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Communicable Diseases

Introduction

At the end of the twentieth century, communicable disease control is still a central task of public health. This chapter describes communicable diseases and programs for their prevention, control, elimination, and eradication. Control of communicable disease requires a systems approach using available resources effectively, mobilizing environmental measures, immunization, as well as clinical and health systems. Rapid transportation and communication make a virus outbreak in any part of the world an international concern. An outbreak of disease will often be covered by international media within a matter of hours or days. A basic understanding of infectious diseases is therefore an expectation of any student, just as a general knowledge of family health, chronic disease, nutrition, and economics are part of the modern public health culture.

The material presented in this chapter is intended to give an overview for the student or review for the public health practitioner, with an emphasis on the applied aspects of communicable disease control. We have relied for the content of this chapter on several standard references, especially Benenson’s Control of Communicable Diseases Manual, Sixteenth Edition, published by the American Public Health Association (1995), and Jawetz, Melnick and Adelberg’s Medical Microbiology, Twenty-first Edition (Brooks et al., 1998), along with Morbidity and Mortality Weekly Report of the Centers for Disease Control and Prevention (CDC) as well as electronic sources such as Promed, the American Academy of Pediatrics, and WHO websites. The references listed will augment the limited discussion possible in this text.

Public Health and the Control of Communicable Disease

Organized public health grew out of the sanitation movement of the mid nineteenth century which sought to reduce the environmental and social factors in com-
A communicable disease "is an illness due to a specific infectious agent or its toxic products that arises through transmission of that agent or its products from an infected person, animal, or inanimate reservoir to a susceptible host." Transmission may be direct from person to person, or indirect through an intermediate plant or animal host, vector, or the inanimate environment.

Source: Benenson, A. S. (ed). 1995. Control of Communicable Diseases Manual, Sixteenth Edition. Washington, DC: American Public Health Association, p. 533.

Communicable disease. Traditionally, the prevention and control of communicable diseases has been accomplished by sanitation, safe water and food supply, isolation, and by immunization.

The potential for infectious disease to disturb or destroy human life still exists and may increase as infectious diseases evolve and escape current man-made control mechanisms. The spread of bubonic plague throughout Europe and Asia in the fourteenth century and subsequent pandemics of smallpox, tuberculosis, syphilis, measles, cholera, and influenza show the explosive potential and epidemic nature of infectious diseases. The spread of AIDS since the 1980s, the cholera epidemic in South America, and diphtheria in the former Soviet Union in the 1990s, remind us why communicable disease control is still one of the major responsibilities of public health.

Both the miasma (environment–host) and bacteriologic (agent–host) theories contributed to great achievements in the control of communicable disease in the first half of the twentieth century. The emergence of the germ theory in the late nineteenth century led to the sciences of bacteriology and immunology, growing out of the work of Jenner, Pasteur, Koch, Lister, and many others (see Chapter 1). The control of the vaccine-preventable diseases has been a boon to mankind, saving countless millions of lives and providing a cornerstone for public health. Despite this, millions of children still die annually from preventable diseases. Infectious diseases of childhood are still tragically undercontrolled internationally. Infectious diseases also undermine health of other vulnerable groups in the population, such as the elderly and the chronically ill, thereby playing a major role in the economics of health care.

Great strides have been made in the control of communicable diseases through vaccination and environmental sanitation, but the field of infectious disease continues to be dynamic. New infectious disease threats are providing great challenges to public health. Increasing resistance to therapeutic agents augment the need for new strategies and coordination between public health and clinical services. Together, these make up what are termed the emerging infectious diseases. Understanding the principles and methodologies of communicable disease control, and eradication, is
important for all health providers and public health personnel so as to be able to cope with the scale of these problems and to absorb new technologies as they emerge from scientific advances and experience, and their successful application.

THE NATURE OF COMMUNICABLE DISEASE

An infectious disease may or may not be clinically manifest so that a person may carry the disease agent without having the full illness. Acute infectious diseases are brief, intense or short-term, self-limiting illness, but may have long-term sequelae of great public health importance, such as streptococcal infection and glomerulonephritis or rheumatic heart disease. Other infectious diseases are chronic with their own long-term effects, such as HIV infection or peptic ulcers. Others have both short-term and long-term effects, such as hepatitis infections. The stages of the infectious disease include

1. Exposure and infection;
2. Presymptomatic stage;
3. Nonmanifest or subclinical disease;
4. Clinically manifest disease and its progression;
5. Resolution, recovery, remission, relapse, suprainfection, or death; and
6. Long-term sequelae.

Each disease has its own characteristic organism and natural history from onset to resolution. Many infectious diseases may remain at a presymptomatic or subclinical stage without progressing to clinical symptoms and signs. Even a subclinical disease may cause an immunologic effect producing immunity. The drama of infectious disease is exemplified in the tragic event of the plague in the fourteenth century and its periodic recurrence as in the epidemic of 1665 in London, described by Daniel Defoe (Box 4.2).

BOX 4.2 DANIEL DEFOE—A JOURNAL OF THE PLAGUE YEAR, LONDON, 1665

"It was about the beginning of September 1664, that I, among the rest of my neighbors, heard, in ordinary discourse that the plague had returned again in Holland; for it had been very violent there, and particularly in Amsterdam and Rotterdam, in the year 1663, whither they say, it was brought, some said from Italy, others from the Levant, among some goods, which were brought home by their Turkey fleet; others said it was brought from Candia; others from Cyprus. It mattered not from whence it came; but all agreed it was come into Holland again.

"It was now mid-July and the plague, which had chiefly raged at the other end of town . . . began to now come eastwards toward the part where I
lived. It was to be observed, indeed, that it did not come straight on toward us; for the city, that is to say within the walls, was indifferently healthy still; nor was it got over the water into Southwark; for though there died that week 1,268 of all distempers, whereof it might be supposed above 900 died of the plague, yet there was but 28 in Southwark, Lambeth parish included; whereas in the parishes of St. Giles and St. Martin-in-the-Fields alone there died 421.”

Source: Defoe, D. 1723. *A Journal of the Plague Year*. Winnipeg: Meridian Classic, 1984, reprint.

**HOST-AGENT-ENVIRONMENT TRIAD**

The agent-host-environment triad, discussed in Chapter 2, is fundamental to the success of understanding transmission of infectious diseases and their control, including those well known, those changing their patterns, and those newly emerging or escaping current methods of control. Infection occurs when the organism successfully invades the host body, where it multiplies and produces an illness.

A host is a person or other living animal, including birds and arthropods, who provides a place for growth and sustenance to an infectious agent under natural, as opposed to experimental, conditions. Some organisms, such as protozoa or helminths, may pass successive stages of their life cycle in different hosts, but the primary or definitive host is the one in which the organism passes its sexual stage. The secondary or intermediate host is where the parasite passes the larval or asexual stage. A transport host is a carrier in which the organism remains alive, but does not develop.

An agent of an infectious disease is necessary, but not always sufficient to cause a disease or disorder. The infective dose is the quantity of the organism needed to cause clinical disease. A disease may have a single agent as a cause, or it may occur as a result of the agent in company with contributory factors, whose presence is also essential for the development of the disease. A disease may be present in an infected person in a dormant form such as tuberculosis, or a subclinical form, such as poliomyelitis or HIV. The virulence or pathogenicity of an infective agent is the capacity of an infectious agent to enter the host, replicate, damage tissue, and cause disease in an exposed and susceptible host. Virulence is indicated by the severity of clinical disease and case fatality rates.

The environment provides a reservoir for the organism, and the mode of transmission, by which the organism reaches a new host. The reservoir is the natural habitat where an infectious agent lives and multiplies, from which it can be transmitted directly or indirectly to a new host. The reservoir refers to the natural habitat of the organism, which may be in people, animals, arthropods, plants, soil, or substances in which an organism normally lives and multiplies, and on which it depends for survival or in which it survives in a dormant form.

Contacts are persons or animals who have been in association with an infected
person, animal, or contaminated inanimate object, or environment that might provide an opportunity for acquiring the infective agent. Persons or animals that harbor a specific infectious agent, often in the absence of discernible clinical disease, and who serve as a source of infection or contamination of food, water, or other materials, are carriers. A carrier may have an inapparent infection (a healthy carrier) or may be in the incubation or convalescent stage of the infection.

**CLASSIFICATIONS OF COMMUNICABLE DISEASES**

Communicable diseases may be classified by a variety of methods: by organism, by mode of transmission, by methods of prevention (e.g., vaccine preventable, vector controllable), or by major organism classification, that is, viral, bacterial, and parasitic disease.

A virus is a nucleic acid molecule (RNA or DNA) encapsulated in a protein coat or capsid. The virus is not a complete cell and can only replicate inside a complete cell. The capsid may have a protective envelope of a lipid containing membrane. The capsid and membrane facilitate attachment and penetration of a host cell. Inside the host cell, the nucleic molecule may cause the cell's chromosomes to be changed in its own genetic material or so that there is cellular manufacture and virus replication. Viroids are smaller RNA structures without capsids which can cause plant disease. Prions are recently discovered (Stanley Prusiner, Nobel prize, 1997) variants of viruses or viroids which are the infective agents cause of scrapie in sheep, and similar degenerative central nervous system diseases in cattle and in man (mad cow disease or Creutzfeld-Jakob disease in humans).

Bacteria are unicellular organisms that reproduce sexually or asexually, grow on cell-free media, and can exist in an environment with oxygen (aerobic) or in one lacking oxygen (anaerobic). Some may enter a dormant state and form spores where they are protected from the environment and may remain viable for years. Bacteria include a nucleus of chromosomal DNA material within a membrane surrounded by cytoplasm, itself enclosed by the cellular membrane. Bacteria are often characterized by their coloration under Gram's stain, as gram-negative or gram-positive, as well as by their microscopic morphology, colony patterns on growth media, by the diseases they may cause, as well as by antibody and molecular (DNA) marking techniques. Bacteria include both indigenous flora (normal resident) bacteria and pathogenic (disease causing) bacteria. Pathogenic bacteria cause disease by invading, overcoming natural or acquired resistance, and multiplying in the body. Bacteria may produce a toxin or poison that can affect a body site distant from where the bacterial replication occurs, such as in tetanus. Bacteria may also initiate an excessive immune response, producing damage to other body tissues away from the site of infection, e.g., acute rheumatic fever and glomerulonephritis.

Parasitology studies protozoa, helminths, and arthropods that live within, on,
or at the expense of a host. These include oxygen-producing, flagellate, unicellular organisms such as *Giardia* and *Trichomonas*, and amoebas such as *Entamoeba histolytica* important in enteric and gynecologic disorders. Sporozoa are parasites with complex life cycles in different hosts, such as cryptosporidium or malarial parasites. Parasitic disease usually refers to infestation, with fungi, molds, and yeasts that can affect humans. Helminths are worms that infest humans especially in poor sanitation and tropical areas.

**MODES OF TRANSMISSION OF DISEASE**

Transmission of diseases is by the spread of an infectious agent from a source or reservoir to a person (Table 4.1). Direct transmission from one host to another occurs during touching, biting, kissing, sexual intercourse, and projection via droplets, as in sneezing, coughing, or spitting, or by entry through the skin. Indirect transmission includes via aerosols of long-lasting suspended particles in air, fecal-oral transmission such as food and waterborne as well as by poor hygienic conditions with inanimate materials, such as soiled clothes, handkerchiefs, toys, or other objects.

Vector-borne diseases are transmitted via crawling or flying insects, in some cases with multiplication, and development of the organism in the vector, as in

| Mode          | Method               | Examples                                                                 |
|---------------|----------------------|--------------------------------------------------------------------------|
| Direct        | Physical contact     | Leprosy, impetigo, scabies, anthrax                                       |
| Direct        | Sexual contact       | HIV, syphilis, gonorrhea, herpes genitalis, hepatitis B, chlamydia, human papillovirus |
| Direct/ indirect | Airborne droplets and aerosols | Viral exanthems (measles), streptococcal diseases, various upper and lower respiratory tract diseases, tuberculosis, Legionnaire’s disease, influenza |
| Indirect      | Blood and blood products | HIV, hepatitis B, hepatitis C                                                 |
| Indirect      | Oral–Fecal           | Cholera, shigella, salmonella, typhoid, botulism, campylobacter, staph aureus, cryptosporidium, listeria, worms, giardia, hepatitis A, rotavirus, enteroviruses, poliovirus, adenoviruses, entameba histolytica |
| Indirect      | Hygiene              |                                                                           |
| Indirect      | Foodborne            |                                                                           |
| Indirect      | Waterborne           |                                                                           |
| Indirect      | Trans cutaneous      | Vector-borne via insects (arthropod): malaria, viral hemorrhagic fevers, schistosomiasis, plague, Animal bite (zoonoses): rabies, Health care (iatrogenic): hospital infections, HIV, hepatitis B, Self-injected (illicit drug users): HIV, hepatitis B |
| Vertical      | Congenital           | Congenital rubella syndrome, congenital syphilis, gonorrheal ophthalmia, cytomegalovirus (CMV) |
| Maternal–fetal |                      | HIV, rubella, syphilis, hepatitis B, gonorrhea, chlamydia                   |
malaria. The subsequent transmission to humans is by injection of salivary gland fluid during biting, e.g., congenital syphilis, or by deposition of feces, urine or other material capable of penetrating the skin through a bite wound or other trauma. Transmission may occur with insects as a transport mechanism, as in salmonella on the legs of a housefly.

Airborne transmission occurs indirectly via infective organisms in small aerosols that may remain suspended for long periods of time and which easily enter the respiratory tract. Small particles of dust may spread organisms from soil, clothing, or bedding.

Vertical transmission occurs from one generation to another, or from one stage of the insect life cycle to another stage. Maternal—infant transmission occurs during pregnancy (transplacental), delivery, as in gonorrhoea, breast-feeding, e.g., HIV, with transfer of infectious agents from mother to fetus or newborn.

**IMMUNITY**

Resistance to infectious diseases is related to many host and environmental factors, including age, sex, pregnancy, nutrition, trauma, fatigue, living and socioeconomic conditions, and emotional status. Good nutritional status has a protective effect against the results of an infection. Vitamin A supplements reduce complication rates of measles and enteric infections. Tuberculosis may be present in an individual whose resistance is sufficient to prevent clinical disease, but the infected person is a carrier of an organism which can be transmitted to another or cause clinical disease if the person's susceptibility is reduced.

Immunity is resistance to infection resulting from presence of antibodies or cells that specifically act on the microorganism associated with a specific disease or toxin. Immunity to a specific organism can be acquired by having the disease, that is, natural immunity, or by immunization, active or passive, or by protection

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**BOX 4.3 VACCINES AND PREVENTION**

"The Greeks had two gods of health, Aesculapius and Hygeia, therapy and prevention, respectively. Medicine in the twentieth century retains those two concepts, and vaccination is a powerful means of prevention. What follows is information on the vaccines that together with sanitation, make modern society possible, and that if wisely used will continue to bestow on mankind the gift of prevention, which according to proverb is worth far more than cure."

Source: Plotkin, S. A., Mortimer, E. A. 1994. *Vaccines*. Second edition. Philadelphia: WB Saunders (with permission).
BOX 4.4 BASIC TERMS IN IMMUNOLOGY
OF INFECTIOUS DISEASES

Infectious agent: a pathogenic organism (e.g., virus, bacteria, rickettsia, fungus, protozoa, or helminth) capable of producing infection or an infectious disease.

Infection: the process of entry, development, and proliferation of an infectious agent in the body tissue of a living organism (human, animal, or plant) overcoming body defense mechanisms, resulting in an inapparent or clinically manifest disease.

Antigen: a substance (e.g., protein, polysaccharide) capable of inducing specific response mechanisms in the body. An antigen may be introduced into the body by invasion of an infectious agent, by immunization, inhalation, ingestion, or through the skin, wounds, or via transplantation.

Antibody: a protein molecule formed by the body in response to a foreign substance (an antigen) or acquired by passive transfer. Antibodies bind to the specific antigen that elicits its production, causing the infective agent to be susceptible to immune defense mechanisms against infections e.g., humoral and cellular.

Immunoglobulins: antibodies that meet different types of antigenic challenges. They are present in blood or other body fluids, and can cross from a mother to fetus in utero, providing protection during part of the first year of life. There are five major classes (IgG, IgM, IgA, IgD, and IgE) and subclasses based on molecular weight.

Antisera or antitoxin: materials prepared in animals for use in passive immunization against infection or toxins.

Source: Jawetz, Melrick, and Adelberg, Medical Microbiology, 1998.

through elimination of circulation of the organism in the community. Immunity may be by antibodies produced by the host body or transferred from externally produced antibodies. The body also reacts to infective antigens by cellular responses, including those that directly defend against invading organisms and other cells which produce antibodies.

The immune response is the resistance of a body to specific infectious organisms or their toxins provided by a complex interaction of antibodies and cells including

a. B Cells (bone marrow and spleen) produce antibodies which circulate in the blood, i.e., humoral immunity;

b. T Cell-mediated immunity is provided by sensitization of lymphocytes of thymus origin to mature into cytotoxic cells capable of destroying virus-infected or foreign cells;
c. Complement, a humoral response which causes lysis of foreign cells;
d. Phagocytosis, a cellular mechanism which ingests foreign microorganisms (macrophages and leukocytes).

