

Management of Water-related Microbial Diseases

Volume 1 - What is the problem? - Disease Characteristics



First Edition 2003



The Department of Water
Affairs and Forestry



Water Research Commission



TT 175/03

OTHER REPORTS IN THIS SERIES

This guide forms part of a series which is aimed at water supply agencies, water resource 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 contamination and thus reduce the incidence of water-related diseases.

The publication of this report emanates from a WRC consultancy no 431: Guide on water-related microbiological 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. ¹ |
| Vol: 3 | How great is the problem? – Health Impact Assessment. ¹ |
| Vol: 4 | How dangerous is the problem? – Communicating the Risk. ¹ |
| Vol: 5 | What we and our children need to know – Health & Hygiene Awareness. ¹ |

Still in preparation.

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ISBN 1 86845 849 0

Printed in the Republic of South Africa

FOREWORD

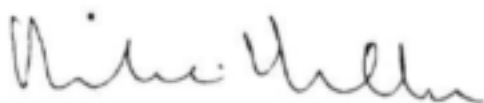
The cholera epidemic in South Africa in the recent past highlighted the need to address the causes of infectious disease transmission. While the provision of clean, disinfected drinking water plays a key role in lessening the incidence of infection, together with regular hand washing before handling food, for example, there are other factors not related to the water field which are as important and often more important than the water route of infection.

Two major and oft-overriding factors facilitating the conditions promoting infectious disease transmission are poverty, with its associated overcrowding, and human behaviour, especially those behaviour patterns resulting in many close human contacts. Some of the waterborne diseases such as gastroenteritis are as easily spread by close human contacts as by water and often cluster where people live in closely crowded conditions.

The need for this series of guides on the management of water-related microbial diseases arose as a result of the cholera epidemic, with the public and regional managers alike asking such questions as: "How can we protect ourselves from cholera and other infectious diseases?" Volume 1 in this series describes those diseases where water may play a role in transmission. From this it must not be concluded that water is the only route of infection – this is by no means the case and close human contact, often tied to poverty, commonly play overriding roles in disease transmission.

The people most vulnerable to water-related microbial disease are often those least able to afford health care. Preventive health care starts with good nutrition, which is so important if the growing child is to develop a healthy immune system.

Clean water plays a vital role as one of the building blocks in raising the quality of life of the poor, and thus of alleviating the burden of disease. It is hoped that this guide will fill a niche in the educational and training material to train the upcoming generation in the basic principles of how water can be involved in the spread of disease, and how to control water-related diseases. This information guide may hopefully provide one of the many incentives to the alleviation of poverty and the suffering which microbial disease induces in so many of our population.



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STRUCTURE OF THE GUIDE

This guide consists of four parts:

Part 1

Provides general information on water quality with respect to microbial status and health issues.

Part 2

Discusses the discovery and role of microbes in the transmission of disease.

Part 3

Provides detailed information on the characteristics of selected water-related diseases, the characteristics of disease, how it is transmitted and how it can be prevented.

Part 4

Provides a summary of management issues essential for the minimisation of water-related microbiological diseases.

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What is the purpose of the water-related microbial disease guideline series?

The purpose of this guideline series is to provide awareness building and management information on the nature and prevention of important water-related microbial diseases.

The purpose of volume one in the series, "Disease Characteristics", is to introduce and describe the basic facts of some important water-related diseases, in terms of:

- how they can be recognised (presenting symptoms)
- how they are transmitted
- the role of water in the transmission routes
- how they can be prevented
- what management options may be exercised in reducing their incidence and risk of transmission.

Note: It is not the purpose of this guide to go into details of differential diagnosis or treatment. These details may be found in medical texts and handbooks.

This guide is primarily an awareness building guide to educate the upcoming generation in the need for: (1) disinfected drinking water, (2) safe waste disposal, (3) good personal and kitchen hygiene, and (4) protection of water resources from faecal pollution.

Who should use the water-related disease characteristics guide?

This guide is aimed specifically at people with limited training in microbial issues or awareness of the need to protect water resources from faecal pollution.

The people who may find this guide useful are:

- water quality managers
- environmental health officers
- field workers who come into direct contact with the general public
- treatment plant operators
- water supply agencies
- educators and students.





Water quality and microbial issues

PART 1

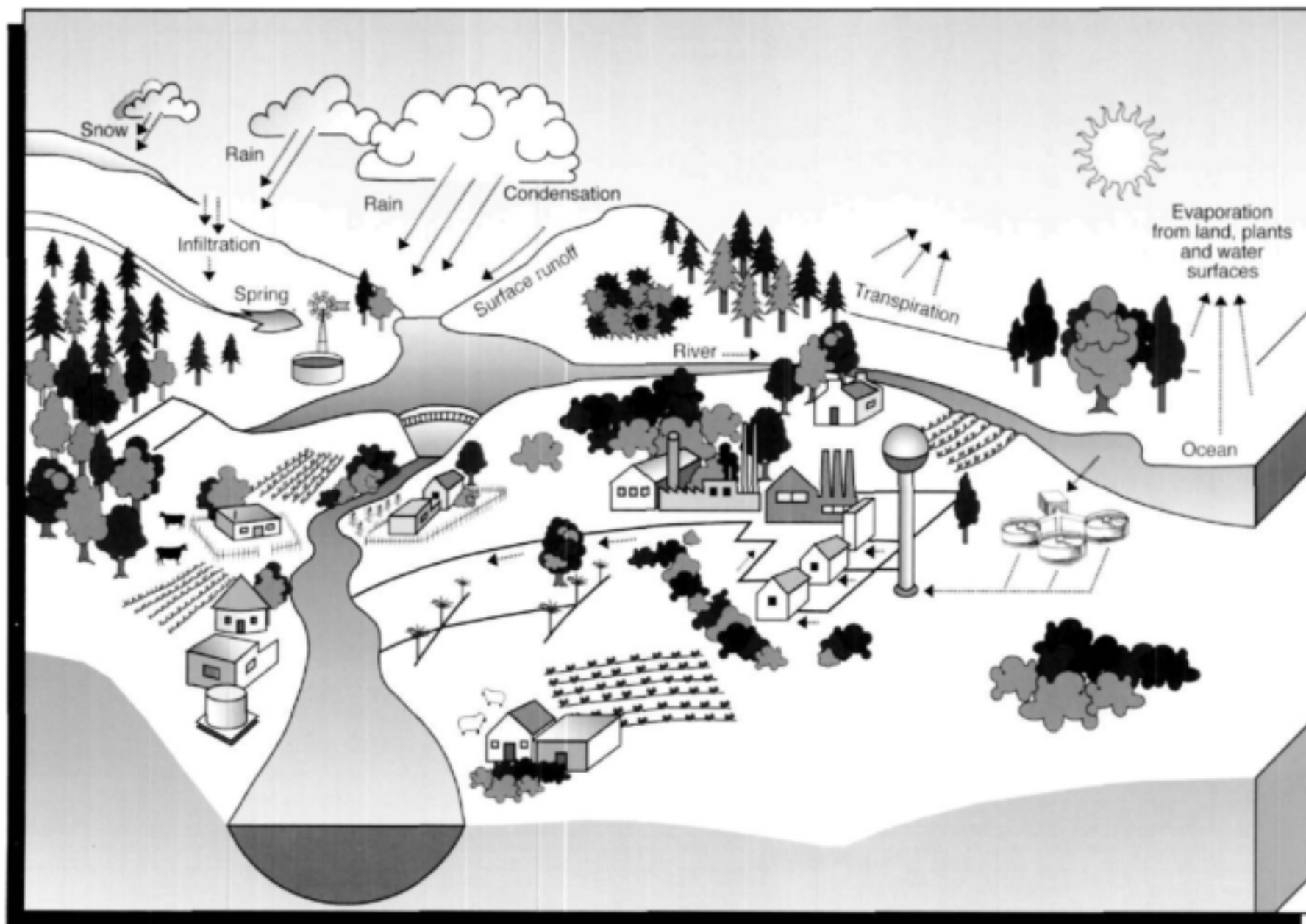


Diagram of the Water Cycle

Why this guide?

Water, that life-sustaining drink, is the basis of all life on this planet. In clean pure form it promotes health and wellbeing. Access to clean safe water is one of the basic human rights.

Water, however, being an excellent solvent and transport medium, can easily be contaminated, for example, by faecal wastes or other pollutants. Water often needs to be treated to make it safe for consumption before it is drunk.

Water contaminated with **faecal material** teems with micro-organisms, and can bring diarrhoea, disease and death as easily, and as quickly, as safe water brings life. Water-related microbial diseases have been a major cause of human misery since time immemorial, and microbial water quality needs to be managed in order to safeguard people from the hazards of drinking contaminated water.

This guide serves as an introduction to the basic principles necessary for the control and management of microbial water-related diseases of importance.

Who should use this guide?

This guide will be of use to water quality managers, water treatment technicians, health professionals, and educationists.

The aim of the guide is to create awareness of the need of both protecting water supplies from contamination and of treating water supplies before their use for drinking and food preparation in order to minimise water-related disease risks.

What is water? (water cycle)

The amount of fresh water is limited and it continuously repeats its journey of: Evaporation from the ocean (leaving the salts behind), formation of clouds, precipitation of rain, ground water and surface water and then back eventually to the salty ocean.

Water, or H_2O , is the most abundant liquid on our planet.

The fresh water we use for drinking, washing and for preparing food comes from:

- rainwater
- surface water sources (such as rivers or dams)
- or ground water sources (such as boreholes and springs).



Why is water of good quality needed for drinking purposes?

Ready availability of water of good microbial quality (which is free from disease-causing organisms, called pathogens) is necessary to reduce the incidence of the common diarrhoeal diseases.

Diarrhoeal diseases include both those of an endemic persistent nature (such as gastroenteritis, which are always around, and readily indispose infants and the elderly), and those of a cyclic or epidemic nature (such as cholera).

The word pathogen, meaning disease-causing organism, is derived from the Greek root "**pathos**", meaning "suffering" or "disease", and the root "**gen**", meaning "giving rise to".

What is microbial (microbiological) water quality?

Microbial water quality is the state of the water with respect to the absence (good water quality) or presence (poor water quality) of micro-organisms. Microbial water quality is usually indicated by reporting the count (number) of indicator organisms present in a given volume of water.



Micro-organisms are tiny forms of life, typically invisible to the naked eye, unless present in their millions (e.g., in a colony). They vary in size from nanometre dimensions (e.g., **viruses**) to several micrometres in size (**bacteria**) to ten or more micrometres in diameter (e.g., **protozoa** and multicellular organisms such as **parasites**). The larger organisms are visible with a light microscope, while the tiny minute viruses need the enormous magnification of an electron microscope to make them visible.

What is microbial water pollution?

*There are many thousands of micro-organisms which can contaminate water. Micro-organisms can come from the soil which is teeming with both vegetative (**actively growing**) as well as spores (**or resting forms**) of bacteria and fungi. Bacteria can also originate from faecal material of animal and/or human origin.*

Water is often massively polluted with microbes during rainfall storm events, where large numbers of organisms are washed from the soil in the catchment and from faecal wastes of animal or human origin, or from decaying vegetable matter, into the water resources. Faecal matter, especially, teems with micro-organisms and must be safely disposed of, if it is not to contaminate water resources.

When and how do we pollute our water?

Water resources can be directly contaminated by natural runoff from rainfall events, as mentioned above, or can be polluted by runoff from such activities as intensive animal feedlots or by untreated sewage wastes.

In the management of water-related microbial diseases, it is important not only to look at the large events, but also at the activities in the home and in the workplace. For example, when a jug or bucket of water is filled from a tap in the home, if the tap is connected to a well-treated water supply, the water may be quite microbially safe as it leaves the tap, but may become subsequently contaminated in the jug/bucket, due to, for example:

- the jug may be dirty and not rinsed before filling
- dust or flies may introduce contamination into the water in the jug if it is not covered
- people may dip a dirty cup or dirty hands into the jug.

