Emerging infectious diseases

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Abstract

Over the last two decades, there has been the emergence of previously unknown infectious diseases and the re-emergence of diseases thought to be in decline. This is the result of social, economic, political and ecological factors, and the interactions of organisms, hosts and the environment. In recent years, Australia has experienced a number of significant outbreaks of emerging diseases such as bat paramyxovirus and *Escherichia coli* O111, and there has been a resurgence of vaccine-preventable diseases. Australia is implementing a National Communicable Diseases Surveillance Strategy in response to this public health threat. The Strategy, similar initiatives in other countries, and enhanced international cooperation will contribute to the global response to emerging diseases. *Comm Dis Intell* 1997;21:89-93.

Introduction

Scientific discoveries in the 19th century resulted in an understanding of the natural history of infectious diseases and the development of control measures such as water treatment, vector control and rodent reduction. These measures, combined with the introduction of mass immunisation programs and the discovery of antibiotics meant that by the middle of the 20th century, it appeared that the battle to control infectious diseases was nearly won[1]. The eradication of smallpox in 1979 exemplified the triumph of science and concerted global action over infectious diseases.

However, in the last couple of decades diseases such as malaria, tuberculosis and vaccine-preventable diseases have increased dramatically in incidence in a number of parts of the world[2,3]. Previously unknown infectious diseases such as Ebola haemorrhagic fever, human immunodeficiency virus (HIV) and hepatitis C have emerged (Table 1)[1,4]. Antimicrobial resistance has become a global problem[5]. Infectious diseases remain a leading cause of death worldwide and their management constitutes a major global challenge for public health. The World Health Organization has recognised the urgency of the situation and the need for global action. *Emerging Infectious Diseases - Global Alert, Global Response* has been chosen as the theme for World Health Day 1997 in the hope this will be a catalyst for countries to review their disease surveillance and control strategies.

The concept of emergence

Emerging infectious diseases can be defined as infections that have newly appeared in the population, or have existed but are rapidly increasing in incidence or geographic range[6]. This may be due to the introduction of a new agent or to a change in the environment that has provided an epidemiological bridge[7]. The recognition of an existing agent that has gone undetected is also included in this category.

Dr Stephen Morse states that emergence can be viewed as a two-step process: (1) the introduction of the agent into a new host population;

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Contents

(2) followed by establishment and further dissemination within the new host population. Most emerging infections originate in one location and then disseminate[6].

Re-emergence is the term used to describe the reappearance of a known disease after a decline in incidence. It is often the result of deficiencies in public health measures due to complacency, changes in human behaviour that increase person-to-person transmission of an infectious agent, or changes in the way humans interact with their environment[4].

Factors associated with emergence

A 1992 Institute of Medicine report classified emerging infections according to factors associated with their emergence (Table 2). An understanding of the matrix of social, economical, political and ecological factors and the complex interactions between microbes, hosts and the environment is important for the development of successful control strategies[8, 9, 10].

The changing distribution of populations from rural areas to urban communities and the growth in populations has been accompanied by overcrowding, poor hygiene, inadequate sanitation and insufficient water supplies in many parts of the world. These conditions have meant increased opportunities for person-to-person transmission of disease and the proliferation of vectors such as *Aedes aegypti* and rodents.

In many countries the proportion of the population who are immunosuppressed has increased, leading to an increase in opportunistic infections. The incidence of HIV, increasing use of immunosuppressive agents and an aging population have all contributed to this phenomenon.

Human behaviour has an important role in the emergence and re-emergence of disease. Sexual practices and intravenous drug use have facilitated the spread of HIV and hepatitis C. Complacency about vaccine- preventable diseases has led to decreasing immunisation rates in some countries and subsequently to major outbreaks of these diseases. The increased utilisation of child-care centres has been associated with outbreaks of childhood illnesses such as gastroenteritis and respiratory infections.

Throughout the centuries the movements of armies, exploration and colonisation have been associated with the introduction of disease and disease vectors. Today the high volume and speed of international travel increase this potential for introduction of disease. In recent years the vector *Aedes albopictus* has been imported from Asia to parts of Africa, the United States of America and Brazil. Importation of cholera via ship bilge water has been postulated as the cause of the first epidemic of cholera in South America this century[7]. The recent spectre of the introduction of a viral haemorrhagic fever or pneumonic plague via international air travel has resulted in the development of contingency plans in many countries. Each year Australia has over 600 cases of imported malaria and these must be followed up closely in malaria receptive areas to prevent local transmission. The first recognised case of airport malaria in Australia has recently been reported[11].

Ecological change may result in people coming into contact with a natural reservoir or host for an infection that is hitherto unfamiliar but usually already present. The Institute of Medicine report states that the significance of zoonoses in emergent diseases cannot be overstated. Argentine haemorrhagic fever emerged as a result of an agricultural practice; Marburg, Hantaan, and Rift Valley fever viruses are of zoonotic origin. Yellow fever, of which the natural cycle of infection takes place in a jungle habitat and involves monkeys and mosquitoes, is probably an ancient zoonosis[7].

