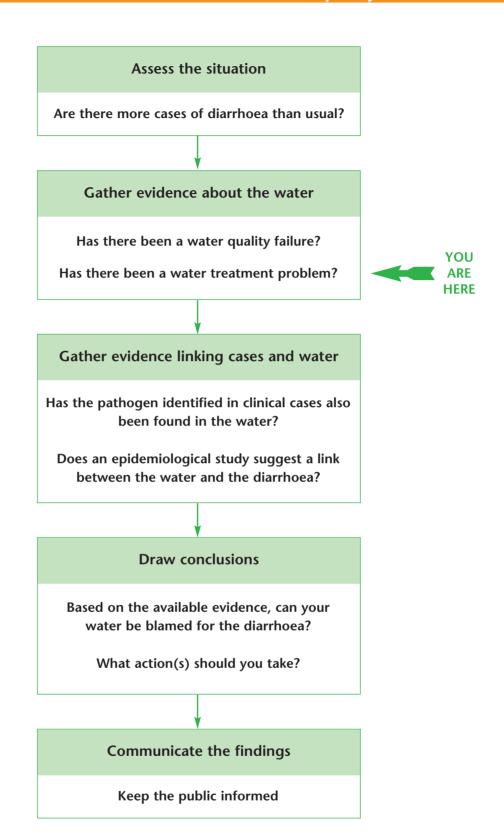




# Interpretation of turbidity readings in Figure 5.2

Over the period April to October 1997, the turbidity of the water at locations ABC and XYZ was marginally higher than is recommended. At location PQR, the turbidity of the water had exceeded the maximum limit on at least one occasion.

### Has there been a water quality failure? • Part 5



# PART 6

Has there been a water treatment problem?







### Part 6 • Has there been a water treatment problem?

#### **Purpose**

To find out whether there has been a water treatment problem.

#### Responsibility

This is the direct responsibility of the water supplier.

#### **Background information**



All water quality failures can be traced back to one or more problems with the treatment of the water. It therefore makes sense to inspect the area where the water comes from and the water treatment process to identify a potential problem, without waiting for water quality results.

The list of on-site inspections suggested in this chapter should be carried out daily. It is important that the results of these inspections are recorded. Recording of results is often done by the entry of a detailed description in a log book – this practice is encouraged and should be continued. In addition, it is recommended that a daily checklist is maintained – checklists as shown in appendix D.

These checklists are comprehensive. Not all parameters included are relevant to every water supplier's situation. The water supplier should amend these checklists as appropriate.

Such checklists have two advantages. Firstly, they readily provide a summary of the required information when a crisis arises. More important, they can be used to monitor critical aspects of water treatment and identify potential problem situations before they arise.

#### What must be done

#### Inspect water treatment process daily

Inspections that should be carried out on a daily basis include the water supply source, general water treatment processes and infrastructure, the coagulation/flocculation process, the sedimentation, filtration and disinfection processes as well as the distribution reticulation. Specific details on these are given in appendix D.

#### Record all problems in detail in log books

Record any problems that are encountered during the inspections in detail in a log book.

#### Complete checklist daily

Use a checklist, such as the one in appendix D, to record all results of the daily inspections. Most items in the checklist can be recorded by means of a tick or a cross. A few items require more specific information.

#### **Evaluate checklist**

On a regular basis, say every week, go through the checklists to see if there are any factors or combination of factors that signal a potential problem. An example focusing on the filtration checklist is given in Table 6.1.

If an outbreak of diarrhoea has already occurred, evaluate the checklists to determine whether any water treatment problems had occurred prior to and during the outbreak.

Complete checklist for geographic areas with cases of diarrhoea

The last part of the checklist in appendix D lists those aspects related specifically to the geographic area(s) with cases of diarrhoea and should be completed in the event of an outbreak.

#### **Priority factors to check**

All the factors listed in the checklists in appendix D are important to inspect daily. However, the following four factors in particular must be evaluated on a regular basis to prevent a possible diarrhoea outbreak:

- Individual filter turbidity this should not exceed 0.5 NTU;
- The disinfection process, as reflected by free residual chlorine – this should be at least 0.2 mg/l after 30 minutes;
- Check whether any work has been done on pipelines or reservoirs in the distribution or reticulation network; and
- The source water in particular, check whether sewage spills have occurred and whether there have been heavy rains, floods or runoff.

The first two factors listed above, namely individual filter turbidity and free residual chlorine, are the most important. If the turbidity exceeds 0.5 NTU or if the level of free residual chlorine is less than 0.2 mg/l, then there definitely is a problem that must be investigated.



## Part 6 • Has there been a water treatment problem?

Table 6.1 Sample filtration checklist

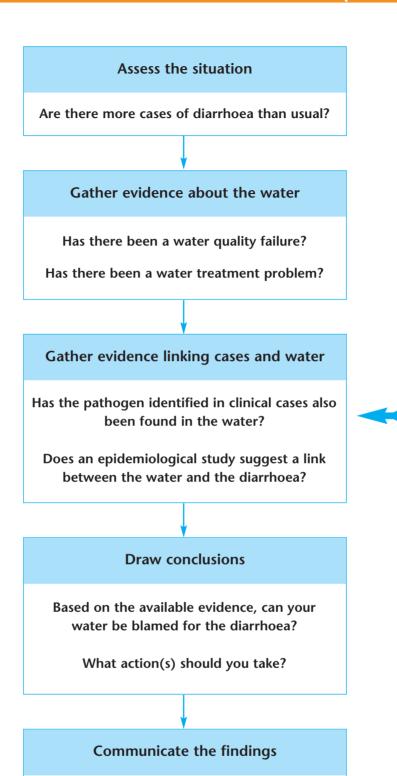
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Filtration	5 11	6 11	7/11	8 11	9 11	10/11	11/1:
Increase in periods between filter backwash	no	yes	yes	no	no	no	no
Full filter bed fluidisation achieved during backwash	yes	yes	yes	yes	yes	yes	yes
Change in backwash procedures	no	yes	yes	no	no	no	no
Turbidities of the filtrate of < 0.5 NTU maintained throughout the filter run	yes	no 2 NJU	no 3 NJU	yes	yes	yes y	es
Increase in filtration rate	no	yes	yes	no	no	no	no
Filter backwash and wastewater recycle practices are adequate	yes	no	no	yes	yes	yes y	es
Filter flow rate compiled with specifications	yes	incr- eased	incr- eased	yes	yes	yes	yes

#### Interpretation of information recorded in checklist in Table 6.1

There was a change in backwash procedures on Tuesday and Wednesday (6 and 7 November) which corresponded with an increased turbidity of the filtrate.



### Has there been a water treatment problem? • Part 6



Keep the public informed

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# PART 7

Has the pathogen identified in clinical cases also been found in the water?









#### **Purpose**

To find out whether the same pathogen occurred in clinical cases of diarrhoea and in the water.

#### Responsibility

The water supplier is responsible for finding out whether the pathogen occurred in the water. Assistance from the district health services will be required to find out which pathogen was isolated from clinical cases.

The case for linking the water with clinical cases of diarrhoea is strengthened considerably if the same pathogen is found in both the water and the cases. However, the reverse is not true – if the pathogen found in clinical cases is not found in the water, one cannot conclude that there is no link. This is because not finding the pathogen does not mean that it is not, or was not, present.

Isolating the pathogen from water is tricky because it is usually present in very low concentrations in the water, for example it may be necessary to detect one enteric virus in 1000 litres of water. Laboratories that are able to carry out pathogen detection methods in water are listed in appendix F.

Isolation of specimens from clinical cases may also be tricky, for different reasons. Only a fraction of patients with diarrhoea visit a doctor. Of those that do visit a doctor, only a few have a faecal specimen taken for testing by a laboratory. In the event of an outbreak of diarrhoea, investigators may take specimens from cases. But these are often taken well past the period during which the chance of isolating a pathogen is optimal. One must also keep in mind that diarrhoea can be caused by non-biological materials, e.g. diarrhoea can be a side-effect of certain medications.

Water is not monitored on a routine basis for pathogens. It is impossible to routinely test a water supply for the many pathogens that are water-related - the methods are often complex and expensive. Instead, water is regularly tested for indicator organisms such as faecal coliforms and E. coli that indicate whether faecal contamination has taken place (see appendix N for more details on indicator organisms). However, the mere presence of faecal coliforms and/or E. coli does not prove that the pathogen found in clinical cases of diarrhoea is also in the water. The proof lies in isolating the pathogen itself from the water.

Of all the procedures described in this handbook, this piece of evidence, namely isolating the same pathogen from clinical cases and from water, is probably the most difficult to obtain.

#### What must be done

#### Find out which pathogen has been isolated from clinical cases of diarrhoea

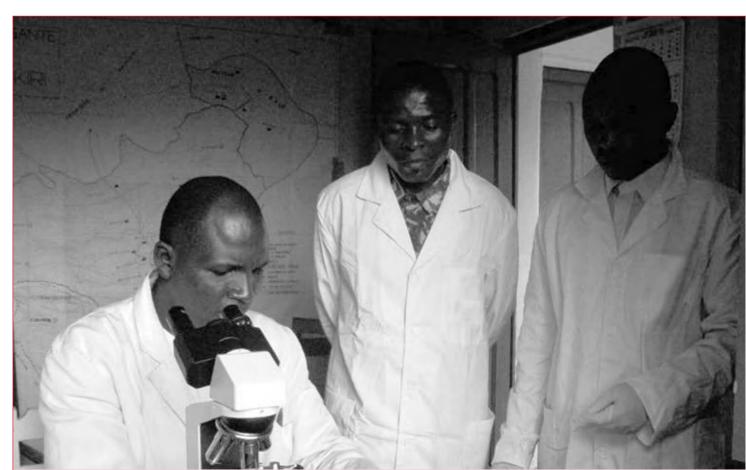
Contact your local department of health to find out whether any pathogen has been isolated from clinical cases of diarrhoea thought to be caused by the water. Such information will probably have to be obtained from the pathology laboratory and/or hospitals.

This information may not be readily available. Not all cases of diarrhoea are serious enough for the patient to seek medical care other than over-the-counter treatment. Even if the patient does go to a doctor, a faecal specimen may not be submitted to the laboratory for testing. For some pathogens, no routine pathology test is available. Also, depending on the instructions of the treating doctor and the policy of the laboratory, specimens may not be subjected to all available tests.

When the information is not available, it may be possible for your local department of health to organise testing of specimens from known cases of diarrhoea. This would need to be done as soon as possible after onset of the symptoms to optimise the chance of isolating any pathogens.

#### Test the water for the same pathogen found in clinical cases

Knowing which pathogen has been isolated from cases of diarrhoea narrows the search for pathogens in the water considerably. Submit specimens of water to one of the laboratories listed in appendix F. Specify which pathogen to look for.



#### What if no pathogen has been isolated from clinical cases?

The situation may arise where no faecal specimens have been taken from cases to send to the laboratory, or where no pathogen has been isolated from faecal specimens. In other words, it is not known what pathogen caused the diarrhoea – if, indeed, it was caused by a pathogen at all.

Under such circumstances, there is no point in spending valuable resources in trying to isolate a pathogen from the water. First, one would be fishing in the dark since one would not know what pathogen to look for. Even if one were to succeed in isolating a potential pathogen from the water, one would not be able to link it to the cases since the causative pathogen is unknown.

If the situation described above arises, it is best to concentrate on evaluating other indicators which may be indicative of pathogen presence from the routine recording results:



- Water treatment technology (chapter 6);
- Water quality indicators (chapter 5)
  - water turbidity
  - no or little chlorine
  - presence of faecal coliforms.

# What if no pathogen has been isolated from the water?

If a particular pathogen has been isolated from cases of diarrhoea, and if the water has been tested for this same pathogen and the tests prove negative, can one conclude that there is no link between the cases and the water? The answer is a resounding No. A negative test means that the pathogen was not isolated; it does not mean that the pathogen is not present in the water. The dilution factor in water makes it extremely difficult to isolate an organism, even if it is present. Also, it may be some days or weeks after first exposure to a pathogen that an outbreak is recognised – by this time, the pathogen may no longer be present in the water.

# So what is the point in testing water for pathogens?

If one can isolate the same pathogen from both clinical cases of diarrhoea and from the water, this is extremely strong evidence for a link between the two.

The reverse, however, is not true. If the pathogen is isolated from only clinical cases, or only from the water, one cannot conclude that there is no link. One can only conclude that there is insufficient evidence to link the cases and the water.

### Part 7 • Has the pathogen identified in clinical cases also been found in the water?

#### Assess the situation

Are there more cases of diarrhoea than usual?

#### Gather evidence about the water

Has there been a water quality failure?

Has there been a water treatment problem?

#### Gather evidence linking cases and water

Has the pathogen identified in clinical cases also been found in the water?

Does an epidemiological study suggest a link between the water and the diarrhoea?



#### **Draw conclusions**

Based on the available evidence, can your water be blamed for the diarrhoea?

What action(s) should you take?

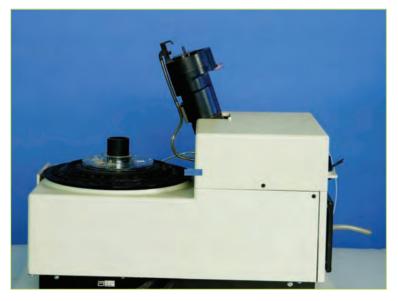
#### Communicate the findings

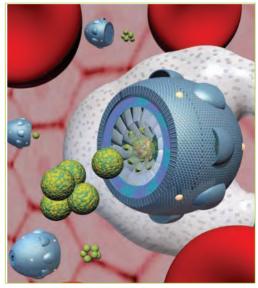
Keep the public informed



# PART 8

Does an epidemiological study suggest a link between the water and the diarrhoea?







#### Part 8 • Does an epidemiological study suggest a link?

#### **Purpose**

To find out whether there is a link between cases of diarrhoea and water.

To establish whether there were any explanations for the diarrhoea other than the water.

#### Responsibility

The water supplier is not responsible for conducting this type of investigation. However, since it is in his/her interests to obtain this information, the water supplier should certainly initiate the activity in collaboration with the district health services. In addition, it would be advisable to include an epidemiologist in the team.

#### **Epidemiological assistance**

This chapter provides some guidelines on how to conduct an epidemiological study to investigate whether cases of diarrhoea could have been caused by the water. However, no guidelines can cover all the issues that arise in a specific situation. It is therefore essential that an epidemiologist be consulted to help design the most appropriate study for the given circumstances and draw valid conclusions from the results.

#### **Background information**

Several types of analytic epidemiological studies can be done to find out whether a particular factor is linked to cases of diarrhoea. The reasoning behind all these studies is that people exposed to the causative factor are likely to develop diarrhoea whilst people not exposed to the causative factor are unlikely to develop diarrhoea. Stated differently, people with diarrhoea are more likely to have been exposed to the causative factor than people without diarrhoea.

A cohort approach, also known as a prospective or follow-up study, selects people on the basis of the hypothesised cause and follows them over time to find out how many develop diarrhoea. Besides being a more costly type of study, this approach is not practical for the typical outbreak situation in which a number of hypothesised causes must be investigated.

The preferred approach in the outbreak situation is the casecontrol study, also known as a retrospective study. People with diarrhoea (cases) are compared to people without diarrhoea (controls). Information on a number of hypothesised causes can be obtained from both groups of people. Comparison of the percentage of people in each group exposed to each factor will indicate which factor(s) is or are the most likely culprit(s).

In order to conduct a case-control study, one must have some idea of what the possible causes might be. A list of such hypothesised causes is often generated by a descriptive study of as many cases as possible in the outbreak. This involves finding the cases and asking them questions about themselves:

- Who they are age, gender, occupation;
- Where they live and work;
- When they became ill.





#### Does an epidemiological study suggest a link? • Part 8

Factors that are common to most cases could help generate a hypothesis about the cause of the diarrhoea. For example, if all cases attend the same school, an obvious next step would be to find out what they might have been exposed to at the school.

When conducting an epidemiological study to determine whether there is a link between cases of diarrhoea and water, it is important to look for alternative explanations. The conclusion that water is not linked to the cases is strengthened considerably if it is accompanied by the conclusion that the cases of diarrhoea are linked to some other factor.

A case-control investigation of an outbreak in South Africa in 1989 is described in appendix O.

#### What must be done

This section provides an outline of one epidemiological approach to determining whether the water is linked to the cases of diarrhoea. It should give the reader an idea of what is involved in doing an epidemiological study. It is not, however, a standard recipe for all such investigations. Many aspects of the circumstances surrounding an outbreak situation influence how the study should be conducted. It is therefore highly recommended that an epidemiologist be invited to join the team to determine the best method for the circumstances.

#### Descriptive study of the cases

The objective of the descriptive study is to formulate hypotheses about the cause of the diarrhoea.