SURVEILLANCE

Surveillance of disease is the continuous scrutiny of all aspects of occurrence and spread of disease pertinent to effective control of that disease. Maintaining ongoing surveillance is one of the basic duties of a public health system, and is vital to the control of communicable disease, providing the essential data for tracking of disease, planning interventions, and responding to future disease challenges. Surveillance of infectious disease incidence relies on reports of notifiable diseases by physicians, supplemented by individual and summary reports of public health laboratories. Such a system must concern itself with the completeness and quality of reporting and potential errors and artifacts. Quality is maintained by seeking clinical and laboratory support to confirm first reports. Completeness, rapidity, and quality of reporting by physicians and laboratories should be emphasized in undergraduate and postgraduate medical education. Enforcement of legal sanctions may be needed where standards are not met. Surveillance of infectious diseases includes the following:

1. Morbidity reports from clinics to public health offices;
2. Mortality reports from attending doctors to vital records;
3. Reports from selected sentinel centers;
4. Special field investigations of epidemics or individual cases;
5. Laboratory monitoring of infectious agents in population samples;
6. Data on supply, use, and side effects of vaccines, toxoids, immune globulins;
7. Data on vector control activities such as insecticides use;
8. Immunity levels in samples of the population at risk;
9. Review of current literature on the disease;
10. Epidemiologic and clinical reports from other jurisdictions.

Epidemiologic monitoring based on individual and aggregated reports of infectious diseases provide data vital to planning interventions at the community level or for the individually exposed patient and his contacts, along with other information sources such as hospital discharge data and monitoring of sentinel centers. These may be specific medical or community sites that are representative of the population and are able to provide good levels of reporting to monitor an area or population group. A sentinel center can be a pediatric practice site, a hospital emergency room, or other location which will provide a “finger on the pulse” to assess the degree and kind of morbidity occurring in the community. It can also include monitoring in a location previously known for disease transmission, such as Hong Kong in relation to influenza.

Epidemiologic analysis provided by government public health agencies should
be published weekly, monthly, and annually and distributed to a wide audience of public health and health-related professionals throughout the country. Feedback to those in the field on whose initial reports the data are based is vital in order to promote involvement and improved quality of data, as well as to allow evaluation of the local situation in comparison to other areas. In a federal system of government, national agencies report regularly on all state or provincial health patterns. State or provincial health authorities provide data to the counties and cities in their jurisdictions. Such data should also be readily available to researchers in other government agencies, universities, and other academic settings for further research and analysis both on internet and hard-copy publications.

Notifiable diseases are those which a physician is legally required to report to state or local public health officials, by reason of their contagiousness, severity, frequency, or other public health importance (Table 4.2). Public health laboratory services provide validation of clinical and epidemiologic reports. They also pro-

| TABLE 4.2 Notifiable Infectious Diseases in the United States |
|---------------------------------------------------------------|
| AIDS/HIV                                                      |
| Anthrax                                                      |
| Botulism                                                     |
| Brucellosis (undulant fever)                                  |
| Chancroid                                                    |
| Chlamydia trachomatis, genital infection                      |
| Cholera                                                      |
| Coccidiomycosis                                              |
| Cryptosporidiosis                                             |
| Diphtheria                                                   |
| Encephalitis (California, eastern and western equine, St. Louis) |
| Escherichia coli 0157:H7                                     |
| Gonorrhea                                                    |
| Haemophilus influenza                                        |
| Hansen disease (Leprosy)                                     |
| Hemolytic uremic syndrome (post diarrhoea)                   |
| Hepatitis (A, B, Cno-n-A/non-B)                              |
| Legionellosis                                                |
| Lyme disease                                                 |
| Malaria                                                      |
| Measles                                                      |
| Meningococcal disease                                       |
| Mumps                                                        |
| Pertussis (whooping cough)                                   |
| Plague                                                       |
| Poliomyelitis, paralytic                                      |
| Psittacosis                                                  |
| Rabies (animal and human)                                    |
| Rocky Mountain spotted fever                                 |
| Rubella                                                      |
| Rubella congenital syndrome                                  |
| Salmonellosis                                                |
| Shigellosis                                                  |
| Streptococcal disease, invasive group A                      |
| Streptococcal pneumonia, drug-resistant invasive             |
| Syphilis (primary, secondary, total of all stages)           |
| Tetanus                                                      |
| Toxic shock syndrome                                         |
| Trichinosis                                                  |
| Tuberculosis                                                 |
| Tularemia                                                    |
| Typhoid fever (cases/carriers)                               |
| Yellow fever                                                 |

Source: Centers for Disease Control. 1997. Case definitions for infectious conditions under public health surveillance. Morbidity and Mortality Weekly Review. 46(RR-10): 1–55; also available at CDC website www.cdc.gov/epo/mmwr/preview/mmwrhtml/0047449.htm

Note: Other diseases for which individual state monitoring may be required include: amebiasis, meningitis (aseptic and other bacterial), campylobacteriosis, cyclosporiasis, dengue fever, ehrlichiosis, genital herpes, genital warts, giardiasis, granuloma inguinale, leptospirosis, listeriosis, lymphogranuloma venereum, mucopurulent cervicitis, nongonococcal urethritis, lymphogranuloma venereum, pelvic inflammatory disease, rheumatic fever, tularemia, varicella and others.
vide day-to-day supervision of public health conditions, and can monitor communicable disease and vaccine efficacy and coverage. In addition, they support standards of clinical laboratories in biochemistry, microbiology, and genetic screening.

**Nosocomial Infections**

Nosocomial or hospital-acquired infections constitute a major health hazard associated with care in institutions. In the United States, they occur in 5–10% of hospital admissions and are the cause of lengthening of hospital stay and an estimated 30,000 deaths per year. In developing countries, nosocomial infection rates may occur in up to 65% of hospitalizations. This category of infectious disease most commonly includes infections of the urinary tract, surgical wounds, lower respiratory tract (pneumonias), and blood poisoning or septicemias. In the United States, up to 60% of hospital-acquired infections are caused by multidrug resistant organisms. Staphylococcus infections resistant to many current antibiotics, for example, methicillin and vancomycin, are a notable cause of prolongation of hospitalization or even death. The increasing number of immunodeficient patients has increased the importance of prevention of nosocomial infections.

Where standards of infection control are lacking, in both developed and developing countries, hospital staff are vulnerable to serious infection. In developing countries, deadly new viruses, such as Ebola and Marburg viruses mainly affect nursing, medical, and other staff as secondary cases. Surveillance and control measures are important elements of hospital management. Hospital epidemiologists and infection control staff are part of modern hospital staffing.

The cost to the health system of nosocomial infections is a major consideration in planning health budgets. Reducing the risk of acquiring such infections in hospital justifies substantial expenditures for hospital epidemiology and infection control activities. With diagnostic related group payment for hospital care (by diagnosis rather than by days of stay) the good manager has a major incentive to ensure that the risk of nosocomial infections is minimized, since they can greatly prolong hospital stays, raising patient dissatisfaction and health care costs.

**ENDEMIC AND EPIDEMIC DISEASE**

An endemic disease is the constant usual presence of a disease or infectious agent in a given geographic area or population group. Hyperendemic is a state of persistence of high levels of incidence of the disease. Holoendemic means that the disease appears early in life and affects most of the population, as in malaria or hepatitis A and B in some regions.

An epidemic is the occurrence in a community or region of a number of cases of an illness in excess of the usual or expected number of cases. The number of cases constituting an epidemic varies with the disease, and factors such as previous epidemiological patterns of the disease, time and place of the occurrence, and
the population involved must be taken into account. A single case of a disease long absent from an area, such as polio, constitutes an epidemic, and therefore a public health emergency because a clinical case may represent a hundred carriers with nonparalytic or subclinical poliomyelitis. In the 1990s, two to three or more cases of measles linked in time and place may be considered sufficient evidence of transmission and presumed to be an epidemic. A pandemic is occurrence of a disease over a very wide area, crossing international boundaries, affecting a large proportion of the population.

Epidemic Investigation

Each epidemic should be regarded as a unique natural experiment. The investigation of an epidemic requires preparation and field investigation in conjunction with local health and other relevant authorities. Verification of cases and the scope of the epidemic will require case definition and laboratory confirmation. Tabulation of known cases according to time, place, and person are important for immediate control measures and formulation of the hypothesis as to the nature of the epidemic. An epidemic curve is a graphic plotting of the distribution of cases by the time of onset or reporting, which gives a picture of the timing, spread, and extent of the disease from the time of the initial index cases and the secondary spread.

Epidemic investigation requires a series of steps. This starts with confirmation of the initial report and preliminary investigation, defining who is affected, determining the nature of the illness and confirming the clinical diagnosis, and recording when and where the first (index) and follow-up (secondary) cases occurred, and how the disease was transmitted. Samples are taken from index case patients (e.g., blood, feces, throat swabs) as well as from possible vectors (e.g., food, water, sewage, environment). A working hypothesis is established based on the first findings, taking into account all plausible explanations. The epidemic pattern is studied, establishing common source or risk factors, such as food, water, contact, environment, and drawing a time line of cases to define the epidemic curve.

How many are ill (the numerator) and what is the population at risk (the denominator) establish the attack rate, namely, the percentage of sick among those exposed to the common factor. What is a reasonable explanation of the occurrence; is there a previous pattern, with the present episode a recurrence or new event? Consultation with colleagues and the literature helps to establish both a biological and epidemiologic plausibility. What steps are needed to prevent spread and recurrence of the disease? Coordination with relevant health and other officials and providers is required to establish surveillance and control systems, document and distribute reports, and respond to the public’s right to know.

The first reports of excess cases may come from a medical clinic or hospital. The initial (sentinel or index) cases provide the first clues that may point to a common source. Investigation of an epidemic is designed to quickly elucidate the cause and points of potential intervention to stop its continuation. This requires skilled investigation and interpretation. Epidemiologic investigations have defined many
public health problems. Rubella syndrome, Legionnaire's disease, AIDS, and Lyme and hantavirus diseases were first identified clinically when unusually large numbers of cases appeared with common features. The suspicions that were raised led to a search for causes and the identification of control methods.

A working hypothesis of the nature of an epidemic is developed based on the initial assessment, the type of presentation, the condition involved, and previous local, regional, national, and international experience. The hypothesis provides the basis for further investigation, control measures, and planning additional clinical and laboratory studies. Surveillance will then monitor the effectiveness of control measures. Communication of findings to local, regional, national, and international health reporting systems is important for sharing the knowledge with other potential support groups or other areas where similar epidemics may occur.

The Centers for Disease Control and Prevention (CDC), originally organized in 1942 as the Office for Malaria Control in War Areas, is part of the U.S. Public Health Service. As of 1993, the CDC had a budget of $1.5 billion, and 7300 employees include epidemiologists, microbiologists, and many other professionals. The CDC includes national centers for environmental health and injury control, chronic disease prevention and health promotion, infectious diseases, prevention services, health statistics, occupational safety and health, and international health.

The Epidemic Intelligence Service (EIS) of the CDC in the United States is an excellent model for the organization of the national control of communicable diseases. Young clinicians are trained to carry out epidemiologic investigations as part of training to become public health professionals. EIS officers are assigned to state health departments, other public health units, and research centers as part of their training, carrying out epidemic investigation and special tasks in disease control.

The CDC, in cooperation with the WHO, has developed and offers free of charge, a personal computer program to support field epidemiology, including epidemic investigations (EPI-INFO), which can be accessed and down-loaded from the worldwide web. This program should be adopted widely in order to improve field investigations, to encourage reporting in real time, and to develop high standards in this discipline.¹

CDC’s *Morbidity and Mortality Weekly Report (MMWR)* is a weekly publication of the CDC’s epidemiologic data, also available free on the internet. It includes special summaries of reportable infectious diseases as well as noncommunicable diseases of epidemiologic interest. *MMWR* publishes periodic special reports of important infectious and noninfectious diseases with comprehensive reviews of the literature and recent investigative work by the CDC and other organizations.

¹Epidemiologic investigation may be arranged at the CDC or WHO by contacting the Epidemiology Program Office, Mailstop G34, Centers for Disease Control, Atlanta, Georgia 30333, or by telephone 404-639-2709 or fax 404-639-3296; or the World Health Organization, 1211 Geneva 27, Switzerland, or by telephone 41-22-791-2111 or fax 41-22-791-0746.
| Control of major infectious diseases                                                                 |
|------------------------------------------------------------------------------------------------------|
| **Vaccination**: preexposure to protect individuals and the community (herd immunity); postexposure  |
| for individual protection (e.g., for rabies following animal bite, or contact after exposure to      |
| measles cases); or immunization to prevent infected meat or milk transfer of disease to               |
| humans (e.g., brucellosis)                                                                          |
| **Environmental measures**: water, sewage, and vector control (e.g., chlorination of water, fly,      |
| tick, and mosquito control)                                                                         |
| **Educational/social/behavior measures**: to promote self-care and self-protection to reduce risk     |
| (e.g., safe sexual practices to prevent STDs and HIV)                                               |
| **Animal and food control**: to reduce transmission (e.g., pasteurization of milk, radiation of food) |
| **Case finding and treatment**: to cure, prevent transmission and reduce the carrier population (e.g., |
| blood, sputum screening)                                                                           |
| **Occupational measures**: to protect persons exposed at place of work (e.g., immunization of food    |
| handlers, health and child care workers)                                                            |

| Viruses                                                                 | Bacteria                                                                 | Parasites                                      |
|------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------|
| Rabies, polio, measles, rubella, mumps, hepatitis B, influenza,         | Diphtheria, pertussis, tetanus, tuberculosi, anthrax, brucella,            | Malaria vaccines being tested                  |
| varicella, and hepatitis A                                              | pneumococcal pneumonia, Haemophilus influenza B                           |                                               |
| Rabies, rotaviruses, polio, arboviruses, tick- and mosquito-borne       | Salmonella, shigella, cholera, Legionnaire's disease, E. coli,            | Malaria, onchocerciasis, dracunculiasis,       |
| viruses (yellow fever)                                                  | Lyme disease                                                             | schistosomiasis, worms, cryptosporidiosis,     |
| HIV, hepatitis B                                                        | Diarrheal diseases, syphilis, gonorrhea, chancroid                       | giardiasis                                     |
| Rabies, herpes, CMV, HIV                                                | Brucellosis, salmonellosis, coliforms                                    | Malaria, scabies, onchocerciasis, dracunculiasis|
| HIV, hepatitis, measles, rubella, arboviruses                           | Tuberculosis, STDs, rheumatic fever                                      | Tapeworms                                      |
|                                                                       | Brucellosis, tuberculosis, anthrax                                       | Malaria, worms, dracunculiasis, onchocerciasis,|
|                                                                       |                                                                         | schistosomiasis, tapeworms                     |
|                                                                       |                                                                         | Hydatid cyst, trichinosis                      |
CONTROL OF COMMUNICABLE DISEASES

Although an infectious disease is an event affecting an individual, it is communicable to others, and therefore its control requires both individual and community measures of protection. Control of the disease is a reduction in its incidence, prevalence, morbidity, and mortality. Elimination of a disease in a specified geographic area may be achieved as a result of intervention programs such as individual protection against tetanus; elimination of infections such as measles requires stoppage of circulation of the organism. Eradication is success in reduction to zero of incidence of the disease and presence in nature of the organism, such as with smallpox. Extinction means that a specific organism no longer exists in nature or in laboratories.

Public health applies a wide variety of tools for the prevention of infectious diseases and their transmission. It includes activities ranging from filtration and disinfection of community drinking water to environmental vector control, pasteurization of milk, and immunization programs (see Table 4.3). No less important are organized programs to promote self protection, case finding, and effective treatment of infections to stop their spread to other susceptible persons (e.g., HIV, sexually transmitted diseases, tuberculosis, malaria). Planning measures to control and eradicate specific communicable diseases is one of the principal activities of public health and remains so for the twenty-first century.

Treatment

Treating an infection once it has occurred is vital to the control of a communicable disease. Each person infected may become a vector and continue the chain of transmission. Successful treatment of the infected person reduces the potential for an uninfected contact person to acquire the infection. Bacteriostatic agents or drugs such as sulfonamides inhibit growth or stop replication of the organism, allowing normal body defenses to overcome the organism. Bacteriocidal drugs such as penicillin act to kill pathogenic organisms.

Traditional medical emphasis on single antibiotics has changed to use of multiple drug combinations for tuberculosis and more recently for hospital-acquired infections. Antibiotics have made enormous contributions to clinical medicine and public health. However, pathogenic organisms are able to adapt or mutate and develop resistance to antibiotics, resulting in drug resistance. Wide-scale use of antibiotics has led to increasing incidence of resistant organisms. Multidrug resistance constitutes one of the major public health challenges at the end of the twentieth century. Antiviral agents (e.g., ribovarin) are important additions to medical treatment potential, as are “cocktails” of antiviral agents for management of HIV infection. Antibiotic use is a health problem requiring attention of clinicians and their teachers as well as the public health community and health care managers, representing the interaction of health issues across the entire spectrum of services.
Methods of Prevention

Organized public health services are responsible for advocating legislation and for regulating and monitoring programs to prevent infectious disease occurrence and/or spread. They function to educate the population in measures to reduce or prevent the spread of disease.

Health promotion is one of the most essential instruments of infectious disease control. It promotes compliance and community support of preventive measures. These include personal hygiene and safe handling of water, milk, and food supplies. In sexually transmitted diseases, health education is the major method of prevention.

Each of the infectious diseases or groups of infectious diseases have one or more preventive or control approaches (Table 4.3). These may involve the coordinated intervention of different disciplines and modalities, including epidemiologic monitoring, laboratory confirmation, environmental measures, immunization, and health education. This requires teamwork and organized collaboration.