So, water can be readily contaminated in the home at the point of use.

There are of course other routes of water pollution, for example, the water that is used to flush the toilet becomes highly contaminated with faecal matter, and must be treated in the sewage treatment plant before it is safe to discharge into rivers or dams (the receiving water body) in the environment.

Water may also be contaminated in the kitchen through washing food or dishes and cutlery either before or after the preparation of a meal.

What is safe water?

Domestic water is considered (for practical management purposes) to be microbially safe where the goal of a zero indicator organism count has been met. The indicator faecal organisms used for this purpose are, usually, either the **faecal coliform** count or the *Escherichia coli* (*E. coli*) count.



Indicator organisms are microbes which are found in large numbers in, e.g., faeces and thus as well in faecally polluted water. Their finding and presence in a water sample indicates that the water has been faecally contaminated and is thus not safe to drink without prior disinfection. The finding of indicator organisms (which may not necessarily be disease-causing on their own) indicates that other harmful microbes (pathogens), which may be more difficult to detect, may be present.

It is not practically feasible to have the indicator organism count to be zero at all times, and a management rule which is usually adopted is to ensure that the indicator count goal of zero is achieved for at least 95% of the samples tested during any given year.

Coupled to this, the water should also be free of suspended particles such as clay or plant debris (which cause turbidity). Microbes have the potential for hiding inside suspended solid matter, and water which is turbid (cloudy) is thus not readily disinfected.

How can faecally polluted water affect healthy people?

If disease-causing micro-organisms are present in large enough numbers, these may overwhelm the immune system and so bring on disease and suffering.

The environment is teeming with micro-organisms, such as bacteria, protozoa and viruses. Yet most of these do not cause disease in healthy individuals, due to the action of the immune system which recognises the penetration of foreign proteins into the bloodstream and destroys them before they can multiply and damage body tissues and functioning and so cause disease. The immune system has, however, its limitations.

Health is the condition of the body where the human organism is functioning as it should and is free of disease. There are a few basic necessities to good health, such as clean air, good nutritious food, clean water and adequate warmth and shelter.

How can faecally polluted water affect children and the elderly?

The immune system is more easily overwhelmed and compromised in infants and young children, where the immune system is still developing, and in the elderly when the system begins to fail. As a result children and the elderly tend to be more susceptible to certain of the water-related diseases, in particular gastroenteritis. Loss of fluids through diarrhoea has sent many a soul to the grave. Ongoing management of microbial quality in order to prevent, as far as possible, this eventuality is an ongoing necessity of water supply management.

How are immuno-compromised people affected by faecally polluted water?

Immuno-compromised individuals are particularly affected by the waterborne diseases called cryptosporidiosis, gastroenteritis and giardiasis, which may eventually become life-threatening in these individuals.

Apart from the situations mentioned above where the immune system is naturally weaker at certain ages in life, there are also situations where the immune system has been weakened by other events. For example, the immune system is also compromised in certain disease conditions, such as AIDS, and as a result of immune suppression, e.g., in the treatment of cancer, or in the recipients of organ transplants. In such immuno-compromised individuals it is essential that they be provided with drinking water of a high microbial standard, and free of disease-causing pathogens.

PART 2

The role of microbes in the transmission of disease



Citations: See footnotes on relevant pages

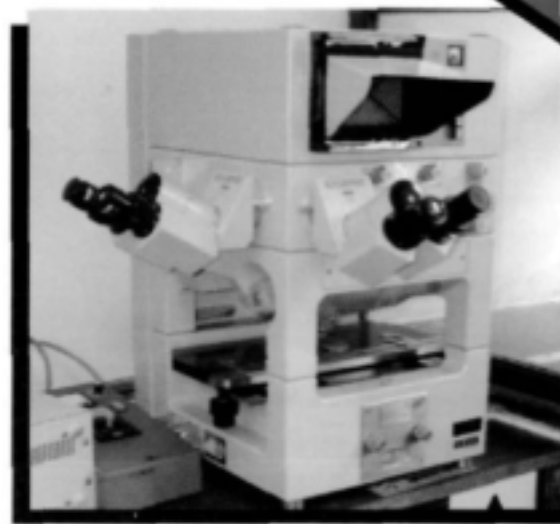
THE ROLE MICROBES PLAY IN WATER SUPPLIES

When were microbes discovered?

The Dutch scientist Leeuwenhoek first demonstrated the existence of minute life forms, which are invisible as single organisms to the naked eye, in the 17th century, through the construction of simple hand-made microscopes to serve as magnifying tools. With these simple microscopes Leeuwenhoek was able to show that the water environment is teeming with microscopic organisms which he called "little animals". He did not realise that some of these microbes may cause disease, and was of the opinion that they were generally friendly organisms in the environment.

It was Pasteur in France in the 19th century who showed that certain microbes can cause disease, and also that they can be destroyed by heat, e.g., in milk, through the process of **pasteurisation** (heating of milk to destroy the disease-causing micro-organisms).

Robert Koch in Germany developed the use of solid growth media (agar plates) to cultivate bacteria in the laboratory. Koch, in contrast to Leeuwenhoek, thought that most bacteria were harmful and caused disease. Yet hindsight shows that both these pioneers were right, and that there are friendly bacteria, which are conducive to health, as well as very dangerous bacteria, which can cause life-threatening diseases.



Modern light microscope

Where are microbes found?

There are an enormous variety of micro-organisms that can be found in the environment, ranging from tiny viruses (such as those causing hepatitis) that can only be seen under an electron microscope, with its enormous magnification factor, to the single-celled bacteria (such as, for example, the bacterium causing cholera), to multicellular organisms, more properly termed parasites (such as the blood-fluke causing bilharzia).

It is said, quite rightly, that without water there is no life, and in many ways, this is true for microbes as well. They require moisture and nutrients to multiply (e.g., in the case of bacteria), or require other living organisms to live on (e.g., in the case of viruses and the much larger multicellular parasites).

Are all micro-organisms harmful?

No, not all microbes are harmful to health; e.g., the large intestine of every human being is teeming with bacteria, known as the normal gut flora. These help to digest the food residues, and also are responsible for the production of vitamin B12 in the gut, without which anaemia would occur. These gut floras constitute a large portion of the bulk of the faeces, together with undigested cellulose from the food and other indigestible food remnants. Faecal material is thus teeming with bacteria, there being over a million bacterial cells in a gram of faecal material.



Yogurt contains friendly microbes

Friendly bacteria are not only found in the gut of the healthy human being, but also on his/her skin. Because the living basal layer of cells is continually regenerating the skin, the upper layer of the skin consists of dead cells that are continually being sloughed off by friction with the environment. These dead cells normally harbour friendly bacteria, which assist with protection from infection by harmful bacteria in the environment. Where the complex biochemistry of the skin is disturbed, pathogenic bacteria can take hold with a resultant variety of skin diseases manifesting.

Life is a fine balance between the anabolic (tissue-building) **processes** and **catabolic** (tissue-destroying) **processes**, and micro-organisms play a key role in this process and the preservation of the **ecological balance** both within the human body, and with its interrelation with the environment.

Friendly micro-organisms also play a key role in priming (stimulating) the immune system to develop antibodies against the more dangerous and disease-causing bacteria. This natural phenomenon has been mimicked by medical science in the development of vaccines to prime the immune system to recognise and counteract infections by the more virulent micro-organisms (such as the polio virus) lurking in the environment.

How do micro-organisms enter the human body?

The most common routes for micro-organisms to enter the human organism are through the food we eat, the water we drink, or the air we breathe. Thus the importance of:

- food hygiene,
- clean drinking water, and
- fresh air.

There are of course other important routes for the spreading of microbes, which do not concern us in this guide, such as close contact sports and especially unprotected sexual intercourse.

We live in an environment that is teeming with micro-organisms, and bacteria can find a host not only in humans, but also in animals and in plants. Normal soil is also teeming with microscopic life. The bacterial composition of soil varies tremendously depending on the history of the soil, particularly with respect to contamination with animal or plant waste products, or even industrial wastes. A new field in microbiology is emerging relating to the classification of soils with regard to the type of bacterial species present, which has important implications as to whether the soil-microflora are balanced and will support healthy farming crops, or whether putrefying organisms are present, e.g., following uncontrolled disposal of waste matter, and which present an undesirable substrate for farming crops.

While inorganic fertilizers to stimulate plant growth, and organic pesticides to control plant pests have been widely used in the past to promote crop yields, it is increasingly being recognised that these two artificial tools for crop boosting must be used in moderation, and that basic horticultural principles of good soil and crop management play a vital role in the preservation and

promotion of a healthy soil microbial flora, as well as promotion, in the final analysis, of the good health of human beings.

Can faecal matter contain harmful microbes?

Apart from harbouring friendly gut-bacteria, faecal material can also be a major source of contamination of the environment with harmful microbes that are excreted in the stool (faeces) of individuals who are ill or by individuals who are temporary carriers of some or other microorganism.

Quite often seemingly healthy people may acquire a temporary infection with a micro-organism, and excrete disease-causing microbes in their faeces for a period, without showing any symptoms of any illness themselves. This phenomenon is called a "sub-clinical infection" or "asymptomatic" infection, (i.e., an infection showing no symptoms of illness). The stool of such individuals presents a risk to others, and thus the importance of safe disposal of faecal wastes, and of good toilet hygiene.

Should safe drinking water contain any microbes at all?

A common misconception must be dispelled at the outset, and that is that safe drinking water should contain no microbes (micro-organisms) at all. Wholesome water, from a microbial viewpoint, contains no disease-causing micro-organisms. However, harmless organisms are often present, sometimes even in quite large numbers, such as, for example, the bacteria that cause slime (biofilm) growth in reservoirs or piping systems.

The microbial safety of drinking water is promoted by several important public health measures:

- Proper treatment and disposal of human, animal and plant wastes, so as to safeguard water resources and prevent or control as far as possible the contamination of the resources with harmful micro-organisms.
- Monitoring of drinking water supplies for **indicator bacteria**, to detect which resources are being contaminated with faecal material, so that available funds to manage the microbial safety of water resources and supplies can be wisely utilised.
- Disinfection of domestic water supplies prior to distribution to the consumer. This is the single most important health measure to reduce infectious water-related diseases.
- Proper hygienic measures to ensure that drinking water is not contaminated on the way to the consumer, or in the consumer's home prior to use for domestic purposes. This brings into view the need for water-health awareness educational drives to raise the community's realisation of the fundamental importance of clean water, and proper treatment and disposal of wastes. This understanding in the long run will contribute towards a public awareness of the need to pay for services in the interests of their own health and wellbeing.

In the next section the types of water-related diseases are discussed, viz., waterborne diseases, water-washed diseases, water-vectored diseases and water-based diseases.

Where in the water environment are microbes found?

Surface water resources in the environment are teeming with micro-organisms, some of which can cause disease in humans. Disease may be transmitted not just by drinking the water, but also on occasion through skin contact with the water, e.g., in the case of the blood-fluke which transmits bilharzia (schistosomiasis), for example, or by eating crops raw.



Contaminated surface water can also contaminate ground water

Where water supplies have not been tested, it is always best to assume that in their raw state, in the water resource, that they may potentially be contaminated with micro-organisms which can cause disease. Even ground water can be contaminated with micro-organisms, although the soil tends to filter out micro-organisms from water, and deep borehole supplies are often free from microbial contamination. This is only true where the aquifer has been protected and the borehole itself is properly equipped so as not to allow the ingress of contamination from the surface into the ground water supply. Shallow ground water boreholes are, on the other hand, easily contaminated especially where there is any possibility of seepage from faecal waste reaching the ground water table.

What are the most common symptoms of microbial water-related diseases?