#### Develop a case definition

Based on what is known about the cases already reported, develop a definition of what is considered to be a case in the outbreak. For example, in the Chronic diarrhoea of unknown origin investigation (appendix O), a case of chronic diarrhoea was defined "as a person who reported himself or was reported by the local doctors and who had had diarrhoea of unknown origin for at least one month".

The definition typically includes a description of the relevant symptoms as well as a place and a time element. The time aspect is usually related to the date of the first known case in the outbreak. It could be as simple as "all people in Somewhere who have had diarrhoea since 1 January 2001".

#### Find all cases in the outbreak

To maximise the validity of the results from the epidemiologic investigation, as many cases as possible should be identified and included in the study. The case definition should be used to decide whether a person is part of the outbreak or not.

A number of approaches can be used to find cases that fulfil the criteria of the case definition:

- include self-reported cases
- ask doctors whether they have seen any cases
- find out from hospitals whether cases have been seen (this approach is only useful for severe types of diarrhoea)
  - place advertisements in the local media asking cases to report themselves
  - place posters at communal locations such as libraries, shopping centres, pharmacists, post offices, clinics asking cases to report themselves.

### Part 8 • Does an epidemiological study suggest a link?

In the Chronic diarrhoea of unknown origin investigation, "a notice was placed in the local newspaper asking all cases to come forward".

#### Develop a questionnaire

Information needs to be obtained from all identified cases. Develop a questionnaire that can be used to record the information. A sample questionnaire is shown in Table 8.1.

The questionnaire should include the following aspects:

- case identification and contact details (this allows the investigator to verify information and/or to obtain follow-up information as may be required)
- details related to the case definition (to ensure that the case does fit the description)
- relevant details about the person, WHO, (e.g. age, gender, occupation), time aspects, WHEN, (date and time of onset of symptoms, duration of symptoms) and place, WHERE, (e.g. place of residence, place of work) (any such details found to be common among the cases could help in developing hypotheses about causative exposures)
- questions related to possible exposures (e.g. water, food, medicines, insecticides, herbicides).

The questions related to possible exposures should be based on what is already known about the cases and/or the outbreak. Analysis of the data obtained may lead to new hypotheses and may thus require a second round of questioning based on a new set of questions. For this reason, it is crucial to have the contact details of cases

Table 8.1 Sample questionnaire for descriptive epidemiological study of cases of diarrhoea in Somewhere with onset since 1 January 2001

Case identification and contact details
What is your name?
What is your address?
Telephone number at home
Telephone number at work
Symptoms
When did the diarrhoea start?
For how many days did the diarrhoea continue?
What was the frequency of stools per day?
Did you experience nausea and/or vomiting? Yes / No
Did you have fever? Yes / No

## Does an epidemiological study suggest a link? • Part 8

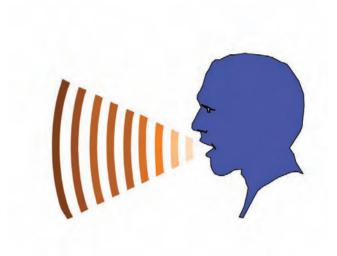
Did you have stomach ache? Yes / No
Did you have headaches? Yes / No
Details of person
How old are you?
Gender? Female / Male
Occupation?
Where do you work / go to school?
Possible exposures
Do you drink tap water? Yes / No
If yes, how many glasses per day?
Do you drink milk? Yes / No
If yes, how many glasses per day?

### Part 8 • Does an epidemiological study suggest a link?

# Conduct interviews to obtain the information

Organise interviews with all known cases:

- make appointments to visit them at home or at their place of work
- set up an interviewing centre (e.g. at the local clinic) and ask cases to come to this centre for their interviews by placing advertisements in the local media and/or placing posters in strategic places.



Although it is preferable to visit the cases for their interviews, this may not be possible due to

logistical constraints. It should be recognised that asking cases to come to interviewing centres may lead to fewer cases being interviewed.

All cases should be asked the same questions, as they appear on the questionnaire. Unsolicited information, however, may provide additional clues and should also be recorded on the questionnaire. For example, several cases may mention in passing that they had attended a church function prior to the onset of diarrhoea.

#### Analyse the data

Develop a table which lists relevant factors about the cases. Count the number of cases that correspond to each factor. Calculate this number as a percentage of the total number of cases interviewed.

The example in Table 8.2 is based on the information obtained from 50 cases.

In addition to tap water, other factors common to the cases in this example are being 18 years and older, living in suburb ABC and having attended a specific function. Note that a factor may be considered common even if the percentage is not 100% - obviously, though, the percentage should be high.

Table 8.2 Sample results of a descriptive study of 50 cases

Factor	Number	Percent
18 years and older	49	98%
Male	23	46%
Lives in suburb ABC	47	94%
Drinks tap water	50	100%
Drinks commercially available milk	38	76%
Attended specific function	49	98%

#### **Develop hypotheses**

Develop hypotheses based on the data collected and analysed. In the above example, one might hypothesise that the cause of the diarrhoea could be linked to the specific function which was attended by adults living in suburb ABC.

#### **Draw conclusions**

A descriptive epidemiologic study does not allow one to draw definitive conclusions. At best, the results suggest linkages between the cases and certain factors.

In the above example, one might conclude that:

- the cases could be water-related, AND
- they could be linked to a specific function.

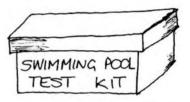
To test the hypotheses and thus be able to draw more definitive conclusions, an analytic epidemiologic study needs to be conducted. Such a study is described below.

#### Analytic (case-control) study

The main objective of a case-control study is to test which of the hypothesised causes is linked to the water.

#### Develop a case definition and define a control

In a case-control study, it is important to ensure that cases really are part of the outbreak and that controls definitely are not part of the outbreak. Inclusion of people with diarrhoea unrelated to the outbreak will diminish the power of the study to identify probable causes. It is therefore recommended that the case definition developed during the descriptive investigation be revisited and amended if necessary.





For example, in the case-control study done during the Chronic diarrhoea of unknown origin investigation (appendix O), a case of chronic diarrhoea was re-defined as "a resident of Diachron who, since June 1989, had had three or more watery stools per day for at least 28 days, and for which no aetiologic cause could be found".

A control was defined as "a resident of Diachron since June 1989, and who had had no diarrhoea lasting longer than three days since then".

#### Identify cases according to the revised case definition

Re-interview cases to obtain the information needed to decide whether they fit the revised case definition or not.

Include at least 30 cases in the case-control study. If the number of cases in the outbreak is less than 30, include them all.

#### Part 8 • Does an epidemiological study suggest a link?

#### **Find controls**

The number of controls to include in the study should be at least as many as the number of cases. In the Chronic diarrhoea of unknown origin investigation, it was decided to have the same number of controls (29) as cases.

It is often useful to match controls to cases on aspects that might otherwise confuse the interpretation of the results. In the Chronic diarrhoea of unknown origin investigation, controls were matched to cases on age (+ or -10 years), gender and residential area.

Develop a scheme to find people that meet the definition of a control. In the Chronic diarrhoea of unknown origin investigation, "fieldworkers were given instructions to turn to the right when leaving the home of a case, and then to go from house to house until a suitable control was found".

#### Develop a questionnaire





Information needs to be obtained from cases as well as from controls (people who do not have diarrhoea). Develop a questionnaire that can be used to record the information. The questionnaire used in the Chronic diarrhoea of unknown origin investigation is shown in the appendix of the article (appendix O).

The questionnaire should include the following aspects:

- identification and contact details of the person being interviewed (this allows the investigator to verify information and/or to obtain follow-up information as may be required)
- screening questions to confirm that the case fits the revised case definition and the control fits the definition of a control
- questions related to all hypothesised exposures (e.g. water, food, medicines, insecticides, herbicides, how much or how frequent the exposure to each factor).

The aim of the case-control study is to test hypotheses about cause, not to develop the hypotheses. The majority of questions will therefore be about possible causes.

Conduct interviews to obtain the information

Organise interviews with cases at their home or at their place of work. If, based on the screening questions, the case does not meet the revised case definition, terminate the interview. Complete the interview if the case does meet the revised case definition

Find the required number of controls according to the planned scheme and administer the same questionnaire to them. The screening questions should indicate the eligibility or otherwise of the control. Complete the interview only if the control is eligible.

#### Analyse the data

Develop a table which lists all potential exposures included on the questionnaire. The table should include one column for cases and one column for controls. Count the number of cases and controls that were exposed to each factor. Calculate this number as a percentage of the total number of cases and controls respectively.

An example is given in Table 8.3.

Table 8.3 Sample results of a case-control study with 30 cases and 30 controls

Factor	Number	Percent
Drinks tap water	30 (100%)	30 (100%)
Attended specific function	30 (100%)	20 (67%)
Ate egg salad at function	24 (80%)	18 (60%)
Ate chicken at function	28 (93%)	3 (10%)

Compare the percentages for each exposure. Find the exposure that corresponds to the biggest difference between the percentages for cases and controls. In the above example, the biggest difference in the percentages is for eating chicken at function – 93% of cases versus only 10% of controls. Of the exposures included in the questionnaire, the chicken is the most likely source of the diarrhoea.

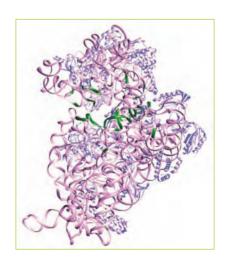
In the *Chronic diarrhoea of unknown origin article* (appendix O), Table 8 shows the results for each factor. Table 8 includes an additional column, namely the p-value; this is a statistical value that helps to interpret the results. An epidemiologist or statistician can assist in obtaining and interpreting these p-values.



Based on the results of the case-control study, you can draw conclusions as to which factor(s) is or are the most likely source(s) of the diarrhoea problem.

In the above example, you can conclude that drinking tap water is *not* linked to the diarrhoea. You can conclude that the chicken served at the specific function was the most likely cause of the outbreak.





#### Assess the situation

Are there more cases of diarrhoea than usual?

#### Gather evidence about the water

Has there been a water quality failure?

Has there been a water treatment problem?

#### Gather evidence linking cases and water

Has the pathogen identified in clinical cases also been found in the water?

Does an epidemiological study suggest a link between the water and the diarrhoea?

#### **Draw conclusions**

Based on the available evidence, can your water be blamed for the diarrhoea?

What action(s) should you take?



#### Communicate the findings

Keep the public informed

# PART 9

Is the water responsible for the diarrhoea?







#### **Purpose**

To determine, from the available evidence, whether the water is responsible for the diarrhoea.

#### Responsibility

Since the water supplier is responsible for the quality of the water and therefore needs to know whether the water is at fault, he/she should regard him/herself responsible for ensuring that the best conclusion is reached. All parties involved in obtaining the evidence, however, should be involved in the process of drawing a conclusion.

#### **Background information**

Answers to one or more of the questions shown in Table 9.1 (as described in chapters 5 to 8) are required in order to reach a conclusion. In general, the more questions you can answer, the more definitive the conclusion. For example, if you only know that there has been a water treatment problem, then you can conclude that the water is possibly responsible for the diarrhoea - but you do not have enough evidence to rule out the possibility of the water being the culprit. If, in addition, you have done a descriptive epidemiological investigation that suggests that the diarrhoea cases are water-related, then you can conclude that the water is probably responsible for the diarrhoea. In both these examples, therefore, one would have to conclude that water could have been responsible for the cases of diarrhoea.

Some questions provide stronger evidence of a link between the water and diarrhoea cases than other questions. Identifying the same pathogen in the water and in the cases is stronger evidence than knowing that there has been a water quality failure. An analytical epidemiological study likewise provides stronger evidence than a descriptive study. The chronological order of events also adds



to the strength of the evidence. If the water is indeed responsible for the outbreak of diarrhoea, one would expect that the water quality problem is present before the first case of diarrhoea is reported. How long before? That depends on the incubation (or latent) period of the organism causing the diarrhoea.

A classification scheme for assessing the likelihood that the water is responsible for the diarrhoea is shown in Table 9.2. This likelihood ranges from very likely to highly unlikely.

#### What must be done

# Summarize the evidence obtained during the investigation

From the evidence obtained during the investigation, answer each of the four questions listed in Table 9.1.

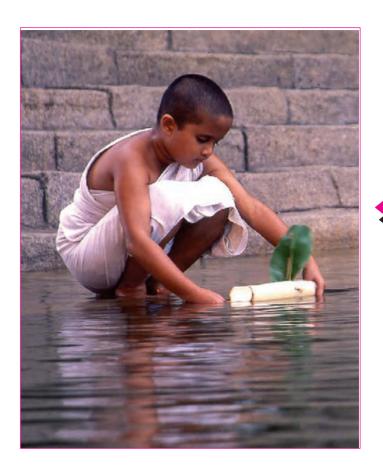


Table 9.1 Questions to be answered when determining whether water could be responsible for an outbreak of diarrhoea

Question	Yes	Answer No	Unknown
Has the pathogen identified in clinical cases also been found in the water?	A	-	-
Has there been a water quality failure	В	E	-
and/or water treatment problem?			
Does evidence from an analytical study	С	F	-
demonstrate a link between water and diarrhoea?			
Does a description of the cases suggest that the outbreak is water-related and does it exclude obvious alternative explanations?	D	G	-

Adapted from Tillett HE, de Louvois J and Wall PG. Surveillance of outbreaks of waterborne infectious disease: categorizing levels of evidence. *Epidemiol. Infect.* (1998), 120, 37-42

For example, during the course of the investigation, faecal coliforms were detected in the water and a case-control study demonstrated a link between the water and the cases. This situation would be summarized as B + C.

## Part 9 • Is the water responsible for the diarrhoea?

#### Determine the likelihood that the water is responsible for the diarrhoea

Based on the summary of the evidence (as determined above), determine the likelihood that the water is responsible for the diarrhoea cases from Table 9.2.

Table 9.2 Classification scheme for assessing the likelihood that the water is responsible for the cases of diarrhoea

Likelihood	Description of evidence	Summary of evidence
Very likely	Evidence from an analytical study demonstrates a link between water and diarrhoea and the pathogen identified in clinical cases is also found in the water	A + C
	OR	OR
	A description of the cases suggests that the outbreak is water-related and excludes obvious alternative explanations and the pathogen identified in clinical cases is also found in the water	A + D
	OR	OR
	Evidence from an analytical study demonstrates a link between water and diarrhoea and water quality failure/water treatment problems of relevance are recorded	B + C
Probably	A description of the cases suggests that the outbreak is water-related and excludes obvious alternative explanations and water quality failure/water treatment problems of relevance are recorded	B + D
	OR	OR
	Evidence from an analytical study demonstrates a link between water and diarrhoea and supporting water microbiology is absent	C only
	OR	OR
	The pathogen identified in clinical cases is also found in the water and supporting epidemiological evidence is absent	A only





Table 9.2 (continued) Classification scheme for assessing the likelihood that the water is responsible for the cases of diarrhoea

Likelihood	Description of evidence	Summary of evidence
Possibly	Water quality failure/water treatment problems of relevance are recorded but pathogen not detected in the water and supporting epidemiological evidence is absent	B only
	OR	OR
	A description of the cases suggests that the outbreak is water-related and excludes obvious alternative explanations and supporting microbiological evidence is absent	D only
Unlikely	No water quality failure/water treatment problems of relevance are recorded and a description of the cases sugge that the outbreak is not water-related but offers an alternative explanation	ests E + G
Highly unlikely	No water quality failure/water treatment problems of releva are recorded and evidence from an analytical study demons no link between water and diarrhoea but rather points to ar	strates

Adapted from Tillett HE, de Louvois J and Wall PG. Surveillance of outbreaks of waterborne infectious disease: categorizing levels of evidence. Epidemiol. Infect. (1998), 120, 37-42





### Part 9 • Is the water responsible for the diarrhoea?

#### **Draw conclusions**

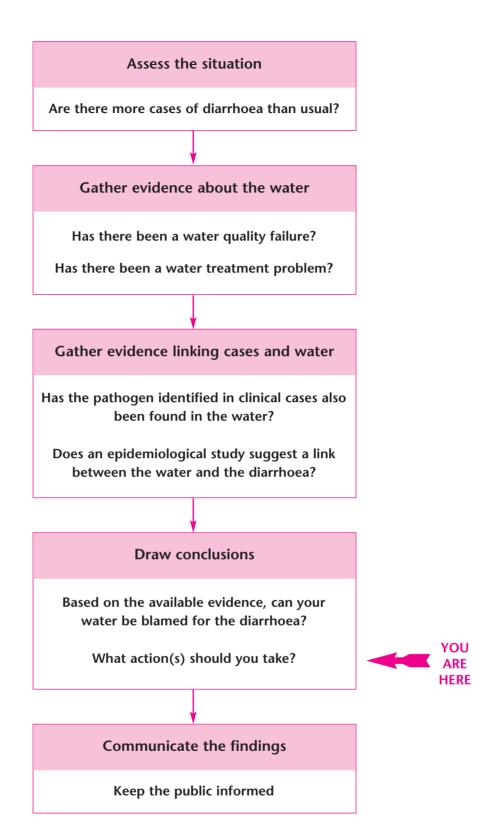
The final step is to come to a conclusion as to whether the water could be responsible for the diarrhoea cases or not. Table 9.3 provides guidelines based on the likelihood determined from Table 9.2.