Technological advances have both facilitated the spread of infectious diseases and provided tools to fight

Table 1. Examples of pathogenic microbes and infectious diseases recognised since 1973[1]

Year	Organism	Type	Disease
1973	Rotavirus	Virus	Major outbreaks of infantile diarrhoea
1974	Barmah Forest virus	Virus	Outbreaks of polyarthritis
1976	*Cryptosporidium parvum*	Parasite	Acute and chronic diarrhoea
1977	Ebola virus	Virus	Ebola haemorrhagic fever
1977	Hantaan virus	Virus	Haemorrhagic fever with renal syndrome
1977	*Campylobacter jejuni*	Bacteria	Enteric pathogen
1982	Escherichia coli O157:H7	Bacteria	Haemorrhagic colitis; haemolytic uraemic syndrome
1982	Borrelia burgdorferi	Bacteria	Lyme disease
1983	Human immunodeficiency virus	Virus	Acquired immunodeficiency syndrome
1983	*Helicobacter pylori*	Bacteria	Peptic ulcer disease
1988	Hepatitis E	Virus	Enterically transmitted hepatitis
1989	Hepatitis C	Virus	Parenterally transmitted hepatitis
1992	Vibrio cholerae O139	Bacteria	New strain associated with epidemic cholera
1994	Bat paramyxovirus	Virus	Respiratory and neurological disease
1996	Australian bat lyssavirus	Virus	Neurological disease

1. Adapted from references 1, 4, 17 and 21.

Table 2. Factors contributing to emergence of infectious diseases[1]

Factor	Specific example	Example of disease
Population demographics	Rural/urban distribution; proportion immunosuppressed	Spread of dengue; increased reports of opportunistic infections
Human behaviour	Sexual practices; intravenous drug use; complacency regarding immunisation; use of child-care	Spread of HIV, hepatitis C; increased incidence of vaccine-preventable diseases; outbreaks of enteric illness
International travel and commerce	Worldwide movement of goods and people; air travel	Dissemination of mosquito vectors; dissemination of O139 cholera
Ecological change	Agriculture; dams; changes in water ecosystems; deforestation/reforestation; flood/drought; famine; climate change	Rift Valley fever (dams); Argentine haemorrhagic fever (agriculture); hantavirus pulmonary syndrome, United States of America (weather)
Technology and industry	Globalisation of food supply; changes in food processing; widespread use of antibiotics;	Outbreak of *E. coli* O111, South Australia; antibiotic resistance
Microbial adaption and change	Microbial evolution	Antibiotic resistance; pesticide resistance; antigenic drift in the influenza virus
Breakdown in public health measures	Reduction in prevention programs; inadequate sanitation and vector control measures	Resurgence of tuberculosis in the United States of America; diphtheria in the former Soviet Union

1. Adapted from references 6 and 7.

them. Food production and processing changes have contributed to the increase in food-borne diseases seen in many developed countries. Centralisation of food production, together with modern transportation, has meant that any contamination of manufactured foods can potentially infect many people over a wide area, even internationally[12]. The blood-borne diseases, HIV and hepatitis C, were spread via blood products prior to the development of tests and the introduction of effective screening algorithms. However, technological advances have also led to the development of new diagnostic tests, antimicrobial agents and vaccines. An excellent example is the dramatic decrease in the incidence of *Haemophilus influenzae* type b infection since the introduction of vaccines in Australia in 1992 and 1993 [13].

Microbial pathogens have the ability to evolve and adapt very quickly. Their evolutionary mechanisms allow them to adapt to new host cells or host species, produce new toxins, bypass or suppress inflammatory and immune responses and develop resistance to drugs and antibodies[7]. Antimicrobial resistance has increased worldwide (Table 3). It is associated with both the use of antimicrobials in humans and the use of these agents in veterinary medicine, animal husbandry, agriculture and aquaculture[5]. Vector resistance to pesticides is also increasing[7]. Judicious use of antimicrobial agents and the development of new agents will be necessary for the implementation of successful control strategies.

The Australian perspective

In the last few years Australia has experienced a number of significant outbreaks of emerging infectious diseases, and there has been a resurgence of vaccine-preventable diseases, with widespread outbreaks of measles, pertussis and rubella[13]. There is still a lot to be learnt about some of these events but they illustrate the need for a cooperative national and international approach to infectious disease control.

The first reported outbreak of Japanese encephalitis (JE) in Australia occurred in the Torres Strait in 1995[14]. This was 3,000 kilometres from the nearest known focus of JE in Bali, Indonesia. There were three human cases associated with the outbreak, and two deaths. The local

Table 3. Global emergence of antimicrobial-resistant organisms[1]

Organism	Antimicrobial	Country[2]	Year
Streptococcus pneumoniae	Penicillin	Australia	1967
Neisseria gonorrhoeae	Penicillin	Phillippines	1976
Streptococcus pneumoniae	Multiresistant	South Africa	1977
Klebsiella pneumoniae	Cefotaxime	Germany	1983
Enterococcus faecium	Vancomycin	France	1988
Neisseria meningitidis	Penicillin	Spain	1988
Salmonella Typhi	Multiresistant	India	1990
Mycobacterium tuberculosis	Multiresistant	USA	1990
Shigella dysenteriae	Mulitresistant	Burundi	1992
Vibrio cholerae	Multiresistant	Ecuador	1993