Very great progress has been made in infectious disease control by clinical, public health, and societal means since 1900 in the industrialized countries and since the 1970s in the developing world. This is attributable to a variety of factors, including organized public health services; the rapid development and wide use of new and improved vaccines and antibiotics; better access to health care; and improved sanitation, living conditions, and nutrition. Triumphs have been achieved in the eradication of smallpox and in the increasing control of other vaccine-preventable diseases. However, there remain serious problems with TB, STDs, malaria, and new infections such as HIV, and an increase in multiple drug-resistant organisms.

VACCINE-PREVENTABLE DISEASES

Vaccines are one of the most important tools of public health in the control of infectious diseases, especially for child health. Vaccine-preventable diseases

| Disease      | 1950 | 1960 | 1970 | 1980 | 1985 | 1990 | 1996 |
|--------------|------|------|------|------|------|------|------|
| Diphtheria   | 3.8  | 0.5  | 0.2  | 0    | 0    | 0    | 0    |
| Pertussis    | 79.8 | 8.2  | 2.1  | 0.8  | 1.5  | 1.8  | 2.9  |
| Poliomyelitis| 22.0 | 1.8  | 0    | 0    | 0    | 0    | 0    |
| Measles      | 211.0| 245.4| 23.2 | 6.0  | 1.2  | 11.2 | 0.2  |
| Mumps        | na   | na   | 55.6 | 3.9  | 1.3  | 2.2  | 0.3  |
| Rubella      | na   | na   | 27.8 | 1.7  | 0.3  | 0.5  | 0.1  |
| Hepatitis A  | na   | na   | 27.8 | 12.8 | 10.0 | 12.6 | 11.7 |
| Hepatitis B  | na   | na   | 4.1  | 8.4  | 11.5 | 8.5  | 4.0  |

Source: Health United States, 1990, 1998.
(VPDs) are those diseases preventable by currently available vaccines (Table 4.4). The word vaccine comes from use of cowpox (vaccinia virus) to stimulate immunity to smallpox, first demonstrated by Jenner in 1796. The term is now generally used for all immunizing agents.

The body responds to invasion of disease-causing organisms by antigen-antibody reactions and cellular responses. Together, these act to restrain or destroy the disease-causing potential. Strengthening this defense mechanism through im-

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**BOX 4.5 DEFINITIONS OF IMMUNIZING AGENTS AND PROCESSES**

Vaccines: a suspension of live or killed microorganisms or antigenic portion of those agents presented to a potential host to induce immunity to prevent the specific disease caused by that organism. Preparation of vaccines may be from:

a. Live attenuated organisms which have been passed repeatedly in tissue culture or chick embryos so that they have lost their capacity to cause disease but retain an ability to induce antibody response, such as polio-Sabin, measles, rubella, mumps, yellow fever, BCG, typhoid, and plague.

b. Inactivated or killed organisms which have been killed by heat or chemicals but retain an ability to induce antibody response; they are generally safe but less efficacious than live vaccines and require multiple doses, such as polio-Salk, influenza, rabies, and Japanese encephalitis.

c. Cellular fractions usually of a polysaccharide fraction of the cell wall of a disease-causing organisms, such as pneumococcal pneumonia or meningococcal meningitis.

d. Recombinant vaccines produced by recombinant DNA methods in which specific DNA sequences are inserted by molecular engineering techniques, such as DNA sequences spliced to vaccinia virus grown in cell culture to produce influenza and hepatitis B vaccines.

Toxoids or antisera: modified toxins are made nontoxic to stimulate formation of an antitoxin, such as tetanus, diphtheria, botulism, gas gangrene, and snake and scorpion venom.

Immune globulin: an antibody-containing solution derived from immunized animals or human blood plasma, used primarily for short-term passive immunization, e.g., rabies, for immunocompromised persons.

Antitoxin: an antibody derived from serum of animals after stimulation with specific antigens and used to provide passive immunity, e.g., tetanus.

Source: Brooks, G. E., Butel, J. S., Morse, S. A. 1998. *Jawetz, Melnick and Adelberg's Medical Microbiology*, Twenty-first edition. Stamford, CT: Appleton & Lange; *Harrison’s Textbook of Internal Medicine* (1998).
munization is one of the outstanding achievements of public health, as treatment of infectious diseases by antimicrobials is a major element of clinical medicine.

Immunization (vaccination) is a process used to increase host resistance to specific microorganisms to prevent them from causing disease. It induces primary and secondary responses in the human or animal body:

a. Primary response occurs on first exposure to an antigen. After a lag or latent period of 3–14 days (depending on the antigen) specific antibodies appear in the blood. Antibody production ceases after several weeks but memory cells that can recognize the antigen and respond to it remain ready to respond to a further challenge by the same antigen.

b. Secondary (booster) response is the response to a second and subsequent exposure to an antigen. The lag period is shorter than the primary response, the peak is higher and lasts longer. The antibodies produced have a higher affinity for the antigen, and a much smaller dose of the antigen is required to initiate a response.

c. Immunologic memory exists even when circulating antibodies are insufficient to protect against the antigen. When the body is exposed to the same antigen again, it responds by rapidly producing high levels of antibody to destroy the antigen before it can replicate and cause disease.

Immunization protects susceptible individuals from communicable disease by administration of a living modified agent, or subunit of the agent, a suspension of killed organisms or an inactivated toxin (see Table 4.5) to stimulate development of antibodies to that agent. In disease control, individual immunity may also protect another individual.

Herd immunity occurs when sufficient persons are protected (naturally or by immunization) against a specific infectious disease reducing circulation of the organism, thereby lowering the chance of an unprotected person to become infected. Each pathogen has different characteristics of infectivity, and therefore different levels of herd immunity are required to protect the nonimmune individual.

**Immunization Coverage**

The critical proportion of a population that must be immunized in order to interrupt local circulation of the organism varies from disease to disease. Eradication of smallpox was achieved with approximately 80% world coverage, followed by concentration on new case findings and immunization of contacts and surrounding communities. For highly infectious diseases, such as measles, immunization coverage of over 95% is needed to achieve local eradication.

Immunization coverage in a community must be monitored in order to gauge the extent of protection and need for program modification to achieve targets of disease control. Immunization coverage is expressed as a proportion in which the numerator is the number of persons in the target group immunized at a specific age, and the denominator is the number of persons in the target cohort who should have been immunized according to the accepted standard:
Vaccine coverage = \frac{\text{no. persons immunized in specific age group}}{\text{no. persons in the age group during that year}} \times 100

Immunization coverage in the United States is regularly monitored by the National Immunization Survey by a household survey in all 50 states, as well as selected urban areas considered to be at high risk for undervaccination. An initial telephone survey is followed by confirmation, where possible, from documentation from the parents or health care providers. The survey for July 1994–June 1995 examined children born between August 1991 and November 1993 (i.e., aged 19–35 months, median age 27 months). The results show improving coverage, with 95% having received three or more doses of DPT (diphtheria, pertussis, and tetanus), 88% with three or more doses of OPV (oral polio vaccine), 92% with three or more doses of \textit{Haemophilus influenzae}, type b (Hib), but only 62% with three or more doses of hepatitis B. However, only 75% had received all recommended vaccines at the recommended ages.

Present technology allows for control or eradication of important infectious dis-

\begin{table}[h]
\centering
\caption{Development of Vaccines by Period of Development and Type of Vaccine}
\begin{tabular}{|c|c|c|c|}
\hline
Period/ & \multicolumn{2}{c|}{Killed, whole} & \multicolumn{1}{c|}{Purified protein or polysaccharide} & \multicolumn{1}{c|}{Genetically engineered} \\
\ cm{'century} & Live attenuated & organism & & \\
\hline
Eighteenth century & Smallpox (1798) & na\textsuperscript{a} & na & na \\
Nineteenth century & Rabies (1885) & Hog cholera (1886) & Diphtheria antitoxin (1888) & na \\
Early twentieth century & BCG tuberculosis (1927) & Pertussis (1926) & Diphtheria (1923) & na \\
Post-World War II & Yellow fever (1935) & Influenza (1936) & Tetanus toxoid (1927) & \\
& Polio, Sabin (1963) & Influenza A (1936) & Infuenza A (1936) & \\
& Measles (1963) & Ricketsia (1936) & Diphtheria toxoid (1949) & na \\
& Mumps (1967) & Typhoid (1952) & Pneumococcus (1976, 1983) & \\
& Rabella (1970) & Polio, Salk (1955) & Meningococcus (1962) & \\
& MMR (1971) & Ambrax (1970) & Tick-borne encephalitis & \\
1980–1999 & Adenovirus (1980) & Rabies (1980, human diploid cell) & \textit{Hemophilus influen}z b (1985) & Hepatitis B (1987) recombinant (yeast or mammalian cell derived) \\
& Typhoid (1992, 1995) & Japanese encephalitis (1993) & Hepatitis B (1981, plasma) & Pertussis, acellular (1993) \\
& (salmonella Type21a, Vi) & & & \\
& Varicella (1995) & & & \\
& Lyme disease (1998) & & & \\
& Rotavirus (1998) & & & \\
2000–2010 & New vaccines for pneumococcal, meningococcal disease, influenza, parainfluenza, respiratory syncytial virus (RSV), H. pylori, human papillomavirus (HPV), streptococcus, HIV, hepatitis C, adenoviruses & & & \\
\hline
\end{tabular}
\textsuperscript{Note: Years developed or licensed in the United States.}
\textsuperscript{Source: Modified from Plotkin SA, Mortimer EA. 1994. \textit{Vaccines}, Second Edition. Philadelphia: Saunders; and Centers for Disease Control, 1999. Vaccines universally recommended for children—United States, 1990–98. \textit{Morbidity and Mortality Weekly Report}, 48:243–248.}
\textsuperscript{\textit{na}}, Not available.
eases that still cause millions of deaths globally each year. Other important infectious diseases are still not subject to vaccine control because of difficulties in their development. In some cases, a microorganism can mutate with changes. Viruses can undergo antigenic shifts in the molecular structure in the organism, producing completely new subtypes of the organism. Hosts previously exposed to other strains may have little or no immunity to the new strains.

Antigenic drift refers to relatively minor antigenic changes which occur in viruses. This is responsible for frequent epidemics. Antigenic shift is believed to explain the occurrence of new strains of influenza virus necessitating, for example, annual reformulation of the influenza vaccine associated with large scale epidemics and pandemics. New variants of poliovirus strains are similar enough to the three main types so that immunity to one strain is carried over to the new strain. Molecular epidemiology is a powerful new technique used to specify the geographic origin of organisms such as poliomyelitis and measles viruses, permitting tracking of the source of the virus and epidemic.

Combinations of more than one vaccine is now common practice with a trend to enlarging the cocktail of vaccines in order to minimize the number of injections, and visits required. This reduces the number of visits to carry out routine immunization saving staff time and costs, as well as increasing compliance. There are virtually no contraindications to use of multiple antigens simultaneously. Examples of vaccine cocktails include DPT (diphtheria, pertussis, and tetanus) in combination with *Haemophilus influenzae* b, poliomyelitis, and varicella, or MMR (measles, mumps, and rubella) vaccines.

Interventions in the form of effective vaccines save millions of lives each year and contribute to improved health of countless children and adults throughout the world. Vaccination is now accepted as one of the most cost-effective health interventions currently available. Continuous policy review is needed regarding allocation of adequate resources, logistical organization, and continued scientific effort to seek effective, safe, and inexpensive vaccines for other important diseases such as malaria and HIV. New technology of recombinant vaccines, such as that of hepatitis B, holds promise for important vaccine breakthroughs in the decades ahead.

Internationally, much progress was made in the 1980s in the control of vaccine-preventable diseases. At the end of the 1970s, fewer than 10% of the world’s children were being immunized. WHO, UNICEF, and other international organizations mobilized to promote an Expanded Programme on Immunization (EPI) with a target of reaching 80% coverage by 1990. Immunization coverage increased in the developing countries, preventing some 3 million child deaths annually. Bacillus Calmette-Guérin (BCG) coverage rose from 31 to 85%; poliomyelitis with OPV (three doses) from 24 to 80%, and tetanus toxoid for pregnant women from 14 to 54%. Since 1991, there has been a decline in coverage in some parts of the world, mainly in sub-Saharan Africa.

The challenge remains to achieve control or eradication of vaccine-preventable diseases, thus saving millions of more lives. Part of the HFA stresses the EPI approach, which includes immunization against diphtheria, pertussis, tetanus, po-
liomyelitis, measles, and tuberculosis. An extended form of this is the EPI PLUS program which combines EPI with immunization against hepatitis B and yellow fever and, where appropriate, supplementation with vitamin A and iodine. The success in international eradication of smallpox is now being followed by a campaign to eradicate poliomyelitis and other important infectious diseases.

**Vaccine-Preventable Diseases**

**Diphtheria.** Diphtheria is an acute bacterial disease of the tonsils, nasopharynx, and larynx caused by the organism *Corynebacterium diphtheriae*. It occurs in colder months in temperate climates where the organism is present in human hosts and is spread by contact with patients or carriers. It has an incubation period of 2–5 days. In the past, this was primarily an infection of children and was a major contributor to child mortality in the prevaccine and preantibiotic eras. Diphtheria has been virtually eliminated in countries with well-established immunization programs.

In the 1980s, an outbreak of diphtheria occurred in the countries of the former Soviet Union among people over age 15. It reached epidemic proportions in the 1990s, with 140,000 cases (1991–1995) with 1100 deaths in 1994 in Russia alone. This indicates a failure of the vaccination program in several respects: it used only three doses of DPT in infancy; no boosters were given at school age or subsequently; the efficacy of diphtheria vaccine may have been low, and coverage was below 80%.

Efforts to control the present epidemic include mass vaccination campaigns for persons over 3 years of age with a single dose of dT (diphtheria and tetanus) and increasing coverage of routine DPT vaccines to four doses by age 2 years. The epidemic and its control measures have led to improved coverage with dT for those over 18 years, and 93% coverage among children aged 12–23 months.

WHO recommends three doses of DPT in the first year of life and a booster at school entry. This is considered by many to be insufficient to produce long-lasting immunity. The United States and other industrialized countries use a four-dose schedule and recommend periodic boosters for adults with dT.

**Pertussis.** Pertussis is an acute bacterial disease of the respiratory tract caused by the bacillus *Bordetella pertussis*. After an initial coldlike (catarrhal) stage, the patient develops a severe cough which comes in spasms (paroxysms). The disease can last 1–2 months. The paroxysms can become violent and may be followed by a characteristic crowing or high pitched inspiratory whooping sound, followed by expulsion of a tenacious clear sputum, often followed by vomiting. In poorly immunized populations and those with malnutrition, pneumonia often follows and death is common.

Pertussis declined dramatically in the industrialized countries as a result of widespread coverage with DPT. However, because the pertussis component of the vaccine caused some reactions, many physicians avoided its use, using DT alone. During the 1970s in the United Kingdom, many physicians recommended against vaccination with DPT. As a result, pertussis incidence increased with substantial mortality rates. This led to a reappraisal of the immunization program, with insti-
tution of incentive payments to general practitioners for completion of vaccination schedules. As a result of these measures, vaccination coverage, with resulting pertussis control, improved dramatically in the United Kingdom.

Pertussis continues to be a public health threat and recurs wherever there is inadequate immunization in infancy. A new acellular vaccine is ready for widespread use and will be safer with fewer and less severe reactions in infants, increasing the potential for improved confidence and support for routine vaccination. Use of the new vaccine is spreading in the United States and forms part of the U.S. recommended vaccination schedule.

*Tetanus.* Tetanus is an acute disease caused by an exotoxin of the tetanus bacillus (*Clostridium tetani*) which grows anaerobically at the site of an injury. The bacillus is universally present in the environment and enters the human body via penetrating injuries. Following an incubation period of 3–21 days, it causes an acute condition of painful muscular contractions. Unless there is modern medical care available, patients are at risk of high case fatality rates of 30–90% (highest in infants and the elderly).

Antitetanus serum (ATS) was discovered in 1890 and during World War I, ATS contributed to saving the lives of many thousands of wounded soldiers. Tetanus toxoid was developed in 1993. The organism, because of its universal presence in the environment, cannot be eradicated. However, the disease can be controlled by effective immunization of every child during infancy and school age. Adults should receive routine boosters of tetanus toxoid once every decade.

Newborns are infected by tetanus spores (tetanus neonatorum) where unsanitary conditions or practices are present. It can occur when traditional birth attendants at home deliveries use unclean instruments to sever the umbilical cord, or dress the severed cord with contaminated material. Tetanus neonatorum remains a serious public health problem in developing countries. Immunization of pregnant women and women of childbearing age is reducing the problem by conferring passive immunity to the newborn. The training of traditional birth attendants in hygienic practice and the use of medically supervised birth centers for delivery also decreases the incidence of tetanus neonatorum.

Elimination of tetanus neonatorum by the year 2000 was made a health target by the World Summit of Children in 1990. In that year, the number of deaths from neonatal tetanus was reported by UNICEF as 700,000 infants worldwide, declining to 600,000 in 1993. Immunization of pregnant women increased from under 20% in 1984 to 52% in 1995–1997. Despite progress, coverage is still too low to achieve the target of elimination.

*Poliomyelitis.* Polio virus infection may be asymptomatic or cause an acute nonspecific febrile illness. It may reach more severe forms of aseptic meningitis and acute flaccid paralysis with long-term residual paralysis or death during the acute phase. Poliomyelitis is transmitted mainly by direct person-to-person contact, but also via sewage contamination. Large-scale epidemics of disease, with attendant paralysis and death, occurred in industrialized countries in the 1940s and
1950s, engendering widespread fear and panic and thousands of clinical cases of "infantile paralysis".

