teaching triple science
quick guide

Disasters and disease

Cholera hospital in Dhaka, Bangladesh. Note: waterproof beds with drain into bucket for acute cases of cholera; many children; stands for delivering saline drips if oral rehydration therapy fails.

What causes diarrhoeal disease?

A few microbial species are a special danger to human communities when arrangements for water supply and sewage disposal fail. Chief among these are the microbes *Vibrio cholerae* (which causes cholera) and species of *Shigella* (dysentery) and *Salmonella typhi* (typhoid fever). Having caused five appalling cholera epidemics in nineteenth-century Europe, with massive loss of life, *Vibrio cholerae* has the most fearsome reputation. The danger was finally eliminated from the developed world by the introduction of clean piped water systems, well-designed sewage disposal systems and massively improved awareness of hygiene principles.

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Facts

Water can be made safe in an emergency by boiling or chlorination.

Microbes that cause diarrhoea get into the water supply when it is contaminated by sewage.

Diarrhoea is not a disease but a symptom, caused by many microbes varying greatly in severity; cholera is the worst.

ORT can save the lives of victims of acute diarrhoea.

Médicins sans Frontières, an independent humanitarian medical aid organisation, is often the key medical agency in cholera outbreaks.

V. cholerae attaches to villi of the intestinal wall and produces a protease to assist entry into gut tissue.

Once inside cells of the gut, cholera endotoxin activates a protein called the cystic fibrosis transmembrane conductance regulator, starting a dramatic release of water and ions that becomes a life-threatening watery diarrhoea.

Diarrhoea and death

In its most severe form, cholera causes acute diarrhoea that kills a victim within three hours if no medical treatment is given. Both *Shigella* and *Salmonella* are diarrhoeal diseases that spread in the same way as cholera but less dramatically. *Shigella* (known as the 'bloody flux' in former times because of severe intestinal bleeding) causes dysentery. *Salmonella* species cause typhoid fever and serious food poisoning.

After they have passed through one human, cholera strains increase their capacity to infect humans through subtle changes in gene regulation. If faeces from an infected individual enter the water supply, the enhanced *Vibrio* is likely to give the epidemic more momentum. *Shigella*, *Salmonella* and a number of other organisms, if introduced into food through bad kitchen practices, can cause severe diarrhoea and vomiting if an infection develops. They produce endotoxins that create the chief symptoms.

Cholera is a particular problem in India and Bangladesh, because there is a permanent reservoir of *Vibrio* in the environment, associated with plankton found in the coastal waters of the Bay of Bengal. The microbe is released when the sea penetrates the fresh water of the Ganges Delta during a typhoon. *Vibrio* can start an epidemic if people use untreated water from the river.

A cheap and effective remedy

Oral rehydration therapy (ORT) is an effective and cheap remedy for dehydration caused by diarrhoea. Devised nearly 30 years ago by an Indian doctor, and now a vital part of all humanitarian efforts, ORT saves the lives of millions of children a year in the developing world.

Salts (sodium and potassium chloride) and glucose are the key ingredients of ORT – salts to replace those lost by diarrhoea and sugar to help salt uptake by the intestine. Zinc salts are also included to help control bacteria in the gut.

Terms

Bacteriophage
A virus that kills bacteria. It is part of the bacterial chromosome and is activated during infection.

Endotoxin
A protein toxin that is released when the victim succumbs to a *V. cholerae* infection. The bacteriophage bursts the bacteria to release the toxin.

Pathogenicity
The capacity of an infectious organism to cause a disease.

Virulence
The degree of pathogenicity (eg very virulent = serious disease).

Activity

Make handprints on nutrient agar plates. Compare unwashed hands, washed hands and hands treated with anti-bacterial hand gel.

Recent epidemics

The greatest risk of epidemics occurs when undernourished populations are displaced by civil conflicts into overcrowded camps lacking safe water and sanitation. The worst recent example occurred in 1994, when 2 million Rwandans fled into neighbouring countries in central Africa. Over 50,000 people died of cholera, dysentery and other infectious diseases within a short time. Such crises are always possible in countries that lack resources and infrastructure and whose systems for preparing for disasters are overwhelmed by sheer numbers. Persistent fighting always makes the situation worse. In the case of the Rwandan refugees, a major international humanitarian relief effort improved the situation substantially.

In 2002, the Nyiragongo volcanic eruption caused another severe disruption of life in the Goma region of the Democratic Republic of Congo (DRC), but no immediate change in levels of cholera. However, the disease returned to the regions around Lake Kivu in subsequent years because it was heavily contaminated from earlier crises.

An acute cholera crisis developed in Zimbabwe in 2008 because urban water supplies either failed or were unsafe as they were not being treated with chlorine. Malnutrition has made the fatality rate from cholera unusually high, and the disease has spread rapidly from the cities to the country with fleeing city-dwellers.

In recent years, smaller outbreaks of cholera have occurred in Iraq (during the war), Vietnam and India. This is always a possibility in countries where water supplies can become contaminated by sewage.

Questions

Why is chlorine used to treat water supplies?

Why are present-day cholera epidemics less alarming than the nineteenth-century European outbreaks?

What aspect of *Vibrio*, *Shigella* and *Salmonella* makes them cause diarrhoea?

What hygiene principles would help anyone avoid an infection of one of these diseases?

Disaster preparedness

The media usually discuss the risk of epidemics after earthquakes or volcanic eruptions, although no significant epidemics were recorded in such circumstances in the twentieth century. The short-term risks are low, because even poor countries have systems for preparing for disasters that are usually reinforced by the international community. In addition to caring for the injured and homeless, a high priority is given to providing clean water and sanitation.

Web links

Cholera outbreak in the DRC in 2002
http://news.bbc.co.uk/1/hi/world/1773033.stm

Cholera outbreak in India in 2007
http://news.bbc.co.uk/1/hi/world/south_asia/6968281.stm

Cholera outbreak in Zimbabwe in 2008
http://en.wikipedia.org/wiki/2008%E2%80%932009_Zimbabwean_cholera_outbreak

Oral rehydration therapy
http://en.wikipedia.org/wiki/Oral_rehydration_therapy

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Over 50% of scientists and engineers responding to a survey conducted by the Royal Society felt that schools were a key audience for their research. They believed that communicating research findings to this audience was an important way of making sure that the general public is well informed about science and technology. On that basis, the Triple Science Support Programme and the UK Research Councils have collaborated to publish Quick Guides on a range of extension topics in physics, chemistry and biology (Triple Science GCSEs). The guides are written specifically for teachers by researchers working in the field. For more information about the Triple Science Support Programme and to download all the Quick Guides please go to www.triplescience.org.uk