LIVING WITH THE EARTH

CHAPTER 7

EMERGING DISEASES
Esherichia coli on EMB Plate
Objectives

• Differentiate emerging infectious diseases in the U.S. & those occurring worldwide

• List 6 major factors associated with the emergence of infectious diseases

• Explain the likely reasons for the emergence of specific infectious diseases
Objectives Cont.

• Recognize & explain the practical approaches to limiting the emergence of infectious diseases
• Explain the etiological agents, epidemiology, & disease characteristics of the major emerging infectious diseases
EMERGING DISEASES

• Infectious diseases continue to be the foremost cause of death worldwide.

• The Centers for Disease Control & Prevention (CDC) reported a 58 percent rise in deaths from infectious diseases since 1980.
Emerging Diseases in the United States

- Cryptosporidium
- AIDS
- Group A STREP
  "Flesh-Eating Bacteria"
- Tuberculosis
- Lyme Disease
- Erlichiosis
- Hanta Virus
- E. coli 0157:H7
Emerging Diseases Worldwide

- CJD
- "Mad Cow Disease"
- PLAGUE
- AIDS
- MALARIA
- DENGUE
- CHAGAS
- EBOLA
- TUBERCULOSIS
What is an Emerging Infectious Disease?

– A disease of infectious origin whose incidence in humans has either increased within the past two decades or threatens to increase in the near future
REASONS FOR THE EMERGENCE OF INFECTIOUS DISEASE

- There are a number of specific explanations responsible for disease emergence that can be identified in most all cases (Table 7-1a-d).
Table 7-1a

Adapted from Morse.\textsuperscript{24}

<table>
<thead>
<tr>
<th>VIRAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viral Diseases that have been identified since 1973</strong></td>
</tr>
</tbody>
</table>
| **1977 Ebola, Marburg**  
Origin undetermined. (importation of monkeys associated with outbreaks in these primates in Europe and the United States) |
| **1980 HTLV Influenza (pandemic)**  
Pig-duck agriculture thought to contribute to reassortment of avian and mammalian influenza viruses |
| **1983 HIV**  
Transmission by intimate contact as in sexual transmission, contaminated hypodermic needles, transfusions, organ transplants. Contributing conditions that spread the disease include war or civil conflict, urban decay, migration to cities and travel |
| **1989 Hepatitis C**  
Transmission in infected blood such as by transfusions, contaminated hypodermic needles, and sexual transmission |
| **1993 Hantaviruses**  
Increased contact with rodent hosts because of ecological or environmental changes |
### Table 7-1b

Adapted from Morse.\textsuperscript{24}

<table>
<thead>
<tr>
<th>Viral Diseases that have re-emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Argentine, Bolivian hemorrhagic fever</strong></td>
</tr>
<tr>
<td>Agricultural changes that promote growth of rodents</td>
</tr>
<tr>
<td><strong>Bovine spongiform encephalopathy (cattle)</strong></td>
</tr>
<tr>
<td>Alterations in the rendering of meat products</td>
</tr>
<tr>
<td><strong>Dengue, dengue hemorrhagic fever</strong></td>
</tr>
<tr>
<td>Travel, transportation, urbanization and migration</td>
</tr>
<tr>
<td><strong>Lassa fever</strong></td>
</tr>
<tr>
<td>Conditions such as urbanization that favor rodent host, increasing exposure (usually in homes)</td>
</tr>
<tr>
<td><strong>Rift Valley fever</strong></td>
</tr>
<tr>
<td>Irrigation dam building, agriculture: possibly change in virulence</td>
</tr>
<tr>
<td><strong>Yellow fever</strong></td>
</tr>
<tr>
<td>Conditions favoring mosquito vector (in &quot;new&quot; areas)</td>
</tr>
</tbody>
</table>
Table 7-1c