Growth of the poliovirus by John Enders and colleagues in tissue culture in 1949 led to development of the first inactivated polio vaccine by Jonas Salk in the mid-1950s and gave hope and considerable success in the control of the disease. The development of the live attenuated oral poliomyelitis vaccine by Albert Sabin, licensed in 1960, added a new dimension to its control because of the effectiveness, low cost, and ease of administration of the vaccine. The two vaccines in their more modern forms, enhanced strength inactivated polio vaccine (eIPV), and triple oral polio vaccine (TOPV), have been used in different settings with great success.

Oral polio vaccine (OPV) induces both humoral and cellular, including intestinal, immunity. The presence of OPV in the environment by contact with immunized infants and via excreta of immunized persons in the sewage gives a booster effect in the community. Immunization using OPV, in both routine and National Immunization Days (NIDs) has proven effective in dramatically reducing poliomyelitis and circulation of the wild virus in many parts of the world. Use of the enhanced strength IPV (eIPV) produces early and high levels of circulating antibodies, as well as protecting against the vaccine-associated disease.

In rare cases OPV can cause vaccine-associated paralytic poliomyelitis (VAPP), with a risk of 1 case per 520,000 with initial doses, and 1 case per over 12 million with subsequent doses. Approximately eight to ten cases of VAPP occur annually in the United States, with clinical, ethical, and legal implications. Use of IPV as initial protection eliminates this problem. Experience in Gaza and the West Bank in the 1970s and 1980s, and later in Israel, showed that a combination of IPV and OPV is effective in overcoming endemic and imported poliovirus. OPV requires multiple doses to achieve protective antibody levels. Where there are many enteroviruses in the environment, as is the case in most developing countries, interference in the uptake of OPV may result in cases of paralytic poliomyelitis among persons who have received 3 or even 4 doses of adequate OPV.

Controversy as to the relative advantages of each vaccine continues. The OPV program of mass repeated vaccination in control of poliomyelitis in the Americas established the primacy of OPV in practical public health, and the momentum to eradicate poliomyelitis is building. A combined schedule of IPV and OPV would eliminate the wild virus and protect against vaccine-associated disease. The sequential use of IPV and OPV was adopted as part of the routine infant immunization program in the United States in 1997, but IPV alone was adopted in 1999.

There are concerns that exclusive use of either vaccine alone will not lead to the desired goal of eradication of poliomyelitis. Progress in global eradication of polio has been impressive. Global coverage of infants with three doses of OPV reached 81% in 1996 as compared to 83% in 1995. The African region of WHO had an increase in OPV coverage from 58% in 1995 to 60% in 1996. National immunization days (NIDs) were conducted in 62 countries in 1995 and 82 in 1996, covering 419 million children in 1996. Mopping up operations to reinforce coverage of children in still endemic areas is proceeding along with increased emphasis on acute flaccid paralysis (AFP) monitoring. Confirmed polio cases reported
continued at 5–6,000 per year in 1997–1998. With continued national and international emphasis, and support of WHO, Rotary International, UNICEF, donor countries, and others, there is a real prospect of a world without polio, if not by the year 2000, then or shortly thereafter.

**Measles.** Measles is an acute disease caused by a virus of the paramyxovirus family. It is highly infectious with a very high ratio of clinical to subclinical case ratio (99/1). Measles has a characteristic clinical presentation with fever, white spots (Koplik spots) on the membranes of the mouth, and a red blotchy rash appearing on the 3rd–7th day lasting 4–7 days. Mortality rates are high in young children with compromised nutritional status, especially vitamin A deficiency.

The measles virus evolved from a virus disease of cattle (rinderpest) some 3000–5000 years ago, becoming an important disease of humans with high mortality rates in debilitated, poorly nourished children, and significant mortality and morbidity even in industrialized countries. In the prevaccine era, measles was endemic worldwide, and even in the late 1990s it remains one of the major childhood infectious diseases. It is one of the commonest causes of death for school age children worldwide. Despite earlier predictions that measles deaths would be halved to 500,000 by 1996, WHO reported 1.1 million measles deaths in that year and over 1 million in 1997. Eradication in the first decade of the next century is a feasible goal, provided that there is an adequate international effort. Measles immunization increased from under 40% worldwide in 1985 to 79% in 1995–1996, but 56% in sub-Saharan Africa.

Single-dose immunization failed to meet control or eradication requirements even in the most developed parts of the world. A live vaccine, licensed in 1963, was later replace by a more effective and heat stable vaccine, but still with a primary vaccination failure rate (i.e., fails to produce protective antibodies) of 4–8%, and secondary failure rate (i.e., produces antibodies but protection is lost over time) of 4%. A two-dose policy incorporates a booster dose, usually at school-age, in addition to maximum feasible infant coverage of children in the 9–15 month period (timing varies in different countries). Catch-up campaigns among school-age children should be carried out until the routine two-dose policy has time to take full effect. Nearly universal primary education in developing countries, offers an opportunity for mass coverage of school age children with a second dose of measles and a resulting increase of herd immunity to reduce the transmission of the virus. The two-dose policy adopted in many countries, should be supplemented with catch-up campaigns in schools to provide the booster effect for those previously immunized and to cover those previously unimmunized, especially in developing countries.

The CDC considers that domestic transmission in the United States has been interrupted and that most localized outbreaks were traceable to imported cases. South America and the Caribbean countries are now considered free of indigenous measles, based on their successful use of NIDs, although a large epidemic occurred in 1999 in Brazil. It now appears that eradication has become a feasible target during the early part of the next century, with a strategy of levels of coverage in in-
fancy with a two-dose policy, supplemented by catch-up campaigns to older children and young adults, and outbreak control.

**Mumps.** Mumps is an acute viral disease characterized by fever, swelling, and tenderness usually of the parotid glands, but also other glands. The incubation period ranges between 12 and 25 days. Orchitis, or inflammation of the testicles, occurs in 20–30% of postpubertal males and oophoritis, or inflammation of the ovaries, in 5% of postpubertal females. Sterility is an extremely rare result of mumps. Central nervous system involvement can occur in the form of aseptic meningitis, almost always without sequelae. Encephalitis is reported in 1–2 per 10,000 cases with an overall case fatality rate of 0.01%. Pancreatitis, neuritis, nerve deafness, mastitis, nephritis, thyroiditis, and pericarditis, although rare, may occur. Most persons born before 1957 are immune to the disease, because of the nearly universal exposure to the disease before that time.

The live attenuated vaccine introduced in the United States in 1967 is available as a single vaccine or in combination with measles and rubella as the measles-mumps-rubella (MMR) vaccine. It provides long-lasting immunity in 95% of cases. Mumps vaccine is now recommended in a two-dose policy with the first dose of MMR given between 12 and 15 months of age and a second dose given either at school entry or in early adolescence. MMR in two doses is now standard policy in the United States, Sweden, Canada, Israel, the United Kingdom, and other countries. The incidence of mumps has consequently declined rapidly. Local eradication of this disease is worthwhile and should be part of a basic international immunization program.

**Rubella.** Rubella (German measles) is generally a mild viral disease with lymphadenopathy and a diffuse, raised red rash. Low grade fever, malaise, coryza, and lymphadenopathy characterize the prodromal period. The incubation period is usually 16–18 days. Differentiation from scarlet fever, measles, or other febrile diseases with rash may require laboratory testing and recovery of the virus from nasopharyngeal, blood, stool, and urine specimens.

In 1942, Norman Gregg, an Australian ophthalmologist, noted an epidemic of cases of congenital cataract in newborns associated with a history of rubella in the mother during the first trimester. Subsequent investigation demonstrated that intrauterine death, spontaneous abortion, and congenital anomalies occur commonly when rubella occurs early in pregnancy.

Congenital rubella syndrome (CRS) occurs with single or multiple congenital anomalies including deafness, cataracts, microphthalmia, congenital glaucoma, microcephaly, meningoencephalitis, congenital heart defects, and others. Moderate and severe cases are recognizable at birth, but mild cases may not be detected for months or years after birth. Insulin-dependent diabetes is suspected as a late sequela of congenital rubella. Each case of CRS is estimated to cost some $250,000 in health care costs during the patient’s lifetime.

Prior to availability of the attenuated live rubella vaccine in 1969, the disease was universally endemic, with epidemics or peak incidence every 6–9 years. In
unvaccinated populations, rubella is primarily a disease of childhood. In areas where children are well vaccinated, adolescent and young adult infection is more apparent, with epidemics in institutions, colleges, and among military personnel.

A sharp reduction of rubella cases was seen in the United States following introduction of the vaccine in 1970, but increased in 1978, following rubella epidemics in 1976–1978. A further reduction in cases was followed by a sharp upswing of rubella and CRS in 1988–1990. An outbreak of rubella among the Amish in the United States, who refuse immunization on religious grounds, resulted in 7 cases of CRS in 1991. It is now thought that vaccination of sufficient numbers in the United States reduced circulation of the virus and protected most vulnerable groups in the population.

In the past, immunization policy in some countries was to vaccinate school girls aged 12 to protect them for the period of fertility. The current approach is to give a routine dose of MMR in early childhood, followed by a second dose in early school age to reduce the pool of susceptible persons. Women of reproductive age should be tested to confirm immunity before pregnancy and immunized if not already immune. Should a woman become infected during pregnancy, termination of pregnancy previously recommended is now managed with hyperimmune globulin.

The infection of pregnant women during their first trimester of pregnancy is the primary public health implication of rubella. The emotional and financial burden of CRS, including the cost of treatment of its congenital defects, makes this vaccination program cost-effective. Its inclusion in a modern immunization program is fully justified. Elimination of CRS syndrome should be one of the primary goals of a program for prevention of vaccine-preventable disease in developed and developing countries. Adoption of MMR and the two-dose policy will gradually lead to eradication of rubella and rubella syndrome.

**Viral Hepatitis.** Viral hepatitis is a group of diseases of increasing public health importance due to their large scale worldwide prevalence, their serious consequences, and our increasing ability to take preventive action. Viral hepatic infectious diseases each have specific etiologic, clinical, epidemiologic, serologic, and pathologic characteristics. They have important short- and long-term sequelae. Vaccine development is of high priority for control and ultimate eradication.

**Hepatitis A.** Hepatitis A (HAV) was previously known as infectious hepatitis or epidemic jaundice. HAV is mainly transmitted by the fecal–oral route. Clinical severity varies from a mild illness of 1–2 weeks to a debilitating illness lasting several months. The norm is complete recovery within 9 weeks, but a fulminating or even fatal hepatitis can occur. Severity of the disease worsens with increasing age. HAV is sporadic/endemic worldwide. Improving sanitation raises the age of exposure, with accompanying complications. It now occurs particularly in persons from industrialized countries when exposed to situations of poor hygiene, or among young adults when traveling to areas where the disease is en-
demic. Common source outbreaks occur in school-aged children and young adults from case contact, or from food contaminated by infected handlers. Hepatitis A may be a serious public health problem in a disaster situation.

Prevention involves improving personal and community hygiene, with safe chlorinated water and proper food handling. Hepatitis A vaccine has been recently licensed for use in the United States, and will probably soon be recommended for routine vaccination programs, as well as for persons traveling to endemic areas.

HEPATITIS B. Hepatitis B (HBV) once called serum jaundice, was thought to be transmitted only by injections of blood or blood products. It is now known to be present in all body fluids and easily transmissible by household and sexual contact, perinatal spread from mother to newborn, and between toddlers. However, it is not spread by the oral–fecal route.

Hepatitis B virus is endemic worldwide and is especially prevalent in developing countries. Carrier status with persistent viremia varies from <1% of adults in North America to 20% in some parts of the world. Carriers have detectable levels of HBsAg, the surface antigen (i.e., Australian antigen), in their blood. High risk groups in developed countries include intravenous drug users, homosexual men, persons with high numbers of sexual partners, those receiving tattoos, body piercing or acupuncture treatments, and residents or staff of institutions such as group homes and prisons. Immunocompromised and hemodialysis patients are commonly carriers of HBV. HBV may also be spread in a health system by use of inadequately sterilized reusable syringes, as in China and the former Soviet Union. Transmission is reduced by screening blood and blood products for HBsAg and strict technique for handling blood and body fluids in health settings.

HBV is clinically recognizable in less than 10% of infected children but is apparent in 30–50% of infected adults. Clinically HBV has an insidious onset with anorexia, abdominal discomfort, nausea, vomiting, and jaundice. The disease can vary in severity from subclinical, very mild to fulminating liver necrosis, and death. It is a major cause of primary liver cancer, chronic liver disease, and liver failure, all devastating to health and expensive to treat.

Hepatitis B virus is considered to be the cause of 60% of primary cancer of the liver in the world and the most common carcinogen after cigarette smoking. The WHO estimates that more than 2 billion people alive today have been infected with HBV. It is also estimated that 350 million persons are chronic carriers of HBV, with an estimated 1–1.5 million deaths per year from cirrhosis or primary liver cancer. This makes hepatitis B control a vital issue in the revision of health priorities in many countries.

Strict discipline in blood banks and testing of all blood donations for HBV, as well as HIV, and hepatitis C, is mandatory, with destruction of those with positive tests. Contacts should be immunized following exposure with HBV immunoglobulin and HBV vaccine. The inexpensive recombinant HBV vaccine should be adopted by all countries and included in routine vaccination of infants. Catch-up
immunization for older children is also desirable. Immunization programs should include those exposed at work, such as health, prison, or sex workers and adults in group settings. HBV immunization has been included in WHO's EPI-PLUS expanded program of immunization.

**Hepatitis C.** First identified in 1989, and previously known as non-A, non-B hepatitis, hepatitis C (HCV) has an insidious onset with jaundice, fatigue, abdominal pain, nausea, and vomiting. It may cause mild to moderate illness, but chronicity is common going on to cirrhosis and liver failure. The CDC estimates that 4 million Americans are chronically infected with HCV, with 8000–10,000 resulting deaths per annum, and the main cause of liver transplants. HCV is transmitted most commonly in blood products, but also among injecting drug users (90% of intravenous drug users were HCV positive in a Vancouver study in 1998), and is also a risk for health workers. The disease may also occur in dialysis centers and other medical situations. Person-to-person spread is unclear. Prevention of transmission includes routine testing of blood donations, antiviral treatment of blood products, needle exchange programs, and hygiene. The WHO in 1998 has declared hepatitis prevention as a major public health crisis, with an estimated 170 million persons infected worldwide (1996), stressing that this "silent epidemic" is being neglected and that screening of blood products is vital to reduce transmission of this disease as for HIV. HCV is a major cause of chronic cirrhosis and liver cancer. No vaccine is available at present, but an experimental vaccine is undergoing field trials. Interferon and ribavirin treatment is reportedly effective in 40% of cases.

**Hepatitis D.** Hepatitis D virus (HDV) also known as Delta hepatitis, may be self-limiting or progress to chronic hepatitis. It is caused by a viruslike particle which infects cells along with HBV as a coinfection or in chronic carriers of HBV. HDV occurs worldwide in the same groups at risk for HBV. It also occurs in epidemics and is endemic in South America, Africa, and among drug users. Prevention is by measures similar to those for HBV. Management for HDV is by passive immunity with immunoglobulin for contacts and high risk groups, and should include HBV vaccination as the diseases often coincide. There is currently no vaccine for HDV.

**Hepatitis E.** Hepatitis E virus has an epidemiological and clinical course similar to that of HAV. There is no evidence of a chronic form of HEV. One striking characteristic of HEV is its high mortality rate among pregnant women. The disease is caused by a viruslike particle with an incubation period of 15–64 days and is most common in young adults. Sporadic cases as well as epidemics have been identified in India, Pakistan, Burma, China, Russia, Mexico, and North Africa. HEV results from waterborne epidemics or as sporadic cases in areas with poor hygiene, spread via the oral–fecal route. It is a hazard in disaster situations with crowding and poor sanitary conditions. Prevention is by safe management of water supplies and sanitation. Disease management is supportive care; passive immunization is not helpful and no vaccine is currently available.
4. Communicable Diseases

*Haemophilus influenzae* type b. *Haemophilus influenzae* type b (Hib) is a bacteria which causes meningitis and other serious infections in children under 18 months of age. Before the introduction of effective vaccines, as many as 1 in 200 children developed invasive Hib infection. Two-thirds of these had Hib meningitis, with a case fatality rate of 2–5%. Long-term sequelae such as hearing impairment and neurological deficits occurred in 15–30% of survivors.

The first Hib vaccine was licensed in 1985, based on capsular material from the bacteria. Extensive clinical trials in Finland demonstrated a high degree of efficacy, but less impressive results were seen in postmarketing efficacy studies. By 1989, a conjugate vaccine based on an additional protein cell capsular factor capable of enhancing the immunologic response was introduced. Several conjugate vaccines are now available.

The conjugate vaccines are now combined with DPT as their schedule is simultaneous with that of the DPT. Although the Hib vaccine has been found to be cost-effective, despite initially being as costly as all the basic vaccines combined (i.e., DPT, OPV, MMR, and HBV). For this reason, its use thus far has been limited to industrialized countries. The vaccine is a valuable addition to the immunologic armamentarium. It showed dramatic results in local eradication of this serious early childhood infection in a number of European countries and a sharp reduction in the United States.

Impressive field trials in the Gambia showed a sharp reduction in mortality from invasive streptococcal diseases. The price of the vaccine has also fallen dramatically since the mid 1990s. As a result, in 1997, the World Health Organization recommended inclusion of Hib vaccine in routine immunization programs in developing countries.