*A "runny tummy", i.e., the frequent passage of loose, usually watery stools, or **diarrhoea** is the symptom commonly observed in many but not all of the water-related diseases. If blood and mucus are also present in the liquid stools then the term "dysentery" is used.*

Accompanying the diarrhoea there may or may not be abdominal pain and cramps as well as vomiting and fever, and a general feeling of malaise and weakness.

If the diarrhoea becomes severe, and especially if vomiting is such that fluids are lost more rapidly than they can be replaced, the individual may go into a state of **circulatory shock** and in untreated and severe cases death may eventuate.

It is important in all cases of **diarrhoea** to ensure that sufficient liquids and salts (re-hydration fluids) are given, timeously and frequently, so as to counteract the loss of body fluids and the occurrence of circulatory shock. Timeous fluid and salt replacement is characteristically life-saving in cases of severe diarrhoeal disease.

How are water-related microbial diseases transmitted?

Chemical and radioactive substances in the water could cause water-related disease. This document, however, focuses on diseases that are caused by pathogenic micro-organisms in the water, such as bacteria, viruses and protozoa.

Micro-organisms thrive when conditions are favourable for their growth and transmission. Water is often a favourable environment to sustain and transmit harmful micro-organisms that are responsible for millions of human deaths yearly from infection worldwide. Prevention of water-related diseases is often based on the management of the transmission route.

Water-related microbial disease is classified into four types relating to the path of transmission:

Water-washed (water-scarce) diseases

These are diseases where interruption of the transmission (and thus management) is achieved through proper attention to effective sanitation, washing and personal hygiene. Regular washing of hands, especially after going to the toilet, is the single most effective measure in preventing many infections, as is proper washing and hygiene during food preparation, together with proper sanitation, waste disposal and fly control.

Examples of water-washed diseases are:

- amoebic dysentery^a
- poliomyelitis^a (polio)
- trachoma.

^a May also be waterborne.



Scarcity of water can cause disease

Waterborne diseases

These are diseases that are transmitted through drinking water, and interruption of transmission is achieved by proper treatment of drinking water. Typical required treatment is filtration and disinfection (on a large or small scale) or boiling of water (on a small scale). Water transmission of these diseases can be prevented through the provision of clean and disinfected drinking water.

Examples of waterborne diseases are:

- cholera^b
- campylobacteriosis^b
- cryptosporidiosis^b
- gastroenteritis^b
- giardiasis^b
- viral hepatitis^b
- shigella dysentery^b
- typhoid fever^b.

^b May also be water-washed.

Water-based diseases

These are diseases transmitted by contact with water, e.g., recreational swimming, where the causative microorganism lives in water bodies, typically in a secondary host such as a snail. These diseases are prevented through avoidance where possible of water contact, or use of protective clothing or barrier creams.

- examples of water-based diseases are:
- bilharzia^{*}
- swimmer's itch = non human bilharzia
- leptospirosis (Weil's disease).

^{*} May also be waterborne.

Water-vectored diseases

These are diseases that are transmitted by an arthropod vector, such as a mosquito, which needs water or moisture in order to breed. Prevention of transmission is through vector control, protection against being bitten by the vector, or vaccination (e.g., in the case of yellow fever).

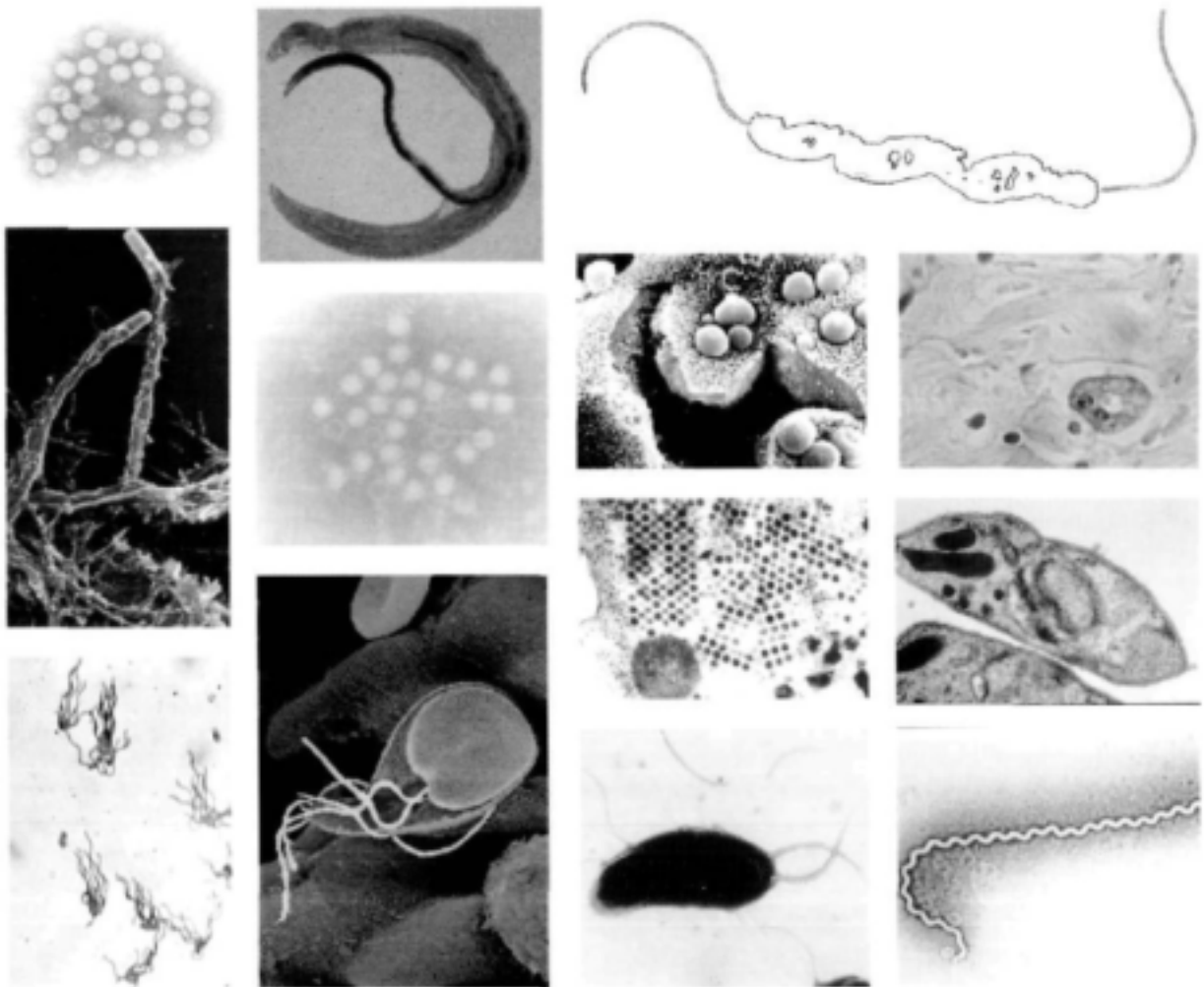
An example of a water-vectored disease is malaria.

There are literally thousands of potentially water-related diseases, where water may play a role in transmission. Only a few selected diseases are addressed in this guide.

PART 3

Summarised fact-sheets on some important water-related diseases

The water-related diseases discussed in brief below, are of major importance and under the right conditions for the spread of these diseases still of common occurrence, with the exception of polio (infantile paralysis), which scourge has been very largely controlled through the development of very effective vaccines in the last century.



Collage of disease-causing organisms

See note box on page 6 for relative sizes of microbes

AMOEBIC DYSENTERY

What is amoebic dysentery?

Amoebic dysentery is a diarrhoeal disease caused by the **parasite** *Entamoeba histolytica*. As much as 90% of infections with this parasite are without symptoms. Where symptoms occur, these appear between three days to three months after infection. The diarrhoea, when it occurs, is often bloody, and associated with tenderness in the abdomen, nausea and weight loss. Life-threatening complications can occur, such as intestinal perforation, or spread of the disease to the liver or other organs.

How is amoebic dysentery transmitted?

The disease is transmitted via the **faecal-oral route**, the organism being excreted in the stool of an infected individual. A new infection is contracted when contaminated drinking water or food is consumed. Person-to-person spread also occurs, especially where hygiene is poor, but is uncommon. Common sources of infection are raw fruit or vegetables that have been irrigated with contaminated water. The organism may remain viable in cyst form outside the human body, especially in moist soil, for long periods.

How should the patient be treated?

Symptomatic cases of the disease require treatment with specific antiparasitic medication. Where complications have occurred, surgical intervention may be necessary.

Transmission route

Primarily a water-washed disease, but may also be spread as a waterborne disease and by sexual contact.

Management options

Hygiene and sanitation / clean water.

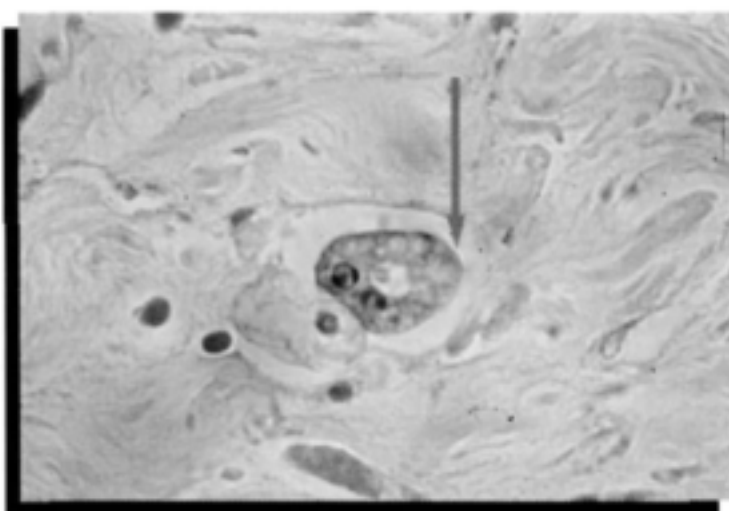
Prevention

- Always wash fruit and vegetables, especially lettuce, well with clean water before eating. A few grains of Condy's crystals (potassium permanganate) can be used to assist disinfection of the lettuce.
- Practise strict hygiene after going to the toilet, and before preparing food.
- Do not drink contaminated water.
- To disinfect water add one teaspoon of domestic bleach to 20 litres of water, and wait 1 hour before drinking. If the water is cloudy (turbid) add 2 to 4 teaspoons of bleach.

AMOEBIIC DYSENTERY

Interesting facts

- As most cases (90%) are without any symptoms, these can be a source of infection for others, and illustrate the importance of sound sanitation practices to avoid contamination of water resources at all times.
- Vegetables eaten raw should not be irrigated with water contaminated with the parasite.
- Individuals infected with HIV are likely to be more seriously ill when infected with the organism.



Amoeba parasite viewed with a light microscope

BILHARZIA (SCHISTOSOMIASIS)

What is bilharzia?

Bilharzia is an infection by a **blood-fluke** (parasitic flatworm). There are two blood-flukes of importance in South Africa, i.e., *Schistosoma haematobium*, which causes urinary or bladder bilharzia; and *Schistosoma mansoni*, which causes intestinal (bowel) bilharzia. The adult flukes can live, and deposit eggs, for many years in the small blood vessels lining the bladder or the large intestine. The eggs are subsequently either trapped in the tissues, where they eventually calcify, or they are passed out with the urine or stool. Infections are sometimes without any symptoms other than a feeling of slight weakness or fatigue. Where heavy infestations are present, blood may be noticed in the last few drops of urine passed.

A phenomenon sometimes encountered relatively early in the disease is the occurrence of a life-threatening systemic allergy to the parasites (Katayama fever), which may occur in the secondary or lung phase of the disease. When heavy infection with bilharzia occurs, there is often a significant long term risk of bladder cancer arising from the irritation produced by the released eggs of the fluke.

How is bilharzia transmitted?

