NATIONAL MICROBIAL MONITORING PROGRAMME

2004

Emerging and Re-emerging Pathogens

Prof. J. Lin
University of KwaZulu-Natal
E - Mail: linj@ukzn.ac.za
Infectious Diseases

- Pathogenic (disease-causing) microorganisms have repeatedly altered the course of human history.
  - 1918-1920: influenza pandemic caused 70 millions deaths worldwide.
  - Since 1817 at least 7 cholera pandemics.
  - Recently, HIV, SARS etc.

- In 2001, infectious diseases accounted for an estimated 26% of deaths worldwide (Kindhauser, 2003).
<table>
<thead>
<tr>
<th>Microbe</th>
<th>Disease</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotavirus</td>
<td>Infantile gastroenteritis</td>
<td>1973</td>
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<tr>
<td><em>Legionella pneumophila</em></td>
<td>Legionnaires disease</td>
<td>1977</td>
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<tr>
<td>Ebola virus</td>
<td>Ebola hemorrhagic fever</td>
<td>1977</td>
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<tr>
<td><em>Borrelia burgdorferi</em></td>
<td>Lyme disease</td>
<td>1982</td>
</tr>
<tr>
<td>HIV</td>
<td>AIDS</td>
<td>1983</td>
</tr>
<tr>
<td>Hepatitis C virus</td>
<td>Hepatitis</td>
<td>1989</td>
</tr>
<tr>
<td><em>Vibrio cholerae</em> O139</td>
<td>Cholera</td>
<td>1992</td>
</tr>
<tr>
<td>Sin Nombre virus</td>
<td>Hantavirus pulmonary syndrome</td>
<td>1993</td>
</tr>
<tr>
<td>Human herpesvirus 8</td>
<td>Kaposi sarcoma in AIDS patients</td>
<td>1995</td>
</tr>
<tr>
<td>Influenza virus A H5N1</td>
<td>Influenza</td>
<td>1997</td>
</tr>
<tr>
<td>SARS coronavirus</td>
<td>Severe acute respiratory syndrome</td>
<td>2002</td>
</tr>
</tbody>
</table>

\(^{A}\)First human cases; virus previously known to infect birds.
Locations of recent outbreaks of emerging infectious diseases (WHO 2002)
Pathogenic organisms

By 2001, a total of 1415 species of infectious organisms known to be pathogenic to humans had been recorded.

- 217 viruses and prions
  - s and prions
  - ia/rickettsiae
- 66 protozoa
- 287 helminths

- 61% were zoonotic and 12% were considered to be emerging (Taylor, Latham and Woolhouse, 2001).
What are emerging pathogens?

- 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)
What are emerging pathogens?

- Re-emerging pathogens are those whose incidence is increasing as a result of long term changes in their underlying epidemiology (Woolhouse, 2002)
<table>
<thead>
<tr>
<th>Categories of Emerging and Re-emerging Infectious Diseases:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emerging</strong></td>
</tr>
<tr>
<td>Newly identified pathogens and syndromes: HIV/AIDS, Hepatitis C, V. cholerae O139, Lyme disease, Leihionnaires’diseases, SARS</td>
</tr>
<tr>
<td>Evolution in existing organisms or new techniques identified existing organisms or transmission to human from other hosts.</td>
</tr>
<tr>
<td><strong>Re-emerging</strong></td>
</tr>
<tr>
<td>Re-emergence of old diseases: Cholera, dengue, yellow fever, Ebola virus, West Nile virus</td>
</tr>
<tr>
<td>Spread of old disease to new area or population ecological changes, environmental resources that harbor pathogens and breakdown of public health measures.</td>
</tr>
<tr>
<td>Emergence of organisms resistant to antimicrobial agents: TB, malaria, shigellos, Salmonella infections,</td>
</tr>
<tr>
<td>Overuse of inappropriate use of antimicrobial agents, poor sanitation, immunocompromised or malnourished population.</td>
</tr>
</tbody>
</table>
Rate of discovery of emerging pathogens 1970-2000

- Total number of infectious agents identified
- Number of bacteria / rickettsiae
- Number of viruses / prions
- Number of protozoa
Drinking-water disease outbreaks of unknown etiology in the USA 1990-2000
The distribution of emerging pathogens according to the main groups of microorganisms

- Viruses/Prions 44%
- Bacteria/Rickettsia 30%
- Protozoa 11%
- Fungi 9%
- Helminths 6%

(Taylor Latham & Woolhouse 2001)
Why do pathogens emerge?