Note that the inconclusive likelihood of possibly leads to the conclusion that the water could be responsible for the cases of diarrhoea, just as the more conclusive very likely does. The fact that there is insufficient evidence to be more definitive than possibly means that one has insufficient proof to conclude that the water is not responsible for the diarrhoea.

Table 9.3 Guidelines for concluding whether the water could be responsible for the diarrhoea cases

Likelihood (determined from Table 9.2)	Conclusion
Very likely	The water is, or could be,
Probably	responsible for
Possibly	the cases of diarrhoea
Unlikely	The water is not
Highly unlikely	responsible for the cases of diarrhoea

### Is the water responsible for the diarrhoea? • Part 9



# **PART 10**

What action(s) should you take?







### **Purpose**

To determine what action(s) should be taken based on the conclusion as to whether the water can be blamed for the diarrhoea or not.

### Responsibility

The water supplier is responsible for deciding what action(s) can be taken regarding the water itself. Nevertheless, it would be best to decide on action(s) together with the district health services.

### **Background information**

If the water is implicated in the outbreak of diarrhoea, the water supplier must ensure that all treatment procedures are followed. The district health services should be kept fully informed.

If some other factor is linked to the outbreak, then the water supplier must make sure that the district health services are aware of this. The responsibility then rests with the district health services to determine what action is required.

### What must be done

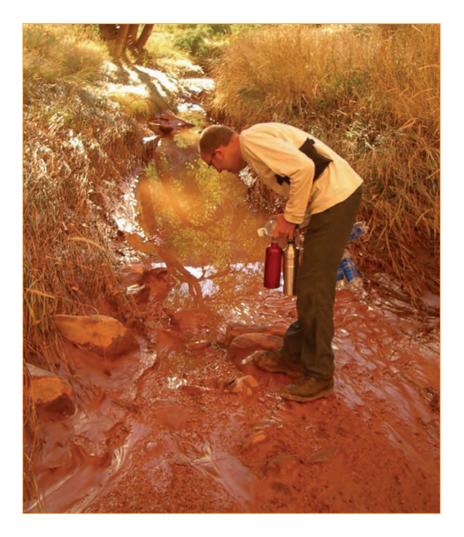
## If there is no water treatment/quality problem and no epidemiological link...

If the evidence obtained during the investigation indicates no problem with the water treatment process and no problem with the water quality and no epidemiological link between the cases of diarrhoea and the water (but rather a link between the cases and some other factor), then the water supplier should do the following:

- write a report documenting the procedures taken during the investigation and the conclusions reached; and
- ensure that the water monitoring process, including the use of daily checklists, is in place.



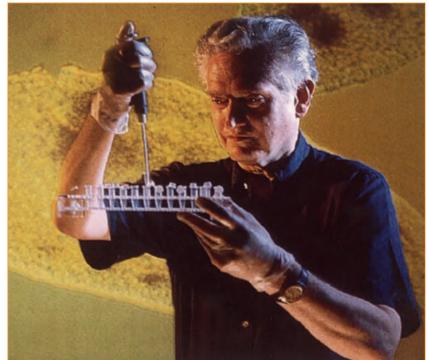
If there is no water treatment/quality problem but there is an epidemiological link...



If the data point to an epidemiological link between the cases and the water but no problem with the water treatment process or the water quality, it may be worthwhile to have an epidemiologist review the methodology of the investigation to confirm the validity of the results. If the methodology holds up under such scrutiny, you have to conclude that the cases of diarrhoea are water-related. Consequently, you should review your water treatment procedures and methods for documenting inspection results (see part 6). If the outbreak is on-going and the pathogen causing the diarrhoea is known and if you have not yet tested the water for this pathogen, then it may be useful to do so now (see part 7).

If there is a water treatment/quality problem regardless of whether there is also an epidemiological link or not...

If there is evidence of a problem with the water treatment process or water quality, regardless of the epidemiological evidence, then you should review your water treatment procedures. Ensure that inspections are done daily and adequately recorded (see part 6). Make sure that the checklists are monitored regularly in order to anticipate problems as soon as possible.



### Part 10 • What action(s) should you take?

### **Emergency response procedures**

The water supplier is more likely to deal confidently with an emergency situation if emergency response procedures have been documented and the infrastructure is in place. A protocol should be developed with the objective of ensuring that all the relevant stakeholders are involved in the formulation of plans and the decision-making process when a crisis occurs (11).

The protocol should include the following issues (11):

- monitoring procedures and when to sound the alert;
- accountabilities of the relevant stakeholders;
- action plans for operational changes at the production sites;
- communication channels with external parties;
- channels through which media releases can be issued; and
- the timeous management, co-ordination and reporting of incidents.

An example of a flowchart describing parasite response procedures is given in appendix E.

In the case of a diarrhoea outbreak, the Department of Health, the Department of Water Affairs and Forestry and the management team of the water supplier should be jointly responsible for making decisions.

### What action(s) should you take? • Part 10

#### Assess the situation

Are there more cases of diarrhoea than usual?

#### Gather evidence about the water

Has there been a water quality failure?

Has there been a water treatment problem?

### Gather evidence linking cases and water

Has the pathogen identified in clinical cases also been found in the water?

Does an epidemiological study suggest a link between the water and the diarrhoea?

### **Draw conclusions**

Based on the available evidence, can your water be blamed for the diarrhoea?

What action(s) should you take?

### Communicate the findings

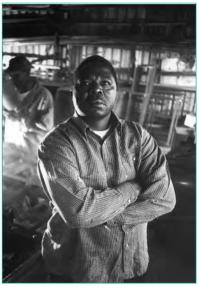
Keep the public informed



# **PART 11**

## Keep the public informed







### Part 11 • Keep the public informed

### **Purpose**

To provide guidelines on how to communicate with the public.

### Responsibility

The water supplier is responsible for communicating with the public regarding all matters to do with the water. If some factor other than the water has been linked with the outbreak of diarrhoea, the district health service is responsible for all communications. It is obviously in the interests of the water supplier to ensure that this does take place.

### **Background information**

The community to which you provide water trusts you to provide good quality water, water that will not have adverse effects on their health. This trust should be respected and valued. Therefore, when the community expresses concern about the quality of the water for whatever reason, your response should be to maintain good relations with the community. This is best done by taking their concerns seriously and addressing the issues.

Communication with the public includes the following:

- At all times the water supplier should be able to provide the public with relevant information;
- The public should be able to lodge specific complaints with the water supplier; and
- *During an outbreak* or crisis situation, the water supplier should keep the public informed of the situation.

### What must be done

#### Appoint a public relations person

Good public relations cannot be achieved without somebody taking on the responsibility for this function – this can either be a professional person or somebody suitable who already works for the organisation. Such a person can provide an optimal public relations service only if he/she is kept up-to-date with all relevant information.

### Make information easily available to the public

Reports should be made available on demand to any member of the public.

Generate user-friendly reports with information of interest to the public. Put these reports on your website if you have one. Consider alternative means of reaching the public – the local newspaper, brochures, etc.

### Implement a consumer complaint procedure

Ensure that your organisation has a consumer complaint procedure. This procedure should be put in writing and made available to all personnel. Staff members must be aware of the role they play in the process.

A sample consumer complaint procedure is shown in Table 11.1.

### Table 11.1 Sample consumer complaint procedure

- Receive call, either directly or via the call centre
- Chat to the consumer determine the nature of the problem (respond in a positive manner, respect their assessment of the situation)
- Complete consumer complaint record i.e. description of complaint, address, information regarding the complaint etc. (ensure records are complete)
- Arrange appointment with consumer for sampling (suit the consumer)
- Visit the consumer, perform a site inspection and the relevant sampling, provide consumer with information package, ensure all needs are identified and addressed
- Arrange for sample analysis
- Interpret results
- If problems are detected, perform an investigation (correlate water supply results with the site findings; contact local authority etc. depending on the nature of the problem, ensure all interested parties are informed)
- Generate a consumer friendly report
- Provide consumer with feedback and assure them of consistent service
- Send reports to statistician for monthly report summary
- Where applicable perform a follow-up call to determine if situation has improved

The consumer complaint record should be a standard set of questions that are asked during each complaint received. Questions should include at least the following:

- name and contact details of the complainant;
- nature of the complaint;
- details of the diarrhoea;
- name of person receiving the complaint and the date of the complaint.

An example of such a form is given in Table 4.1.

### Communication during a crisis

If you do not have a permanent public relations system, then institute one as soon as possible after you become aware of allegations about the quality of the water.

Maintain communication with the public throughout the entire investigative process - until such time as you are able to provide evidence that the allegations were false or, if they prove to be true, until such time as the water quality is restored. Inform the public by means of local newspapers, local radio and/or the organisation's website (if it has one).



# **PART 12**

### Flowchart to assist the water supplier



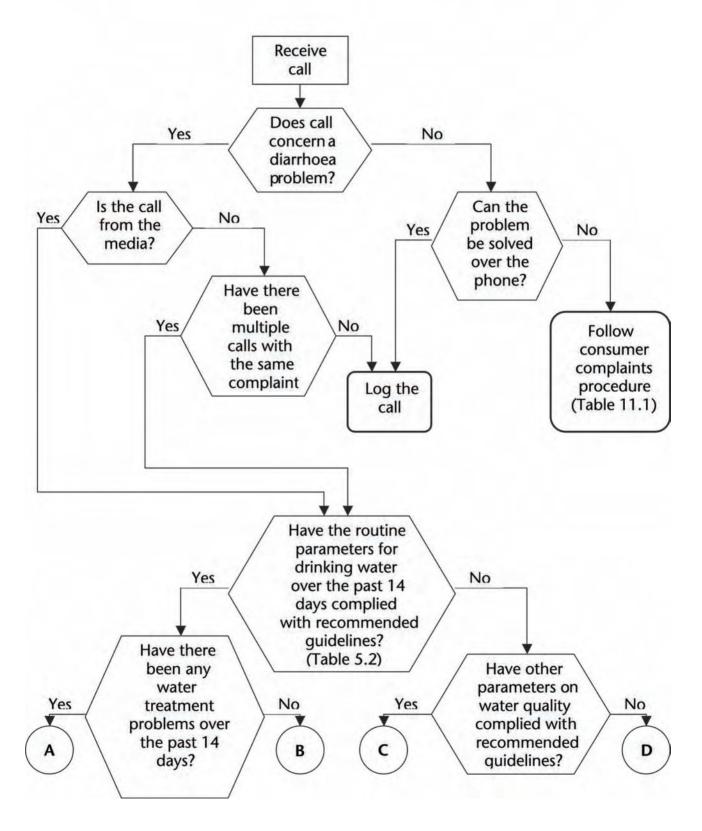




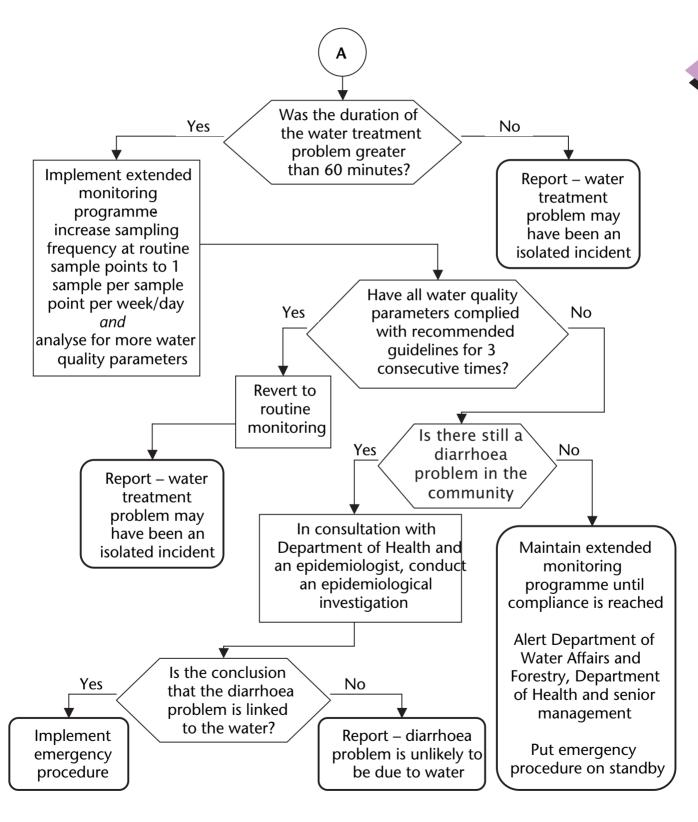
**Purpose** 

To assist the water supplier in deciding on the appropriate procedures to follow in the investigation of a diarrhoea-related problem, a flowchart is presented on the following 5 pages. This flowchart indicates when the water supplier should involve the local Department of Health in the investigation and when to call for the services of an epidemiologist.

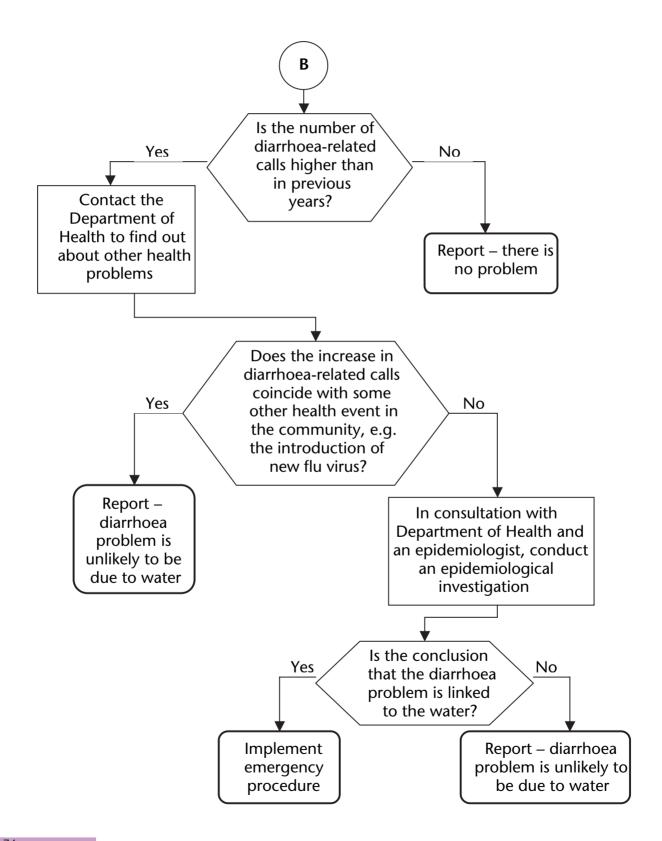
Flowchart



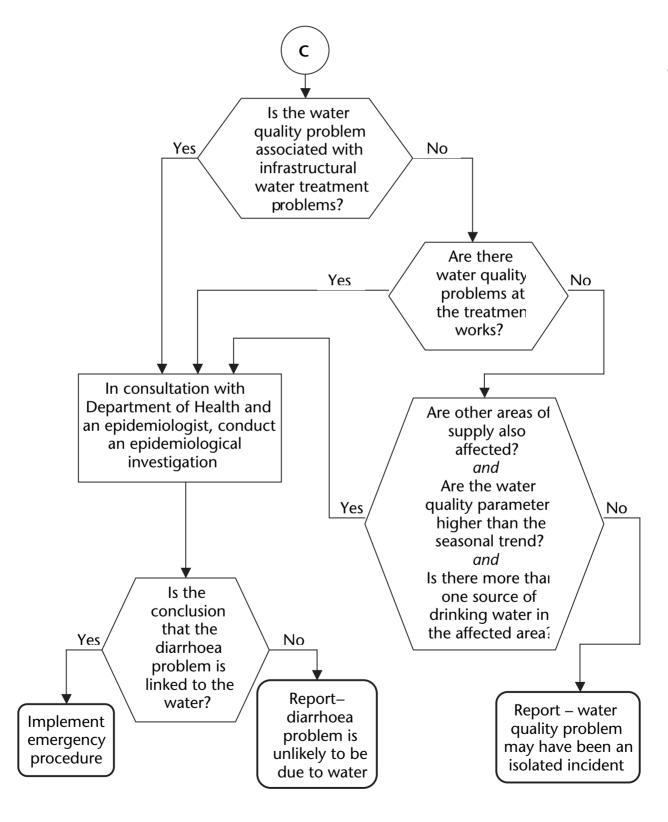
### Flowchart (continued)



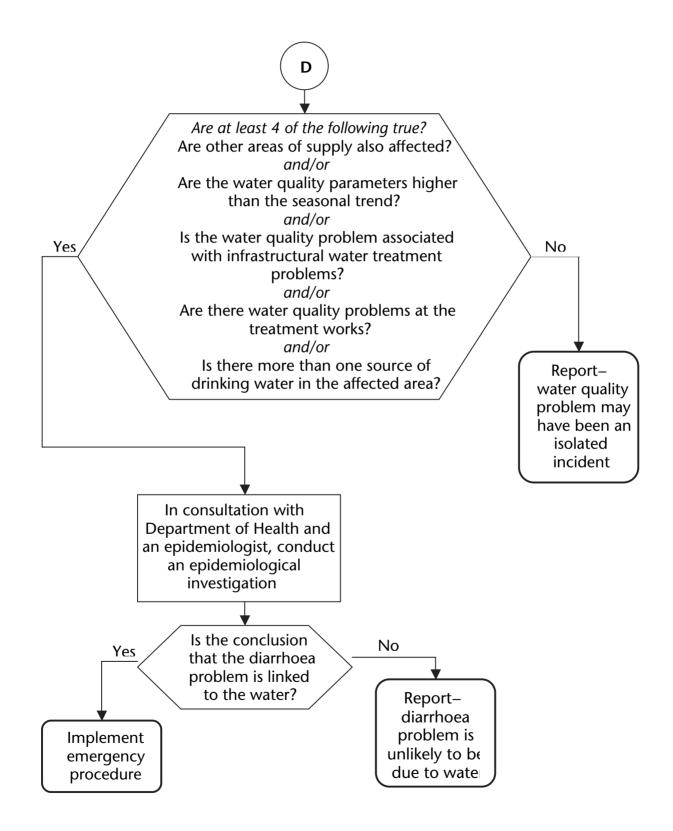
### Flowchart (continued)



### Flowchart (continued)



### Flowchart(continued)



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### Glossary of terms

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- Acute
- 1. Referring to a health effect, brief; sometimes loosely used to mean severe.
- 2. Referring to exposure, brief, intense or short-term; sometimes specifically referring to brief exposure of high intensity.
- Agent (of disease)

A factor, such as a microorganism, chemical substance, or form of radiation, whose presence, excessive presence, or (in deficiency diseases) relative absence is essential for the occurrence of disease. A disease may have a single agent, a number of independent alternative agents (at least one of which must be present), or a complex of two or more factors whose combined presence is essential for the development of the disease.