The bilharzia fluke uses humans as its primary host, and fresh water snails as the secondary host. The life cycle of the fluke is kept going by infected humans urinating or defecating in or near water bodies, or by untreated sewage reaching the water body. The eggs of the fluke hatch in the water, and the larval stage (miracidium) enters fresh water snails, where maturation of the parasite occurs. The snails then release free-swimming larvae (called cercariae), which penetrate the skin of a human swimming in the water. The infective cercariae can survive in water for up to 48 hours, and on contact with skin, can penetrate the skin within a few seconds. The organ systems affected in bilharzia are the liver, lungs, spleen, intestine and bladder.

There is always a danger of contracting bilharzia, when contaminated water is drunk, or while swimming in contaminated water.

How should the patient be treated?

Very effective specific anti-bilharzial medication is available with which to destroy the flukes in the body. Should Katayama fever occur, this is treated with allergic suppression medication.

Transmission route

Usually a water-based (water-contact) disease. May on occasion also be waterborne.

BILHARZIA (SCHISTOSOMIASIS)

Management option

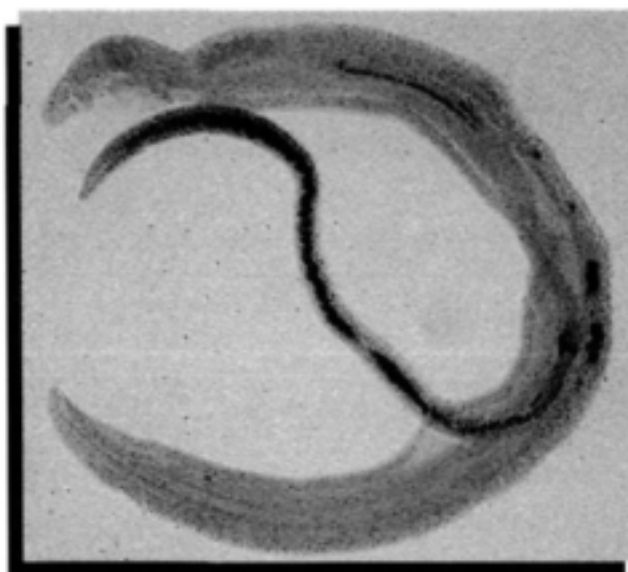
Avoid contact with contaminated water, install treated water supplies, proper sanitation, recreational facilities (swimming pools) and laundry facilities (troughs connected to a treated water supply).

Preventive measures

- Avoid all skin contact with infected water bodies, use suitable protective waterproof clothing. The use of barrier creams will only supply partial protection.
- Avoid drinking contaminated water.
- Long term prevention lies in screening and treating people on a large scale for bilharzia, so that the source of parasite eggs entering the water body is diminished. This is especially important in the case of children.

Interesting facts

- The diagnosis of bilharzia is confirmed by identification of the eggs of the fluke in the urine or in the stool, or in biopsy material, e.g., of the rectum, or by a **serological blood test**. With the blood test it is, however, difficult to distinguish between past and present infection.
- The habitat of the water-snail host is highest in the shallow water. In dams, the highest risk of contracting bilharzia is while entering or leaving the water, along the shoreline.
- Recent infection by the bilharzia parasite is readily cured medically, but where pronounced tissue damage has occurred from infections of many years standing, a full cure is not possible.



Enlarged view of bilharzia flukes

CAMPYLOBACTERIOSIS

What is campylobacteriosis ("campy")?

Campylobacteriosis is a diarrhoeal disease of the gut, caused by the **bacterium** *Campylobacter jejuni*. It is characterised by slight to severe diarrhoea, which may be bloody (dysenteric), together with abdominal cramps, fever and, in severe cases, vomiting and convulsions. Some infections may be with very mild, or no symptoms at all. When symptoms occur, the incubation period is typically 2 to 5 days after exposure.

How is "campy" transmitted?

Transmission is predominantly via the faecal-oral route. Animals, especially poultry and cattle, are an important reservoir of the bacterium. Good hygiene and scrupulous cleanliness when preparing poultry for cooking is therefore essential to prevent accidental contamination of other foods and drinks. Water sources are contaminated by faecal matter from animals, and raw water should always be chlorinated prior to use for drinking purposes.

Always clean the knife and cutting board very thoroughly after preparing poultry for cooking.

How should the patient be treated?

The basis of treatment is fluid and salt replacement. If the infection is severe, specific antibiotics may be used to shorten the period of infection. Recovery can be prolonged in the case of individuals in the advanced stage of HIV infection.

The disease is diagnosed by culturing a stool (faecal) sample for micro-organisms.

Transmission route

Water-washed and waterborne.

Management options

Hygiene and sanitation / clean drinking water.

Preventive measures

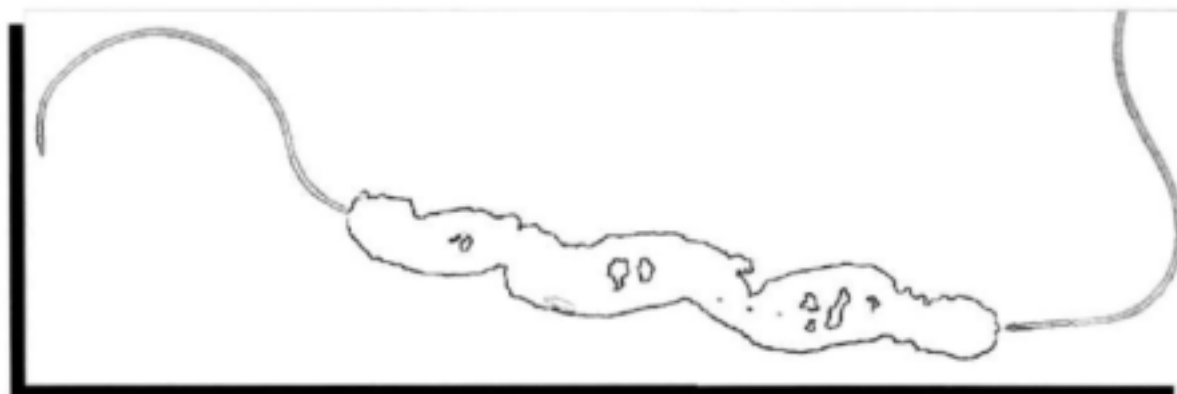
- Practise good personal hygiene and wash hands thoroughly, especially after going to the toilet.
- Never eat undercooked poultry.

CAMPYLOBACTERIOSIS

- Always clean the cooking board and knives with soap and hot water after cutting up poultry.
- Children should wash their hands thoroughly with soap and water after handling pets and before eating food.
- Always wash your hands well after changing a baby's nappies.
- Do not drink untreated water.
- Water can be disinfected by adding 1 teaspoon of domestic bleach to 20 litres of water, allowing it to stand for 1 hour before drinking. If water is cloudy (turbid) add 2 to 3 extra teaspoons of bleach.

Interesting facts

- The most important carriers are pets, cattle and poultry, but humans also act as carriers for a week or two after the symptoms have subsided.
- Milk may on occasion be a source of infection. Do not drink unpasteurised milk.
- If a microwave oven is used for cooking chicken, make sure that the chicken is well cooked, or it may be a source of infection.
- Campylobacter is one of the leading causes of bacterial diarrhoea in humans.
- Infants and the elderly, together with immuno-compromised people are most susceptible to the disease.



Drawing of *Campylobacter* cell with flagella

CHOLERA

What is cholera?

Cholera is a diarrhoeal disease that is very sudden in onset. It is characterized by a massive loss of body fluids, through profuse diarrhoea and vomiting, leading to severe dehydration, which can be fatal. Stools have the appearance of "rice water". Infants and small children show the most rapid advance of the illness. Untreated cases of cholera can lead to death within 6 hours, depending on the degree of dehydration.

How is cholera transmitted?

Any person can contract the disease by ingesting water or food contaminated with the toxic strain of the **bacterium** called *Vibrio cholerae*. The bacteria are excreted by infected individuals and can live for at least three weeks in saline, warm and alkaline water. The bacteria can also survive in food, especially seafood.

How should the patient be treated?

Urgent and immediate replacement of the water and salts that are lost through the diarrhoea and vomiting is the only effective treatment for cholera. Such treatment is dramatically life-saving. In emergencies sports drinks containing isotonic fluids can be used to replace the necessary salts and fluids. A weak solution of salt and sugar can also be used (get details from your local clinic).

Transmission route

Waterborne and water-washed (water-scarce).

Management option

Hygiene and sanitation and clean drinking water.

Preventive measures

- Untreated water should not be drunk.
- Water can be disinfected by adding 1 teaspoon of domestic bleach to 20 litres of water and leaving it for at least 1 hour before drinking, or if no bleach is available the water can be boiled vigorously for at least three minutes (take care to avoid burns). Where water is cloudy, add 2 to 3 extra teaspoons of bleach.
- Proper personal hygiene and sanitation infrastructure should be installed and maintained.
- Clean drinking water containers should always be used. Recontamination of stored clean water should be avoided by not inserting the hands or dirty equipment when removing water from the container.

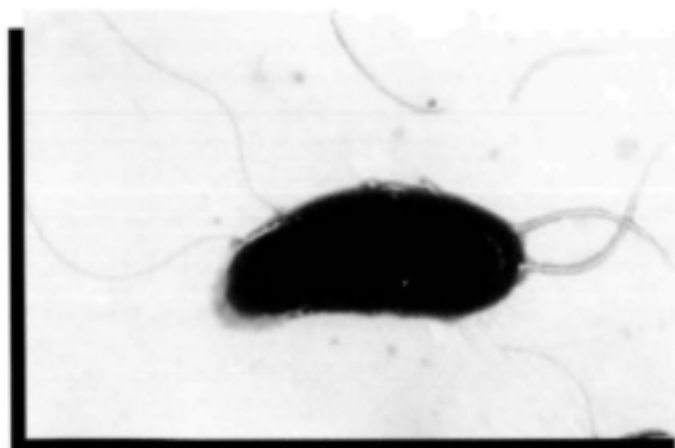
CHOLERA

Interesting facts

- A large number of people (up to 70% or more) who drink contaminated water can become carriers with little or no symptoms at all. People who are carriers can continue to excrete the bacteria for a period of up to a few weeks. Hence the need for proper sanitation and personal hygiene.
- Vaccination of individuals with cholera vaccine can offer slight protection against the disease, but this will only last 6 months, and does not prevent infection and therefore transmission of the disease.
- After ingestion of the bacteria it takes two to four days before cholera symptoms may show.
- Although antibiotics may help by shortening the duration of diarrhoea, the cause of death is severe and rapid dehydration, which can only be treated by rehydration by oral and/or intravenous fluids.
- Not all *Vibrio cholerae* are harmful. Non-toxic strains of the bacteria also occur naturally.

Testing of water and interpretation of results

- To test river samples, take a Moore swab, leave it in the river water for five to seven days, remove and put the swab in peptone broth before taking it to the microbiology laboratory. Consult with the laboratory before doing the sampling.
- If *Vibrio cholerae* is cultured from the Moore swab, this is indicative of cholera contamination. If the strain agglutinates with Ogawa or Inaba antisera (i.e., sero-typed), it is almost certainly capable of producing the disease.
- It is customarily assumed that non-agglutinating (NAG) strains do not produce cholera. NAG strains do not usually produce cholera, but may still on occasion produce less severe diarrhoeal disease similar to gastroenteritis (see gastroenteritis). However, a NAG strain that does not agglutinate with the polyvalent O1 or with the Ogawa and Inaba antisera has been shown to cause severe cholera in India and nearby countries, but not yet in Africa. This NAG strain is known as the O139 or the Bengal strain.



Microscope photo of the *Vibrio cholerae* "comma" bacterium

CRYPTOSPORIDIOSIS ("CRYPTO")

What is Cryptosporidiosis?

