Emerging Issues in Water and Infectious Disease

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EMERGING ISSUES IN WATER AND INFECTIOUS DISEASE

FOREWORD

> *Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity.*
> Kofi Annan, United Nations Secretary-General

Human development and population growth exert many and diverse pressures on the quality and quantity of water resources and on access to them. Nowhere are the pressures felt so strongly as at the interface of water and human health.

Infectious, water-related diseases are a major cause of morbidity and mortality worldwide. Although a significant proportion of this immense burden of disease is caused by 'classical' water-related pathogens, such as typhoid and cholera, newly-recognized pathogens and new strains of established pathogens are being discovered that present important additional challenges to both the water and public health sectors. Between 1972 and 1999, 35 new agents of disease were discovered and many more have re-emerged after long periods of inactivity, or are expanding into areas where they have not previously been reported. Amongst this group are pathogens that may be transmitted by water.

Understanding why pathogens emerge or re-emerge is fundamental to effective water resource management, drinking-water treatment and delivery, and has become a priority for many national and international organizations. It is also important to be able to gauge the risk from any emerging disease. The perceived severity of risk and significance of an emerging infectious disease may be so far removed from reality that there is potential for inappropriate allocation of resources. This can have repercussions for countries at all stages of development.

Investigating important emerging issues in water and infectious disease and communicating discoveries create unique challenges, which are addressed by an initiative being taken by the World Health Organization (WHO), and collaborators. The initiative seeks to accelerate the identification of actual and perceived issues, to bring together information and knowledge in critical areas, and to disseminate information to policy makers and practitioners in a timely fashion.

We are pleased to issue this publication to broaden awareness of emerging issues in water and infectious disease and to guide readers to sources of information that deal with these issues in greater depth.

CONTENTS

EVOLUTION OF INFECTIOUS DISEASE

Nothing in the world of living things is permanently fixed.
Hans Zinnser. Rats, Lice and History (1935)

Pathogenic (disease-causing) micro-organisms have repeatedly altered the course of human history. From the earliest examples of art, literature and scientific writing, the devastating consequences for the populations gripped by diseases of different kinds and severity have been documented in great detail. For example, the influenza pandemic between 1918 and 1920 resulted in an estimated 70 million deaths worldwide. Even today, the overall burden of infectious disease remains high. In 2001, infectious diseases accounted for an estimated 26% of deaths worldwide (Kindhauser, 2003).

In the context of scientific and medical history, microbiology emerged relatively recently as a specialist discipline. Although micro-organisms had been observed in the 17th century and some workers had speculated about the germ theory of infectious disease before the 19th century, the science of microbiology did not become established until after 1850. The skills and perseverance of the early pioneers, combined with advances in analytical tools and techniques, added rapidly to the growing catalogue of pathogens. By 2001, a total of 1415 species of infectious organisms known to be pathogenic to humans had been recorded. Whilst many of these organisms are associated with diseases that have been known for many years, a small but significant percentage are associated with emerging diseases, such as Acquired Immunodeficiency Syndrome (AIDS), Ebola and most recently Severe Acute Respiratory Syndrome (SARS). Indeed, the transmission of the coronavirus responsible for SARS through 'faecal droplets' has re-focused attention on this recognized route of transmission of some viruses.

I discovered, in a tiny drop of water, incredibly many very little animalcules, and these of diverse sorts and sizes. They moved with bendings, as an eel always swims with its head in front, and never tail first, yet these animalcules swam as well backwards as forwards, though their motion was very slow.
Antony van Leeuwenhoek (1632–1723)

Respiratory Transmission of Faecally Excreted Viruses*

The transmission of the coronavirus responsible for Severe Acute Respiratory Syndrome (SARS) through 'faecal droplets' has re-focused attention on this recognized route of transmission of some viruses. This document reviews what is known about viruses transmitted by this route and the adequacy of control measures, including building design and management, and plumbing practices.

* This publication is expected in 2004

Water-related infectious diseases, such as cholera, have also influenced social and political development. Since 1817 at least seven cholera pandemics have been recorded and most have provided specific examples of issues of pathogen emergence, or have significantly influenced public health reforms and the development of microbiology.

Investigating the history of many diseases demonstrates clearly that the evolution of both humans and pathogens is interlinked: human migration has disseminated infectious disease or brought people into contact with new pathogens; global environmental change has expanded the range of known pathogens or created the conditions for indigenous micro-organisms to emerge as significant human pathogens; modern techniques in animal husbandry, as well as some of the more traditional methods of livestock farming, create a risk from new zoonotic diseases (an infectious disease which normally circulates in an animal host but that can be contracted by humans).