Analytic study

A study designed to examine associations, commonly putative or hypothesized causal relationships. An analytic study is usually concerned with identifying or measuring the effects of risk factors or is concerned with the health effects of specific exposure(s). Contrast descriptive study, which does not test hypotheses.

Anecdotal evidence

Evidence derived from descriptions of cases or events rather than systematically collected data that can be submitted to statistical tests. Anecdotal evidence must be viewed with caution but sometimes is useful to generate hypotheses.

Association

Statistical dependence between two or more events, characteristics, or other variables. An association is present if the probability of occurrence of an event or characteristic, or the quantity of a variable, depends upon the occurrence of one or more other events, the presence of one or more other characteristics, or the quantity of one or more other variables.

Case

In epidemiology, a person in the population or study group identified as having the particular disease, health disorder, or condition under investigation. A variety of criteria may be used to identify cases, e.g., individual physicians' diagnoses, registries and notifications, abstracts of clinical records, surveys of the general population, population screening, and reporting of defects such as in a dental record. The epidemiologic definition of a case is not necessarily the same as the ordinary clinical definition.

• Case control study

The observational epidemiologic study of persons with the disease (or other outcome variable) of interest and a suitable control (comparison, reference) group of persons without the disease. The relationship of an attribute to the disease is examined by comparing the diseased and non-diseased with regard to how frequently the attribute is present or, if quantitative, the levels of the attribute, in each of the groups. In short, the past history of exposure to a suspected risk factor is compared between "cases" and "controls", persons who resemble the cases in such respects as age and sex but do not have the disease or condition of interest.

Causality

The relating of causes to the effects they produce. Most of epidemiology concerns causality and several types of causes can be distinguished. It must be emphasized, however, that epidemiologic evidence by itself is insufficient to establish causality, although it can provide powerful circumstantial evidence.

- Chronic
- 1. Referring to a health-related state, lasting a long time.
- 2. Referring to exposure, prolonged or long-term, often with specific reference to low intensity.
- Clinical cases

See Case

Cohort study

The analytic method of epidemiologic study in which subsets of a defined population can be identified who are, have been, or in the future may be exposed or not exposed, or exposed in different degrees, to a factor or factors hypothesized to influence the probability of occurrence of a given disease or other outcome. The main feature of a cohort study is the observation of large numbers over a long period (commonly years) with comparison of incidence rates in groups that differ in exposure levels.

Coliform

Belonging to a group of rod-shaped bacteria typified by E. coli.

Control

Person(s) in a comparison group that differs, retrospectively, in disease experience from the subjects of the study.

Control group

Subjects with whom comparison is made in a case control study, randomized controlled trial, or other variety of epidemiologic study. Selection of appropriate controls is crucial to the validity of epidemiologic studies and has been much discussed.

• Controls, matched

Controls who are selected so that they are similar to the study group, or cases, in specific characteristics. Some commonly used matching variables are age, sex, race, and socioeconomic status.

• Descriptive study

A study concerned with and designed only to describe the existing distribution of variables, without regard to causal or other hypotheses. Contrast analytic study. An example is a community health survey, used to determine the health status of the people in a community. Descriptive studies, e.g., analyses of cancer registry data, can be used to measure risks, generate hypotheses, etc.

• Diarrhoea

A condition in which faeces are discharged from the bowels frequently and in a liquid form.

Domestic water \*

Water that is used for household purposes such as drinking, bathing, food preparation and laundry.

• Epidemic

The occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health-related events clearly in excess of normal expectancy. The community or region and the period in which the cases occur are specified precisely. The number of cases indicating the presence of an epidemic varies according to the agent, size and type of population exposed; previous experience or lack of exposure to the disease; and time and place of occurrence. Epidemicity is thus relative to usual frequency of the disease in the same area, among the specified population, at the same season of the year.

### Appendix A • Glossary of terms

• **Epidemiology** The study of the distribution and determinants of health-related states or events in

specified populations, and the application of this study to control of health problems. There have been many definitions of epidemiology. In the past 50 years or so, the definition has broadened from concern with communicable disease

epidemics to take in all phenomena related to health in populations.

• Faecal coliforms \* Rod-shaped bacteria found in faeces.

• Gastroenteritis Inflammation of the stomach and intestines, typically resulting from bacterial toxins

or viral infection and causing vomiting and diarrhoea.

Health facility
 A building or establishment housing local medical services, e.g., clinic, hospital.

• **Historical data** \* Data collected in previous years.

• **Hypothesis** 1. A supposition, arrived at from observation or reflection, that leads to refutable

predictions.

2. Any conjecture cast in a form that will allow it to be tested and refuted.

• Infant \* Child less than one year old.

Microorganism
 A microscopic organism, especially a bacterium, virus or fungus.

• Outbreak An epidemic limited to localized increase in the incidence of a disease, e.g., in a

village, town, or closed institution.

• Parameter In statistics and epidemiology, a measurable characteristic of a population.

• **Pathogen** Organism capable of causing disease.

• **Pathology** The science of the causes and effects of diseases, especially the branch of medicine

that deals with the laboratory examination of samples of body tissue for diagnostic

or forensic purposes.

• Prospective study See Cohort study.

• Retrospective study The essential feature is that some of the persons under study have the disease or

other outcome condition of interest, and their characteristics and past experiences are compared with those of other, unaffected persons. See also Case control study.

• Routine data \* Data collected on a regular basis according to a prescribed format.

• Statutorily notifiable Medical conditions that, by law, must be reported to the relevant health medical

conditions \* department.

• Tally sheet \* A form used to record the number of occurrences of an event.

## Form and tally sheets for recording and monitoring diarrhoea-related complaints

These form and tally sheet templates have been included here for possible photocopying and use by the water supplier.

## Sample form to be used for recording each diarrhoea-related complaint received by the water supplier

Name of person lodging complaint				
Telephone number (home)				
Telephone number (work)				
Address				
Capacity of person	Private	Profes (hea		Media
Name of media				
Nature of complaint	Diarrhoe	ea		Other
Specify if 'Other'				
Details of diarrhoea:				
Number of cases				
If more than 1 case	Members of 1	family	Diffe	rent families
Approximate date when diarrhoea started (in first case)				
Address of case(s)				
Name of person receiving complain				
Date complaint received				

# Sample tally sheet for recording number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

Day			Sub	urb			All
Day	Name of suburb	suburbs					
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

# Sample summary sheet for recording number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

	Number	of diarrh	oea-relate	d reports	received	in (year)	
NA II-			Sub	ourb			All
Month	Name of suburb	suburbs					
Jan							
Feb							
Mar							
Apr							
May							
Jun							
Jul							
Aug							
Sep							
Oct							
Nov							
Dec							
Total							

## Sample summary sheet for historic data of number of diarrhoea-related reports/complaints per suburb (FOR USE BY WATER SUPPLIER)

	, r	Average n eceived fr	umber of om (year)	diarrhoea	a-related r o (year)	eports	
			Sub	ourb			All
Month	Name of suburb	Name of suburb	Name of suburb	Name of suburb	Name of suburb	Name of suburb	suburbs
Jan							
Feb							
Mar							
Apr							
May							
Jun							
Jul							
Aug							
Sep							
Oct							
Nov							
Dec							
Total							

### Table and graphs recording test results of water samples • Appendix C

### Table and graphs for recording test results of water samples

These table and graph templates have been included here for possible photocopying and use by the water supplier.

Test results of water samples taken at sample site in town

Parameter					Date					Calcu	Calculated
	Date	Maximum	Average								
Faecal coliforms / E. coli (per 100 ml)											
Cl <sub>2</sub> (md//)											
Turbidity (NTU)											
Electrical conductivity (mS/m)											

Faecal coliforms / E. coli per 100 ml at sample site in town 

Date of sample collection

Faecal coliforms /E. coli per 100 ml

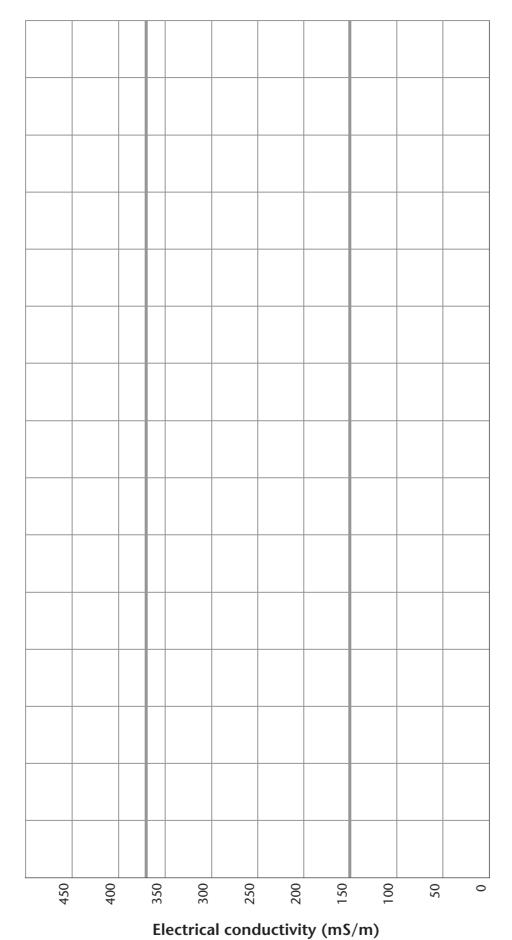
Cl<sub>2</sub> (mg/*l*) at sample site in town 4. 1.2 1.0 0.4  $\mathsf{Cl}_2\left(\mathsf{mg}/l\right)$ 

Date of sample collection

Turbidity readings at sample site in town Turbidity (NTU)

Date of sample collection

Electrical conductivity readings at sample site in town



Date of sample collection

Faecal coliforms /  $E.\ coli$  per 100 m I - maximum reading over period dates 

Faecal coliforms / E. coli per 100 ml - maximum reading

Sample site

Cl<sub>2</sub> (mg/l) – maximum and average readings over period dates

Sample site

 $Cl_2 (mg/l) - maximum (-)$  and average (•) readings

1.0

8.0

9.0

1.8

1.6

1.4

1.2

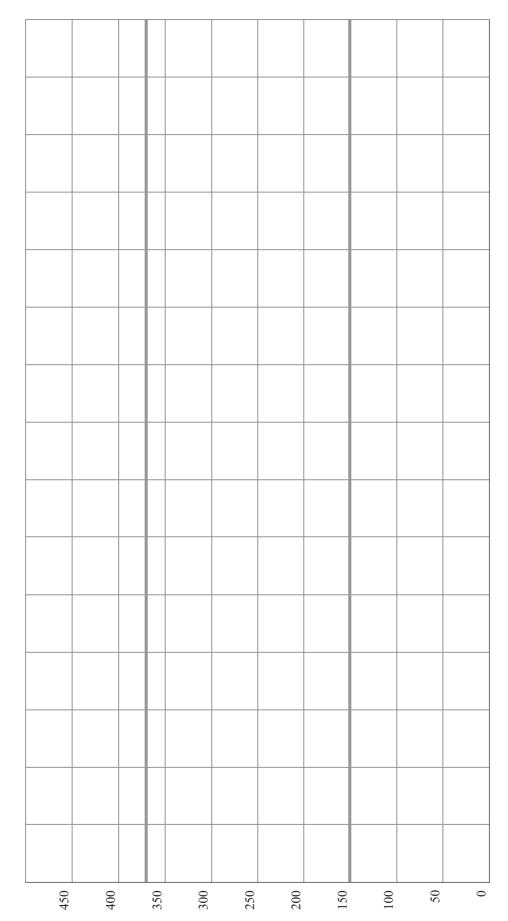
### Table and graphs recording test results of water samples • Appendix C

Turbidity (NTU) - maximum and average readings over period dates 

Turbidity (NTU) – maximum (→) and average (•) readings

Sample site

Electrical conductivity – maximum and average readings over period dates



Sample site

Electrical conductivity (mS/m) – maximum (–) and average ( $\bullet$ ) readings

### Routine checklists for monitoring water treatment • Appendix D

### Routine checklists for monitoring water treatment

These checklist templates have been included here for possible photocopying and use by the water supplier.