Cryptosporidiosis, often abbreviated as "crypto" is an infection of the gut caused by the **parasite** *Cryptosporidium parvum*. From one to 12 days after infection, there is the onset of watery diarrhoea and stomach pains. Sometimes also vomiting and a slight fever. Recovery takes place *after one to two weeks in otherwise healthy people, but in individuals with advanced HIV infection, recovery is delayed, and the disease can be life-threatening.*

The disease occurs where the person is "under-par" and the immune system has not been functioning as it should. Recovery is rapid in people with healthy immune systems.

How is "crypto" spread?

Infection takes place when the parasite is ingested, often through drinking water or through food *contaminated by someone with diarrhoea from the disease, or who has recently had the disease.* Person-to-person contact may also spread the disease, especially where there is poor personal hygiene. Animals often serve as a reservoir for the parasite, which may be present in animal faeces.

The parasite is generally not destroyed by chlorination, and effective filtration is essential to remove the parasite from water. Boiling for one minute does inactivate the parasite.

How should the patient be treated?

Destruction of the parasite with drugs is difficult, and treatment is largely **symptomatic**, to ensure that prolonged diarrhoea does not lead to a loss of fluids and salts. Antidiarrhoeal drugs may help, together with rehydration therapy. The infection is usually self-limited in immuno-competent persons.

Transmission route

Both a waterborne disease and water-washed disease.

Management option

Clean drinking water, sanitation and hygiene.

Preventive measures

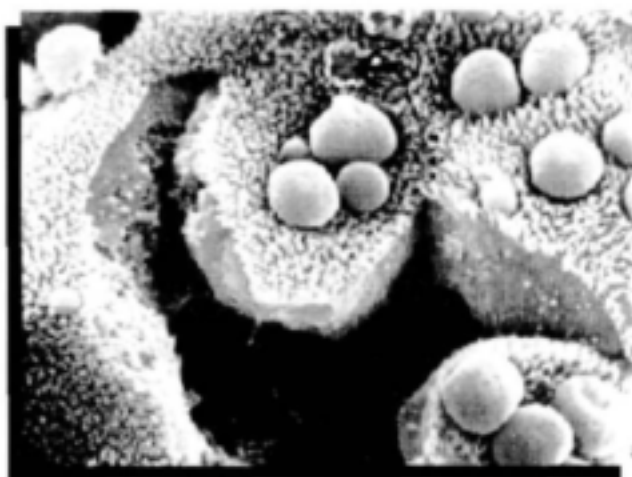
- If drinking water has not been filtered very effectively (through an extremely small pore size filter), then it is necessary to boil the water for at least one minute.

CRYPTOSPORIDIOSIS ("CRYPTO")

- Adding bleach to water does not make it safe for "crypto", unless accompanied by very intense UV light. Small, low power UV lamps are unsuitable in this regard.
- Very fine filters (0,1 to 1,0 micrometre) may remove the parasite and make the water safe. Therefore many conventional filters do not make the water safe.
- Boiling the water is the best way to make it safe.
- Good personal hygiene and effective sanitation are critical.

Interesting facts

- Persons with advanced HIV disease should take extra precautions to avoid infection, such as boiling drinking water, especially if the drinking water treatment supply is suspect.
- As reinfection may occur, practise good personal hygiene, especially after going to the toilet.
- Persons with weakened immune systems should always wash fruit and vegetables well with clean or boiled water, and should avoid touching farm animals, especially calves and lambs.



Electron micrographs of the
Cryptosporidium parasite



GASTROENTERITIS

What is gastroenteritis?

Gastroenteritis is a disease where there is sudden onset of vomiting and watery diarrhoea, often accompanied by moderate fever and sometimes stomach cramps. The incubation period is generally short (8 to 48 hours). The disease is colloquially referred to as "gastric flu", "gyppo guts", or "a stomach bug". Gastroenteritis can be caused by a wide variety of micro-organisms, both **bacterial and, especially, viral**. Examples of bacterial causes of gastroenteritis are *Salmonella enteritis* and *E. coli* O157, while viral causes are for example rotaviruses, enteroviruses or adenoviruses.

Otherwise healthy adults usually recover within a few days, but the disease can be life-threatening in the case of infants, the elderly and individuals in the advanced stages of HIV infection.

Untreated gastroenteritis in infants can rapidly lead to death by dehydration.

How is gastroenteritis transmitted?



Transmission of the disease can occur by a variety of routes, such as eating contaminated food or drinking contaminated water. Very rapid spread within families or groups of people sharing the same utensils, or living together is common, especially with the viral forms of the disease, as it is spread via the faecal-oral route with poor hygiene.

The micro-organisms causing gastroenteritis can survive freezing, and ice blocks made from contaminated water can be a significant route of infection.

Ice cubes must be made from clean water

How should the patient be treated?

Urgent and immediate replacement of the water and salts that are lost, especially in infants and the elderly, is of critical importance. Antibiotics are not recommended as a routine measure, except in very young infants, some elderly persons, or in the presence of fever or bloody stools.

In emergencies, sports drinks containing isotonic fluids can be used to replace the necessary salts and fluids. A weak solution of salt and sugar can also be used (get details from your local clinic).

GASTROENTERITIS

Transmission route

Gastroenteritis is predominantly a water-washed disease, but may also be waterborne.

Management options

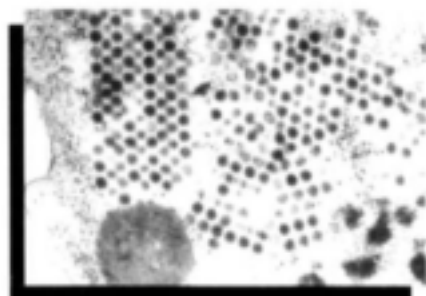
Clean drinking water and effective sanitation and good hygiene.

Preventive measures

- Untreated water should not be drunk.
- Water can be disinfected by adding one teaspoon of domestic bleach to 20 litres of water and leaving it for one hour before drinking, or if no bleach is available the water can be boiled vigorously for at least five minutes and kept simmering for at least another 15 minutes (take care to avoid burns). If water is cloudy, add 2 to 3 extra teaspoons of bleach.
- Proper personal hygiene and sanitation infrastructure should be installed and maintained.
- Clean drinking water containers should always be used.

Interesting facts

- Carriers showing no symptoms can occur, thus the importance of proper personal hygiene, and the importance of washing your hands after going to the toilet, and the proper cleaning of soiled linen with hot water.
- Vaccination is not possible in practice, as there are so many different micro-organisms that can cause gastroenteritis, and each epidemic is generally due to a different organism.
- Gastroenteritis can be life-threatening in the case of an individual with advanced HIV infection, and extra vigilance to ensure clean drinking water and food is essential for such patients.
- Adequate sanitation, treatment of wastes and fly control is an essential adjunct to drinking water disinfection in lowering the incidence of epidemic outbreaks of the disease.



**Electron microscope photo of
adenoviruses**

GIARDIASIS

What is Giardiasis?

Giardiasis is an infection of the gut by the **parasite** *Giardia lamblia*. Giardiasis is usually a mild diarrhoeal disease with flatulence, bloating, "stomach" cramps and loose greasy stools. In some people no signs of the disease occur at all. The diarrhoea normally only lasts for a few days to a week, but it may last longer and result in associated weight loss.

Giardiasis can be life-threatening in individuals in the advanced stages of HIV infection.

How is giardiasis transmitted?

People infected with *Giardia* in their faeces excrete the parasite. It may also be found in animal excreta. Infection occurs through contamination of drinking water as a result of inadequate sanitation, through person-to-person spread by poor hygiene, or through contamination of drinking water containers or food.

Children in nappies with the disease may readily spread the disease to contacts, unless good hygiene is practised.

How should the patient be treated?

Giardiasis is easily treatable with prescription medicines effective against the parasite; however, in otherwise healthy individuals recovery is usually rapid. HIV infected persons generally require medical treatment.

As the diarrhoea tends to be mild, additional fluid replacement is usually not indicated. Of greater concern to the patient is the cramping, bloating and flatulence that tend to occur.

Transmission routes

Water-washed and waterborne.

Management options

Clean drinking water and effective hygiene and sanitation.

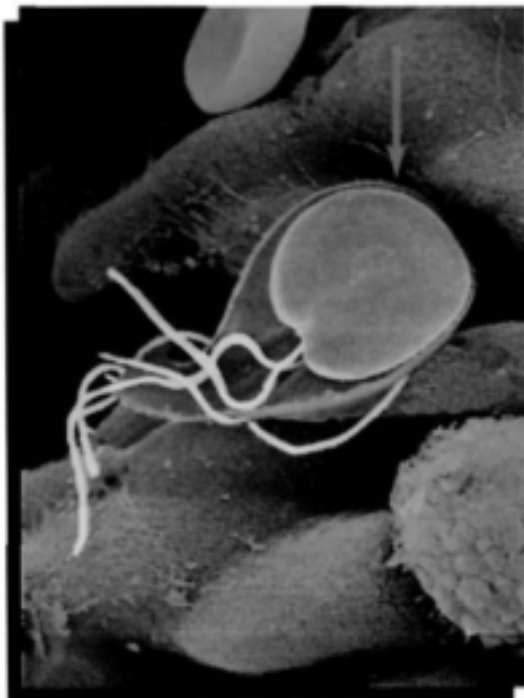
GIARDIASIS

Prevention

- Thorough hand washing with soap and water, especially after changing a baby's nappies, and after using the toilet.
- Wash your hands with soap and water before preparing food.
- If drinking water is suspect, then boil it for five minutes. Be careful not to get burnt.
- Submicron filters will also remove *Giardia* cysts from water.

Interesting facts

- The disease is normally diagnosed from a stool sample.
- Food handlers should be booked off work if they become infected, and avoid preparing food until they are clear of the infection.
- A common source of cross-infection is in child day-care centres, where one infant with giardiasis may readily transmit the disease to others unless the child care nurse practises scrupulous hygiene and thorough hand washing after changing nappies.



Electron microscope photo of
Giardia parasite

HEPATITIS A

What is hepatitis A?

Hepatitis A is a **virus** that causes inflammation of the liver. After an incubation period of two to six weeks the patient experiences fatigue, loss of appetite, especially for fatty foods, tender liver, with sometimes diarrhoea, chalk white stools and jaundice (yellow discolouration of the skin and whites of the eyes). Patients recover in the majority of cases, and chronic infection is rare.

Some cases of hepatitis A infection are without any symptoms at all. **Asymptomatic** cases are also infectious.

How is hepatitis transmitted?

Hepatitis A infection is transmitted predominantly by the faecal-oral route and by drinking contaminated water or eating contaminated food. It may also be transmitted by close person-to-person contact.

There are other hepatitis viruses that are also spread by the faecal-oral route, such as hepatitis E virus. The hepatitis B virus, which often causes chronic liver disease, is normally spread either through infected blood, or through sexual contact.

How should the patient be treated?

Patients with hepatitis A or E infection normally recover fully on symptomatic treatment, bed rest and avoidance of alcohol until the liver has recovered. In rare cases, when the acute phase of the disease is severe, hospitalisation may be required.

Transmission route

Waterborne or water-washed.

Management

Clean drinking water, hygiene and sanitation.

Preventive measures

- Untreated water should not be drunk.
- Adding one teaspoon of domestic bleach to 20 litres of water and leaving for one hour before

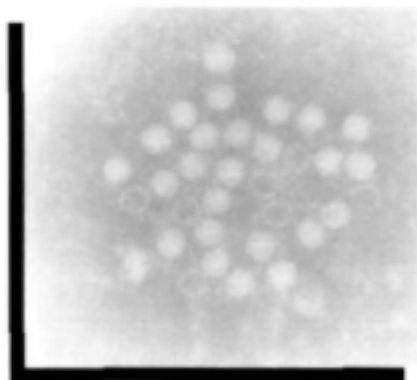
HEPATITIS A

drinking can disinfect water. If no bleach is available the water can be boiled vigorously for at least five minutes, and kept simmering for at least another 15 minutes (avoid burns). If water is cloudy (turbid) add 2 to 3 extra teaspoons of bleach.