*Influenza.* Influenza is an acute viral respiratory illness characterized by fever, headache, myalgia, prostration, and cough. Transmission is rapid by close contact with infected individuals and by airborne particles with an incubation period of 1–5 days. It is generally mild and self-limited with recovery in 2–7 days. However, in certain population groups, such as the elderly and chronically ill, infection can lead to severe sequelae. Gastrointestinal symptoms commonly occur in children. During epidemics, mortality rates from respiratory diseases increase because of the large numbers of persons affected, although the case fatality rates are generally low.

Over the past century, influenza pandemics have occurred in 1889, 1918, 1957, and 1968, while epidemics are annual events. The influenza pandemic of 1918 caused millions of deaths among young adults, by some estimates killing more than had died in World War I. It was the fear of recurrence of this pandemic which led the CDC to launch a massive immunization program in the United States in 1976 to prevent swine flu (the virus was a strain antigenically similar to that of the 1918 pandemic influenza) from spreading from an isolated outbreak in an army camp. The effort was stopped after millions of persons were immunized with an urgently produced vaccine when serious reactions occurred (Guillain-Barre Syndrome, i.e., a type of paralysis), and when no further cases of swine flu were seen. This demonstrated the difficulty of extrapolating scenarios from a historical experience.
Each year, epidemiologic services of the WHO and collaborating centers such as the CDC recommend which strains should be used in vaccine preparation for use among susceptible population groups. These vaccines are prepared with the current anticipated epidemic strains. The three main types of influenza (A, B, and C) have different epidemiological characteristics. Type A and its subtypes, which are subject to antigenic shift, are associated with widespread epidemics and pandemics. Type B undergoes antigenic drift and is associated with less widespread epidemics. Influenza Type C is even more localized.

Active immunization against the prevailing wild strain of influenza virus produces a 70–80% level of protection in high risk groups. The benefits of annual immunization outweigh the costs, and it has proven to be effective in reducing cases of influenza and its secondary complications such as pneumonia and death from respiratory complications in high-risk groups.

**Pneumococcal Disease.** Pneumococcal diseases, which are caused by *Streptococcus pneumoniae*, include pneumonia, meningitis, and otitis media. The 23 capsular types of pneumococci selected out of 83 known types of the organism for the vaccine are those responsible for 88% of pneumococcal pneumonia cases and 10–25% of all pneumonia cases in the United States, and are responsible for some 40,000 deaths per year.

This vaccine has been found to be cost-effective for high risk groups, including persons with chronic disease, HIV carriers, patients whose spleens were removed, the elderly, and those with immunosuppressive conditions. It should be included in preventive-oriented health programs, especially for long-term care of the...
4. COMMUNICABLE DISEASES

BOX 4.7 RISK GROUPS RECOMMENDED FOR PNEUMOCOCCAL VACCINE

Given once to the following categories of persons at high risk:

1. People over 65 years of age;
2. The chronically ill, e.g., with cardiovascular, respiratory, liver, renal disease, diabetes mellitus, renal disease, cancer, sickle cell disease, or cirrhosis;
3. Asplenic patients;
4. Adult immunocompromised patients, including HIV positive persons;
5. Children 2 years or older who are chronically ill, or immunocompromised;
6. Persons traveling abroad.

Source: Cassens, B. 1992. Preventive Medicine and Public Health, Second Edition. Malvern, PA: Harwal Co., p. 95.

chronically ill. Because pneumococci cause bacterial meningitis, pneumococcal vaccine may be a future candidate for use in routine immunization programs for children (over age 2).

Varicella (Chicken Pox, Shingles, Herpes Zoster). Varicella is an acute, generalized virus disease caused by the varicella zoster virus (VZV). Despite its reputation as an innocuous disease of childhood, varicella patients can be quite ill. A mild fever and characteristic generalized red rash lasts for a few hours, followed by vesicles occurring in successive crops over various areas of the body. Affected areas may include the membranes of the eyes, mouth, and respiratory tract. The disease may be so mild as to escape observation or may be quite severe, especially in adults. Death can occur from viral pneumonia in adults and sepsis or encephalitis in children. Neonates whose mothers develop the disease within 2 days of delivery are at increased risk with a case fatality rate of up to 30%.

Long-term sequelae include herpes zoster or shingles with a severely painful, vesicular rash along the distribution of sensory nerves, which can last for months. Its occurrence increases with age and it is primarily seen in the elderly. It can, however, occur in immunocompromised children (especially those on cancer chemotherapy), AIDS patients, and others. Some 15% of a population will experience herpes zoster during their lifetimes. Reye’s syndrome is an increasingly rare but serious complication from varicella or influenza B. It occurs in children and affects the liver and central nervous system. Congenital varicella syndrome with birth defects similar to congenital rubella syndrome has been identified recently. Varicella vaccine is now recommended for routine immunization at age 12–18
months in the United States, with catch-up for children up to age 13 years and for occupationally exposed persons in health or child care settings. Varicella vaccine is also recommended for nonpregnant women of child bearing years. Cost–benefit studies indicate a 1:5 ratio if both direct and indirect costs are included (see Chapter 11). Varicella vaccine is likely to be added to a “cocktail vaccine” containing DPT, polio (IPV), and Hib.

**Meningococcal Meningitis.** Meningococcal meningitis, caused by the bacterium *Neisseria meningitides*, is characterized by headache, fever, neck stiffness, delirium, coma, and/or convulsions. The incubation period is 2–10 days. It has a case fatality rate of 5–15% if treated early and adequately, but rises up to 50% in the absence of treatment. There are several important strains (A, B, C, X, Y, and Z). Serogroups A and C are the main causes of epidemics, with B causing sporadic cases and local outbreaks. Transmission is by direct contact and droplet spread.

Meningitis (group A) is common in sub-Saharan African countries, but epidemics have occurred worldwide. During epidemics, children, teenagers, and young adults are the most severely affected. In developed countries, outbreaks occur most frequently in military and student populations. In 1997, meningococcal meningitis spread widely in the “meningitis belt” in Central Africa.

Epidemic control is achieved by mass chemoprophylaxis with antibiotics (e.g., rifampin or sulfa drugs) among case contacts, although the emergence of resistant strains is a concern. Vaccines against serotypes A and C (bivalent) or A, C, W, and Y are available. Their use is effective in epidemic control and prevention institutions and military recruits, especially for A and C serogroups.

**ESSENTIALS OF AN IMMUNIZATION PROGRAM**

Vaccination is one of the key modalities of primary prevention. Immunization is cost-effective and prevents wide-scale disease and death, with high levels of safety. Despite the general consensus in public health regarding the central role of vaccination, there are many areas of controversy and unfulfilled expectations.

A vaccination program should aim at 95% coverage at appropriate times, including infants, school children, and adults. Immunization policy should be adapted from current international standards applying the best available program to national circumstances and financial capacities (Table 4.6). Public health personnel with expertise in vaccine-preventable disease control are needed to advise ministries of health and the practicing pediatric community on current issues in vaccination and to monitor implementation and evolution of control programs. Controversies and changing views are common to immunization policy, so that discussions must be conducted on a continuing basis. Policy should be under continuing review by a ministerially appointed national immunization advisory committee, including professionals from public health, academia, immunology, laboratory sciences, economics, and relevant clinical fields.
### TABLE 4.6 Recommended Childhood Immunization Schedule, United States, 1999

| Vaccine     | Birth | 1 mo | 2 mo | 4 mo | 6 mo | 12 mo | 15–18 mo | 4–6 yrs | 11–12 yrs | 14–16 yrs |
|-------------|-------|------|------|------|------|-------|----------|---------|------------|-----------|
| Hepatitis B | Hep B1 |      |      |      |      |       |          |         |            |           |
| DPT/DTaP    |       | Hep B2 | DPT1 | DPT2 | DPT3 | DPT4  |          |         |            |           |
| Hib         | Hib1  | DPT1  | Hib2 | Hib3 |      | Hib4  |          |         |            |           |
| Hib         | Hib1  | DPT1  | Hib2 | Hib3 |      | Hib4  |          |         |            |           |
| Poliovirus  | IPV1  | DPT1  | IPV2 |      |      | OPV1  |          |         |            |           |
| MMR         |       |       |      |      |      | MMR1  |          |         |            |           |
| Varicella   | Rv1   | Rv2   | Rv3  |      |      |       |          |         |            |           |
| Rotavirus   |       |       |      |      |      |       |          |         |            |           |
|             |       |       |      |      |      |       |          |         |            |           |

Source: Center for Disease Control, 1999. Recommended childhood immunization schedule—United States, 1999. *Morbidity and Mortality Weekly Report*, 48:12–16.

*OPV, Oral polio vaccine; IPV, inactivated polio vaccine; DPT or DPaT, diphteria, pertussis, tetanus; preferably the acellular preparation (DTaP) and tetanus toxoid (DPT4 can be given at age 12 months if 6 months elapsed since previous DPT); Td, Diphteria and tetanus; MMR, measles, mumps, rebella; Hep B, hepatitis B; Hib, Haemophilus influenzae type b; Var, varicella zoster virus; RV, rotavirus; #, for those who are not immunized in infancy.

*During 1999, the recommendation for polio virus was changed to 3 doses of IPV in infancy.*

Vaccine supply should be adequate and continuous. Supplies should be ordered from known manufacturers meeting international standards of good manufacturing practice. All batches should be tested for safety and efficacy prior to release for use. There should be an adequate and continuously monitored cold chain to protect against high temperatures for heat labile vaccines, sera, and other active biological preparations. The cold chain should include all stages of storage, transport, and maintenance at the site of usage. Only disposable syringes should be used in vaccination programs to prevent any possible transmission of blood-borne infection.

A vaccination program depends on a readily available service with no barriers or unnecessary prerequisites, free to parents or with a minimum fee, to administer vaccines in disposable syringes by properly trained individuals using patient-oriented and community-oriented approaches. Ongoing education and training on current immunization practices are needed. Incentive payments by insuring agency or managed care systems promote complete, on-time coverage. All clinical encounters should be used to screen, immunize, and educate parents/guardians.

Contraindications to vaccination are very few; vaccines may be given even during mild illness with or without fever, during antibiotic therapy, during convalescence from illness, following recent exposure to an infectious disease, and to persons having a history of mild/moderate local reactions, convulsions, or family history of sudden infant death syndrome (SIDS). Simultaneous administration of vaccines and vaccine “cocktails” reduces the number of visits and thereby improves coverage; there are no known interferences between vaccine antigens.
Accurate and complete recording with computerization of records with automatic reminders helps promote compliance, as does co-scheduling of immunization appointments with other services. Adverse events should be reported promptly, accurately, and completely. A tracking system should operate with reminders of upcoming or overdue immunizations; use mail, telephone, and home visits, especially for high risk families, with semiannual audits to assess coverage and review patient records in the population served to determine the percentage of children covered by second birthday. Tracking should identify children needing completion of the immunization schedule and assess the quality of documentation. It is important to maintain up-to-date, easily retrievable medical protocols where vaccines are administered, noting vaccine dosage, contraindications, and management of adverse events.

All health care providers and managers should be trained in education, promotion, and management of immunization policy. Health education should target parents as well as the general public. Monitoring of vaccines used and children immunized, individually and by category of vaccination can be facilitated by computerization of immunization records, or regular manual review of child care records. Where immunization is done by physicians in private practice, as in the United States, determination of coverage is by periodic surveys.

Regulation of Vaccines

Inspection of vaccines for safety, purity, potency, and standards is part of the regulatory function. Vaccines are defined as biological products and are therefore subject to regulation by national health authorities. In the United States, this comes under the legislative authority of the Public Health Service Act, as well as the Food, Drug and Cosmetics Act, with applicable regulations in the Code of Federal Regulations. The federal agency empowered to carry out this regulatory function is the Center for Drugs and Biologics of the Federal Food and Drug Administration.

Litigation regarding adverse effects of vaccines led to inflation of legal costs and efforts to limit court settlements. The U.S. federal government enacted the Child Vaccine Injury Act of 1988. This legislation requires providers to document vaccines given and to report on complications or reactions. It was intended to pay benefits to persons injured by vaccines faster and by means of a less expensive procedure than a civil suit for resolving claims. Using this no-fault system, petitioners do not need to prove that manufacturers or vaccine givers were at fault. They must only prove that the vaccine is related to the injury in order to receive compensation. The vaccines covered by this legislation include DTP, MMR, OPV, and IPV.

Vaccine Development

Development of vaccines from Jenner in eighteenth century to the advent of recombinant hepatitis B vaccine in 1987, and of vaccines for acellular pertussis, varicella, hepatitis A, and rotavirus in the 1990s, has provided one of the pillars of public health and led to enormous savings of human life. Vaccines for viral in-
fections in humans for HIV, respiratory syncytial virus, papilloma, Epstein-Barr virus, dengue fever, and hantavirus are under intense research with genetic approaches using recombinant techniques. The potential for the future of vaccines will be greatly influenced by scientific advances in genetic engineering, with potential for development of vaccines attached to bacteria or protein in plants, which may be given in combination for an increasing range of organisms or their harmful products.

Recombinant DNA technology has revolutionized basic and biomedical research since the 1970s. The industry of biotechnology has produced important diagnostic tests, such as for HIV, with great potential for vaccine development. Traditional whole organism vaccines, alive or killed, may contain toxic products that may cause mild to severe reactions. Subunit vaccines are prepared from components of a whole organism. This avoids the use of live organisms that can cause the disease or create toxic products which cause reactions. Subunit vaccines traditionally prepared by inactivation of partially purified toxins are costly, difficult to prepare, and weakly immunogenic. Recombinant techniques are an important development for production of new whole cell or subunit vaccines that are safe, inexpensive, and more productive of antibodies than other approaches. Their potential contribution to the future of immunology is enormous.

Molecular biology and genetic engineering have made it feasible to create new, improved, and less costly vaccines. New vaccines should be inexpensive, easily administered, capable of being stored and transported without refrigeration, and given orally. The search for inexpensive and effective vaccines for groups of viruses causing diarrheal diseases led to development of the rotavirus vaccine. Some “edible” research focuses on the genetic programming of plants to produce vaccines and DNA. Vaccine manufacturers, who spend huge sums of money and years of research on new products, tend to work on those which will bring great financial rewards for the company and are critical to the local health care community. This has led to less effort being made in developing vaccines for diseases such as malaria. Yet industry plays a crucial role for continued progress in the field.

CONTROL/ERADICATION OF INFECTIOUS DISEASES

Since the eradication of smallpox, much attention has focused on the possibility of similarly eradicating other diseases, and a list of potential candidates has emerged. Some of these have been abandoned because of practical difficulties with current technology. Diseases that have been under discussion for eradication have included measles, TB, and some tropical diseases, such as malaria and dracunculiasis. Eradication is defined as the achievement of a situation whereby no further cases of a disease occur anywhere and continued control measures are unnecessary. Reducing epidemics of infectious diseases, through control and eradication
in selected areas or target groups, can in certain instances achieve eradication of the disease. Local eradication can be achieved where domestic circulation of an organism is interrupted with cases occurring from importation only. This requires a strong, sustained immunization program with adaptation to meet needs of importation of carriers and changing epidemiologic patterns.

**Smallpox**

Smallpox was one of the major pandemic diseases of the Middle Ages and its recorded history goes back to antiquity. Prevention of smallpox was discussed in ancient China by Ho Kung (circa AD 320), and inoculation against the disease was practiced there from the eleventh century AD. Prevention was carried out by nasal inhalation of powdered dried smallpox scabs. Exposure of children to smallpox when the mortality rate was lowest assumed a weakened form of the disease, and it was observed that a person could only have smallpox once in a lifetime. Isolation and quarantine were widely practiced in Europe during the sixteenth and seventeenth centuries.

Variolation was the practice of inoculating youngsters with material from scabs of pustules from mild cases of smallpox in the hope that they would develop a mild form of the disease. Although this practice was associated with substantial mortality, it was widely adopted because mortality from variolation was well below that of smallpox acquired during epidemics. Introduced into England in 1721 (see Chapter 1) it was commonly practiced as a lucrative medical specialty during the eighteenth century. In the 1720s, variolation was also introduced into the American colonies, Russia, and subsequently into Sweden and Denmark.

Despite all efforts, in the early eighteenth century smallpox was a leading cause of death in all age groups. Toward the end of the eighteenth century an estimated 400,000 persons died annually from smallpox in Europe. Vaccination, or the use of cowpox vaccinia virus to protect against smallpox, was initiated late in the eighteenth century. In 1774, a cattle breeder in Yorkshire, England, inoculated his wife and two children with cowpox to protect them during a smallpox epidemic. In 1796, Edward Jenner, an English country general practitioner, experimented with inoculation from a milkmaid’s cowpox pustule to a healthy youngster, who subsequently proved resistant to smallpox by variolation (see Chapter 1). Vaccination, the deliberate inoculation of cowpox material, was slow to be adopted universally, but by 1801, over 100,000 persons in England were vaccinated. Vaccination gathered support in the nineteenth century in military establishments, and in some countries which adopted it universally.

Opposition to vaccination remained strong for nearly a century based on religious grounds, observed failures of vaccination to give lifelong immunity, and because it was seen as an infringement of the state on the rights of the individual. Often the protest was led by medical variolationists whose medical practice and large incomes were threatened by the mass movement to vaccination. Resistance was also offered by “sanitarians” who opposed the germ theory and thought cleanliness was the best method of prevention. Universal vaccination was increasingly
adopted in Europe and America in the early nineteenth century and eradication of smallpox in developed countries was achieved by the mid twentieth century.