Checklist for optimising conventional water treatment systems to prevent health-related problems

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
Water supply source							
Possible contamination from agriculture, wastewater, roads, railroads, industry, homes, pipelines, etc. in drainage area							
Sewage spill in the catchment of the source water							
Spills affecting the source water quality							
Inflow to the source increased to above the long-term average for the specific month							
Any short-term change in source water quality e.g. increase in turbidity, changes in taste and odour, colour, organic content, chemical variables such as phosphorus and nitrogen							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
General water treatment processes and infrastructure							
Any significant change in the quality of the water reaching the purification plant							
If yes, which water quality variable changed							
Any infrastructure problems e.g. power trips, pump failures, burst pipes							
Any infrastructure taken out of commission							
Water quality checks done after commissioning of the infrastructure e.g. pipelines, pump, reservoirs, chemical dosing apparatus, sand filters							
Demand for water increased significantly in past 12 hours							
Any biological guidelines for drinking water exceeded in past 14 days							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
Coagulation/Flocculation							
Any interruption or decrease of more than 15 minutes in the dose of coagulants							
Mixing energy requirements met							
Floc formed as usual							
Correct mixing energy, time and dispersion of coagulant							
Design flow rate exceeds specs							
Condition of equipment good							
Correct mixing energy and time							
Condition of equipment and baffling (between chambers and before settling) good							
Design flow rates correct to prevent floc shearing							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
Sedimentation							
Any environmental conditions affecting conditions required for effective sedimentation e.g. wind							
Turbidity of the supernatant complied with the operational standards							
Turbidity more than 3 NTU							
Any problems experienced with desludging							
Flow rates, detention times, weir loadings according to design parameters							
Condition of sludge removing equipment in good order							
Short circuiting possible							
Baffle between flocculation and sedimentation basin in good order							
Sludge draw off procedures working							
Low sludge levels are being maintained							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
Filtration							
Increase in periods between filter backwash							
Full filter bed fluidisation achieved during backwash							
Change in backwash procedures							
Turbidities of the filtrate of $< 0.5 \ \text{NTU}$ maintained throughout the filter run							
Increase in filtration rate							
Filter backwash and wastewater recycle practices are adequate							
Filter flow rate complied with specifications							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date							
Disinfection							
The required contact time (CT) guidelines were complied with for 99% of the volume disinfected							
The minimum residual disinfectant was maintained after disinfection e.g. 0.2 mg $arphi$ l							
Distribution reticulation							
Pressure continually maintained within the system							
A disinfectant residual maintained in all parts of the system							
Dead ends and mains were flushed							

Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

Checklist for optimising conventional water treatment systems to prevent health-related problems (continued)

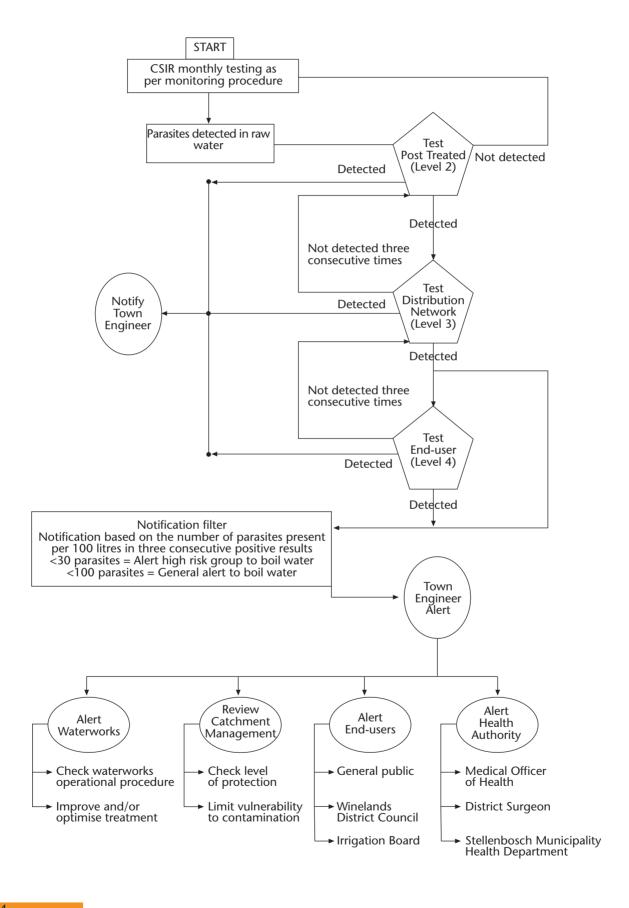
Water treatment assessment as on (date)	
Geographic area	
In geographic areas with cases of diarrhoea	
When last were storage reservoirs (all types) cleaned?	
Was any pipe maintenance done on pipes feeding the relevant area?	
Did the water quality in the distribution/reticulation network or at the consumers tap show any changes in the past 14 days?	
Adapted from WE Bellamy, JL Cleasby, GS Logsdon, MJ Allen. Assessing Treat	Logsdon, MJ Allen. Assessing Treatment Plant Performance. 1993. Journal AWWA, 85(12):34-38

## Example of a documented emergency response procedure • Appendix E

## Example of a documented emergency response procedure

From: Mackintosh, G, Delport, E and Mansfield, J. Drinking-water Parasites: Monitoring, Management and Treatment – South African Case Study. Cape Water Programme, CSIR, PO Box 320, Stellenbosch Parasite Response Procedures, Stellenbosch Municipality

#### Parasite Response Procedures, Stellenbosch Municipality



## List of major/bulk water suppliers in South Africa

Please note that this list may not be complete

Talanda	Basic water quality indicator	Pathogen detecti wat	
Laboratory	and chemical analyses	Bacteria and parasites	Viruses
State laboratories in major cities, e.g. the SAIMR	✓	_	
SABS, Pretoria and Cape Town	✓		
CSIR, Pretoria	✓	<b>√</b>	<b>√</b>
CSIR, Stellenbosch	✓		
Swift laboratories	√		
ARC Stellenbosch	✓		
Most universities and tech	nikons		
University of Pretoria	✓	✓	√
University of Venda	✓		
University of Fort Hare	√		
Free State Technikon	√		
Some bulk water suppliers	,		
Bloem Water	✓		
Cape Metropolitan Council Scientific Services	✓	✓	
Lepelle Northern Water	✓		
Magalies Water	✓		
Mhlatuze Water	✓		
Midvaal Water Company	✓		
Rand Water	✓	✓	
Sedibeng Water	✓		
Umgeni Water	✓	√	

## List of laboratories in South Africa that test water quality

## List of major/bulk water suppliers in South Africa

Source: Department of Water Affairs and Forestry, Department of Health, Water Research Commission. 1998 Assessment Guide

Bulk water supplier	Area		
Albany Coast Water Board	Eastern Cape		
Amatola Water Board	Eastern Cape		
Bloem Water	Free State		
Cape Metropolitan Council – Scientific Services	Western Cape		
Sedibeng Water	Free State		
Ikangala Water	Gauteng		
Kalahari East Water Board	Northern Cape		
Kalahari West Water Board	Northern Cape		
Karos-Geelkoppen Water Board	Northern Cape		
Lepelle Northern Water	Northern Province		
Magalies Water	North-West, Northern Province		
Mhlatuze Water	Northern KwaZulu-Natal		
Namakwa Water	Western Cape		
North West Water Supply and Authority	North-West		
Overberg Water	Eastern Cape		
Pelladrift Water Board	Eastern Cape		
Rand Water	Gauteng, North-West, Northern Free State		
Umgeni Water	KwaZulu-Natal		
Midvaal Water Company	Klerksdorp, Orkney, Stilfontein		

## Water-related documents and literature Epidemiological resources

#### The 'must haves'

Every person responsible for water quality should have at their disposable the following two documents

SABS 241, 1999, *Drinking Water Specification*, 4<sup>th</sup> Edition (available from the South African Bureau of Standards directly)

DWA&F, DoH and WRC, 1998, Quality of Domestic Water Supplies Volume 1: *Assessment Guide* (available from the Water Research Commission, Pretoria)

### The 'nice to haves'

The following documents provide a great deal of useful information

DWA&F, DoH and WRC, 2000, Quality of Domestic Water Supplies Volume 2: *Sampling Guide* 

DWA&F, DoH and WRC, 2001, Quality of Domestic Water Supplies Volume 3: *Analysis Guide* 

DWA&F, DoH and WRC, Quality of Domestic Water Supplies Volume 4: *Treatment Guide* (in preparation)

DWA&F, DoH and WRC, Quality of Domestic Water Supplies Volume 5 *Management Guide* (in preparation)

## **More South African publications**

DWA&F 1996, South African Water Quality Guidelines (second edition) Volume 1 *Domestic Use* 

SABS 241, 2001, *Drinking Water Specification*, 5<sup>th</sup> Edition

## Useful publications from the World Health Organization

can be ordered through a local university library or over the internet at http://www.who.int/ and viewed at

http://www.who.int/water sanitation health/GDWQ/GDWQindex.html

WHO 1993, Guidelines for Drinking Water Quality 2<sup>nd</sup> edition, Volume 1. *Recommendations*, Geneva

WHO 1996, Guidelines for Drinking Water Quality 2<sup>nd</sup> edition, Volume 2. *Health Criteria and Supporting Information*, Geneva

WHO 1997, Guidelines for Drinking Water Quality 2<sup>nd</sup> edition, Volume 3. *Surveillance and control of community supplies*, Geneva

### **Useful but pricey**

APHA, 1998. *Standard Methods for the Examination of Water and Wastewater* 20<sup>th</sup> Edition, APHA-AWWA-WPCF, Washington DC., USA

An extremely useful, but expensive (>\$400), book for water quality managers. It provides a comprehensive description of methodologies that can be used for different parameters. It also discusses *inter alia* sampling, quality control and reporting issues.

# Water-related documents and literature Where to find epidemiologists in South Africa at local level

## Where to find epidemiologists in South Africa

(Please note that this is not a comprehensive list)

#### **Department of Health**

At local level (municipal, district)

At provincial level

At national level

#### **Universities**

**MEDUNSA** 

National School of Public Health www.medunsa.ac.za

University of Cape Town

School of Public Health and Primary Health Care <a href="https://www.uct.ac.za/depts/cmh/epibio1.htm">www.uct.ac.za/depts/cmh/epibio1.htm</a>

University of KwaZulu-Natal, Durban

Department of Community Health www.ukzn.ac.za

University of Pretoria

School of Health Systems and Public Health <a href="https://www.up.ac.za/academic/medicine/shsph">www.up.ac.za/academic/medicine/shsph</a>

University of Stellenbosch

Department of Community Health www.sun.ac.za

University of the Free State

Department of Community Health <a href="https://www.uovs.ac.za/faculties/Med/comm/index.htm">www.uovs.ac.za/faculties/Med/comm/index.htm</a>

University of the Western Cape <u>www.uwc.ac.za</u>

University of the Witwatersrand

School of Public Health www.wits.ac.za

#### Research council

Medical Research Council

Cape Town, Pretoria, Durban <u>www.mrc.ac.za</u>

Listed here are a few useful websites that provide epidemiology training materials

Centers for Disease Control and Prevention (USA)

Public Health Practice Program Office <a href="https://www.phppo.cdc.gov/training.asp">www.phppo.cdc.gov/training.asp</a>

Department of Energy (USA)

Comprehensive Epidemiologic Data Resource <a href="http://cedr.lbl.gov/">http://cedr.lbl.gov/</a>

Supercourse – Epidemiology, the Internet

and Global Health <a href="https://www.pitt.edu/~super1/index.htm">www.pitt.edu/~super1/index.htm</a>

World Health Organization

GEENET (Global Environmental <a href="https://www.who.int/peh/geenet/">www.who.int/peh/geenet/</a>

**Epidemiology Network)** 

## Acts and laws related to water quality monitoring in South Africa

The National Water Act (Act number 36 of 1998) and the Water Services Act (Act number 108 of 1997) are the two important water-related acts in South Africa. In addition, we have the Bill of Rights and the Constitution, which advocate the right of everyone to an environment that is not harmful to his or her health or well-being and to have that environment protected for the benefit of present and future generations.

The National Water Act focuses on the management of the water resources in the natural environment. The main area of focus of the Water Services Act is on ensuring that water is provided to the population, with a particular emphasis on the previously disadvantaged and unprovided sector of the population. The emphasis of the two acts is different, with the National Water Act focusing on the water in the river or dam, and the Water Services Act focusing on the water as soon as it is extracted from the river or dam as a water supply.

The National Water Act states that the Minister has a duty to establish national monitoring systems. The focus is on monitoring the quality of water in the various water resources.

The main area of focus of the Water Services Act is on ensuring that water is provided to the population. The quality of potable water, taken or discharged into any water service or water resource system in terms of Section 9(1)(b) of the Act, is described in clause 4 as follows:

#### Quality of potable water

- (1) The quality of potable water provided to consumers must comply with SABS Code 241: Water for Domestic Supplies.
- (2) A water service provider who is at any time, unable to provide potable water in compliance with SABS Code 241: Water for Domestic Supplies, to consumers, must inform the Minister and the Province and take reasonable steps to inform its consumers.
  - (a) That it is unable to provide potable water of the prescribed quality;
  - (b) Of the reasons therefor;
  - (c) Any precautions to be taken by the consumers; and
  - (d) The time frame, if any, within which it may reasonably be expected that the prescribed quality will be provided.

Regulations and national standards in terms of the Water Services Act have been developed, related to Section 9 of the Act. The regulations became available in June 2001.

## Water-related diseases

Note: Also refer to Volume 1 in this series:

Management of Water-related Microbial Diseases. Volume 1: What is the Problem? Disease Characteristics (WRC Report TT 175/03)

Many infectious diseases are related to water in a variety of ways. They can be grouped into four categories, namely water-borne, water-washed, water-vectored or water-based diseases. Among the most typical water-related diseases are gastroenteritis, amoebiasis, salmonellosis, dysentery, cholera, typhoid fever and hepatitis.

## Appendix J • Acts and laws related to water quality monitoring in S.A.

Water-borne diseases are those diseases transmitted directly by the ingestion of contaminated water. Classic examples are gastroenteritis, cholera and typhoid, but also included are a wide range of other diseases such as infectious hepatitis. Infectious agents include bacteria, viruses, protozoa and parasites and are typically transmitted by the faecal-oral route from human-to-human or animals-to-humans.

Water-washed diseases are closely related to poor hygiene and lack of sanitation. The availability of a sufficient quantity of water is thought to play an important role in water-washed diseases. In addition to diarrhoeal diseases, infectious diseases transmitted via this route include those affecting the eyes and skin, such as trachoma, conjunctivitis, scabies and leprosy. The diarrhoeal diseases of this group are often transmitted person-to-person and comprise one of the major causes of morbidity and mortality in developing areas.

**Water-based** diseases are due to pathogens dependent on aquatic organisms for the completion of their lifecycles. Examples are bilharzia and dracunculiasis (Guinea-worm disease). Both water quality and social behaviour are of importance in the transmission of these diseases.

Water-vectored diseases are caused by insects which breed in water. Examples include malaria, yellow fever and trypanosomiasis (sleeping sickness).

Other water-related diseases which cannot be classified under the above scheme include legionellosis, associated with inhalation of aerosols contaminated with *Legionella* bacteria, and other respiratory diseases, through inhalation of endotoxins produced by blue-green algae.

Examples of the many pathogens causing water-borne disease outbreaks and the diseases associated with them are given in the table on the next page.

As is illustrated in the table, diarrhoea (gastroenteritis) can be caused by numerous agents, including viruses, bacteria, parasites and toxins. It is a symptom of many of the illnesses caused by the various pathogens that might be involved in water-related disease.

Current understanding of the health consequences of the consumption of pathogens in drinking water is to this day not clearly understood, with dose-response relationships available for only a limited number of organisms. Now, more than ever, we are faced in South Africa with the challenge of how to decide on ensuring that drinking and source water are safe in the face of increasing demands on public funds and resources.

## Water-related pathogens

Pathogen		Disease
Bacteria		
Campylobacterspp.		gastroenteritis
Shigella spp.		dysentery and gastroenteritis
Salmonella typhi and	d other spp.	typhoid fever and gastroenteritis
Yersinia spp.		gastroenteritis
enteropathogenic E	. coli	gastroenteritis
Vibrio cholerae		cholera
Viruses		
poliovirus		poliomyelitis
Enteroviruses	echovirus	meningitis and gastroenteritis
	Coxsackievirus	respiratory, meningitis and diabetes
Hepatitis virus (A, C	&E)	hepatitis/jaundice
Adenovirus		gastroenteritis and respiratory disease
Rotavirus		infantile gastroenteritis
Norwalkvirus		gastroenteritis
SRSV (small round s	tructured viruses)	gastroenteritis
Protozoan Parasite	es .	
Giardia intestinalis		giardiasis (gastroenteritis)
Cryptosporidium par	vum	cryptosporidiosis
Entamoeba histolytic	ca	amoebic dysentery
Helminths		
Dracunculis mediner	osis	"Guinea worm"/ dracunculiasis

## Water quality guidelines

The main aim of water quality guidelines is to protect public health. According to the World Health Organisation (1993), the potential consequences of microbial contamination are such that its control must be of paramount importance and must never be compromised. Generally the greatest microbial risks are associated with ingestion of water contaminated with human and animal excreta. Water must, as the first line of defence, be protected from contamination by human and animal waste.

The methods used to determine whether water is safe vary according to guidelines and standards. According to the majority of international guidelines and standards, water intended for human consumption should be safe, palatable and aesthetically pleasing. This implies that the water should ideally be free of pathogenic microorganisms and other substances that may present a health risk.

At present a number of South African water quality guidelines and specifications are available, and are used by all concerned at their discretion. South African water quality guidelines are currently not legally enforceable.

## 1. The DWAF Water Quality Guideline (1996)

These guidelines make use of the "fitness for use" concept. The "fitness for use" of water is a judgement of how suitable the quality of water is for its intended use. The characteristics of water use involve determining and describing those characteristics which will help determine its significance as well as those that dictate its water quality requirements. Target water quality ranges are given for various constituents. The DWA&F guidelines generally specify target ranges that fall into the "No Effect Range" which is the range of concentration at which the presence of the constituent would have no known or anticipated adverse effect on the fitness of water for a particular use. These ranges were determined assuming long-term continuous use and they incorporate a margin of safety.

The guidelines were developed so that they could as far as practically possible serve as a source of information for water resource managers to make judgements about the "fitness for use" of water for different domestic purposes. A total of 42 parameters are presented in the DWA&F 1996 Guideline. No attempt is made to prioritise the various parameters that should be assessed.

### 2. The DWAF, DoH & WRC (1998) Assessment Guide

This is a user-friendly guide designed for assessing water supplied for domestic use. It involves a simple colour-coded classification system and information is presented in a simplified format so that a wide spectrum of users will be able to understand the underlying concepts of water quality as it affects the domestic user.

This guideline prioritises the substances according to four different groups.

#### **Group A substances**

Five parameters are listed in a priority table that specifies tests that should be carried out frequently at all points in the water supply system. These include electrical conductivity (EC), faecal coliforms, pH, turbidity and free residual chlorine.