- Proper personal hygiene and attention to scrupulous cleanliness in the kitchen while preparing food is essential.
- Proper sanitation practices.
- Consider vaccination of close contacts with immune globulin within 2 weeks of exposure.
- Practise safe sex.

Interesting facts

- There are a number of virus types that cause hepatitis. Types A and E are the ones which are commonly spread by water. Types B, C and D are classically spread through contact with contaminated blood, but also by perinatal spread from mother to child, by sexual contact, and by the use of contaminated needles.
- Hepatitis types A and E do not usually cause long-term disease.
- Hepatitis types B, C and D often cause chronic liver disease.
- Vaccines are available for hepatitis A and B.
- In mild cases of infection, sometimes the only symptom is fatigue, with the diagnosis being made on blood tests.



Electron microscope photo of a clump of hepatitis A viruses

LEPTOSPIROSIS (WEIL'S DISEASE)

What is leptospirosis?

Leptospirosis is the most common of the **zoonotic diseases**, i.e., a disease that can be transmitted from animals to humans. Leptospirosis is a systemic infection by one or more of over 200 serotypes of the **spirochaete** *Leptospira interrogans*. In its usually relatively mild forms it is often mistaken for "influenza". Typical symptoms are a fever, muscle aches and fatigue. Asymptomatic infections are common. While undiagnosed leptospirosis is thought to be quite common, the severe form of the disease, known as Weil's disease, with jaundice (yellowing of the skin), kidney and liver failure and haemorrhagic symptoms, which may often be fatal, is very rare.

How is leptospirosis transmitted?

The natural hosts of *Leptospira* organisms are wild animals, especially rodents, the spirochaete being excreted in the urine of the affected animal. The infection is contracted through contact with infected animal urine (e.g., through an open skin wound, or the conjunctiva of the eyes) or ingestion of water, food or moist soil, that has been contaminated with the urine of the infected animal. Leptospirosis is often an occupational infection in, e.g., miners, rice farmers, sugar cane workers, sewer workers and anyone working in a watery environment that is contaminated with rodent urine. The incubation period is a few days to 3 weeks. The spirochaete can live in fresh water or moist soil for many months, but dies on drying.

How should the patient be treated?

Except in its rare haemorrhagic jaundice form (Weil's disease) leptospirosis is often not suspected, and the problem lies in identifying it when the symptoms are relatively mild. It should be considered in any fever of unknown origin where the patient has had contact with contaminated water. Specific antibiotics are available to combat the infection. Severe forms of the disease require hospitalisation.

Transmission route

Water-based disease, occasionally waterborne.

Management option

Rodent control, and avoidance of contact with contaminated water and sewerage. Proper water disinfection before drinking.

Preventive measures

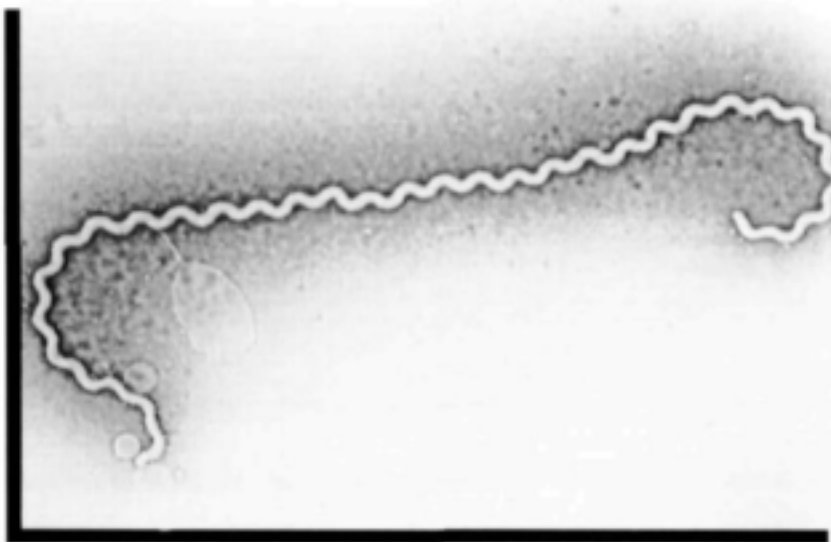
- Avoid direct skin contact with contaminated water, especially if you have an open wound or where you see that animals have been urinating in the water. Use rubber boots.
- Rodent control.

LEPTOSPIROSIS (WEIL'S DISEASE)

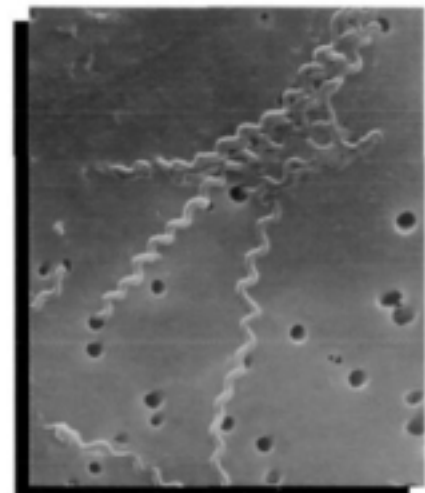
- Fencing off of recreational water bodies to prevent animals from urinating in the water.
- Proper hygiene and sanitation in food storage areas.
- Do not drink contaminated water without first disinfecting it with domestic bleach.

Interesting facts

- Domestic animals may occasionally act as intermediate hosts, being infected from the wild animal reservoir, as a route of infection to humans.
- While classically it was a disease of sewage workers and veterinarians, it is becoming a disease risk in contact water sports.
- Protective boots should always be worn when walking in marshy areas where rodents abound.
- While most patients recover, professional clinical follow-up should always be done as lingering symptoms may occur in some cases, sometimes for many years.



Electron microscope photos of *Leptospira* microbes



MALARIA

What is malaria?

Malaria is a **parasitic disease** of the blood and liver caused by infection with one of four types of *Plasmodium*, the four types being *P. falciparum*, *P. vivax*, *P. ovale* and *P. malariae*. The vast majority of malarial cases in South Africa are caused by *P. falciparum*, which is the most dangerous of the four types of malaria.

Symptoms usually start within 1 to 4 weeks after having been bitten by an infected mosquito, but may be delayed for as long as a year. Characteristically intermittent headache, aching joints, fever, and sweating followed by cold shivers occur at intervals of 1 to 3 days. Malaria can be easily misdiagnosed as influenza, gastroenteritis or viral hepatitis. In the case of falciparum malaria early diagnosis is extremely important, as this form of malaria can progress very rapidly to brain involvement (cerebral malaria), coma and death.

Malaria is endemic to the hotter areas of South Africa, especially the northern (e.g., Northern Province) and eastern (e.g., Mpumalanga and KwaZulu-Natal) regions of lower altitude. As people move, the mosquito vector may be translocated from one area to another in vehicles, e.g., taxi-malaria, and sporadic cases of malaria may occasionally occur in other areas of the country.

How is malaria transmitted?

Malaria is predominantly transmitted from person to person by the bite of an anopheles mosquito. Other possible routes of transmission are occasionally by blood transfusion, as well as through the placenta from a pregnant mother to her unborn child, and by contaminated needles among intravenous drug users.

How should the patient be treated?

Early diagnosis is critical for successful treatment of falciparum malaria, and in order to lessen and, if possible, avoid dangerous complications. Diagnosis is classically made through microscopic examination of a blood smear. Treatment is through the use of specific antimalarial medication.

Prevention of malaria is just as important as early treatment.

Transmission route

Water-vectored disease.

Management options

- (a) Control vector – drain breeding places and spray with effective insecticides. (b) Take measures to avoid being bitten by mosquitoes. (c) Use of **prophylactic** antimalarial medication.

MALARIA

Preventive measures

- Use of mosquito repellents, especially in the evenings.
- Use of bed-nets impregnated with residual insecticides.
- Use of prophylactic medication, but only after consultation with a doctor, especially in the case of pregnancy.
- Drainage of puddles and stagnant waters where the mosquitoes may breed.
- Spraying of dwellings and areas around dwellings with insecticides.

Interesting facts

- Untreated, undiagnosed "neglected" malaria can often prove fatal. Early diagnosis is extremely important, and in any **febrile illness** in someone who lives in or has recently visited an area where malaria is endemic, the possibility of malaria should be considered.
- Malaria can have atypical symptoms in persons who are partly immune, or who have taken prophylactic "antimalaria" medication.
- Some strains of malaria have become resistant to the usually used antimalarial medication, so consult with your health professionals before entering an endemic malaria area.
- Some anti-malarial medication can have serious side effects, and should only be taken under professional guidance.



Microscope photo of *Plasmodium falciparum*

POLIOMYELITIS ("POLIO" OR "INFANTILE PARALYSIS")

What is poliomyelitis?

Poliomyelitis or "polio", for short, is a **viral disease** where damage to the motor nerves which activate movement may occur and is characterised by acute **flaccid paralysis** (AFP) in severe cases, without any loss in sensation. The incubation period between infection and appearance of symptoms is usually one to two weeks. Polio starts off as a throat and gastrointestinal infection, which resembles influenza in the early stages. Most people affected get better after this stage, and it is only a small number of cases that progress to the stage of muscle paralysis, with severe muscle pain and often stiffness in the back and neck. Up to 95% of infections with the polio virus are without any symptoms at all, and the patient recovers completely when the infection is asymptomatic or mild. In rare cases, the polio virus can destroy the nerves controlling the breathing muscles, and death often follows.

Paralytic polio may very rarely be caused by vaccination with the live attenuated oral polio vaccine (OPV). The incidence of this complication of vaccination is said to be less than one in 2 to 8 million cases.

How is polio transmitted?

The polio virus is excreted in the throat secretions and stool of a person infected with polio just before the appearance of symptoms and often for several weeks thereafter. The disease is highly contagious, and is spread by close person-to-person contact. Where hygiene is compromised, polio is mostly spread via the faecal-oral route. Spread by drinking contaminated water is relatively rare. The susceptible age group is mainly small children (thus the alternative name for polio of "infantile paralysis").

The polio virus is easily destroyed by chlorine.

How should the patient be treated?

As there is no cure for polio infection, treatment of the patient is symptomatic. Control of polio is therefore geared to prevention. Immunisation with polio vaccine is only effective if given prior to infection with the virus.

Transmission route

Water-washed (poor hygiene), and waterborne.

Management option

Hygiene and sanitation, and clean drinking water.

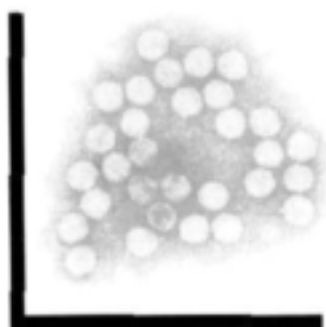
POLIOMYELITIS ("POLIO" OR "INFANTILE PARALYSIS")

Preventive measures

- Use of injectable inactivated polio vaccine (IPV), or live attenuated oral polio vaccine (OPV) to confer immunity to infection by the three strains capable of causing paralysis. This is the single most important preventive measure.
- Untreated water should not be drunk
- Water can be disinfected by adding 1 teaspoon of domestic bleach to 20 litres of water and leaving it for 1 hour before drinking, or if no bleach is available the water can be boiled vigorously for at least 5 minutes, and kept simmering for at least another 15 minutes (take care to avoid burns). If water is cloudy (turbid) add 2 to 3 extra teaspoons of bleach.
- Scrupulous personal hygiene, especially after use of the toilet or changing nappies, or before preparing food.
- Proper sanitation infrastructure should be installed and maintained.
- Clean drinking water containers should always be used.

Interesting facts

- Prior to the introduction of inactivated polio vaccine (IPV) and live attenuated oral polio vaccine (OPV), polio reached epidemic proportions in many countries. It is now very rare in developed countries, but still common in some developing countries.
- The live oral polio vaccine (OPV) immunises the vaccinated infant, as well as **close contacts**.
- Because of the rare danger of vaccine-induced paralytic polio from OPV either in the very rare individual vaccinated or close contacts, there is now a move in some developed countries to use IPV immunisation instead of, or prior to, using the oral polio vaccine.