Adapted from Morse.24

<table>
<thead>
<tr>
<th>BACTERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial Diseases that have been identified since 1973</strong></td>
</tr>
</tbody>
</table>
| 1977 Legionella disease  
Cooling and plumbing systems that allow the organism to grow in biofilms that form on water |
| 1982 Hemolytic uremic syndrome *(Escherichia coli - O157:H7)*  
Modern food processing on a large scale permitting contamination through meat storage tanks and unsterile plumbing |
| 1982 Lyme borreliosis *(Borrelia burgdorferi)*  
Close contact between homeowners encroaching on forested areas and the mice and deer (a secondary reservoir host) that maintain the tick vector for Borrelia |
| 1983 Helicobacter pylori  
Newly recognized as agent involved with gastric ulcers, probably widespread before recognition |
| 1987 Toxic shock syndrome *(Staphylococcus aureus)*  
Ultra-absorbency tampons |
| 1992 Cholera (type 0139)  
Likely introduced from Asia to South America by ship, with spread made possible by reduced water chlorination; Strain (type O139) from Asia newly spread by travel (similarly to past introductions of classic cholera) |
Table 7-1d

Adapted from Morse.\textsuperscript{24}

<table>
<thead>
<tr>
<th>Bacterial Diseases that have re-emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tuberculosis</strong></td>
</tr>
<tr>
<td>Breakdown in Public health measures such as reduction in prevention programs, inadequate sanitation, homelessness, AIDS</td>
</tr>
<tr>
<td><strong>Streptococcus, group A (invasive necrotizing)</strong></td>
</tr>
<tr>
<td>Unknown, may be increased use of NAIDS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PARASITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasitic Diseases that have been identified since 1973*</td>
</tr>
<tr>
<td>1976 Cryptosporidium, other waterborne pathogens</td>
</tr>
<tr>
<td>Contaminated surface water, lack of proper filtration methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parasitic Diseases that have re-emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria (in &quot;new&quot; areas)</td>
</tr>
<tr>
<td>Spread of mosquito vectors, worldwide travel or migration, “Airport” malaria</td>
</tr>
<tr>
<td><strong>Schistosomiasis</strong></td>
</tr>
<tr>
<td>Agriculture, dam building, deforestation, flood/drought, famine, climate changes</td>
</tr>
</tbody>
</table>

*Compiled by CDC staff. Dates of discovery are assigned on the basis of the year the isolation or identification of etiologic agents was reported.
Emergence Factors

1. Ecological changes
2. Human demographic changes
3. Travel & commerce
4. Technology & industry (globalization)
5. Microbial adaptation & change (resistance)
6. Breakdown of public health measures
Ecological Changes

• Agriculture
  – Agricultural or economic development
  – People may expand into an area where the animal host thrives, the animal host may expand into human living areas
Ecological Changes

- Climate
  - Extreme weather patterns, as a result of natural fluctuations in the atmosphere or man-made changes (i.e., global warming) have routinely been followed by outbreaks of disease.
  - Examples include:
    - El Niño
    - Vibrio
    - Hanta Virus
Human Demographic Changes

- Increased population density in urban areas - migration in hopes of a better, more comfortable lifestyle - has surpassed basic services, including clean water supplies, sanitary conditions such as sewage disposal & adequate housing
Human Demographic Changes

- Public health measures in overcrowded cities are often strained or unavailable to large groups of the urban impoverished living in inner city slums or in shanty towns on the periphery, thereby increasing the opportunity for emerging infections such as HIV, cholera, & dengue
Travel & Commerce

- Increased economic growth into national & international boundaries has led to increased travel, contributing to the notion of "diseases without boundaries"
Travel & Commerce

• Bubonic Plague
• Smallpox
• Aedes aegypti
• Vibrio cholerae
Technology & Industrialization

• Globalization
  – Denationalization of markets, laws, & politics in the sense of interlacing peoples & individuals for the sake of the common good
Globalization’s Influence

1. Diseases are moving rapidly due to technology & economic interdependence, increasing international travel & the international nature of food processing & handling

2. Funding of public health reduced due to increased competition & pressures to cut expenditures

3. Public health programs becoming international through WHO & health-related nongovernmental organizations
Technology & Industrialization

- Globalization’s successes have contributed to a population crisis, producing overcrowding, inadequate sanitation, & overstretched public health infrastructures.
Microbial Adaptation

• Antibiotic-resistant bacteria are emerging from the environment in response to the wide distribution of antimicrobials
• Selection for antibiotic-resistant bacteria, & drug-resistant parasites have become common, generated by the wide & often unsuitable use of antimicrobial drugs
Antibiotic Resistance