#### **Group B substances**

A further six parameters are listed as substances which are commonly present at concentrations which may lead to health problems. These include nitrate & nitrite, fluoride, sulphate, chloride, arsenic and total

## Water quality guidelines • Appendix L

coliforms. It is recommended that these substances should be assessed before the water is supplied, with the frequency of testing depending on the source and treatment applied.

#### **Group C substances**

These are substances that might be a health concern on a much less frequent basis. Only cadmium and copper occur at concentrations of real concern. These substances are of concern in areas where soft acidic water is used.

The Assessment Guide makes use of a classification system where water is classified into one of 5 classes, as follows:

- *Ideal* water is safe for domestic use;
- Good quality water is safe for domestic use;
- Marginal quality water is safe for use, but may affect certain sensitive groups;
- *Poor* quality water may be used for short-term emergency use where no other supply is available; and
- Water of *unacceptable* quality is unsafe without treatment.

#### 3. The SABS 241 2001 Standard Specification for Drinking Water

These guidelines specify three classes of water in terms of physical, microbiological and chemical quality, as follows:

- Class 0 an *ideal* standard that is closely comparable to current international standards;
- Class I water which is known to be acceptable for whole lifetime consumption; and
- Class II water considered to be *maximum allowable* for short term consumption (usual and continuous daily consumption for periods not exceeding one year).

With respect to microbiological parameters, 3 groups are provided for:

- The limit which must be met in 95% of samples;
- The 4% maximum limit: and
- The 1% maximum limit.

The inclusion of the Class II waters in the updated SABS 241-2001 acknowledges that in many cases, and in particular with regard to microbiological requirements, South African drinking waters will not satisfy the previous existing standards, and that the need for a relaxed level for short-term consumption is a practical necessity.

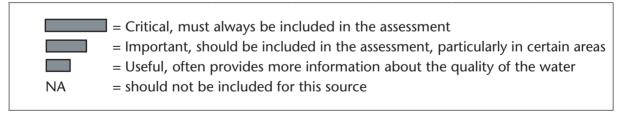
# Summary comparing the more recent South African microbial drinking water quality guidelines

	Heterotrophic plate count (HPC/ml)	Total coliforms /100ml	Faecal coliforms and E. coli /100ml		iphages/ pathogei	
1. The DWA	F Water Quality	y Guideline	(1996)			
Target range	<100	5	0	0-1	0 <sup>a</sup>	0 b
Above target	1000	5-100	10	10	1 <sup>a</sup>	>1 b
range	>1000	>100	20	100	10 <sup>a</sup>	
2. The DWA	F, DoH & WRC	(1998) Ass	essment Gu	iide		
Ideal	-	0	0			
Good	-	0-10	0-1			
Marginal		10-100	1-10			
Poor	-	100-1000	10-100			
Unacceptable	-	>1000	>100			
	241 2001 "Star of disinfection is imum					
95% min	100	0	0	0	0 °	0 b
4% max	1000	10	1	1	1 <sup>c</sup>	0 b
1% max	10000	100	10	10	10 <sup>c</sup>	1 b

## Assessing domestic water quality

The substances which must be included when assessing domestic water quality at different points in the supply system and from different sources

		SOURCE			
SUBSTANCE	River, well, stream	Dam	Borehole	TREAT WORKS	POINT OF USE
Group A Electrical conductivity (EC) Faecal coliforms pH Turbidity Free available chlorine	NA NA	NA NA	NA NA		
Group B Nitrate/nitrite as N Fluoride Sulphate Chloride Arsenic Total coliforms					
Group C Cadmium Copper					
Group D  Manganese Zinc Iron Potassium Sodium Magnesium Calcium Hardness, Total					



Reproduced from DWA&F, DoH and WRC, Quality of Domestic Water Supplies, 2000

## The principle of indicator organisms as an assessment of water quality

Ideally drinking water should not contain any known pathogenic microorganisms and it should be free from bacteria indicative of pollution with excreta. To ensure that a supply of drinking water satisfies these guidelines of bacterial quality, it is important that water be examined regularly for indicators of pollution (WHO, 1993).

It is impossible to routinely test the water supply for all pathogens related to water-borne diseases because of the complexity of the testing and the time and cost related to it. Indicator systems which are able to index the presence of pathogens and related health risks in water are therefore used.

An indicator organism should fulfil the following criteria:

- it should be present when the pathogen is present and it should be absent in unpolluted water;
- it should be present in numbers greater than the pathogens it indicates;
- its survival in the environment and resistance to treatment processes should be comparable to that of pathogens;
- it should not be harmful to human health; and
- it should be easy to identify and isolate.

At present there is no single indicator which complies with all the above criteria. The traditional indicators of drinking water quality include the coliform group (including thermo-tolerant or faecal coliforms and *E. coli*). The faecal coliforms, or thermo-tolerant coliforms, and *E. coli* have been differentiated from the total coliforms as being more specific indicators of faecal pollution. The standard or heterotrophic plate count is also used in many countries, including South Africa, as a useful parameter in the quality control of water and water treatment processes.

The **coliform group** is defined as any Gram negative, oxidase negative, non-sporing, rod-shaped organisms capable of growth in the presence of bile salts and capable of fermenting lactose with the production of acid, gas and aldehyde within 48 hours. Total coliforms include the genera *Escherichia*, *Citrobacter*, *Klebsiella and Enterobacter*. Coliform bacteria should not be detected in treated water supplies; their presence suggests inadequate treatment or post-treatment contamination.

**Faecal (thermo-tolerant) coliforms** refer to those coliforms which retain the specified fermentative properties at 44.5°C and include the genera *Escherichia* and, to a lesser extent, occasional strains of *Enterobacter, Citrobacter and Klebsiella*. Of these organisms, only *E. coli* is specifically of faecal origin, being found in large numbers in the faeces of man, animals and birds. Presumptive *E. coli* are defined as those faecal coliforms that ferment lactose and mannitol with acid and gas production at 44 or 45°C and which also produce indole from tryptophan.

**Heterotrophic plate counts (HPC)** (also referred to as standard plate counts) represent those microorganisms present in water which are able to form colonies in nutrient media under specified culture conditions, *i.e.* at 37°C within 48 hours or at 22°C within 72 hours. Heterotrophic plate counts may be used to assess the general bacterial content of water.

**Bacteriophages** are viruses that infect bacterial host cells. More specifically, coliphages are viruses that infect coliform bacteria. Coliphages have been proposed as alternative indicators of enteric viruses in contaminated waters because they are present in numbers greater than or equal to enteric viruses, are more resistant to disinfection than enteric viruses, persist in water longer than enteric viruses and are detected using simple, rapid and economical techniques. However, many limitations exist. Phages have often been proposed as indicators of faecal pollution (rather than indicators of enteric viruses).

## The principle of indicator organisms as an assessment • Appendix N

**Exceptions where pathogen presence is set in water quality guidelines.** Because the potential presence of pathogens in water cannot be predicted solely by faecal indicators, it may be necessary under certain circumstances to monitor for the presence of pathogens in addition to routine indicators - provided that the facilities are available. The World Health Organization (1984) has recommended that, under certain circumstances, it is necessary to monitor for *Salmonella spp., Shigella spp., Vibrio cholera, Yersinia enterocolitica, Campylobacter fetus,* enteropathogenic *E. coli* and enteric viruses. The EEC specifies that water intended for human consumption should not contain pathogens and, if it is intended to supplement the microbiological analysis of water intended for human consumption, the samples should be examined for pathogens including *Salmonella*, pathogenic staphylococci, enteroviruses and faecal bacteriophage.

**Protozoan parasites**. Parasites, as do viruses, have a low infective dose and a greater resistance to chlorine than faecal indicators. Both *Giardia* and *Cryptosporidium* have caused water-borne outbreaks throughout the world. Methods have been developed for the detection of these organisms in water. In general, no cysts or oocysts should be present in water. In the USA, the Environmental Protection Agency (1989) requires that a reduction in the treatment process should ensure a 3 log reduction of *Giardia* cysts. Most guidelines merely state that pathogens should be absent from drinking water. The Department of Water Affairs and Forestry guidelines (1996) have included suggested guidelines for protozoan parasites. It is suggested that water to be used directly or to receive treatment should contain <1 *Giardia* cyst/10L and <1 *Cryptosporidium* oocyst/10L. The South African Bureau of Standards 1999 specifications are stricter, specifying a volume of 100L.

Enteroviruses. There is general agreement that human viruses are not acceptable in drinking water and that virological analysis may be necessary under certain circumstances. Viruses have been isolated from drinking water supplies in the absence of faecal indicators and with 0,8 mg/l of free chlorine. Because bacterial indicators are not able to indicate the potential viral health risks associated with water, direct tests for viruses are recommended for certain situations where virological facilities are available. Suggestions as to when virological testing should be carried out include the following: raw water evaluation to give an indication of any health hazard should treatment fail; to check on an installed treatment process to demonstrate virus removal; on any occasion when treatment is deficient; service reservoirs and parts of distribution systems where contamination is suspected; periodic checks on underground sources and during outbreaks of possible water-borne viral disease. The Department of Water Affairs and Forestry guidelines (1996) have included suggested guidelines for enteric viruses, with a target value of 0/10L. Again, the South African Bureau of Standards 1999 specifications are stricter with a volume of 100L specified

## Chronic diarrhoea of unknown origin

translated from the Afrikaans report published in Epidemiological Comments Volume 17(11) November 1990 by the Department of Health, Pretoria

This article is reproduced here as an example of an epidemiological investigation; it is <u>not</u> a blueprint for investigating outbreaks of diarrhoea

## <u>Chronic diarrhoea of</u> <u>unknown origin – Part I</u>

#### Introduction

Diachron (fictitious name), a town in the Western Cape, has a total population of approximately 9200 people of whom 3300 are Whites. There are five medical practitioners in the town. Diachron has one hospital and two clinics, one of which is a full-time clinic in the Coloured township.

During the second half of 1989, the health department of the municipality became aware that several residents of Diachron had a chronic diarrhoea problem. The health inspector of the sub-regional office of the Department of National Health and Population Development in Worcester was asked to help in investigating possible causes.

Specimens of household water taken from the various reservoirs were analysed bacteriologically. No E. coli or coliform organisms were found in these specimens.

Milk specimens were obtained from the main supplier of unpasteurised milk in Diachron. Results of the bacteriological investigation showed that the milk was suitable for human consumption (Table 1).

The regional office of the Department in Bellville became involved in the investigation in March 1990. A registrar in Community Health visited Diachron on 13 March to determine the extent of the problem.

The medical practitioners in

Diachron confirmed the epidemic. They were aware of only one similar case which occurred five years previously. The symptoms of that case cleared up spontaneously after about two years.

The doctors felt that the problem was probably due to a virus. They were aware of approximately 20 affected persons. To describe the epidemic in terms of time, place and person, it was decided to interview each case by means of a questionnaire. At the same time, a notice was placed in the local newspaper asking all cases to come forward. A list of 32 cases was thus compiled.

This investigation was conducted on 13, 19 and 20 March 1990.

#### Results

Only 24 of the 32 identified cases were available for an interview. All the cases were residents of the town of Diachron.

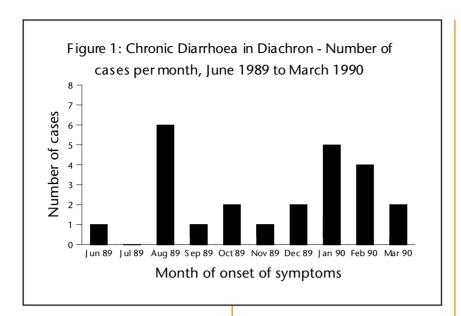
The symptoms were as follows: Nausea/vomiting - 2 patients Fever - None Stomachache - 2 cases, usually cramps, only now and then Malaise - None Headache - 1 case Stool patterns: Urgency - 100% of cases

Table 1: Bacteri ological investigation of the milk from the main supplier of unpasteurised milk to the residents of Diachron, 31 October 1989

Examina tion	Result	Standard
Colony forming bacteriological units per 1.0 ml of sample	25 000	< 50 000
Coliform organisms in 1.0 ml of sample	15	< 10
Escherichia coli in 1.0 ml of sample	Negative	Absent
Salmonellae and/or Shigellae in 1.0 ml of sample	Negative	Absent
Staphyllococcus aureus present i n 0.1 ml of sample	Negative	Absent
Milk Ring Test for Brucella	Negative	Absent
Antibiotics or other antimicrobial substances	Negative	Absent

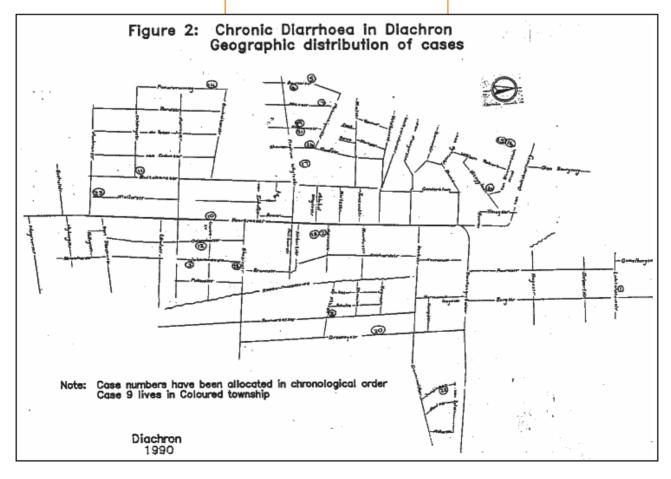
A case was defined as a person who reported himself or was reported by the local doctors and who had had diarrhoea of unknown origin for at least one month.

Frequency - Initially up to 20 times a day, decreasing to about 2-5 times per day
Smell - 8 cases described a bad smell when the problem began, then it became less noticeable.



100% of cases complained of flatulence and an explosive nature of the stool In 13 out of 24 cases, the diarrhoea was brought on by food In 5 out of 24 cases, the diarrhoea was brought on by any physical activity Stools did not float and usually did not have a firm composition but were merely watery None of the cases had a history of possible dehydration (lost weight initially, about 3-4 Kg, then stabilised).

The symptoms worsened after ingestion of fruit, wine, beer and dairy products. Only three cases could think of an event which was possibly associated with the onset of symptoms. One case had a 14 year old son who had had a stomach disorder which lasted one week. A second case associated the onset of symptoms with stress, and the third person had had a meal in a local restaurant shortly before the symptoms started. Twelve of the 24 cases left Diachron for a period of 1 to 4 weeks. None of them experienced any relief of symptoms during this time. The first case had a date of onset in June 1989. The monthly average up to March 1990 was



## Appendix O • Chronic diarrhoea of unknown origin

Table 2: Chronic diarrhoea in Diachron -Age distribution of the White cases as in March 1990

Age group (yr)	Number of cases	Attack rate (%)
< 25	0	0.00
25 - 34	2	0.53
35 - 44	7	1.78
45 - 54	5	1.43
55 - 64	5	1.17
65 - 74	1	0.27
75 +	2	0.89
Total	22	0.67

2.4 cases. More than two cases per month occurred in August 1989, January and February 1990 (Figure 1).

Residential addresses of all cases are shown on a map of the

Table 3: Chronic diarrhoea in Diachron -Distribution of occupations of cases as in March 1990

Occupation	Number of cases	%
Professional	7	29
Housewife	7	29
Pensioner	5	21
Adminis trative	3	13
Technical	2	8
Total	24	100

town (Figure 2). Cases occurred throughout Diachron. There was no obvious association between date of onset and residential address.

Cases were also asked where

they worked. Their work addresses were concentrated around the main street of Diachron, which corresponds with the distribution of businesses in the town.

Two cases – a pensioner and her domestic help – were from one household.

Only two of the cases were Coloureds – the domestic help and a nurse in the service of the municipality.

Of the 22 Whites, 9 (41%) were males. The sex-specific attack rates were 0.59% and 0.74% for males and females respectively. Ages of cases ranged from 32 to 81 years. The attack rate in the 35 to 64 year age group was

higher than one percent (Table 2).

Five of the cases were pensioners. Cases came from a wide variety of occupations (Table 3).

Twenty-three cases used unpasteurised milk from a farmer in the area. Apparently this milk was used by a large number of residents in Diachron. The remaining case was lactose-intolerant and did not use any dairy products.

All cases used municipal water. The main source of water in Diachron is provided by the Klipriver which has a catchment area of about 980 hectares. Diachron has 6 reservoirs with a combined storage capacity of 6500 m3 [1].