Electron microscope
photo of polio viruses

SHIGELLOSIS (SHIGELLA DYSENTERY)

What is shigellosis?

Shigellosis is caused by the **bacterium** *Shigella dysenteriae*, and other *Shigella* species. The symptoms are a sudden onset of abdominal pain, cramps and diarrhoea. There is often mucus and blood in the stools, and a fever is common. Dehydration may occur in severe cases, with decreased urine production which may progress to kidney failure if the dehydration is untreated. The infection is most common in young children of pre-school age, although people of all ages can be affected. The incubation period is usually 1 to 3 days. Symptoms usually last for a few days to a week, but can last longer. Asymptomatic infections also occur, where apparently well people can be a source of infection for a few weeks.

Shigella dysenteriae is highly infectious, as the infective dose is small (may occur with exposure to as little as ten organisms). The infection is most common in child day care centres, and also among institutionalised people.

How is Shigellosis transmitted?

Shigellosis can be spread by close person-to-person contact, as well as on occasion by contaminated food or water, via the faecal-oral route. Scrupulous cleaning of hands after using the toilet, changing nappies, or prior to preparing or eating food needs to be practised to prevent transmission, especially if a close contact is infected with the organism and is thus excreting the bacterium in the stool.

How is the patient treated?

Rehydration with fluids is necessary to prevent dehydration. In rare cases, with kidney failure or severe rectal bleeding, hospitalisation is required. Antibiotics are normally administered to shorten the duration of the infection and to hasten recovery. The diagnosis is confirmed through culture of stool samples. Day care workers and food handlers should be especially careful not to return to work until two consecutive stool samples are negative for shigella.

Transmission route

Water-washed, and waterborne.

Management options

Hygiene and sanitation, and clean drinking water.

Prevention

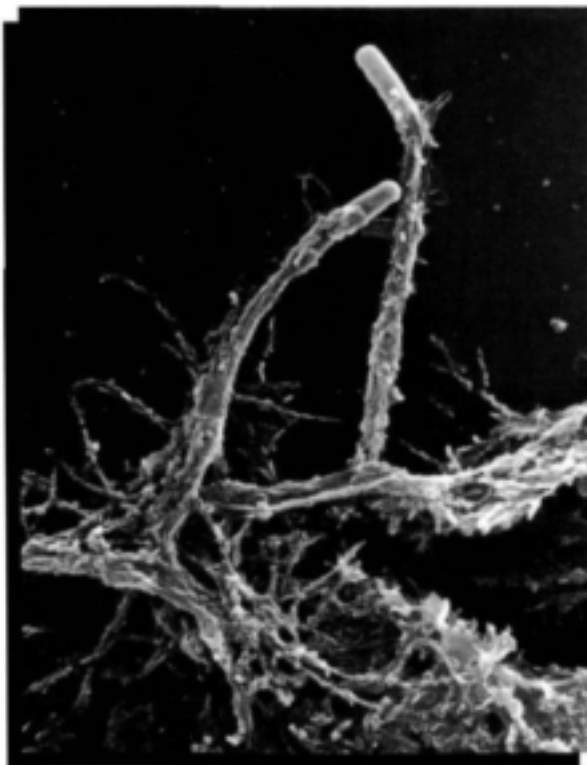
- Always wash your hands thoroughly with soap and water after going to the toilet, changing nappies, or before preparing food.

SHIGELLOSIS (SHIGELLA DYSENTERY)

- Untreated water should not be drunk.
- Water can be disinfected by adding 1 teaspoon of domestic bleach to 20 litres of water and leaving it for 1 hour before drinking, or if no bleach is available, the water can be boiled for at least 5 minutes (take care to avoid burns). If water is cloudy (turbid) add 2 to 3 extra teaspoons of bleach.
- Adequate sanitation and fly control, as well as provision of clean, disinfected drinking water.
- Clean drinking water containers should always be used.

Interesting facts

- Recovery from shigellosis is in most cases spontaneous, except in the very young and the very old, where life-threatening dehydration and other complications can occur, or in cases of infection with the **nephrotoxic** strain of shigella, when renal dialysis may be required.
- Special care needs to be taken by food handlers with thorough hand washing before preparing food, especially if they have been in contact with young children with suspected shigellosis.
- Shigellosis can on occasion be spread by ice cubes made from contaminated water.
- A significant source of shigellosis is shellfish harvested from areas subject to sewage outfall contamination.



Greatly enlarged view of *Shigella* microbes

SWIMMER'S ITCH (NON-HUMAN BILHARZIA)

What is swimmer's itch?

Swimmer's itch is an intensely irritating **dermatitis** caused by the free swimming stages of **blood flukes (parasitic flatworms)**, whose primary hosts are normally ducks, geese, gulls or other animals, and where the **cercariae** inadvertently penetrate human skin, causing an allergic reaction or local irritation of the skin.

In the differential diagnosis, swimmer's itch should be distinguished from the itchy dermatitis which has commonly been reported where recreational bathers swim in water containing algal scums, and come into contact with the toxins secreted by blue-green bacteria. The dermatitis caused by the toxin of algal scums is often associated with transient gastroenteritis-like symptoms, which do not appear with schistosomal dermatitis.

How is swimmer's itch acquired?

Schistosomal dermatitis is caused by contact with water frequented typically by water birds, serving as a source of the water-based flukes. Skin penetration by the cercariae occurs when water is allowed to evaporate on the skin.

How should the patient be treated?

If a rash appears, calamine lotion may help to control the itching, together with the use of antihistamines. Recovery is spontaneous, within a week to a month.

Transmission route

Water-based (water-contact) disease.

Management option

Various options have been tried, such as the use of barrier creams, the use of copper sulphate to control the secondary snail host, and avoidance of swimming near breeding or feeding areas of water birds.

Prevention

- Avoid skin contact with contaminated water.
- Avoid swimming in affected water bodies.
- Shower immediately after swimming.
- Towel skin dry with a rough towel, immediately after emerging from the water, and wash the towel subsequently in hot water.
- Application of an astringent (drying) agent, such as rubbing alcohol to the skin immediately after swimming may also help to reduce fluke penetration.

SWIMMER'S ITCH (NON-HUMAN BILHARZIA)

Interesting facts

- Only some people show an allergic response to the flukes.
- The itching may be so severe as to lead to bleeding of the skin from scratching.
- The allergic response and the severe itch may be either an immediate response (within a few hours) to the parasites entering the skin, or may be delayed with maximum allergy and itching occurring several days to 2 weeks after swimming in infected water.



Life cycle of swimmer's itch parasite

TRACHOMA

What is trachoma?

Trachoma is a chronic infection of the surface (cornea and conjunctiva) of the eye, caused by the **microorganism** *Chlamydia trachomatis*. Untreated it leads to blindness in later years. Trachoma is the most common cause of blindness in developing countries. The infection usually starts in childhood, with sore, watering red eyes. Repeated infections are common, and lead to turning in of the eyelashes, scarring and opacity of the cornea, with blindness.

How is trachoma transmitted?

Trachoma is transmitted from person to person by finger/hand contact with the eyes. It may also be transmitted by flies. Trachoma typically occurs in dry dusty environments, where there is water scarcity and a lack of water for regular washing of the face and hands. The disease may also be transmitted by handling contaminated items, such as towels, face cloths, handkerchiefs, etc.

How should the patient be treated?

The long-term complications of trachoma, such as scarring and blindness can be prevented by early treatment of the eye infection with antibiotics. If turning-in of the eyelashes has occurred, then eyelid surgery is necessary. If corneal scarring has already occurred, then **corneal graft surgery** may be necessary.

Transmission route

Water-washed (water-scarce) disease.

Management option

Provision of sufficient water for personal hygiene and face washing. Also fly control.

Preventive measures

- Provision of adequate supplies of water for personal hygiene and hand and face washing.
- Early training of children to wash their faces and hands often.
- Early diagnosis and treatment of eye infections, especially "red, itchy watering eyes".
- Fly control.

Interesting facts

- Trachoma is an eye disease endemic in many of the poorer and drier parts of the world, and is found wherever there is insufficient water for regular personal hygiene.
- The infection is most common in children, and is usually transmitted during communal play through finger-eye contact.

TRACHOMA

- Provision of adequate water supplies results in regular bathing, washing and laundry activities, which effectively reduce the risk of disease transmission. Trachoma is very rare in the industrialised countries of the world.



Trachoma starts with sore
watering red eyes

TYPHOID FEVER

What is typhoid fever?

Typhoid fever is a debilitating fever caused by infection with the **bacterial organism** *Salmonella typhi*. Following infection, after an incubation period of around 1 to 3 weeks, the patient has a gradual onset of illness, starting with a headache, followed by fever and abdominal pain. Constipation is more common than diarrhoea in the early stages of the illness. Later bronchitis develops. In untreated cases death can occur from intestinal perforation or haemorrhage. In untreated cases, the death rate can be as high as 30%. The infection may last up to 3 weeks or even longer. In some individuals infection may occur with no signs of illness at all.

A characteristic rash on the trunk, called "rose spots" only occur in a few percent of cases, but is not seen on a dark skin.

How is typhoid transmitted?

Typhoid bacilli are excreted in the stool of infected individuals, and continue to be excreted by untreated patients after recovery for up to 4 months. The disease is transmitted by the faecal-oral route, either via drinking water, or food. Flies may also play a role as a passive vector leading to food contamination.

In some recovered cases, a chronic carrier state develops, which may persist lifelong, and such typhoid carriers should not be allowed to prepare food for others, or work in day-care centres, as they present a continual source of the organisms in their stools. They should be treated with antibiotics until three consecutive stool cultures are negative for *Salmonella typhi*.

How should the patient be treated?

The use of antibiotics at an early stage in the infection is essential to prevent the appearance of life-threatening complications, and bed rest is essential. A loss of appetite and weight loss are characteristic of the disease. The consequences of typhoid can be very severe in the case of HIV positive individuals.

Transmission route

Typhoid fever is predominantly a water-washed disease, but may also be waterborne.

Management option

Hygiene and sanitation / clean drinking water.

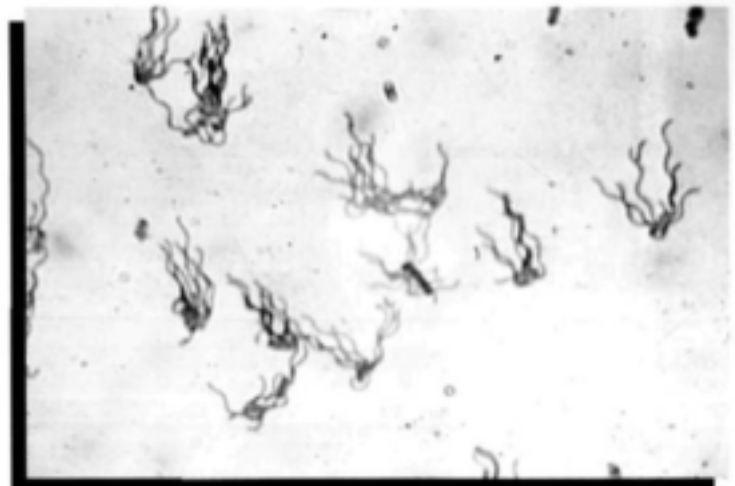
TYPHOID FEVER

Preventive measures

- Don't drink untreated water.
- Add 1 teaspoon of domestic bleach to 20 litres of water and allow to stand for 1 hour before drinking or, if no bleach is available, the water can be boiled vigorously for at least 3 minutes (avoid burns). If water is cloudy (turbid) add 2 to 3 extra teaspoons of bleach.
- Proper personal hygiene and sanitation infrastructure should be installed and maintained.
- Wash or peel fruit and vegetables before eating.
- Wash your hands after going to the toilet and before preparing food.