In 1958, the Soviet Union proposed to the World Health Assembly a program to eradicate smallpox internationally and subsequently donated 140 million doses of vaccine per year as part of the 250 million needed to promote vaccination of at least 80% of the world population. In 1967, WHO adopted a target for the eradication of smallpox. A program was developed which included a massive increase in coverage to reduce the circulation of the virus through person-to-person contact. Where smallpox was endemic, with a substantial number of unvaccinated persons, the aim of the mass vaccination phase was 80% coverage.

Increasing vaccination coverage in developing countries reduced the disease to periodic and increasingly localized outbreaks. In 1967, 33 countries were considered endemic for smallpox, and another 11 experienced importation of cases. By 1970, the number of endemic countries was down to 17, and by 1973 only 6 countries were still endemic, including India, Pakistan, Bangladesh, and Nepal. In these countries, a new strategy was needed, based on a search for cases and vaccination of all contacts, working with a case incidence below 5 per 100,000. The program then moved into the consolidation phase, with emphasis on vaccination of newborns and new arrivals. Surveillance and case detection were improved with case contact or risk group vaccination. The maintenance phase began when surveillance and reporting were switched to the national or regional health service with intensive follow-up of any suspect case. The mass epidemic era had been controlled by mass vaccination, reducing the total burden of the disease, but eradication required the isolation of individual cases with vaccination of potential contacts.

Technical innovations greatly eased the problems associated with mass vaccination worldwide. During the 1920s, there was wide variation in sources of smallpox vaccine. In the 1930s, efforts to standardize and further attenuate the strains used reduced complication rates from vaccinations. The development of lyophilization (freeze-drying) of the vaccine in England in the 1950s made a heat-stable vaccine that could be effective in tropical field conditions in developing countries. The invention of the bifurcated needle (Bernard Rubin 1961) allowed for easier and more widespread vaccination by lesser trained personnel in remote areas. The net result of these innovations was increased world coverage and a reduction in the spread of the disease. Smallpox became more and more confined by increasing herd immunity, thus allowing transition to the phase of monitoring and isolation of individual cases.

In 1977 the last case of smallpox was identified in Somalia, and in 1980 the WHO declared the disease eradicated. No subsequent cases have been found except for several associated with a laboratory accident in the United Kingdom in 1978. The WHO recommends that the last stores of smallpox virus should be destroyed in 1999. The cost of the eradication program was $112 million or $8 million per year. Worldwide savings are estimated at $1 billion annually. This monumental public health achievement set the precedent for eradication of other infectious diseases. The World Health Assembly decided to destroy the last two
remaining stocks of the smallpox virus in Atlanta and Moscow in 1999. Destruction of the remaining stock was delayed in 1999 to 2002 because of concern that illegal stocks may be held by some states or potential bioterrorists for potential use in weapons of mass destruction, concern regarding the appearance of monkeypox and a wish to use the virus for further research.

**Eradication of Poliomyelitis**

In 1988, the WHO established a target of eradication of poliomyelitis by the year 2000. Global immunization coverage with three doses of OPV increased from some 45% in 1984 to over 80% in 1990, with a slight decline in the period 1991–1993. Support from member countries and international agencies such as UNICEF and Rotary International has led to widespread increases in immunization coverage throughout many parts of the world. The World Health Organization promotes use of OPV only as part of routine infant immunization or National Immunization Days (NIDs). This strategy has been successful in the Americas and in China, but India and the Middle East remain problematic. Eradication of wild poliomyelitis by the year 2000 will require flexibility in vaccination strategies and may require the combined approach, using OPV and IPV, as adopted in the United States in 1997 to prevent vaccine-associated clinical cases. The combination of OPV and IPV may be needed where enteric disease is common and leads to interference in OPV uptake, especially in tropical areas where endemic poliovirus and diarrheal diseases are still found. The World Bank estimated that achievement of global eradication would save $300 million annually in the United States alone.

**Other Candidates for Eradication**

Since the eradication of smallpox, discussion has focused on the possibility of similarly eradicating other diseases, and a list of potential candidates has emerged. Some of these have been abandoned because of practical difficulties with current technology. Diseases that have been under discussion for eradication have included measles, TB, and tropical diseases such as malaria and dracunculiasis.

Eradication of malaria was thought to be possible in the 1950s when major gains were seen in malaria control by aggressive case environmental control, case finding, and management. However, lack of sustained vector control and an effective vaccine has prevented global eradication. Malaria control suffered serious setbacks because of failure in political resolve and capacity to continue support needed for necessary programs. In the 1960s and 1970s, control efforts were not sustained in many countries, and a dreadful comeback of the disease occurred in Africa and Asia in the 1980s. The emergence of mosquitoes resistant to insecticides, and malarial strains resistant to antimalarial drugs, have made malaria control even more difficult and expensive.

Renewed effort in malaria control may require new approaches. Use of community health workers (CHWs) in small villages in highly endemic regions of Colombia resulted in a major drop in malaria mortality during the 1990s. The CHWs investigate suspect cases by taking clinical histories and blood smears.
They examine smears for malaria parasites and a diagnosis is made. Therapy is instituted and the patient is followed. Quality control monitoring shows high levels of accuracy in reading of slides compared to professional laboratories.

In the late 1970s, there was widespread discussion in the literature of the potential for eradication of measles and TB. Measles eradication was set back as breakthrough epidemics occurred in the United States, Canada, and many other countries during the 1980s and early 1990s, but regional eradication was achieved combining the two-dose policy with catch-up campaigns for older children or in National Immunization Days, as in the Caribbean countries.

Tuberculosis has also increased in the United States and several European countries for the first time in many decades. Unrealistic expectations can lead to inappropriate assessments and policy when confounding factors alter the epidemiologic course of events. Such is the case with TB, where control and eradication have receded from the picture. This deadly disease has returned to developed countries, partly in association with the HIV infection and multiple-drug-resistant strains, as well as homelessness, rising prison populations, poverty, and other deleterious social conditions. Directly observed therapy is an important recent breakthrough, more effective in use of available technology and will play a major role in TB control in the twenty-first century.
Future Candidates for Eradication

A decade after the eradication of smallpox was achieved, the International Task Force for Disease Eradication (ITFDE) was established to systematically evaluate the potential for global eradicability of candidate diseases. Its goals were to identify specific barriers to the eradication of these diseases that might be surmountable and to promote eradication efforts.

The subject of eradication versus control of infectious diseases is of central public health importance as technology expands the armamentarium of immunization and vector control into the twenty-first century. The control of epidemics, followed by interruption of transmission and ultimately eradication, will save countless lives and prevent serious damage to children throughout the world. The smallpox achievement, momentous in itself, points to the potential for the eradication of other deadly diseases. The skillful use of existing and new technology is an important priority in the New Public Health. Flexibility and adaptability are as vital as resources and personnel.

| Organism       | Control—Elimination as a Public Health Problem | Eradicable—Regional/Global |
|----------------|-----------------------------------------------|-----------------------------|
| Bacterial diseases | Pertussis, Neonatal tetanus, Congenital syphilis, Trachoma, Tuberculosis, Leprosy | Diphtheria, Haemophilus influenzae b |
| Viral disease   | Hepatitis B, Hepatitis A, Yellow fever, Rabies, Japanese encephalitis | Poliomyelitis, Measles, Rubella, Mumps |
| Parasitic disease | Onchocerciasis, Malaria, Helminthic infestation, Schistosomiasis, Leichmaniasis, visceral | Dracunculiasis, Chagas' disease, Filariasis, Echinococcus, Taeniasis |
| Noninfectious disease | Lead poisoning, Silicosis, Protein energy malnutrition, Micronutrient malnutrition, Iodine deficiency, Vitamin A deficiency, Folic acid deficiency, Iron deficiency |

Source: Goodman RA, Foster KL, Trowbridge FL, Figuero JP (eds). 1998. Global Disease Elimination and Eradication as Public Health Strategies: Proceedings of a Conference Held in Atlanta, Georgia, USA, 23–25 February 1998. Bulletin of the World Health Organization, 76 (Supplement 2):1–161.
Selecting diseases for eradication is not purely a professional issue of resources such as vaccines and manpower, organization and financing. It is also a matter of political will and perception of the burden of disease. There will be many controversies. The selection of polio for eradication while deferring measles when polio kills few and measles kills many may be questioned. The CDC published criteria for selection of disease for eradication are shown in Box 4.8.

The WHO, in a 1998 review of health targets in the field of infectious disease control for the twenty-first century, selected the following targets: eradication of Chagas' disease by 2010; eradication of neonatal tetanus by 2010; eradication of leprosy by 2010; eradication of measles by 2020; eradication of trachoma by 2020; reversing the current trend of increasing tuberculosis and HIV/AIDS.

In 1998, a conference in Atlanta, Georgia, reviewed the subject, which is still very much in a state of flux. Table 4.7 summarizes the selection of diseases which are presently seen as controllable and those considered to be potentially eradicable. The subject will be under review in the years ahead.

**TUBERCULOSIS**

Tuberculosis (TB) is caused by a group of organisms including *Mycobacterium tuberculosis* in humans and *M. bovis* in cattle. The disease is primarily found in humans, but it is also a disease of cattle and occasionally other primates in certain regions of the world. It is transmitted via airborne droplet nuclei from persons with pulmonary or laryngeal TB during coughing, sneezing, talking, or singing. The initial infection may go unnoticed, but tuberculin sensitivity appears within a few weeks. About 95% of those infected enter a latent phase with a lifelong risk of reactivation. Approximately 5% go from initial infection to pulmonary TB. Less commonly, the infection develops as extrapulmonary TB, involving meninges, lymph nodes, pleura, pericardium, bones, kidneys, or other organs.

Untreated, about half of the patients with active TB will die of the disease within 2 years, but modern chemotherapy almost always results in a cure. Pulmonary TB symptoms include cough and weight loss, with clinical findings on chest examination and confirmation by findings of tubercle bacilli in stained smears of sputum and, if possible, growth of the organism on culture media, and changes in the chest X-ray. Tuberculosis affects people in their adult working years, with 80–90% of cases in persons between the ages of 15 and 49. Its devastating effects on the work force and economic development contribute to a high cost-effectiveness for TB control.

The tubercle bacillus infects approximately 1.7 billion people in the world today, causing over 7 million cases and nearly 3 million deaths in 1997. During 1995, new cases of TB included 2.8 million (40%) in southeast Asia and the western Pacific regions of WHO, with 2.3 million cases in India, and 0.5 million in Indonesia. By 2005, the incidence of TB may increase to 11.9 million new cases per year, a 58% increase over 1990. Between 1990 and 1999, WHO estimates there were
88 million new cases of TB, of which 8 million cases were in association with HIV infection. During the 1990s, an estimated 30 million persons died of TB, including 2.9 million with HIV infection.

A new and dangerous period for TB resurgence has resulted from parallel epidemiologic events: first, the advent of HIV infection and second, the occurrence of multiple drug resistant TB (MDRTB), that is, organisms resistant at least to both Isoniazid (INH) and rifampicin, two mainstays of TB treatment. MDRTB can have a case fatality rate as high as 70%. HIV reduces cellular immunity so that people with latent TB have a high risk of activation of the disease. It is estimated that HIV negative persons have a 5–10% lifetime risk of TB; HIV positive people have a risk of 10% per year of developing clinical tuberculosis.

Drug resistance, the long period of treatment, and the socioeconomic profile of most TB patients combine to require a new approach to therapy. Directly observed treatment, short-course (DOTS), has shown itself to be highly effective with patients in poor self-care settings, such as the homeless, drug users, and those with AIDS. The strategy of DOTS uses community health workers to visit the patient and observes him or her taking the various medications, providing both incentive, support, and moral coercion to complete the needed 6 to 8 month therapy. DOTS has been shown to cure up to 95% of cases, at a cost of as little as $11 per patient. It is one of the few hopes of containing the TB pandemic.

In 1994, WHO released a new strategy for control of tuberculosis over the next decade. The plan calls for new guidelines for control, new aid funds for developing countries, and enlistment of NGOs to assist in the fight. The new guidelines stress short-term chemotherapy in well-managed programs of DOTS, stressing strict compliance with therapy for infectious cases with a goal of an 85% cure rate. Even under adverse conditions, DOTS produces excellent results. It is one of the most cost-effective health interventions combining public health and clinical medical approaches.

Tuberculosis incidence in the United States decreased steadily until 1985, increased in 1990, and has declined again since. From 1986 to 1992, there was an excess of 51,600 cases over the expected rate if the previous decline in case incidence had continued. This rise was largely due to the HIV/AIDS epidemic and the emergence of MDRTB, but also greater incidence among immigrants from areas of higher TB incidence, drug abusers, the homeless, and those with limited access to health care. This is particularly true in New York City, where MDRTB has appeared in outbreaks among prison inmates and hospital staff.

From 1992 to 1997, TB incidence in the United States declined by 26% and in some states, including New York, by 50% or more. This turnaround was due to stronger TB control programs that promptly identified persons with TB and initiated and ensured completion of appropriate therapy. Aggressive staff training, outreach, and case management approaches were vital to this success. Concern over rising rates among recent immigrants and the continued challenge of HIV/AIDS and coincidental transmission of hepatitis A, B, and C among drug users and marginal population groups show that continued support for TB control is needed.

Bacillus Calmette-Guérin (BCG) is an attenuated strain of the tubercle bacillus
used widely as a vaccination to prevent TB, especially in high incidence areas. It induces tuberculin sensitivity or an antigen–antibody reaction in which antibodies produced may be somewhat protective against the tubercle bacillus in 90% of vaccinees. Although the support for its general use is contradictory, there is evidence from case–control and contact studies of positive protection against TB meningitis and disseminated TB in children under the age of 5. In some developed, low-incidence countries, it is not used routinely but selectively. It may also be used in asymptomatic HIV-positive persons or other high risk groups.

The BCG vaccine for tuberculosis remains controversial. While used widely internationally, in the United States and other industrialized countries, it is thought to hinder rather than help in the fight against TB. This concern is based on the usefulness of tuberculin testing for diagnosis of the disease. Where BCG has been administered, the diagnostic value of tuberculin testing is reduced, especially in the period soon after the BCG is used. Studies showing equivocal benefit of BCG in preventing tuberculosis have added to the controversy. While those in the field in the United States continue to oppose the use of BCG, internationally it is still felt to be of benefit in preventing TB, primarily in children.

A 1994 metaanalysis of the literature of BCG carried out by the Technology Assessment Group at Harvard School of Public Health concluded:

On average, BCG vaccine significantly reduces the risk of TB by 50%. Protection is observed across many populations, study designs, and forms of TB. Age at vaccination did not enhance predictiveness of BCG efficacy. Protection against tuberculous death, meningitis, and disseminated disease is higher than for total TB cases, although this result may reflect reduced error in disease classification rather than greater BCG efficacy. [Colditz et al., JAMA, 1994.]

**Box 4.9 CONTROL OF TUBERCULOSIS**

1. Identifying persons with clinically active TB;
2. Diagnostic methods—clinical suspicion, sputum smear for bacteriologic examination, tuberculin skin testing, chest radiograph;
3. Case finding and investigation programs in high risk groups;
4. Contact investigation;
5. Isolation techniques during initial therapy;
6. Treatment, mainly ambulatory, of persons with clinically active TB;
7. Treatment of contacts;
8. Directly observed treatment, short-course (DOTS), where compliance suspect;
9. Environmental control in treatment settings to reduce droplet infection;
10. Educate health care providers on suspicion of TB and investigation of suspects.
Currently, the WHO recommends use of BCG as close to birth as possible as part of the Expanded Programme of Immunization (EPI).

Tuberculosis control remains feasible with current medical and public health methods. Deterioration in its control should not lead to despair and passivity. The recent trend to successful control by DOTS despite the growing problem of MDRTB suggest that control and gradual reduction can be achieved by an activist, community outreach approach. The WHO in 1999 made TB control one of its major priorities, expressing grave concern that the MDR organism, now widely spread in countries of Asia, eastern Europe, and the former Soviet Union, may spread the disease much more widely. The disease constitutes one of the great challenges to public health at the start of the new century.

**STREPTOCOCCAL DISEASES**

Acute infectious diseases caused by Group A streptococci include streptococcal sore throat, scarlet fever, puerperal fever, septicemia, erysipelas, cellulitis, mastoiditis, otitis media, pneumonia, peritonsillitis (quinsy), wound infections, toxic shock syndrome, and fasciitis, the "flesh eating bacteria." *Streptococcus pyogenes* group A include some 80 serologically distinct types which vary in geographic location and clinical significance. Transmission is by droplet, person-to-person direct contact, or by food infected by carriers. Important complications from a public health point of view include acute rheumatic fever and acute glomerulonephritis, but also skin infections and pneumonia.

Acute rheumatic fever is a complication of strep A infection that has virtually disappeared from industrialized countries as a result of improved standards of living and antibiotic therapy. However, outbreaks were recorded in the United States in 1985, and an increasing number of cases have been seen since 1990. In developing countries, rheumatic fever remains a serious public health problem affecting school age children, particularly those in crowded living arrangements. Long-term sequelae include disease of the mitral and aortic heart valves, which require cardiac care and surgery for repair or replacement with artificial valves.

Acute glomerulonephritis is a reaction to toxins of the streptococcal infection in the kidney tissue. This can result in long-term kidney failure and the need for dialysis or kidney transplantation. This disease has become far less common in the industrialized countries, but remains a public health problem in developing countries.