Table 4: Chronic diarrhoea in
Diachron –
Bacteriological investigation
of the water, 21 March 1990

Sample	Total coliform organisms per 100 ml	<i>E. coli</i> per 100 ml
Reservoir 1	110	33
2	79	70
3	33	7
Household 1	0	0
2	33	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	2	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0
*18	≥2400	≥2400
19	0	0
20	0	0

<sup>\*</sup> Possible contamination during taking of sample

Fresh fruit was obtainable from three main sources in the town. Only one case cultivated his own vegetables and fruits. One case suspected that poisons in the air as a result of agricultural spraying were at the root of the problem. Six cases suspected the water. Five said that the water had a strong chlorine

Table 5: Chronic diarrhoea in Diachron Chemical analysis of the water on three different days

Condition of water		ch 1990 nples	4 May 1990	15 June 1990
Colour	Cl	ear	Clear	-
Sedimentation	No	one	None	-
Smell	Noi	mal	Normal	-
Conductivity(mS/m)	9.0	7.1	5.8	8.38
рН	5.25	5.88	5.5	7.25
Ammonia (N)	0.0	0.0	0.0	-
Chemical oxygen demand (O)	-	-	6	-
Nitrate (N)	0.0	0.0	0.0	1.8
Nitrite (N)	0.0	0.0	0.00	-
Chloride (Cl)	2.9	2.94	14	12
Sulphate (SO <sub>4</sub> )	0.00	0.00	9	12
Fluoride (F)	0.2	0.2	2.8	0.2
Ortho-phosphate (P)	0.6	0.4	0.0	0.2
Total alkalinity (CaCO <sub>3</sub> )	17.1	19.7	22	12
Total hardness (CaCO 3)	51.9	11.3	37	14
Calcium (Ca)	17.2	1.7	0	14
Magnesium (Mg)	2.2	1.7	9	0
Potassium (K)	0.0	0.0	0	-
Sodium (Na)	8.9	9.0	5	-
Sulphur (S <sup>2-</sup> )	None	None	-	-

Note: - = information not available on reports

smell at times. Three cases observed that the water was very brown and muddy after pipes had broken.

Water purification in Diachron consists of the removal of colour by adding aluminium sulphate and sodium aluminate, flocculation, precipitation and filtration through a system of slow sand filters supplemented by pressure filters, and sterilisation by the administration of chlorine gas. Despite the addition of lime since the second semester of 1989, the water has a low pH every now and then [1].

Follow-up Information

On 11 September 1990 the situation was reviewed. By that stage, the total number of known cases was 61.

The symptoms of three of the 32 original cases cleared up spontaneously with no change in lifestyle. One case had immediate relief after two courses of indomethacine for osteo-arthritis of the neck. This clue was followed up by the Pharmacology Department of the University of Stellenbosch. According to them, any anti-inflammatory will clear up diarrhoea with an inflammatory basis. The medical practitioners prescribed this to a selection of

cases after obtaining informed consent. No improvement of symptoms was experienced.

One of the biggest problems in obtaining the true number of cases was the fact that residents labelled themselves as having the "Diachron diarrhoea" without having this confirmed by the doctors. In addition, not all people with the syndrome made themselves known.

Several of the cases were sent to physicians for further investigations. With the patients' consent, the physicians were contacted telephonically. The following is a summary of their reports: Stool examinations microbiologically and virologically normal; Full blood counts - normal; Physical examination - normal; Colonoscopies – slight inflammation of the intestinal walls, otherwise normal; One patient even had a negative laparotomy.

#### Discussion

The disease process could probably be interrupted if the aetiological agent were known. Based on the results obtained from the questionnaires, it was decided to focus the search for the aetiology on microbiological and chemical causes. The reason for supporting a microbiological aetiology is that this is the most common cause of diarrhoea outbreaks in communities. Factors against a microbiological aetiology are: Long duration of the epidemic (not self-limiting) Gradual increase over time (about 60 cases in one year)

## Appendix O • Chronic diarrhoea of unknown origin

Generally only one case per household Children not affected Cases not ill or dehydrated.

Reasons in favour of a chemical agent include all the evidence against a microbiological agent. A factor against a chemical agent is that this rarely causes an outbreak of diarrhoea in a community.

The method of transmission does not appear to have been person-to-person since there was no fixed pattern in the incidence of cases. For example, there were few familyrelated cases. The fact that new cases occurred sporadically and did not appear to be associated with known cases indicates that the most likely source of infection is a common source which is still active. The most logical common sources are water, milk and foods such as bread, vegetables, fruit, poultry, meat and fish.

Several questions remain unanswered – why do cases occur so haphazardly, why are there so few cases in the Coloured township, why is there usually only one case per household?

## **Sample Testing**

Based on the above discussion, it was decided to test the following samples:

Water samples

Basic microbiological analysis of water was done by the regional laboratory of the Department in

Table 6: Chronic diarrhœa in Diachron Milk samples taken on 25 April 1990

Examina tion	Sam	Standard	
Examina don	1	2	values
Plate count	93 000	< 30 000	< 50 000
Coliform organisms	45	110	< 10
E. coli	-	-	None
Salmonella	-	-	None
S higella	-	-	None
Staph. aure us	-	-	None
Brucella	-	-	Negative
Antibiotics	-	-	None

Cape Town (Bacteriology).

Water samples from 20 households and 3 reservoirs were submitted for bacteriological investigation (Table 4).

Possible contamination of one sample is suspected. Several coliform organisms were found. This however has little meaning when the size of the problem is taken into account.

Chemical analysis of the water was done by the Forensic laboratory of the Department in Pretoria. The water was declared safe for human use throughout (Table 5).

Note that these were merely routine chemical screening tests, not specific tests searching for a cause. The results showed no chemical abnormalities in the water which might explain the diarrhoea epidemic.

Virological, parasitological and other bacteriological investigations were not done due to the costs involved for the local authority.

Milk samples

A large proportion of the inhabitants of Diachron use fresh unpasteurised milk from a farm just outside the town. Without prior warning to the farmer, four milk samples were taken – two per day, one day a week for two weeks. The results of two samples were normal, those of the other two are summarised in Table 6.

According to the health inspectors, the results are not out of keeping with what is normally observed as far as fresh milk is concerned.

Stool samples

Virological tests were done on 17 samples from 11 patients on 29 April 1990. No adenovirus was detectable in any of the samples.

On 4 April, stools from 18 cases were cultured. No Shigella, Salmonella, Yersinia, Campylobacter, Aeromonas, Vibrio or enteropathogenic *E. coli* could be isolated. The rotavirus latex test was also negative.

Microbiological examination did not reveal any eggs, amoebae, pus cells or red blood cells. *Giardia lamblia* cysts were seen in only one case (the Coloured domestic help).

**Blood** samples

Five of the long-standing cases were tested for red cell cholinesterase. The results were within normal limits for men and women respectively.

Negative blood tests eliminated low-grade chronic organophosphate poisoning as a possible cause.

Thus, until the end of October 1990, all investigations of water, milk and stools were negative or not significant.

#### References

1. Municipality (Diachron), ANNUAL REPORT ON HEALTH, 1989

### Reported by

This report was compiled by Dr S Carstens, Registrar in Community Health, Department of National Health and Population Development, Regional Office, Bellville.

## <u>Chronic diarrhoea of</u> <u>unknown origin – Part II</u>

### Introduction

In October 1990, the Directorate: Epidemiology was approached to help with finding the cause of the chronic diarrhoea problem in Diachron. A team of three left for the Cape on 5 November. The next day, after discussing the problem with personnel at the regional office in Bellville and with the health inspector of Diachron, the investigation team left for Diachron.

## The Surveillance System

A list of 61 possible cases was compiled based on information obtained during previous investigations. It was, however, not known whether these were all the cases of chronic diarrhoea or not. To determine

the full extent of the problem, as well as to find out whether new cases had occurred subsequently, a surveillance system was set up.

On 8 November, a report was placed in the local newspaper requesting all residents of Diachron who thought they suffered from "Diachron diarrhoea" to report themselves. To make the Coloured community aware of this appeal, a similar notice was delivered to every house in the Coloured township. Forms, with details such as name, address and telephone number, were left at the hospital, clinics, general practitioners, municipal offices, library and pharmacies.

Each such report was followed up by the completion of a questionnaire which concentrated on details of the symptoms of the diarrhoea. This information was used to determine whether the person was a definite case (according to the case definition described below) or a suspect case. Cases were graphed on an epidemic curve according to month of onset. It will thus be clear when the epidemic comes to an end whether this be due to specific actions, or because all susceptibles already have the disease.

This surveillance system will be run by the geriatric nurse of Diachron until no new cases occur.

# Extent of the problem in the Coloured community

Only two of the 61 known cases were Coloureds, despite the fact

that more Coloureds (5900) than Whites (3300) live in Diachron. Giardia lamblia was isolated from one of these two; her symptoms were thus unlikely to be due to "Diachron diarrhoea".

To find out whether there really were so few cases in the Coloured community, or whether cases were just not being reported, a quick survey was done. Five streets in the Coloured township were chosen, and in each of these five streets between 5 and 9 houses (altogether 39 houses) were visited. Only one of the two hundred people living in these houses suffered from diarrhoea – his symptoms had started six weeks earlier, with 5 watery stools per day.

It was concluded that "Diachron diarrhoea" was not more prevalent amongst Coloureds than initially thought.

# The Case-Control Study Hypotheses

The cause of the chronic diarrhoea was unknown. No organisms had been isolated from stool samples of cases. This does not exclude the possibility that the condition is due to an infectious agent, but then it would have to be one for which no test has been done yet. The cause could also be chemical in nature, such as exposure to poisonous substances.

The fact that cases occurred only in the municipal area of Diachron and not in surounding areas indicated that the search for the cause should be in

## Appendix O • Chronic diarrhoea of unknown origin

Diachron itself. It was suspected that the cause was associated with lifestyle since mainly White adults were affected. This would include factors such as eating and drinking habits, use of medication, other chronic conditions and exposure to chemical substances.

From the interviews with cases in March 1990, it was established that all cases had been exposed to the municipal water, and that 23 of the 24 drank milk from the same source. Water and milk were thus definitely possible risk factors.

## **Study Design**

A matched case-control study was done to determine which factors occurred more frequently amongst people with chronic diarrhoea than amongst those without the problem.

#### Case definition

A case of chronic diarrhoea was defined as a resident of Diachron who, since June 1989, had had three or more watery stools per day for at least 28 days, and for which no aetiologic cause could be found.

A control was defined as a person who had been a resident of Diachron since June 1989, and who had had no diarrhoea lasting longer than three days since then.

### Obtaining the information

To satisfy the case definition, a person with chronic diarrhoea had to have been to a doctor to exclude other causes. In consultation with the medical practitioners in Diachron,

29 cases were identified - 26 from the original list of 61 possible cases and three subsequent cases.

For each case, a control was chosen of the same sex and the same age group (+ or - 10 years). The control also lived in the same residential area as the case (Figure 3). Fieldworkers were given instructions to turn to the right when leaving the home of a case, and then to go from house to house until a suitable control was found. This was not always possible in practice, and in such instances the direction was determined in advance using a map of the area. If a possible control was not at home, he or she was interviewed at work.

Appointments for interviews were made telephonically with each case. A standard questionnaire (appended) was used for all 29 cases and 29 controls. An interview with a case lasted up to 90 minutes; interviews with controls were much shorter - 15 to 30 minutes. Six fieldworkers obtained the information over a period of seven days (8-14 November 1990).

#### **Analysis**

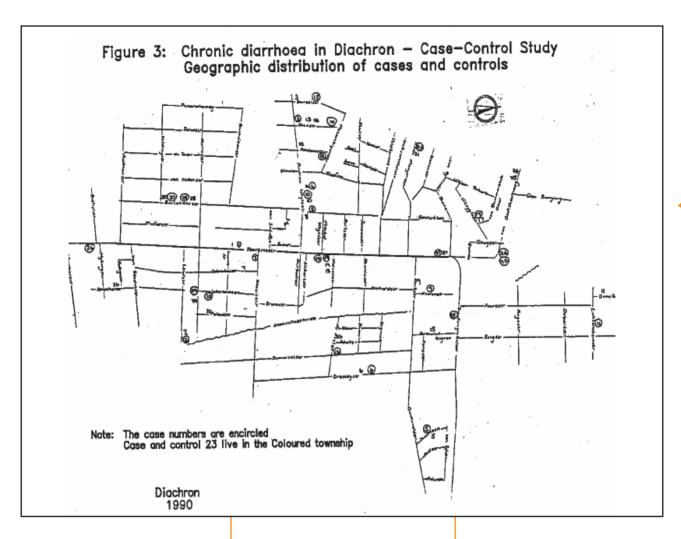
Epi Info version 5 was used for all analyses.

A basic description of cases and controls is given in Table 7.

Questions on the questionnaire were transformed into possible risk factors. For each person, it was determined whether he/she had been exposed to each factor - as far as the cases were concerned, exposure was determined on the basis of information relating to the time period before onset of the condition. The percentage exposed in each of the two groups is summarised in Table 8.

Although a matched design was used, the appropriate matched statistical tests could not be used since the data for several factors contained a zero in the denominator. Instead, the analytical methods for unpaired data were used. Yates' corrected chi-squared test was applied to each factor to determine whether the observed differences between cases and controls were statistically significant. Fisher's exact probability was calculated whenever the expected cell values were less than 5. The only factors which could not be explained as a result of chance were those concerning the use of milk (Table 8). Results for the various suppliers of food are not shown in Table 8 - there were no differences between cases and controls.

The relative risk associated with the use of farm milk was estimated by the odds ratio (Table 9). Exact confidence limits were calculated to obtain 95% confidence intervals. It appears that the risk of having the diarrhoea is 15 times higher for people who drink fresh farm milk than for those who do not use farm milk. For those people who obtain their milk from a specific supplier, the risk is 20 times higher than for those who do not use his milk. Data



concerning the use of milk from a specific supplier were further analysed. All persons included in the study were divided into three groups: those who do not use his milk at all, those who use his milk only in boiled form and those who use his milk unboiled (Table 10). There is no evidence that people who use his milk in boiled form only have a higher risk than those who do not use his milk at all (the confidence interval includes the value 1.0). The risk for the group who uses his milk unboiled, however, is 39 times higher than those who do not use his milk.

To determine whether the amount of unboiled milk made a

difference, a rough estimate was made of the daily number of glasses used by each person.

During the interview, respondents were asked specifically how many glasses of milk they drank per day; an additional glass was added if the person also used unboiled milk in food. The results in Table 11 indicate a dose-response. Compared to people who did not drink milk from the supplier at all, those who drank only one

glass of unboiled milk per day had a 24 times higher risk; this increased to 54 times for people

Table 7: Chronic diarrhoea of unknown origin Description of persons included in the case-control study

	Cases	Controls
Total	29	29
Males	13	13
Age (years):		
Average	51	51
Minimum	29	27
Maximum	82	86
Live in Diachron (years):		
Average	19	15
Minimum	0	2
Maximum	52	57

## Appendix O • Chronic diarrhoea of unknown origin

Table 8: Chronic diarrhœa of unknown origin

Dossible wiek feeten	Nι	umber of pe	ers ons ex p	os ed	p-value
Possible risk factor	Cases		Controls	5	Yates correcte
Eats bread	29	(100%)	29	(100%)	n:
Eats vegetables	29	(100%)	29	(100%)	n:
Eats raw vegetables	26	(90%)	25	(86%)	n
Eats unwashed raw vegetables	0	(0%)	0	(0%)	n
Eats fruits	28	(97%)	29	(100%)	n:
Eats unwashed fruits	10	(35%)	9	(31%)	n
Eats unpeeled fruits	12	(41%)	14	(48%)	n:
Eats meat	29	(100%)	29	(100%)	n:
Eats fish	26	(90%)	29	(100%)	n:
Eats eggs	27	(93%)	29	(100%)	n
Uses milk (excluding powder milk)	28	(97%)	26	(90%)	n
Uses farm milk	28	(97%)	19	(66%)	0.007
Uses milk from specific supplier	28	(97%)	17	(59%)	0.001
Drinks milk from specific supplier	26	(90%)	8	(28%)	0.00000
Transports farm milk in plætic container	17	(59%)	13	(45%)	n
Uses other dair y products	27	(93%)	29	(100%)	n
Drinks tap water	29	(100%)	28	(97%)	n
Drinks unboiled tap water	27	(93%)	27	(93%)	n
Drinks water:					
1+ glasses	29	(100%)	28	(97%)	n
2+ glasses	28	(97%)	28	(97%)	n
3+ glasses	26	(90%)	27	(93%)	n
Drinks unboiled water:					
1+ glasses	27	(93%)	27	(93%)	n
2+ glasses	21	(72%)	24	(83%)	n
3+ glasses	19	(66%)	21	(72%)	n
Drinks rooibos tea	18	(62%)	15	(52%)	n
Drinks other herbal tea	1	(3%)	2	(7%)	n
Drinks wine	21	(72%)	21	(72%)	r
Drinks beer	8	(28%)	13	(45%)	n
Drinks other alcoholic drink	15	(52%)	18	(62%)	n

who drank two or more glasses per day.

#### Conclusion

The use of unboiled milk from a specific supplier markedly increases the risk of getting chronic diarrhoea. This means

that the search for the cause of the diarrhoea must concentrate on the interface between the milk source and certain individuals.