• There is growing concern that bacterial pathogens are developing a resistance to antibiotics as a result of patients not completing the prescribed course of treatment or the inappropriate & over prescribing of common antibiotics by physicians.
Antibiotic Resistance

• The use of unsupervised prophylactic tetracycline administration to 100,000 pilgrims en route to Mecca from Indonesia is thought to have been significantly responsible for the fact that 50% of cholera strains in that country are now tetracycline resistant
Antibiotic Resistance

• Many hospitals consider Vancomycin & Rocephin their “big guns” in the disease war

• A recent report by the CDC found that Vancomycin resistance measured at 0.3% in 1986, rose to 7.9% across several facilities in 1994
Viruses

• Antibiotics have no effect on viruses, & vaccines are often ineffective against bacterial infections
Breakdown of Public Health

- Advances in 18th & 19th centuries in overall population health
  - Vector control
  - Water chlorination
  - Sewage Disposal
  - Milk Pasteurization
  - Immunization

- Smaller reservoirs continue to exist & pose continuing threat if sanitary methods not maintained
SPECIFIC EMERGING DISEASES

• Viruses
  – The viruses with the greatest potential for emergence in the near future include: hantaan (hantavirus), dengue, influenza, & HIV
Hanta Virus

• Background
  – Navajo Flu
  – CDC personnel trapped & tested rodents from the area, they found the deer mouse, *Peromyscus maniculatus* primary reservoir in New Mexico
Hanta Virus

• The Disease
  – The hantaviruses that emerged in the Four Corners region of the United States were determined to be the cause of an acute respiratory disease now termed hantavirus pulmonary syndrome (HPS)
Hanta Virus

• The Disease
  – Initial symptoms of the American version (HPS) were flu-like & manifested as fever, chills, headache, muscular aches & pains
  – With time the lungs fill with fluids causing severe respiratory distress for which there is no specific treatment
Hanta Virus

• Epidemiology
  – The virus is spread to humans from contact with rodents
  – The most common route of transmission to humans is by aerosolized mouse droppings containing the virus particles, although there is evidence that bites may also transmit the disease
Hanta Virus

• Epidemiology
  – Hantaviruses can be carried by at least 16 various rodent species including rats, mice, & voles
  – Activities such as heavy farm work, threshing, sleeping on the ground, & military exercises increase exposure
Dengue Fever

• Background
  – There are in excess of 10s of million cases of dengue fever annually, with several hundred thousand cases of the more severe dengue hemorrhagic fever (DHF)
Dengue Fever

• The Disease
  – There are four antigenically distinct viral serotypes
  – There is no cross-protective immunity with any of the viruses, so that it is possible for a person to acquire multiple dengue infections
Dengue Fever

• The Disease
  – Dengue is primarily an urban tropical disease with severe flu-like symptoms that causes high fevers, frontal headache, severe body aches & pains, nausea & vomiting
Dengue Fever

• The Disease
  – When the fever eases, patients start to develop “leaky capillary syndrome” in which the blood vessels leak & untreated patients will go into shock & die
Dengue Fever

• Epidemiology
  – The greatest emerging health menace from dengue/DHF has been in Central & South America (Fig. 7-1)
  – Complacency in mosquito control programs has allowed *Aedes aegypti* to return with a vengeance & it is a competent vector for dengue viruses (Fig. 7-2)
Fig. 7-1

Adapted from EID Dispatch.93
Fig. 7-2

Adapted from EID Dispatch.93
Influenza

• Background
  – Types A & B are responsible for the epidemics of respiratory influenza (Fig. 7-3)
  – Type C is produces very mild symptoms or none at all
Fig. 7-3

Adapted from WHO.100
Influenza

• The Disease
  – Influenza is normally characterized by a fever (100¼F to 103¼F); respiratory symptoms, that include cough, sore throat, stuffy nose; muscle aches & pain; & extreme fatigue
Influenza

• The Disease
  – There are about 20,000 deaths annually in the United States with the majority of serious illness & death occurring in the aged, very young, & debilitated
Influenza

• Epidemiology
  – To this date, there have been more than 30 pandemics of influenza with three occurring within the last 80 years
  – The Spanish Flu (1918-19) caused an estimated 500,000 deaths in the United States & 20 million deaths worldwide
1918: Spanish Flu A(H1N1)