The streptococcal diseases are controllable by early diagnosis and treatment with antibiotics. This is a major function of primary care systems. Recent increases in rheumatic fever may herald a return of the problem, perhaps due to inadequate access to primary care in the United States for large sectors of the population, along with increased social hygiene problems.

Where access to primary care services is limited, infections with streptococci can result in a heavy burden of chronic heart and kidney disease with substantial health, emotional, and financial tolls. Measures to improve access to care and pub-
lic information are needed to assure rapid and effective care to prevent chronic and costly conditions.

**ZOONOSES**

Zoonoses are infectious diseases transmissible from vertebrate animals to humans. Common examples of zoonoses of public health importance in nonindustrialized countries include brucellosis and rabies. In industrialized countries, salmonellosis, "mad cow disease" and influenza have reinforced the importance of relationships of animal and human health. Strong cooperation between public health and veterinary public health authorities are required to monitor and to prevent such diseases.

**Brucellosis**

Brucellosis is a disease occurring in cattle (*Brucella abortus*), in dogs (*Br. canis*), in goats and sheep (*Br. melitensis*), and in pigs (*Br. suis*). Humans are affected mainly through ingestion of contaminated milk products, by contact, or inhalation. Brucellosis (also known as relapsing, undulant, Malta, or Mediterranean fever) is a systemic bacterial disease of acute or insidious onset characterized by fever, headache, weakness, sweating, chills, arthralgia, depression, weight loss, and generalized malaise. Spread is by contact with tissues, blood, urine, vaginal discharges, but mainly by ingestion of raw milk and dairy products from infected animals. The disease may last from a few days to a year or more. Complications include osteoarthritis and relapses. Case fatality is under 2%, but disability is common and can be pronounced.

The disease is primarily seen in Mediterranean countries, the Middle East, India, central Asia, and in Central and South America. Brucellosis occurs primarily as an occupational disease of persons working with and in contact with tissues, blood, and urine of infected animals, especially goats and sheep. It is an occupational hazard for veterinarians, packinghouse workers, butchers, tanners, and laboratory workers. It is also transmitted to consumers of unpasteurized milk from infected animals. Animal vectors include wild animals, so that eradication is virtually impossible. Diagnosis is confirmed by laboratory findings of the organism in blood or other tissue samples, or with rising antibody titers in the blood, with confirmation by blood cultures.

Clinical cases are treated with antibiotics. Epidemiologic investigation may help track down contaminated animal flocks. Routine immunization of animals, monitoring of animals in high risk areas, quarantining sick animals, destroying infected animals, and pasteurizing milk and milk products prevents spread of the disease. Control measures include educating farmers and the public not to use unpasteurized milk. Individuals who work with animals (cattle, swine, goats, sheep, dogs, coyotes) should take special precautions when handling animal carcasses and materials. Testing animals, destroying carriers, and enforcing mandatory pasteurization will restrict the spread of the disease. This is an economic as well as public
health problem, requiring full cooperation between ministries of health and of agriculture.

**Rabies**

Rabies is primarily a disease of animals, with a variety of wild animals serving as a reservoir for this disease, including foxes, wolves, bats, skunks, and raccoons, who may infect domestic animals such as dogs, cats, and farm animals. Animal bites break the skin or mucous membrane, allowing entry of the virus from the infected saliva into the bloodstream. The incubation period of the virus is 2–8 weeks; it can be as long as several years or as short as 5 days, so that postexposure preventive treatment is a public health emergency.

The clinical disease often begins with a feeling of apprehension, headache, pyrexia, followed by muscle spasms, acute encephalitis, and death. Fear of water ("hydrophobia") or fear of swallowing is a characteristic of the disease. Rabies is almost always fatal within a week of onset of symptoms. The disease is estimated to cause 30,000 deaths annually, primarily in developing countries. It is uncommon in developed countries.

Rabies control focuses on prevention in humans, domestic animals, and wildlife. Prevention in humans is based on preexposure prophylaxis for groups at risk (e.g., veterinarians, zoo workers) and postexposure immunization for persons bitten by potentially rabid animals. Because reducing exposure of pets to wild animals is difficult, immunization of domestic animals is one of the most important preventive measures. Prevention in domestic animals is by mandatory immunization of household pets. All domestic animals should be immunized at age 3 months and revaccinated according to veterinary instructions.

Prevention in wild animals to reduce the reservoir is successful in achieving local eradication in settings where reentry from neighboring settings is limited. Since 1978, the use of oral rabies immunization has been successful in reducing the population of wild animals infected by the rabies virus. Rabies eradication efforts, using aerial distribution of baits containing fox rabies vaccine in affected areas of Belgium, France, Germany, Italy, and Luxembourg, have been underway since 1989. The number of rabies cases in these affected areas has declined by some 70%. Switzerland is now virtually rabies-free because of this vaccination program. The potential exists for focal eradication, especially on islands or in partially restricted areas with limited possibilities of wild animal entry. Livestock need not be routinely immunized against rabies, except in high risk areas. Where bats are major reservoirs of the disease, as in the United States, eradication is not presently feasible.

**Salmonella**

Salmonella, discussed later in this chapter under diarrheal diseases, is one of the commonest of all infectious diseases among animals and is easily spread to humans via poultry, meat, eggs, and dairy products. Specific antigenic types are associated with food-borne transmission to humans, causing generalized illness and gastroenteritis. Severity of the disease varies widely, but the diseases can be devastating among vulnerable population groups, such as young children, the elderly,
and the immunocompromised. Epidemiologic investigation of common food source outbreaks may uncover hazardous food handling practices. Laboratory confirmation or serotypes helps in monitoring the disease. Prevention is by maintaining high standards of food hygiene in processing, inspection and regulation, food handling practices, and hygiene education.

**Anthrax**

_Bacillus anthracis_ causes a bacterial infection in herbivore animals. Its spores contaminate soil, worldwide. It affects humans exposed in occupational settings. Transmission is cutaneous by contact, gastrointestinal by ingestion, or respiratory by inhalation. It has gained recent attention (Iraq, 1997) as a highly potent agent for germ warfare or terrorism. Limited supplies of vaccine are available.

**Creutzfeld-Jakob Disease**

Creutzfeld-Jakob disease is a degenerative disease of the central nervous system linked to consumption of beef from cattle infected with bovine spongiform encephalopathy. It is transmitted by prions in animal feed prepared from contaminated animal material and in transplanted organs. This disease was identified in the United Kingdom linked to infected cattle leading to a 1997 ban on British beef in many parts of the world and slaughter of large numbers of potentially contaminated animals.

**Other Major Zoonotic Diseases**

The tapeworm causing diphyllobothriasis (_Diphyllobothrium latum_) is widespread in North American freshwater fish, passing from crustacean to fish to humans by eating raw freshwater fish. It is especially common among Inuit peoples and may be asymptomatic or cause severe general and abdominal disorder. Food hygiene (freezing and cooking of meat) is recommended; treatment is by anthelminthics.

Leptospiroses are a group of zoonotic bacterial diseases found worldwide in rats, raccoons, and domestic animals. It affects farmers, sewer workers, dairy and abattoir workers, veterinarians, military personnel, and miners with transmission by exposure to or ingestion of urine-contaminated water or tissues of infected animals. It is often asymptomatic or mild, but may cause generalized illness like influenza, meningitis, or encephalitis. Prevention requires education of the public in self protection and immunization of workers in hazardous occupations, along with immunization and segregation of domestic animals and control of wild animals.

**VECTOR-BORNE DISEASES**

Vector-borne diseases are a group of diseases in which the infectious agent is transmitted to humans by crawling or flying insects. The vector is the intermediary between the reservoir and the host. Both the vector and the host may be affected by climatic condition; mosquitoes thrive in warm, wet weather and are
suppressed by cold weather; humans may wear less protective clothing in warm weather.

**Malaria**

The only important reservoir of malaria is humans. Its mode of transmission is from person to person via the bite of an infected female anopheles mosquito (Ronald Ross, Nobel prize, 1902). The causative organism is a single cell parasite with four species: *Plasmodium vivax*, *P. malariae*, *P. falciparum*, and *P. ovale*. Clinical symptoms are produced by the parasite invading and destroying red blood cells. The incubation period of approximately 12–30 days, depending on the specific plasmodium involved. Some strains of *P. vivax* may have a protracted incubation period of 8–10 months and even longer for *P. ovale*. The disease can also be transmitted through infected blood transfusions. Confirmation of diagnosis is by demonstrating malaria parasites on blood smears.

Falciparum malaria, the most serious form, presents with fever, chills, sweats, and headache. It may progress to jaundice, bleeding disorders, shock, renal or liver failure, encephalopathy, coma, and death. Prompt treatment is essential. Case fatality rates in untreated children and adults are above 10%. An untreated attack may last 18 months. Other forms of malaria may present as a nonspecific fever. Relapse of the *P. ovale* may occur up to 5 years after initial infection; malaria may persist in chronic form for up to 50 years.

Malaria control advanced during the 1940s–1960s through improved chloroquine treatment and use of DDT for vector control with optimism for eradication of the disease. However, control regressed in many developing countries as allocations for environmental control and case findings/treatment were reduced. There has also been an increase in drug resistance, so that this disease is now an extremely serious public health problem in many parts of the world. The need for a vaccine for malaria control is now more apparent than ever.

The World Health Organization estimated that, in 1997, sub-Saharan Africa (SSA) had 270 million new malaria cases, with 5% of children up to age 5. Over 1 million deaths occur annually from malaria more than two-thirds of them in SSA. Large areas, particularly in forest or savannah regions with high rainfall, are holoendemic. In higher altitudes, endemicity is lower, but epidemics do occur. Chloroquine-resistant *P. falciparum* has spread throughout Africa, accompanied by an increasing incidence of severe clinical forms of the disease. The World Bank estimates that 11% of all disability-adjusted life years (DALYs) lost per year in SSA are from malaria, which places a heavy economic burden on the health systems.

In the Americas, the number of cases detected has risen every year since 1974, and the WHO estimates there to have been 2.2–2.5 million cases in 1991. The nine most endemic countries in the Americas achieved a 60% reduction in malaria mortality between 1994 and 1997.

Southeast Asian region reports some 3.4 million cases of malaria in 1996 and 8000 deaths from TB. This accounts for more than one-third of all non-African
malaria cases. There is an increase in resistant strains to the major available drugs and of the mosquitoes to insecticides in use.

Vector control, case finding, and treatment remain the mainstay of control. Use of insecticide-impregnated bed nets and curtains, and residual house spraying, and strengthened vector control activities are important, as are early diagnosis and carefully monitored treatment with monitoring for resistance. Control of malaria will ultimately depend on a safe, effective, and inexpensive vaccine. Attempts to develop a malaria vaccine have been unsuccessful to date due to the large number of genetic types of *P. falciparum* even in localized areas. A Colombian-developed vaccine is being field-tested with partial effectiveness. Research in vaccines for malaria has also been hampered by the fact that it is a relatively low priority for vaccine manufacturers because of the minimal potential for financial benefit. Research on malaria concentrates on the pharmacological aspects of the disease because of increasing drug resistance.

In 1998, WHO has initiated a new campaign to “Roll Back Malaria” and maintain the dream of eradication in the future. Effective low technology interventions include community-based case finding, early treatment of good quality, insecticide use, and vector control. The use of community health workers in endemic areas, has shown promising results. Local control and even eradication can be achieved with currently available technology. This requires an integration of public health and clinical approaches with strong political commitment.

**Rickettsial Infections**

The rickettsia are obligate parasites, i.e., they can only replicate in living cells, but otherwise they have characteristics of bacteria. This is a group of clinically similar diseases, usually characterized by severe headache, fever, myalgia, rash, and capillary bleeding causing damage to brain, lungs, kidneys, and heart. Identification is by serological testing for antibodies, but the organisms can also be cultured in laboratory animals, embryonic eggs, or in cell cultures. The organisms are transmitted by arthropod vectors such as lice, fleas, ticks, and mites. The diseases caused millions of deaths during war and famine periods prior to the advent of antibiotics.

These diseases appear in nature in ways that make them impossible to eradicate, but clinical diagnosis, host protection, and vector control can help reduce the burden of disease and deal with outbreaks that may occur. Public education regarding self-protection, appropriate clothing, tick removal, and localized control measures such as spraying and habitat modification are useful.

Epidemic typhus, first identified in 1836, is due to *Rickettsia prowazekii*. Spread primarily by the body louse, typhus was the cause of an estimated 3 million deaths, i.e., during war and famine, in Poland and the Soviet Union from 1915–1922. Untreated, the fatality rate is 5–40%. Typhus responds well to antibiotics. It is currently largely confined to endemic foci in central Africa, central Asia, eastern Europe, and South America. It is preventable by hygiene and pediculicides such as DDT and lindane. A vaccine is available for exposed laboratory personnel.
Murine typhus is a mild form of typhus due to *Rickettsia typhi*, which is found worldwide and spread in rodent reservoirs. Scrub typhus, also known as Tsutsugamushi or Japanese river fever, is located throughout the Far East and the Pacific islands, and was a serious health problem for U.S. armed forces in the Pacific during World War II. It is spread by the *Rickettsia tsutsugamushi* and has a wide variation in case fatality according to region, organism, and age of patient.

Rocky Mountain spotted fever is a well-known and severe form of tick-borne typhus due to *Rickettsia rickettsii*, occurring in western North America, Europe, and Asia. Q. fever is a tick-borne disease caused by *Coxiella burnetii* and is worldwide in distribution, usually associated with farm workers, in both acute and chronic forms. Regular anti-tick spraying of sheep, cows, and goats helps protect exposed workers. Protective clothing and regular removal of body ticks help protect exposed persons.

**Arboviruses (Arthropod-Borne Viral Diseases)**

Arthropod-borne viral diseases are caused by a diverse group of viruses which are transmitted between vertebrate animals (often farm animals or small rodents) and people by the bite of blood-feeding vectors such as mosquitoes, ticks, and sandflies and by direct contact with infected animal carcasses. Usually the viruses have the capacity to multiply in the salivary glands of the vector, but some are carried mechanically in their mouthparts.

These viruses cause acute central nervous system infections (meningoencephalitis), myocarditis, or undifferentiated viral illnesses with polyarthritis and rashes, or severe hemorrhagic febrile illnesses. Arbovirus diseases are often asymptomatic in vertebrates but may be severe in humans. Over 250 antigenetically distinct arboviruses are associated with disease in humans, varying from benign fevers of short duration to severe hemorrhagic fevers. Each has a specific geographic location, vector, clinical, and virologic characteristics. They are of international public health importance because of the potential for spread via natural phenomena and modern rapid transportation of vectors and persons incubating the disease or ill with it, with potential for further spreading at the point of destination.

**Encephalitides**

Arboviruses are responsible for a large number of encephalitic diseases characterized by mode of transmission and geographic area. Mosquito-borne arboviruses causing encephalitis include Eastern and Western equine, Venezuelan, Japanese, and Murray Hill encephalitides. Japanese encephalitis is caused by a mosquito-borne arbovirus found in Asia and is associated with rice-growing areas. It is characterized by headache, fever, convulsions, and paralysis, with fatality rates in severe cases as high as 60%. A currently available vaccine is used routinely in endemic areas (Japan, Korea, Thailand, India, and Taiwan) and for persons traveling to infected areas. Tick-borne arboviruses causing encephalitis include the Powassan virus, which occurs sporadically in the United States and Canada. Tick-borne encephalitis is endemic in eastern Europe, Scandinavia, and the former Soviet Union. An epidemic of mosquito-borne encephalitis in New York City in 1999
included 54 cases and 6 deaths, due to the West Nile Fever virus, never before found in the United States.

**Rift Valley Fever.** Rift Valley fever (RVF) is a virus spread by mosquitoes and other insect vectors. It affects animals and humans who are in direct contact with the meat or blood of affected animals. The virus causes a generalized illness in humans with encephalitis, hemorrhages, retinitis and retinal hemorrhage leading to partial or total blindness, and death (1–2%). It also causes universal abortion in ewes and a high percentage of death in lambs.

The normal habitat is in the Rift Valley of eastern Africa (the Great Syrian–African Rift), often spreading to southern Africa, depending on climactic conditions. The primary reservoir and vector is the *Aedes* mosquito, and affected animals serve to multiply the virus which is transmitted by other vectors and direct contact with animal fluids to humans.

An unusual spread of RVF northward to the Sudan and along the Aswan Dam reservoir to Egypt in 1977–1978 caused hundreds of thousands of animal deaths, with 18,000 human cases and 598 deaths. RVF appeared again in Egypt in 1993. This disease is suspected to be one of the ten plagues of Egypt leading to the exodus of the Children of Israel from Egypt during pharaonic-biblical times.

In 1997, an outbreak of RVF in Kenya, initially thought to be anthrax, with hundreds of cases and dozens of deaths, was related to abnormal rainy season and vector conditions. Satellite monitoring of rainfall and vegetation is being used to predict epidemics in Kenya and surrounding countries. Animal immunization, monitoring, vector control, and reduced contact with infected animals can limit the spread of this disease.

**Hemorrhagic Fevers**

Arboviruses can also cause hemorrhagic fevers. These are acute febrile illnesses, with extensive hemorrhagic phenomena (internal and external), liver damage, shock, and often high mortality rates. The potential for international transmission is high.