1. Adapted from reference 5.
2. Location does not necessarily represent the first identified resistant isolate of a particular species.

community were vaccinated prior to the 1996 wet season when seroconversions in sentinel pigs on one of the islands confirmed a reappearance of the virus[15]. The potential for the virus to spread to mainland Australia is of considerable public health concern. Details about the route and origin of the JE virus emergence are not understood, although local environmental factors appeared to facilitate the outbreak[16]. However, a surveillance and control strategy needs to be developed in the event of further incursions.

Of considerable interest to both the scientific community and the general public has been the discovery of two novel viruses in fruit bats and humans, bat paramyxovirus and Australian bat lyssavirus[17,18,19,20]. There is still much to be learnt about these viruses, the factors that precipitated their emergence, potential hosts, geographic range, transmissibility and their incidence in fruit and insectivorous bats. A prevention strategy for human lyssavirus infection has been implemented and will be updated as more information becomes available[21].

The first reported outbreak of *E. coli* O111 occurred in South Australia in 1995. Eighteen children required dialysis and one child died. Food manufacturing processes were implicated in the outbreak[22]. In 1996 there was a multi-State outbreak of *Salmonella* Mbandaka associated with a specific brand of peanut butter[23]. The product was distributed to most States and Territories and the investigation required close cooperation between Federal and State and Territory agencies and the private sector.

The links between the recent outbreaks of Ross River fever and Barmah Forest virus infection and factors such as ecological change and population demographics would be interesting to explore. These diseases have affected significant numbers of people and further research is needed to determine their long term morbidity.

Components of an effective response to emerging infectious diseases

An effective response to the challenge of emerging infectious diseases must be based on an improved understanding of the complex relationships between microbes and the multiplicity of factors that influence emergence[9]. This must be conducted within a supportive and responsive public health infrastructure. Coordination and cooperation across sectors and international boundaries is essential.

The fundamental components of a response include:

- disease surveillance systems capable of early detection of emerging infectious diseases;
- a capacity to investigate outbreaks in the field and manage problems as they occur;
- a laboratory system capable of providing diagnostic and reference tests to assist in the detection and management of infectious diseases;
- applied research capacity to assist in the identification of new pathogens, the development of diagnostic tools and potential treatments;
- fostering of links between human health and animal health practitioners to ensure effective management of zoonoses;
- research into factors associated with emergence including behavioural factors;
- training programs for epidemiologists, researchers, laboratory workers and clinicians;
- effective communication strategies.

Australia has developed a National Communicable Diseases Surveillance Strategy to provide a national framework to monitor infectious diseases and plan and prioritise interventions. The Strategy was developed under the auspices of the Chief Health Officers of Australia and is currently being implemented. As part of this process, public health officials and infectious disease experts from around Australia recently attended an outbreak response workshop at the Australian Institute of Emergency Management.

In recent years, the United States of America, Canada, the Pan American Health Organization and the European Union have also reviewed their communicable disease surveillance and response capacity and are implementing changes.

Conclusions

The experiences of the last decades have shown that public health complacency about infectious diseases was misplaced. The National Communicable Diseases Surveillance Stretegy, similar initiatives in other countries, and the enhanced international cooperation fostered by events such as World Health Day, should assist us in facing the challenges of the future.

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World Health Day 1997

Emerging Infectious Diseases - Global Alert, Global Response
7 April 1997

The World Health Organization (WHO) has chosen the theme *Emerging Infectious Diseases - Global Alert, Global Response* for World Health Day 1997. This is in recognition of the global public health impact of these diseases.

WHO has recently established the Division of Emerging and Other Communicable Diseases Surveillance and Control in Geneva to assist the global effort to control emerging diseases. In addition WHO is strengthening global monitoring systems which serve as part of the overall detection system for such diseases. If diseases are detected early enough, potential epidemics and pandemics can be prevented or minimised. The global systems include WHO collaborating centres, antimicrobial resistance monitoring and the International Health Regulations.

WHO is also working in countries to strengthen national disease detection and response through improved surveillance and training in epidemic preparedness. WHO also works to ensure a coordinated global response to infectious diseases of international importance.

It is hoped that the 1997 World Health Day will encourage countries to look at the problems of emerging infectious diseases and concentrate on enhancing or rebuilding the foundations of infectious disease surveillance and control.

Information on WHO is available on the World Wide Web at www.who.ch.

Notice to readers

The 2nd National Tuberculosis Conference

On 17 and 18 November 1997 the Public Health Association of Australia Inc. will be hosting The 2nd National Tuberculosis Conference in Sydney, New South Wales.

The conference will focus on Australia's regional role in tuberculosis control. It will also provide an opportunity for workers in the field to consider and discuss the latest developments in epidemiology, diagnostic techniques, vaccine development, infection control and multi-drug resistant tuberculosis.

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