#### Discussion

Follow-up actions

Although the aetiology of the chronic diarrhoea has not been established, the evidence that unboiled farm milk increases the risk almost 40 times is strong enough to take preventive measures. On 22 November 1990, a notice was placed in the local newspaper advising the residents of Diachron to boil all fresh farm milk before use.

Several cases had mentioned that dairy products aggravated their symptoms. On the basis of this observation, people with the chronic diarrhoea were also advised to exclude all dairy products from their diet until the symptoms cleared up. Further investigations of the milk were done to try to identify the cause. Tests for possible pesticidal residues were all negative. Experts from the Agricultural College in Elsenburg visited the farm concerned. No obvious problems were found. It was,

however, determined that new cows were introduced into the herd two years previously (i.e. before the first case of chronic diarrhoea). These cows were bred for producing milk with a high fat content. The fat

content of this supplier's milk was 5.5% - compared with the norm for full cream milk which prescribes a fat content of no less than 3.3% [1].

Explanation for lactose intolerant case

One case did not use milk at all. She had previously been diagnosed as being lactose intolerant. Before the onset of symptoms, however, she had had a meal at a restaurant in Diachron which was known to use the milk from the specific supplier. It is thus not impossible that she had unknowingly ingested some milk.

Additional information

Generally no more than one case occurred per household. This was, however, not

always the case. The wife of one case became ill one month after him; their two sons (20 and 26 years old) became ill approximately one month before the interview, and their servant

	iarrhœa of u n of possible				
Possible risk factor	Nı	Number of persons ex posed			
Possible risk factor	Cases		Controls	i .	Yates' correcte d
Uses diet products	9	(31%)	9	(31%)	ns
Is on a special diet	5	(17%)	6	(21%)	ns
Used diet remedy	0	(0%)	1	(3%)	ns
Regularly uses medication	15	(52%)	13	(45%)	ns
Uses laxatives	8	(28%)	7	(24%)	ns
Uses home reme dies	2	(7%)	5	(17%)	ns
Suffers from:					
High blood pressure	5	(17%)	10	(35%)	ns
Diabetes	3	(10%)	1	(3%)	ns
Arthritis	9	(31%)	7	(24%)	ns
Heart disease	5	(17%)	0	(0%)	ns
Lactose intolerance	1	(3%)	0	(0%)	ns
Spastic colon	5	(17%)	5	(17%)	ns
Other chronic condition	6	(21%)	4	(14%)	ns
Does gardening	17	(59%)	22	(76%)	ns
Uses pesticides in garden	8	(28%)	11	(38%)	ns
Uses fertilisers in garden	11	(38%)	12	(41%)	ns
Uses insecticide in house	25	(86%)	28	(97%)	ns
Uses other pesticide in house	5	(17%)	1	(3%)	ns
Has contact with pets	18	(62%)	17	(59%)	ns
Visited dentist	17	(59%)	9	(31%)	ns
Teeth were filled	9	(31%)	5	(17%)	ns
Note: ns = not statistically significant					

also developed symptoms. In yet another household, the sister of a case developed chronic diarrhoea after a three-week visit from another area. It is therefore possible that secondary cases do

Table 9: Chronic diarrhœa of unknown origin in Diachron – Estimated odds ratios for risk factors

Risk factor	Odds ratio	95% confidence interval
Drinks farm milk	14.7	(1.8; 661.8)
Drinks milk from specific supplier	19.8	(2.4; 874.2)

occur.

There were unconfirmed reports of cases who had the chronic diarrhoea in Diachron, left the town and still had the condition up to one year later. In others who left Diachron, the symptoms cleared up after one to four months. This shows that the symptoms persevere long after the person is no longer exposed to the risk factor.

Chronic diarrhoea elsewhere

A similar epidemic of chronic diarrhoea took place in

## Appendix O • Chronic diarrhoea of unknown origin

Montagu about ten years ago. Apparently the epidemic came to an end spontaneously after two years.

At the moment, a village in the Orange Free State has a problem with chronic diarrhoea of unknown origin. The first case started in May 1990. Since then about 40 cases have occurred.

The problem is being investigated by the University of the Orange Free State.

Several outbreaks of chronic diarrhoea have been reported in the United States of America. The one described most fully occurred in Brainerd, Minnesota in 1983/4 [2]. Consumption of raw milk showed a strong association with the illness. The investigators were not able to identify the aetiology of the condition. They considered an infectious agent to be responsible, and speculate that it is an enteropathogen not previously recognised.

The age distribution of cases is somewhat unexpected. If milk is the source of the problem, one might expect more children than adults to become ill since they probably drink more milk. In the Brainerd investigation, age-specific attack rates were determined for people drinking raw milk. The lowest rate was amongst those under 20 years (2.9%); the highest rate was amongst people 60 years and older (23.1%).

Table 10: Chronic diarrhœa of unknown origin

Analysis of the use of boiled or unboiled milk from specific supplier

Fooder		Persons exposed				95%	
Factor	Cases Controls		ntrols	ratio	confidence interval		
Does not drink milk from specific supplier	1	(3%)	12	(41%)	1.0	-	
Drinks milk from specific supplier only in boiled form	2	(7%)	9	(31%)	2.7	(0.1; 170.2)	
Drinks unboiled milk from specific supplier	26	(90%)	8	(28%)	39.0	(4.2; 1728.4)	
Total	29		29				

# Conclusions and Recommendations

Public health considerations

By far the most important finding of the case-control study was the identification of a risk factor strongly associated with for recommending an intervention, namely to boil all farm milk before use and excluding dairy products from the diet of known cases.

Considerations concerning the underlying aetiology

Table 11: Chronic diarrhoea of unknown origin in Diachron
Analysis of the dose response of unboiled milk from a specific supplier
compared to those who did not use his milk at all

Factor	Persons	exposed	Odds ratio	95% confidence	
ractor	Cases	Cas es Controls		interval	
Does not use milk from specific supplier	1	12	1.0	-	
Drinks one glass of unboiled milk from specific supplier	8	4	24.0	(1.9; 1150.3)	
Drinks two or more glasses of unboiled milk from specific supplier	18	4	54.0	(4.7 ; 2429.8)	

getting the diarrhoea.

The estimated odds ratio is considerable. It increases with the use of unboiled milk and disappears when only boiled milk is used. The dose-response pattern further supports the argument.

This finding in itself is a necessary and sufficient reason

The available information indicates that the aetiological mechanism of "Diachron diarrhoea" is the result of an interaction between raw farm milk with a fat content 67% above the minimim norm and the use thereof by certain individuals, mainly White adults in Diachron.

Infection hypothesis

When the milk is boiled, the risk disappears. This suggests an infectious agent in the milk which is destroyed by heat. There are, however, a few inconsistencies in connection with this hypothesis.

- Infections of the gastrointestinal tract are usually acute. The Diachron diarrhoea is chronic.
- It is unusual for a condition of the gastrointestinal tract to affect a community without involving children, especially since they are more likely to be exposed to the risk factor than adults.
- Infections are usually accompanied by fever. None of the patients mentioned that they had developed fever.
- Infectious diseases usually give rise to secondary cases, particularly in families. This appeared to have occurred only rarely.

To date, all efforts to trace an infectious agent in the milk have been unsuccessful. It is recommended that more selective bacteriological testing of the milk be continued, especially to exclude the rarer organisms such as *Listeria* from the differential diagnosis.

Toxicological hypothesis

Alternatively, a toxicological hypothesis can be considered, including certain medications. To correspond with the risk factor, such a disease agent must be present in the milk, for example penicillin to prevent possible mastitis in cows. The sporadic occurrence of patients would then reflect all exposed

persons who are allergic or sensitive to penicillin and/or its breakdown products in the milk. A similar argument could be made in connection with other medications or toxins.

Investigations done so far to trace residues of a chemical or toxicological nature have not led to any positive results. These investigations are continuing.

Pathophysiological hypothesis

A third possibility is a pathophysiological hypothesis. For example, lactose intolerance occurs amongst babies, but also amongst adults with increasing age. The same pattern probably occurs as far as other sensitivities are concerned.

Say that the diarrhoea is caused by overburdening the lipase systems in sensitive individuals. The observed age distribution would fit in with this. The absence of fever and the fairly common sysmptom of borborygmi is typical of this. The absence of secondary cases would also fit in. The milk in question is known for its particularly high fat content. Boiling denatures the fat, and thus lowers the load on the relevant enzyme system.

Affected persons would thus be those whose physiological limits are exceeded by the butterfat, leading to diarrhoea. Since the milk has not been identified as a risk factor previously, it continues to be used. Sensitive individuals thus continue to resensitise themselves which might explain the chronicity of the condition.

It is recommended that, during the search for the underlying aetiology, this hypothesis is not overlooked.

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#### Reported by

Dr Sidney Carstens, Registrar in Community Health, Department of National Health and Population Development, Bellville and Annemieke van

## Appendix O • Chronic diarrhoea of unknown origin

Middelkoop, Ronél Swanevelder	/ No How do you clean them?	/ No What kind?
and Betsie van Wyk, Directorate:	Changes?	Changes?
Epidemiology, Department of	Do you	Do you
National Health and Population	eat fruit? Yes / No Where do	drink ordinary tea or coffee? Yes
Development, Pretoria.	you get it? Do you	/ No Do you drink it with milk?
·	wash the fruit? Yes / No Do you	Yes / No Changes?
QUESTIONNAIRE	peel it? Yes / No Changes?	Do you
Chronic diarrhoea of unknown	Do you	drink wine? Yes / No Where do
origin in Diachron Number	eat meat? Yes / No Where do	you get it?
Case / Control What is your	·	
name?	you get it?	Changes?
How old are you? Sex? M /	Changes?	Do you
F What is your address?	They are	drink beer? Yes / No Where do
	blaming our water for the	you get it?
Telephone number?	diarrhoea!	Changes?
How long have you lived in	134 Appendix O	Do you
Diachron? What is		drink any other alcoholic
your occupation?	Do you eat seafood? Yes / No	beverage? Yes / No What?
What is	Where do you get it?	Changes?
your work address?	Changes?	They are
What is	Do you	blaming our water for the
your telephone number at	eat eggs? Yes / No Where do	diarrhoea!
work? Are you	you get it?	135 Appendix O
suffering from diarrhoea? Yes /	Changes?	133 Арренаіх О
9	Do you	Do you eat or drink any diet
No When did it start?	use milk? Yes / No Where do	products? Yes / No What?
What was the	you get it? (If from a	Changes?
frequency of stools when the	farm) What type of containers	Do you
diarrhoea started?	do you use to transport it?	follow a special diet e.g. salt-
What is the frequency of stools	Do you boil it	free, slimming, restricted
now? Have you	before use? Yes / No How many	carbohydrates, diabetic? Yes /
been to the doctor? Yes / No	glasses do you drink per day?	No What? Changes?
What was his diagnosis?	Do you use milk in food?	Do you
Have you	Yes / No Boiled or unboiled?	use any medication on a regular
had diarrhoea any time over the	Boiled / Unboiled Changes?	basis? Yes / No What?
past 18 months? Yes / No Has it	Do you	Changes?
ever lasted longer than 3 days?	use other dairy products? Yes /	Changes: Do you
Yes / No I am now going to ask	No What? Where do	use slimming products? Yes /
you questions concerning your		
lifestyle. Please indicate if there	you get it?	No What kind?
have been any changes during	Changes?	Changes?
the past 18 months / since you	Do you	(Case)
became ill. Do you eat bread?	drink tap water? Yes / No (If	Before the symptoms started,
Yes / No What type of bread?	yes) How many glasses per day?	did you use laxatives? (Control)
Where do you get	Do you boil it before use?	Do you use laxatives? Yes / No
it? Changes?	Yes / No Changes?	What kind? How
Do you	Do you	regularly? Changes?
_	drink rooibos tea? Yes / No	Do you
eat vegetables? Yes / No Where	Changes?	use any home remedies? Yes /
do you get them?	Do you	No What? What for?
Do you eat raw vegetables? Yes	drink any other herbal teas? Yes	Changes?

Do you suffer from: High blood pressure? Yes / No Diabetes? Yes / No Arthritis? Yes / No Heart disease? Yes / No Crohn's disease? Yes / No Ulcerative colitis? Yes / No Lactose intolerance? Yes / No Cancer of the colon? Yes / No Spastic colon? Yes / No Any other chronic condition (except diarrhoea)? Yes / No Do you do any gardening? Yes / No Do you use any pesticides in the garden? Yes / No What? \_\_\_ Do you use any fertiliser in the garden? Yes / No What? \_\_\_\_\_ They are blaming our water for the diarrhoea! 136 Appendix O Do you use insecticides in the house/flat? Yes / No What? \_\_ Do you use any other pesticides in the house? Yes / No Do you have any physical contact with pets? Yes / No Have you been to the dentist the past 18 months? Yes / No Did the dentist fill any teeth? Yes / No Is there anybody else in this household with chronic diarrhoea? Yes / No Who? Is there anything you would like to add? Thank you for your attention. May we contact you again if we need further information? Yes / No

# **QUESTIONAIRE**Chronic diarrhea of unknown origin in Diachron

Number Case/ Control	What was the frequency of stools when the diarrhea started?	Where do you get them?	
What is your name?		Do you eat raw vegetables? Yes / No	
How old are you?	What is the frequency of stools now?	How do you clean them?	
Sex? M / F			
What is your address ?	Have u been to the doctor?  Yes / No	Changes?	
	What was his diagnosis?	Do you eat fruit?  Yes / No	
Telephone number?	Have u had diarrhea any time over the past 18 months?  Yes / No	Where do you get it?	
How long have you lived in Diachron?	Has it ever lasted longer than 3 days?  Yes / No	Do you wash the fruit? Yes / No	
What is your occupation?	I am now going to ask you questions concerning your lifestyle. Please indicate if there	Do you peel it?  Yes / No  Changes?	
What is your work address?	have been any changes during the past 18 months / since you became ill.		
	Do you eat bread? Yes / No	Do you eat meat?  Yes / No	
What is your telephone number at work?	What type of bread?	Where do you get it?	
Are u suffering from diarrhea?	Where do you get it?	Changes?	
Yes / No When did it start?	Changes?	Do you eat sea food? Yes / No	
		Where do you get it?	
	Do you eat vegetables? Yes / No		

Changes?	Changes?		
Do you drink tap water? Yes / No	Do you drink beer?  Yes / No		
(if yes) How many glasses per day?	Where do you get it?		
	Changes?		
Do you boil it before use? Yes / No			
Changes?	Do you drink any other alcoholic beverage? Yes / No		
Do you drink rooibos tea? Yes / No	What?		
Changes?	Changes?		
Do you drink any other herbal teas? Yes / No	Do you eat or drink any diet products?  Yes / No		
What kind?	What?		
Changes?	Changes?		
Do you drink ordinary tea or coffee?	Do you follow a special diet e.g. salt-free, slimming, restricted		
Do you drink it with milk?  Yes / No	carbohydrates, diabetic?  Yes / No  What?		
Changes?			
Do you drink wine? Yes / No	Changes?		
Where do u get it?	Do you use any medication on regular basis?		
	Do you drink tap water? Yes / No  (if yes) How many glasses per day?  Do you boil it before use? Yes / No  Changes?  Do you drink rooibos tea? Yes / No  Changes?  Do you drink any other herbal teas? Yes / No  What kind?  Changes?  Do you drink ordinary tea or coffee? Yes / No  Do you drink it with milk? Yes / No  Changes?  Do you drink with milk? Yes / No		

What?	Do you suffer from: High blood pressure?	Yes / No	What?	
Changes?	Diabetes?	Yes / No	Do you use any other in the house?	pesticides Yes / No
Do you use slimming products?	Arthritis?	Yes / No	Do you have any phy contact with pets?	sical
Yes / No What kind?	Heart disease?	Yes / No	Have you been to the	Yes / No dentist
	Crohn`s disease?  Ulcerative colitis?	Yes / No	the past 18 months?  Yes / No	
Changes?	Lactose intolerance?	Yes / No	Did the dentist fill any	Yes / No
(Case) Before the symptoms started, did you use laxatives?	Cancer of the colon?	Yes / No	Is there anybody else household with chron diarrhea?	
Yes / No  (Control) Do you use laxatives?	Spastic colon?	Yes / No	Who?	163 / NO
Yes / No What kind?	Any other chronic cor	Yes / No		
	(except diarrhea)?	Yes / No	to add?	would like
How regularly?	Do you do any garde	ning? Yes or No		
Changes?	Do you use any pestion garden?	cides in the Yes / No	Thank you for your attention.May we cor	utact you
Do you use any home remedies?	What?		again if we need furth information?	
What?	Do you use any fertiliz garden?	zer in the Yes / No		
What for?	What?			
Changes?	Do you use insecticide house/flat?	es in the Yes / No		