Selected cholera pandemics since 1817 and principal outcomes

Dates	Principal outcomes
1817–1823	Possible emergence of a more virulent strain of *Vibrio cholerae (V. cholerae)*. Global trade with the Indian sub-continent carried the cholera vibrio around the world.
1829–1851	Waterborne transmission of *V. cholerae* established.
1852–1859	First isolation of cholera bacterium. Fear of cholera stimulated international co-operation in health.
1881–1896	Conclusive demonstration that cholera was caused by a bacterium.
1961–	Emergence of *V. cholerae* O1, biotype El Tor.
1992–	Emergence of *V. cholerae* O139.

EMERGING WATERBORNE PATHOGENS

WHAT ARE EMERGING PATHOGENS?

Long before the advent of modern medical care, industrialized countries decreased their levels of water-related disease through good water management. Yet, even in these countries, outbreaks of waterborne disease continue to occur, sometimes with lethal consequences. In developing countries, water-related disease blights the lives of the poor.

Gro Harlem Brundtland, WHO Director-General, (2001)

Emerging pathogens are those that have appeared in a human population for the first time, or have occurred previously but are increasing in incidence or expanding into areas where they have not previously been reported, usually over the last 20 years (WHO, 1997). Re-emerging pathogens are those whose incidence is increasing as a result of long-term changes in their underlying epidemiology (Woolhouse, 2002). By these criteria, 175 species of infectious agent from 96 different genera are classified as emerging pathogens. Of this group, 75% are zoonotic species.

In 2001, a review of the scientific literature identified 1415 species of infectious organisms known to be pathogenic to humans, including 217 viruses and prions, 538 bacteria and rickettsiae, 307 fungi, 66 protozoa and 287 helminths. Of these, 61% were zoonotic and 12% were associated with diseases considered to be emerging (Taylor, Latham & Woolhouse, 2001).

Improved methods of surveillance, epidemiological studies and the continuous development of more advanced methods of diagnosis have allowed us to detect new pathogenic species of micro-organism or to associate a known micro-organism with a new or atypical set of disease symptoms. Furthermore, the agents of several diseases that were thought to have been controlled are re-emerging as a result of adaptive changes in the pathogen, changes to the immunological status of the

host, or environmental, demographic and socio-economic changes. Each of these pathogens represents a public health problem.

Developments in our understanding of the relationships between water and human health have been characterized by the periodic recognition of previously unknown pathogens or of the water-related significance of recognized pathogens. Several studies have confirmed that water-related diseases not only remain a leading cause of morbidity and mortality worldwide, but that the spectrum of disease is expanding and the incidence of many water-related microbial diseases is increasing. Since 1970, several species of micro-organism from human and animal faeces and from environmental sources, including water, have been confirmed as pathogens. Examples include *Cryptosporidium, Legionella, Escherichia coli* O157 (*E. coli* O157), rotavirus, hepatitis E virus and norovirus (formerly Norwalk virus). Furthermore, the importance of water in the transmission of recognized pathogens is being continually assessed as new tools become available through advances in science, technology and epidemiology. *Helicobacter pylori (H. pylori)* is an example of a recently emerged pathogen that may be transmitted through water.