Ebola

• Background
  – Ebola & Marburg viruses belong to a family of viruses called Filoviridae (Fig. 7-4)
  – Their extreme pathogenicity combined with the lack of effective vaccines or antiviral drugs classify them as biosafety level four agents
Ebola

• The Disease
  – Ebola fever typically starts suddenly 4 to 16 days after infection with malaise, fever & flu-like symptoms which can be followed by rashes, bleeding & kidney & liver failure
Ebola

• The Disease
  – Generalized bleeding occurs with massive internal hemorrhaging of the internal organs, with bleeding into the gastrointestinal tract, from the skin, & even from injection sites as the clotting ability of the blood is diminished.
Ebola

• The Disease
  – The death of the patient usually occurs from shock within 7 to 16 days & is accompanied by extreme blood loss
Ebola

• Epidemiology
  – Infections from Ebola virus were first reported in 1976 when two outbreaks occurred at the same time but in different locations & with different subtypes of the Ebola virus
    – Sudan
    – Zaire
Ebola

– The total number of cases in these two outbreaks was 550 with 340 deaths.
– The case fatality rate from the Zaire subtype Ebola virus was 90 percent & case fatality rate for the Sudan subtype was 50 percent.
AIDS/HIV

• Background
  – The AIDS virus (Fig.7-5) belongs to a special group of viruses known as retroviruses & is referred to as human immunodeficiency virus (HIV)
• **Background**
  
  - The AIDS virus almost exclusively focuses on these white blood cells since these helper T cells have CD4 molecules on the surface to which the AIDS virus binds.
  
  - The viral genetic information is then able to enter the cell & is transferred to the nucleus.
AIDS/HIV

• The Disease
  – HIV is transmitted most commonly by sexual contact with an infected partner & can enter the body through the vaginal lining, vulva, penis, rectum or mouth
AIDS/HIV

• The Disease
  – Since the virus appears in the blood & many body fluids, it can be transmitted by infected blood as through contaminated needles
  – HIV has been transmitted to fetuses during pregnancy & birth
AIDS/HIV

• The Disease
  – Many people remain asymptomatic for months or years after acquiring the infection
AIDS/HIV

• The Disease
  – Symptoms may emerge that include prolonged enlargement of lymph nodes, energy & weight loss, recurrent sweating & fevers, skin rashes, or flaky skin, yeast infections, & pelvic inflammatory disease
AIDS/HIV

• The Disease
  – The disease will often advance to a stage referred to as AIDS or acquired immunodeficiency syndrome
  – Opportunistic infections produce a myriad of debilitating symptoms from respiratory distress, severe headaches, extreme fatigue, nausea, vomiting, to wasting & coma
AIDS/HIV

• Epidemiology
  – A joint surveillance effort by UNAIDS & WHO now estimates that over 30 million people are living with HIV infection at the end of 1997
  – This figure also includes over 1 million children under the age of fifteen
AIDS/HIV

• Epidemiology
  – More than two-thirds of the total number of people in the world living with HIV are from sub-Saharan Africa (Fig. 7-6).
Fig. 7-6

Adapted from UNAIDS & WHO.108
Bacteria

• *Escherichia coli*
  – Background
    • Gram negative, facultatively anaerobic, short straight rods that inhabit the intestines of humans & other animals & belong to family Enterobacteriaceae
Escherichia coli

• Background
  – Members of the enterics cause gastroenteritis, mostly, but have also been implicated in urinary tract infections, wound infections, pneumonia, septicemia, & meningitis
Escherichia coli

- **Background**
  - The strains of *E. coli* capable of causing hemorrhagic colitis are referred to as Enterohemorrhagic *Escherichia coli* (EHEC)
Escherichia coli

• The Disease
  – *Escherichia coli* 0157:H7 is pathogenic for humans & has characteristically produced bloody diarrhea with abdominal cramps; sometimes the infection causes non-bloody diarrhea with very few symptoms
Escherichia coli

• The Disease
  – Children under 5 years of age & the elderly, the infection may progress into a more severe & life-threatening form of the disease known as hemolytic uremic syndrome (HUS)
  – In the United States, HUS is the leading cause of acute kidney failure in children
Escherichia coli