Most have a common theme and can be grouped under a few general headings:

- New Environments;
- New technologies;
- Scientific advances,
- Changes in human population, behaviour and vulnerability.
New Environments

- Climate shifts/deforestation
- Water-cooled air conditioning plants
- Water resources development (dams and irrigation)
Cases: New Environments

- **Climate shifts/ deforestation**
  
  - Expanding the range of mosquito species responsible for the transmission of the malarial parasite and the dengue virus.
  
  - Malaria is now occurring high in the mountains of central Africa and in the highlands of Papua New Guinea.

- **Water-cooled air conditioning plants.**
  
  - In 1976, an outbreak of pneumonia (Legionnaires disease) at an American Legion Convention → *Legionella pneumophila*. 
Cases: New Environments

- **Water resources development project (dams and irrigation):**
  - The Aswan High Dam in Egypt
    - Increasing prevalence of schistosomiasis
    - The redistribution of the two species of snail, Bulinus truncatus and Biomphalaria alexandrina (the intermediate host)
  - The Itaparica Dam reservoir in Brazil, 1988
    - 2000 gastro-enteritis cases
    - Toxin produced by Cyanobacteria as the responsible agent.
A natural environmental bacterium can exploit a niche within man-made water systems and emerge as a significant pathogen.
New technologies

- Changing industrial and agricultural practices (livestock rearing)
- Waterborne sewage and sewage treatment alternatives
- Piped water systems and their inadequate design and operation
Changing industrial and agricultural practices (livestock rearing)

- Zoonotic pathogens are almost twice as likely to be regarded as emerging or re-emerging than non-zoonotic pathogens
  - implications for intensive livestock farming: *Cryptosporidium*, *E. coli O157* and *Campylobacter*.

- Waterborne sewage and sewage treatment alternatives
Cases: New Technologies

- Piped water systems and their inadequate design and operation
  - Outbreaks through leaks of the system, and during maintenance work.
  - Biofilms e.g. *Mycobacterium avium complex*
New water treatment, storage and distribution technologies are being developed to improve and maintain the quality of drinking water. But unforeseen problems with a few technologies may introduce new risks that may lead to the re-emergence of water-related pathogens.
Scientific advances in water microbiology

- Improved methods of detection and analysis
- Inappropriate, excessive use of antibiotics, anti-parasitic drugs and insecticides
Scientific advances in water microbiology

- Improved methods of detection and analysis
  - Improved selective media for pathogens
  - New techniques to visualization of organisms, e.g. EM, Fluorescence microscopy, antibody techniques
  - Cell culture → mammalian viruses
  - Genetic analysis especially PCR

In 1972 and 1973, the caliciviruses and rotaviruses were identified as the causative agents of diarrhoea. Subsequent work has shown these two groups to be a significant cause of mortality amongst children.
Cases: Scientific advances

- **Emerging resistance to antimicrobial drugs**
  - The changing dynamics of growing population and the overuse of antibiotics.
  - *S. aureus* (30-40% MRSA)
  - *Mycobacterium tuberculosis* (15% MDR)
  - *Enterobacteriaceae* isolates (95% is resistant at least one antibiotic tested)
Changes in human population, behaviour and vulnerability

- Human circulation and accessibility and rapidity of transport worldwide
- Demographic changes
- Increase in size of high risks populations
- An increasing number of humanitarian emergencies
Cases: Changes in human population and vulnerability

- Increase in size of high risks populations
  - In combination, the aging of the world’s population, the use of immunosuppressive procedures and the global spread of HIV/AIDS have created a large and growing population with impaired immune systems.

  → Cryptosporidium and MAC
Cases: Changes in human population and vulnerability

- **Human Migration**
  - Desertification, deforestation, urbanization
  - Most notable are diseases that have emerged as humans have encroached upon forest regions, bringing people into closer contact with animal species carrying pathogens that can be transmitted across the species barrier, e.g. HIV, SARS, Influenza A virus.

- **Tourism**
Conclusions

- Human development and population growth exert many and diverse pressures on the quality and quantity of resources eg water and on access to them.

- Understanding why pathogens emerge or re-emerge is fundamental to effective water resource management, drinking water treatment and delivery. It is important to be able to gauge the risks from any emerging disease.
Conclusions (cont’d)

- Investigating important emerging issues in water and infectious disease and communicating discoveries create unique challenges.

- Developing effective monitoring programmes (e.g. NMMP & DoH Microbial Monitoring Initiatives) both nationally and internationally to reduce the health risks is imperative.