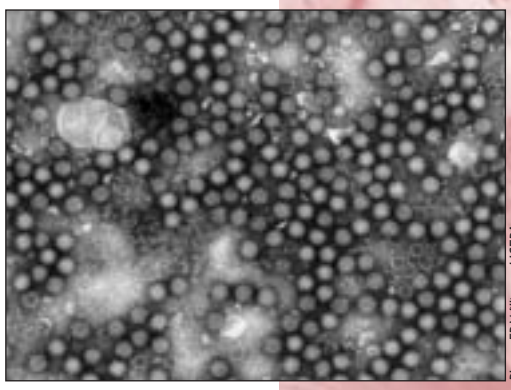


Photo: FP Williams, USEPA

Rotavirus

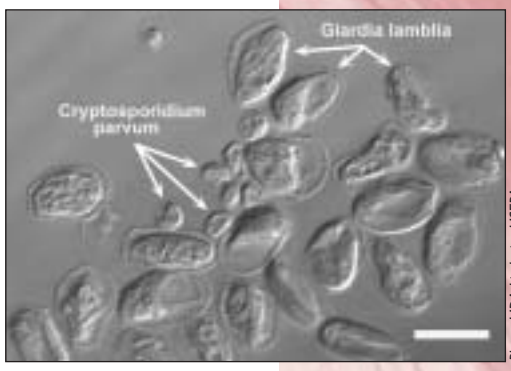


Photo: HDA Lindquist, USEPA

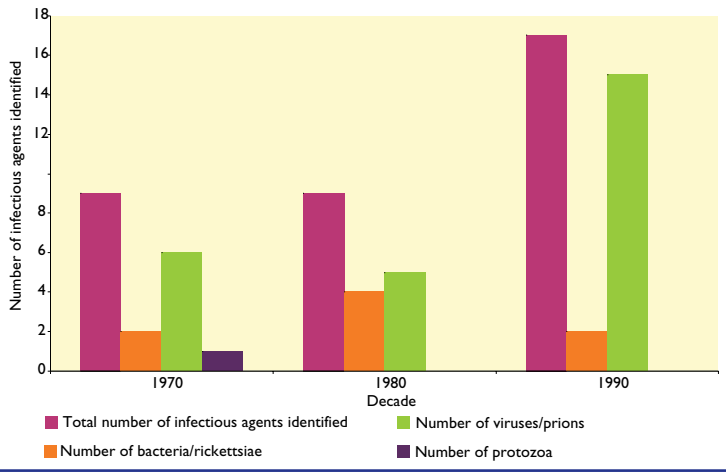
Cryptosporidium and *Giardia*

There is a strong link between *H. pylori* infection and gastric cancer in many countries, but there are large intercountry variations in incidence of gastric cancer and *H. pylori* seroprevalence seen among many Asian countries. For example, the prevalence of *H. pylori* infection is high in India and Bangladesh, but low gastric cancer rates have been reported. Factors that may influence the etiology of gastric cancer include the genetic diversity of the infecting *H. pylori* strains and differences in the host genetic background in various ethnic groups. These factors, in addition to environmental factors, such as personal hygiene and dietary habits, reflect the multifactorial etiology of gastric cancer (Miwa, Sakaki & Sugiyama, 2002). A number of studies have demonstrated that *H. pylori* survives in water although isolation of *H. pylori* from water systems has been shown to be difficult.

Similarly, water-related vector-borne pathogens have been (re-) emerging over the past 20 years. To a large extent this has been caused by the emergence and spread of drug-resistant parasites (for example, the *Plasmodium* species causing malaria)

Rate of discovery of emerging pathogens 1970–2000

(Adapted from Desselberg, 2000)

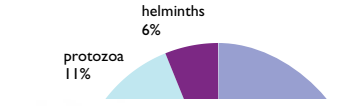


Major etiological agents of infectious diseases identified since 1972

Year	Agent	Disease
1972	Small round structured viruses	Diarrhoea
1973	Rotaviruses	Infantile diarrhoea
1975	Astroviruses	Diarrhoea
1975	Parvovirus B19	Aplastic crisis in chronic haemolytic anaemia
1976	*Cryptosporidium parvum*	Acute enterocolitis
1977	Ebola virus	Ebola haemorrhagic fever
1977	*Legionella pneumophila*	Legionnaires' disease
1977	Hantaan virus	Haemorrhagic fever with renal syndrome
1977	*Campylobacter spp.*	Diarrhoea
1980	Human T-cell lymphotropic virus-1	(HTLV-1) Adult T-cell leukaemia/ HTLV-1 associated myelopathy
1982	HTLV-2	Hairy T-cell leukaemia
1982	*Borrelia burgdorferi*	Lyme disease
1983	HIV-1, HIV-2	Acquired immunodeficiency syndrome
1983	*Escherichia coli* O157:H7	Haemorrhagic colitis; haemolytic uremic syndrome
1983	*Helicobacter pylori*	Gastritis, gastric ulcers, increased risk of gastric cancer
1988	Human herpesvirus-6	Exanthema subitum
1989	*Ehrlichia spp.*	Human ehrlichiosis
1989	Hepatitis C virus	Parenterally transmitted non-A, non-B hepatitis
1990	Human herpesvirus-7	Exanthema subitum
1990	Hepatitis E virus	Enterically transmitted non-A, non-B hepatitis
1991	Hepatitis F virus	Severe non-A, non-B hepatitis
1992	*Vibrio cholerae* O139:H7	New strain associated with epidemic cholera
1992	*Bartonella henselae*	CAT-scratch disease, bacillary angiomatosis
1993	Sin nombre virus	Hantavirus pulmonary syndrome
1993	Hepatitis G virus	Non A-C hepatitis
1994	Sabia virus	Brazilian haemorrhagic fever
1994	Human herpesvirus-8	Kaposi's sarcoma
1995	Hendravirus	Castleman's disease
1996	Prion (BSE)	Meningitis, encephalitis
1997	Influenza A virus	New variant Creutzfeldt-Jakob disease
1997	Transfusion-transmitted virus	
1997	Enterovirus 71	Epidemic encephalitis
1998	Nipah virus	Meningitis, encephalitis
1999	Influenza A virus	Influenza (Hong Kong)
1999	West Nile-like virus	Encephalitis (New York)

(Desselberg, 2000)

Distribution of emerging pathogens by group



An outbreak of arboviral encephalitis was first recognized in New York City in 1999. The cause of the outbreak was confirmed as a West Nile-like virus. Before and concurrent with this outbreak, local health officials observed increased fatalities among New York City birds, especially crows. Tissue specimens from these birds with pathologic evidence of encephalitis were reported as positive for West Nile-like