• Epidemiology
  – The majority of infections with serotype 0157:H7 have come from eating undercooked beef products, but many other sources of infection have been identified
Escherichia coli

• Epidemiology
  – In 1993 a foodborne outbreak of serotype O157:H7 was linked to the undercooked hamburgers eaten at a fast-food chain restaurant
  – The outbreak involved the infection of 700 persons from 4 different states with 51 of these persons developing HUS & four people dying from the syndrome
Lyme Disease

• Background
  – Lyme disease is caused by the spirochete *Borrelia burgdorferi*, a gram negative, slender, flexible bacteria that is helically coiled
Lyme Disease

• Background
  – The organism is anaerobic & fermentative in its energy metabolism & it is spread to humans by the bite of ticks of the genus Ixodes (Fig 7-8)
Fig. 7-8

From the slide collection of Dr. John Edman, Entomology, Umass, Amherst
Lyme Disease

• Disease & Epidemiology
  – Lyme disease was first reported in 1975 near Lyme, Connecticut, following a mysterious outbreak of arthritis
Lyme Disease

- Disease & Epidemiology
  - The early stages of Lyme disease are characterized by headache, fever, chills, swollen lymph glands, muscle & joint pain, & a characteristic skin rash (erythema migrans)
  - Lyme disease rarely results in death but chronic Lyme disease can lead to permanent damage to joints or the nervous system
Lyme Disease

• Disease & Epidemiology
  – Prevention is best accomplished by avoiding tick-infested areas in the summer periods
  – Spraying with DEET on exposed skin surfaces other than the face will also be helpful
Streptococcus

• Background
  – Streptococci are gram positive cocci (spheres) arranged in chains or in pairs
  – Major pathogens are included in groups A & B, & pathogenicity is associated with certain enzymes & surface proteins including hemolysins, erythrogenic toxins, & M-protein
Streptococcus

• Background
  – Hemolysins are enzymes capable of breaking or lysing blood cells.
  – The streptococci may produce a broad array of enzymes including neuraminidases, hyaluronidases, streptokinases, ATPases, DNAses, & many others that participate in the destruction & invasion of human tissue.
Streptococcus

• The Disease
  – The Group A Streptococci produce a variety of diseases that include strep throat, impetigo, & scarlet fever
  – The more severe of these invasions results in necrotizing fasciitis & / or streptococcal toxic shock syndrome
Streptococcus

• The Disease
  – Streptococcal toxic-shock syndrome (strep TSS) is defined as any Group A streptococcal infection associated with the early onset of shock & organ failure
Streptococcus

• Epidemiology
  – Beginning in the 1980s there has been a sudden elevation in the reporting of a highly invasive group A streptococci infection with or without necrotizing fasciitis associated with shock & organ failure
Streptococcus

• Epidemiology
  – The mortality rate for streptococcal TSS is about 60 percent of the 2,000 to 3,000 cases reported per year
  – Annually, about 20 percent of the 500-1,500 patients who acquire Streptococcal fasciitis have died
Tuberculosis

- Chronic infectious disease of the lower respiratory tract
- Caused by *Mycobacterium tuberculosis*
- Transmitted by aerosols from persons with active disease
Tuberculosis

• Background & Disease
  – Symptoms normally begin to develop at this stage from a cell mediated immunity that walls off the pathogen within multinucleated giant cells surrounded by lymphocytes & macrophages
Infection vs. Clinical Manifestation

http://www.cpmc.columbia.edu/resources/tbcpp/abouttb.html
Tuberculosis

• Epidemiology
  – Tuberculosis kills over 3 million people worldwide each year, & many more become ill from it
  – Tuberculosis was declared a U.S. public health emergency in 1992
Tuberculosis

• Epidemiology
  – WHO estimates that the 1990's will see 90 million new cases & 30 million deaths with annual rates in infection in developing countries exceeding 2%
Parasites

• Cryptosporidium
  – Background
  • *Cryptosporidium* is a single celled microscopic protozoan parasite that belongs to the Class Sporozoa
Cryptosporidium