Interesting facts

- A vaccine against typhoid is available, but it only provides limited protection.
- A common source of infection is contaminated water or food from street vendors.
- The typhoid bacillus only lives in humans, and apparently healthy carriers are usually the source of new outbreaks.
- Testing of food handlers for typhoid status provides a false sense of security, as handlers can become **subclinically** infected at any time after the negative test. A much more useful approach is the ongoing education of employers and employees alike about hygiene in the food-handling industry. Regular inspection of premises and equipment is essential to ensure that hygiene rules are observed at all times. Employers must also provide ample, clean toilet facilities with running water, soap and clean disposable towels.
- Infection can be acquired from ice cubes prepared from contaminated water.



Microscope photo of *Salmonella typhi* organisms

Masai children with flies

PART 4

Water, the environment and people's health



MANAGEMENT ISSUES FOR DOMESTIC WATER SUPPLY

What factors are important in the management of the microbial quality of domestic water supplies?

The important factors are (i) disinfected drinking water, (ii) sound disposal of faecal wastes, (iii) application of good personal, food and water use hygiene, (iv) use only of safe water for crops eaten raw.

In the management of water quality for domestic purposes it is important to bear in mind that the achievement of the goal of providing safe water for drinking and food preparation rests on the management of the safety of the water supply along the whole supply chain. The water supply chain consists of the water source, treatment works, distribution system, the supply tap, the drinking water container, jug or cup. (See vol., 5, Management Guide, DWAF, DOH & WRC, 2002).

Dirt that has gained access to the water supply line or tank (e.g. high-rise buildings) often causes problems in the management of water for domestic purposes,

- In the case of the repair of a burst pipe where dirt may gain access to the supply line, this may cause a temporary elevation of the microbiological total plate count in the supply line, but the consumer is usually alerted to the problem by brown water coming out of the tap. The situation is usually remedied by flushing the tap and allowing the **plug of contaminated water** to flow down the drain.
- Rodents may gain access to gravity feed tanks on top of high-rise buildings which may not be covered properly. This typically results in foul smelling and tasting water, and the consumer is alerted to the problem. Such tanks will need flushing and proper screening of any access points.

The other situation which needs attention is to ensure that containers that are used in the home for storing drinking water are clean and that they are properly covered to ensure that flies and dirt do not settle into the water in the container. One of the quickest ways to contaminate water in a bucket, for example, is to dip an unwashed hand into the water while scooping water out of the bucket with a cup. Containers for drinking water which have a narrow mouth and a tap at the lower end are preferable in order to keep the water clean.

What are the water supply requirements for food preparation?

The water supply requirements for food preparation are as for drinking purposes with, however, the following points which must be kept in mind:

Kitchen hygiene is highly important in controlling disease transmission. The use of refrigeration for perishable foods is a must.

There needs to be a general awareness of the need to work cleanly when cutting and preparing

meat, especially chicken, and that knives and cutting boards must be washed with very hot water immediately after use if the incidence of campylobacteriosis is to be reduced.

There also needs to be an awareness-building of the importance of clean water for food preparation by vendors of fast foods, particularly those that operate from the roadside. Dust blown up from the road can so easily contaminate their drinking water container, especially if it is an open container which has not been provided with a cover and a tap.

Always be very careful of using only clean water when filling ice trays and preparing ice cubes. Ice cubes prepared from contaminated water can so easily be a source of transmission of disease.

Why is personal hygiene so important?

The aim of water hygiene practices is:

- To ensure that water used for drinking purposes or in food preparation is clean and microbiologically safe up to the point of use, i.e., where the water is drunk or the food eaten. The safety of the water is normally achieved by chemical disinfection, typically at a central treatment plant, although boiling of the water is an important additional safety factor in the home, where an additional safety barrier may be recommended, e.g., if disinfection has been compromised. Great care must be taken that the water is cooled down again before drinking, especially where it is given to an infant.
- To ensure that water is used in appropriate hygienic practices to prevent the faecal/oral contamination route. Such practices, e.g., include washing of hands after using the toilet, washing of hands after changing a baby's nappy, washing of hands before preparing or handling food, washing of cutting boards, knives and cutlery as well as utensils in the kitchen, etc.



In this latter class, in the broader sense the proper treatment and handling of sewage wastes can also be seen as a hygienic practice, although it is usually termed a waste treatment practice.

Where proper water hygiene is practised there is characteristically a dramatic drop in the incidences of waterborne and water-related diseases, and the health of the society is enormously benefited.

The general practice of personal hygiene is essential in limiting the spread of water-related diseases. Children must be educated from a young age, with the adults setting the example to always wash their hands after going to the toilet.

It is important to make soap or hand-washing liquid available, in addition to running water where possible, as this helps disinfect the skin of the hands which may be microbiologically contaminated after using the toilet.

Where running water is not available, e.g., where camping or out in the field, then a small basin of clean water will also serve the purpose of making hand washing possible.

Hand washing after toilet use, or before preparing or eating food, has been identified as the single most important factor in the limitation and control of person-to-person disease transmission, and needs to be encouraged in the young, so that they grow up with a lifetime habit of washing their hands.

In arid places where salt water abounds and fresh water is at a premium, it can be noted that water for hand washing need not be fresh water, but must be microbiologically clean, and not irritating to the skin.

Why is clothes washing important?

Clothes washing is almost as important as hand washing in the limitation of the harbouring and transmission of disease.

Water for clothes washing must also be microbiologically clean, as some micro-organisms can survive on the dried clothing after drying, and can be a source of infection either to an open graze or wound to the skin, or via inhalation to dust breathed in through the nose.

Why is waste management important?

In order to minimise the contamination of the water resources with disease-causing micro-organisms, it is essential to implement good waste management practices, such as the collection and proper treatment or disposal of faecal waste matter, the proper disposal of domestic waste, and the proper disposal of any animal carcasses, as well as adequate rodent and fly control.

Both rodents and flies serve as vectors in the transmission of disease and, if uncontrolled, can readily spread certain diseases, e.g., typhoid fever in the case of flies or leptospirosis in the case of rodents.

Why is medical treatment important?

While prevention of water-related diseases is the best approach to use, medical treatment is **essential** when a person is seriously ill with a disease. For example, cerebral malaria can easily be fatal unless timeously treated.

CONCLUSION

Key principles in controlling water-related diseases

The key principles in the limitation and control of the spread of water-related diseases are:

- 1) Water treatment and disinfection before use.
- 2) Proper personal and domestic hygiene.
- 3) Adequate waste disposal as well as the ancilliary measures of rodent and fly control.
- 4) Proper medical care (both prevention and treatment).

It is only by applying these 4 principles simultaneously and with sustained effort, that the scourges of waterborne diseases, which affect so many people each and every year, will be brought under a measure of control.

It is our hope that by producing this guide, we have provided basic educational material and helped the teachers of the new upcoming generation to set an example which they will with keenness and determination follow, when they understand the wisdom and knowledge which have led to the formulation of these rules of managing water-related microbial diseases.

GLOSSARY

- **Anabolic processes:** Metabolic processes (living chemical processes) which result in tissue building including, for example, an increase in muscle mass.
- **Asymptomatic case:** A condition where a person has a particular disease, but where there are no symptoms of the disease present, so that the person does not know that he or she has acquired the disease. The person feels well.
- **Bacteria:** Unicellular microbes (very small living single cells) which utilise simple nutrients to grow and multiply. There are various ways of classifying them. They can, e.g., be divided into aerobic bacteria which need oxygen to grow and anaerobic bacteria which can grow and divide in the absence of oxygen. They can also be divided into pathogenic (disease-causing) bacteria and non-pathogenic (non-disease causing or friendly) bacteria.
- **Bacterium:** Singular of the plural bacteria.
- **Blood fluke:** Parasitic flat-worm that inhabits blood vessels in the primary host.
- **Catabolic processes:** Metabolic processes (living chemical processes) which result in the destruction of tissues and decrease in mass of tissues present.
- **Cercariae:** Free-swimming life stage of a parasitic blood fluke.
- **Circulatory shock:** A state of collapse due to insufficient circulating blood or body fluid volume and which is often life-threatening.
- **Close contacts:** Individuals with which the individual comes into the close vicinity of, e.g., members of the same household or office environment, school class, etc.
- **Corneal graft surgery:** Surgical operation where an opaque, damaged cornea (normally transparent covering front surface of the pupil of the eye) is removed and replaced with a donor corneal graft.
- **Dermatitis:** An inflammation of the skin.
- **Diarrhoea:** Watery stools (faeces).
- **Diarrhoeal diseases:** Diseases presenting with diarrhoea (watery stools), or where diarrhoea is a prominent feature of the disease condition.
- **Differential diagnosis:** List of possible alternate causes of a given set of symptoms and signs of a presenting disease condition.
- **Dysentery:** Diarrhoea with blood and mucus present.
- **Ecological balance:** That complex series of interactions and interdependencies whereby all living things and the living cells within organisms maintain that delicate balance which makes the sustenance and sustainability of life possible.
- **Faecal material:** Solid, usually brownish coloured waste matter (excreta) produced during defecation, and which consists largely of undigested cellulose and food residues, as well as bacteria.
- **Faecal-oral route:** The most common route of transmission of gastrointestinal diseases where the disease-causing organism is excreted in the faeces and faecal matter containing the causative organisms finds its way to the mouth of the same or another individual either, e.g., via contamination of the water or food with faecal matter.
- **Febrile illness:** A disease characterised by the presence of a fever, i.e., an elevated body temperature.
- **Flaccid paralysis:** A paralysis (loss of motor movement), where the muscles are soft and limp, and where the limbs remain soft and supple.

GLOSSARY

- **Fungi:** A class of micro-organisms which tend to join together to form a vegetative mass which can vary in size from microscopic to macroscopic in size (e.g., mushrooms), and which are often spore-forming (minute resting phase, like a dust).
- **Indicator organisms:** Microbes of faecal origin occurring in large numbers in faeces, but which are not causative themselves of the particular disease under consideration, but which indicate the presence of faecal contamination of water, and thus the possibility of the presence of disease-causing microbes (pathogens).
- **Indicator bacteria:** See "Indicator organisms". That class of indicator organisms which are bacteria.
- **Nephrotoxic:** Causing damage to the kidneys through toxic action.
- **Parasite:** An organism which can only live off another living organism and which causes damage to the host organism in or on which it lives.
- **Parasitic disease:** A disease in the host organism caused by the parasite.
- **Pasteurisation:** The disinfection process applied to milk, where the milk is heated for a short period to a specific temperature in order to destroy a large portion of disease-causing microbes which may be present in the raw, unpasteurised milk from the cow's udder.
- **Plug of contaminated water:** Section of water that has become contaminated in a piping system and that needs to be flushed out.
- **Prophylactic medication:** Medication taken typically prior to and/or just after exposure to a disease and which protects against or prevents the disease condition from appearing.
- **Protozoa:** Tiny organisms without a vertebral column (invertebra) which are able to move through amoeboid action, i.e., by changing the shape of the surface of the organism or by ciliate action.
- **Serological blood test:** A biochemical test using the blood serum, which is the blood plasma from which the clotting factors have been removed.
- **Spirochaete:** That class of bacteria where the organism has a corkscrew-like (spiral) shape.
- **Subclinical infection:** An asymptomatic infection where the patient feels well, and has no symptoms of disease.
- **Typhoid bacilli:** The vegetative rod-like (bacillus) forms of the bacterial organism which causes typhoid fever.
- **Viruses:** That class of microbes which are intracellular parasites consisting of genetic material with a protein coating which can only multiply by using the protein synthesis biochemical processes found inside living cells. Viruses are unable to replicate on their own without the presence of a parasitized living host cell.
- **Viral disease:** A disease caused by a virus.
- **Zoonotic disease:** A disease which is found normally only in animals, but which may under certain conditions also be transmitted to humans.

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