• Background
  – The resistant form of the parasite is called an oocyst which is characterized by an outer protective shell which protects the organism against environmental extremes such as heat, cold, dryness, & chemical insult
Cryptosporidium

• Background
  – It is estimated that as few as 30 or even one oocyst(s) may cause infection when swallowed
  – *Cryptosporidium* is resistant to chlorine & difficult to filter thereby making it a serious threat to water supplies
Cryptosporidium

• Disease
  – The ingested oocysts reach the upper small bowel where they excyst & produce four infectious sporozoites that attach to the surface epithelium of the digestive tract & reproduce, forming more oocysts & sporozoites
Cryptosporidium

- Disease
  - The symptoms are self limiting, & include watery diarrhea, stomach cramps, nausea, & a slight fever
  - The immunocompromised are at increased risk from infection, & may develop serious & life-threatening illness from this organism
Cryptosporidium

• Epidemiology
  – There have been five major outbreaks associated with public water supplies of *Cryptosporidium* gastroenteritis in the USA & seven in the UK since 1983
Cryptosporidium

• Epidemiology
  – Contamination of drinking water by *Cryptosporidium* is a growing concern especially after the outbreak in Milwaukee in 1993 which affected some 400,000 people
Cryptosporidium

• Epidemiology
  – Cryptosporidium is found in animal droppings & human feces, soil, drinking water & recreational water, food, hands, & surfaces contaminated by such wastes
Typical Transmission

1. Thick-walled oocyst (sporulated) exits host
2. Contamination of water and food with oocysts.
3. Thick-walled oocyst ingested by host

Recreational water | Drinking water

www.cdc.gov
Malaria

• Background
  – Malarial diseases are caused by protozoan parasites belonging to the genus Plasmodium
  – There are four species known to infest humans & they are: *P. falciparum, P. vivax, P. ovale,* & *P. malariae*
Malaria

• Background
  – These parasites are transmitted from human to human by the bite of a female anopheline mosquito in which the parasite has gone through a complex development cycle
Malaria

• Background
  – A complex cycle takes place that involves the union of the gametocytes in the stomach of the mosquito & results in the development of slender, microscopic sporozoites that appear in the salivary glands, & are infective for humans (Fig. 7-10a,b)
Fig. 7-10a

- **Bite**
- **Primary attack on red blood cells in days**
- **Ring form**
- **Merozoites invade more RBCs**
- **Some develop into gametocytes**
- **Sporozoites enter liver cells**
- **Development and reproduction of merozoites in liver cells**
- **Mosquito takes a blood meal with some RBCs containing gametocytes**
Malaria

• Background
  – Inside the cell, the parasite form the classical signet ring stage (Fig. 7-11) & feed on the cells contents as they grow through the stages of trophozoites, & schizonts
Fig. 7-11
Malaria

• Disease
  – The symptomology & pathogenesis of malaria infection is related to the parasite's stage of growth & the host's parasitemia
  – High parasitemias result in decreased hemoglobin & a lower oxygen carrying capacity
Malaria

• Disease
  – Untreated infections lead to splenomegaly (enlarged spleen) & particularly in falciparum to cerebral malaria & death
Malaria

• Epidemiology
  – The World health Organization (WHO) estimates that there are 300 to 500 million people worldwide infected with malaria
  – The majority of malarial transmission occurs in tropical & subtropical countries (Fig 7-12)
Malaria

• Re-emergence
  – Decreased spraying of homes with DDT
  – Drug resistant malaria
  – Global warming
Malaria

• Epidemiology
  – There have been 76 cases of malaria reported from 1957 through 1994 including the three outbreaks occurring in the densely populated areas of New Jersey (1991), New York (1993) & Texas (1994)
PRACTICAL APPROACHES TO LIMITING THE EMERGENCE OF INFECTIOUS DISEASE

– The emergence of 29 new infectious diseases & re-emergence of many others are creating national & international crises
U.S. Prevention Strategy Goals

(1) Promptly investigate & monitor emerging pathogens, the diseases they cause, & factors of emergence

(2) Integrate lab science & epidemiology to optimize public health practice

(3) Enhance communication of public health info about emerging diseases & ensure prompt implementation prevention strategies

(4) Strengthen local, state, & federal public health infrastructures to support surveillance & implement prevention & control programs