**Yellow Fever.** Yellow fever is an acute viral disease of short duration and varying severity with jaundice. It can progress to liver disease and severe intestinal bleeding. The case fatality rate is <5% in endemic areas, but may be as high as 50% in nonendemic areas and in epidemics. It caused major epidemics in the Americas in the past, but was controlled by elimination of the vector, *Aedes aegypti*. A live attenuated vaccine is used in routine immunization endemic areas and recommended for travelers to infected areas. Determining the mode of transmission and vector control of yellow fever played a major role in the development of public health (see Chapter 1). In 1997, the WHO reported 200,000 cases and 30,000 deaths from yellow fever globally.

**Dengue Hemorrhagic Fever.** Dengue hemorrhagic fever is an acute sudden onset viral disease, with 3–5 days of fever, intense headache, myalgia, arthralgia,
BOX 4.10 DENGUE FEVER AND DENGUE HEMORRHAGIC FEVER, 1996–1997

Dengue fever, a severe influenza-like illness, and dengue hemorrhagic fever are closely related conditions caused by four distinct viruses transmitted by Aedes aegypti mosquitoes. Dengue is the world’s most important mosquito-borne virus disease. A total of 2,500 million people worldwide are at risk of infection. An estimated 20 million cases occur each year, of whom 500,000 need to be hospitalized. This is a spreading problem, especially in cities in tropical and subtropical areas. Major outbreaks were reported in Colombia, Cuba, and many other locations in 1997.

Gastrointestinal disturbance, and rash. Hemorrhagic phenomena can cause case fatality rates of up to 50%. Epidemics can be explosive, but adequate treatment can greatly reduce the number of deaths. Dengue occurs in Southeast Asia, the Pacific islands, Australia, West Africa, the Caribbean, and Central and South America. An epidemic in Cuba in 1981 included more than 500,000 cases, and 158 deaths. Vector control of the A. aegypti mosquito resulted in control of the disease during the 1950s–1970s, but reinestation of mosquitos led to increased transmission and epidemics in the Pacific Islands, Caribbean, Central and South America in the 1980s and 1990s.

Outbreaks in Vietnam included 370,000 cases in 1987, another 116,000 cases in 1990, and a similar sized outbreak in 1997. Indonesia had over 13,000 cases in 1997 with 240 deaths, and in 1998 over 19,000 cases (January–May) with at least 531 deaths. In 1998, epidemics of dengue were reported in Fiji, the Cook Islands, New Caledonia, and northern Australia.

The WHO estimates 140,000 deaths and 3.1 million cases worldwide in 1997. Monkeys are the main reservoir, and the vector is the A. aegypti mosquito. No vaccine is currently available, and management is by vector control.

Other Hemorrhagic Fevers

Lassa Fever. Lassa fever was first isolated in Lassa, Nigeria, in 1969 and is widely distributed in West Africa, with 200,000–400,000 cases and 5000 deaths annually. It is spread by direct contact with blood, urine, or secretions of infected rodents and by direct person-to-person contact in hospital settings. The disease is characterized by a persistent or spiking fever for 2–4 weeks, and may include severe hypotension, shock, and hemorrhaging. The case fatality rate is 15%.

Marburg Disease. Marburg disease is a viral disease with sudden onset of generalized illness, malaise, fever, myalgia, headache, diarrhea, vomiting, rash, and hemorrhages. It was first seen in Marburg, Germany, in 1967, following ex-
posure to green monkeys. Person-to-person spread occurs via blood, secretions, organs, and semen. Case fatality rates can be over 50%.

**Ebola Fever.** Ebola fever is a viral disease with sudden onset of generalized illness, malaise, fever, myalgia, headache, diarrhea, vomiting, rash, and hemorrhages. It was first found in Zaire and Sudan in 1976 in outbreaks which killed more than 400 persons. It is spread from person to person by the blood, vomitus, urine, stools, and other secretions of sick patients, with a short incubation period. The disease has case fatality rates of up to 90%. An outbreak of Ebola among laboratory monkeys in a medical laboratory near Washington, D.C., was contained with no human cases. The reservoir for the virus is thought to be rodents.

An outbreak of Ebola in May 1995 in the town of Kikwit, Zaire, killed 245 persons out of 316 cases (78% case fatality rate). This outbreak caused international concern that the disease could spread, but it remained localized. Another outbreak of Ebola virus occurred in Gabon in early 1996, with 37 cases, 21 of whom had direct exposure to an infected monkey, the remainder by human-to-human contact, or not established; 21 of the cases died (57%). This disease is considered highly dangerous unless outbreaks are effectively controlled. In Zaire, lack of basic sanitary supplies, such as surgical gloves for hospitals, almost ensures that this disease will spread when it recurs.

**Lyme Disease**

Lyme disease is characterized by the presence of a rash, musculoskeletal, neurologic, and cardiovascular symptoms. Confirmation is by laboratory investigation. It is the most common vector-borne disease in the United States, with 33,000 cases reported between 1993 and 1995. It primarily affects children in the 5–14 age group and adults aged 30–49. Lyme disease is preventable by avoiding contact with ticks, by applying insect repellant, wearing long pants and long sleeves in infected areas, and by the early removal of attached ticks. Several U.S. manufacturers produced vaccines which are approved for animal and human use.

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**BOX 4.11 LYME DISEASE**

In the mid 1970s, a mother of two young boys who were recently diagnosed with arthritis in the town of Lyme, Connecticut, conducted a private investigation among other town residents. She mapped each of the six arthritis cases in the town, cases which had occurred in a short time span among boys living in close proximity. This suggested that this syndrome of "juvenile rheumatoid arthritis" was perhaps connected with the boys playing in the woods. She presented her data to the head of Rheumatology at Yale Medical School in New Haven, who investigated this "cluster of a new disease entity." Some parents reported that their sons had experienced tick
bites and a rash before onset of the arthritis. A tick-borne, spiral shaped bacterium, a spirochete, *Borrelia burgdorferi*, was identified as the organism, and ticks shown to be the vector. Cases respond well to antibiotic therapy.

In 1996 over 16,000 cases (6.2 per 100,000) were reported from 45 states, an increase from 11,000 in 1965 and 13,000 in 1994. Cases were mainly located in the northeast, north central, and mid-Atlantic regions. The disease accounts for over 90% of vector-borne disease in the United States and was the ninth leading reported infection in 1995. Lyme disease has been identified in many parts of North America, Europe, the former Soviet Union, China, and Japan. A newly licensed vaccine is effective for people exposed to ticks but not general usage. Personal hygiene for protection from ticks and environmental modification are important to limit spread of the disease.

Source: CDC, 1996, *MMWR*, 45:481–484; and CDC, 1997, *MMWR*, 46, no. 23. Lyme disease website http://www.cdc.gov/ncidad/disease/lyme/lyme.htm

**PARASITIC DISEASES**

Medically important parasites are animals that live, take nourishment, and thrive in the body of a host, which may or may not harm the host, but never brings benefit. They include those caused by unicellular organisms such as protozoa, which include amoebas (malaria, schistosomiasis, amebiasis, and cryptosporidium), and helminths (worms), which are categorized as nematodes, cestodes, and trematodes.

Public health continues to face the problems of parasitic diseases in the developing world. Increasingly, parasitic diseases are being recognized in industrialized countries. Giardiasis and cryptosporidium infections in waterborne and other outbreaks have occurred in the United States. Parasitic diseases are among the most common causes of illness and death in the world, e.g., malaria. Milder illnesses such as giardiasis and trichomoniasis cause widespread morbidity. Intestinal infestations with worms may cause of severe complications, although they commonly cause chronic low-grade symptomatology and iron deficiency anemia.

**Echinococcosis**

Echinococcosis (hydatid cyst disease) is infection with *Echinococcus granulosus*, a small dog tapeworm. The tapeworm forms unilocular (single, noncompartmental) cysts in the host, primarily in the liver and lungs, but they can also grow in the kidney, spleen, central nervous system, or in bones. Cysts, which may grow up to 10 cm in size, may be asymptomatic or, if untreated, may cause severe symptoms and even death. This parasite is common where dogs are used with herd grazing animals and also have intimate contact with humans.

The Middle East, Greece, Sardinia, North Africa, and South America are endemic areas, as are a few areas in the United States and Canada. The human dis-
ease has been eliminated in Cyprus and Australia. While the dog is the major host, intermediate hosts include sheep, cattle, pigs, horses, moose, and wolves. Preventive measures include education in food and animal contact hygiene, destroying wild and stray dogs, and keeping dogs from the viscera of slaughtered animals.

A similar, but multilocular, cystic hydatid disease is widely found in wild animal hosts in areas of the northern hemisphere, including central Europe, the former Soviet Union, Japan, Alaska, Canada, and the north-central United States. Another echinococcal disease (*Echinococcus vogeli*) is found in South America, where its natural host is the bush dog and its intermediate host is the rat. The domestic dog also serves as a source of human infection.

Surgical resection is not always successful, and long-term medical treatment may be required. Control is through awareness and hygiene as well as the control of wild animals that come in contact with humans and domestic animals. Control may require cooperation between neighboring countries.

**Tapeworm**

Tapeworm infestation (taeniasis) is common in tropical countries where hygienic standards are low. Beef (*Taenia saginata*) and pork (*T. solium*) tapeworms are common where animals are fed with water or food exposed to human feces. Freezing or cooking meat will destroy the tapeworm. Fish tapeworm (*Diphyllobothrium latum*) is common in populations living primarily on uncooked fish, such as Inuit people. These tapeworms are usually associated with northern climates.

Toddlers are especially susceptible to dog tapeworm (*Dipylidium caninum*), which is present worldwide, and domestic pets are often the source of oral–fecal transmission of the eggs. The disease is usually asymptomatic. Similarly, dwarf tapeworm (*Hymenolepis nana*) is transmitted through oral–fecal contamination from person to person, or via contaminated food or water. Rat tapeworm (*Hymenolepis diminuta*) also mostly affects young children.

**Onchocerciasis**

Onchocerciasis (river blindness) is a disease caused by a parasitic worm, which produces millions of larvae that move through the body causing intense itching, debilitation, and eventually blindness. The disease is spread by a blackfly that transmits the larva from infected to uninfected people. It is primarily located in sub-Saharan Africa and in Latin America, with over 120 million persons at risk. Control is by a combination of activities including environmental control by larvicidal sprays to reduce the vector population, protection of potential hosts by protective clothing and insect repellents, and case treatment.

A WHO-initiated program for onchocerciasis control started in 1974 is sponsored by four international agencies: the Food and Agriculture Organization (FAO), the United Nations Development Program (UNDP), the World Bank, and WHO. It covers 11 countries in sub-Saharan Africa, focusing on control of the blackfly by destroying its larvae, mainly via insecticides sprayed from the air. Prevalence in 1997 was reported by WHO as over 17 million persons.

The program has been successful in protecting some 30 million persons and
helping 1.5 million infected persons to recover from this disease. WHO estimates
that the program will have prevented 500,000 cases of blindness by the year 2000
and has freed 25 million hectares of land for resettlement and cultivation. The pro-
gram cost $570 million. This investment is considered by the World Bank to have
a return of 16–28% in terms of large scale land reuse and improved output of the
population. A WHO program, the African Program for Onchocerciasis Control
(APOC), started in 1996, uses a new drug (Ivermectin) and selective vector con-
trol efforts by spraying. This involves 30 countries in Africa, and 6 in a similar pro-
gram in south America. See website http://www/who.int/ocp and is financed by
many donor countries, internation organizations, Merck & Company, and NGOs.

Dracunculiasis

Dracunculiasis (Guinea worm disease) is a parasitic disease of great public
health importance in India, Pakistan, and Central and West Africa. It is an infec-
tion of the subcutaneous and deeper tissues caused by a large (60 cm) nematode,
usually affecting the lower extremities and causing pain and disability. The nema-
tode causes a burning blister on the skin when it is ready to release its eggs. After
the blister ruptures, the worm discharges larvae whenever the extremity is in wa-
ter. The eggs are ingested in contaminated water and the larva released migrate
through the viscera to locate as adults in the subcutaneous tissue of the leg. Incu-
bation is about 12 months. The larva released in water are ingested by minute crust-
taceans and remain infective for as long as a month.

Prevention is based on improving the safety of water supplies and by prevent-
ing contamination by infected persons. Education of persons in endemic areas to
stay out of water sources and to filter drinking water reduces transmission. Insec-
ticides remove the crustaceans. Chlorine also kills the larvae and the crustaceans
which prologue larval infectivity. There is no vaccine. Treatment is helpful, but
not definitive.

Dracunculiasis was traditionally endemic in a belt from West Africa through
the Middle East to India and central Asia. It was successfully eliminated from cen-
tral Asia and Iran and has disappeared from the Middle East and from some African
countries (Gambia and Guinea).

The World Health Organization has promoted the eradication of dracunculia-
sis. Major progress has been made in this direction. Worldwide prevalence is re-
ported to have been reduced from 12 million cases in 1980 to 3 million in 1990,
152,814 in 1996, and 77,863 cases in 1997. Eradication was anticipated for the
year 2000, and in 1995 the WHO established a commission to monitor and certi-
fy eradication in formerly endemic areas. India’s reported cases fell from 17,000
in 1987 to 900 in 1992, and the country was free of transmission in 1997. In 1997,
formerly high prevalence countries such as Kenya reported no cases in 1997, while
Chad, Senegal, Cameroons, Yemen, and the Central African Republic less than 30
cases each. Eradication of this disease appears to be imminent.

The WHO eradication program was developed successfully as an independent
program with its own direction and field staff, but further progress will require the
integration of this program with other basic primary care programs in order to be
self-sustaining as an integral part of community health. Community-based surveillance systems for this disease are being converted to work for monitoring of other health conditions in the community.

**Schistosomiasis**

Schistosomiasis (snail fever or bilharziasis) is a parasitic infection caused by the trematode (blood fluke) and transmitted from person to person via an intermediate host, the snail. It is endemic in 74 countries in Africa, South America, the Caribbean, and Asia. There are an estimated 200 million persons infected worldwide and more than 600 million at risk for the disease. The clinical symptoms include fever, nausea, vomiting, abdominal pain, diarrhea, and hematuria. The organisms *Schistosoma mansoni* and *S. japonicum* cause intestinal and hepatic symptoms, including diarrhea and abdominal pain. *Schistosoma haematobium* affects the genitourinary tract, causing chronic cystitis, pyelonephritis, with high risk for bladder cancer the ninth most common cause of cancer deaths globally. Infection is acquired by skin contact with freshwater containing contaminated snails. The cercariae of the organism penetrate the skin, and in the human host it matures into an adult worm that mates and produces eggs. The eggs are disseminated to other parts of the body from the worm's location in the veins surrounding the bladder or the intestines, and may result in neurological symptoms.

Eggs may be detected under microscopic examination of urine and stools. Sensitive serologic tests are also available. Treatment is effective against all three major species of schistosomiasis. Eradication of the disease can be achieved with the use of irrigation canals, prevention of contamination of water sources by urine and feces of infected persons, treatment of infected persons, destruction of snails, and health education in affected areas. Persons exposed to freshwater lakes, streams, and rivers in endemic areas should be warned of the danger of infection. Mass chemotherapy in communities at risk and improved water and sanitation facilities are resulting in improved control of this disease.

**Leishmaniasis**

Leishmaniasis causes both cutaneous and visceral disease. The cutaneous form is a chronic ulcer of the skin, called by various names, e.g., rose of Jericho, oriental sore, and Aleppo boil. It is caused by *Leishmania tropica*, *L. brasiliensis*, *L. mexicana*, or the *L. donovani* complex. This chronic ulcer may last from weeks to more than a year. Diagnosis is by biopsy, culture, and serologic tests. The organism multiplies in the gut of sandflies (*Phlebotomus* and *Lutzoni*) and is transmitted to humans, dogs, and rodents through bites. The parasites may remain in the untreated lesion for 5–24 months, and the lesion does not heal until the parasites are eliminated.

Prevention is through limiting exposure to the phlebotomines and reducing the sandfly population by environmental control measures. Insecticide use near breeding places and homes has been successful in destroying the vector sandflies in their breeding places. Case detection and treatment reduce the incidence of new cases. There is no vaccine, and treatment is with specific antimonials and antibiotics.
Visceral Leishmaniasis

Visceral leishmaniasis (kala azar) is a chronic systemic disease in which the parasite multiplies in the cells of the host's visceral organs. The disease is characterized by fever, the enlargement of the liver and spleen, lymphadenopathy, anemia, leukopenia, and progressive weakness and emaciation. Diagnosis is by culture of the organism from biopsy or aspirated material, or by demonstration of intracellular (Leishman–Donovan) bodies in stained smears from bone marrow, spleen, liver, or blood.

Kala azar is a rural disease occurring in the Indian subcontinent, China, the southern republics of the former U.S.S.R., the Middle East, Latin America, and sub-Saharan Africa. It usually occurs as scattered cases among infants, children, and adolescents. Transmission is by the bite of the infected sandfly with an incubation period of 2–4 months. There is no vaccine, but specific treatment is effective and environmental control measures reduce the disease prevalence. This includes the use of antimalarial insecticides. In localities where the dog population has been reduced, the disease is less prevalent.

Trypanosomiasis

Sleeping Sickness. Sleeping sickness a disease caused by Trypanosoma brucei, transmitted but the tsetse fly, primarily in the African savannahs, affecting cattle and humans. Some 55 million persons are at risk in sub-Saharan Africa. WHO reported 200,000 new cases, a total prevalence of 300,000 cases, and 150,000 deaths from this disease in 1996. Prevention depends on vector control, and effective treatment of human cases.

Chagas Disease (American trypanosomiasis)

Chagas disease is a chronic and incurable vector and blood transfusion borne parasitic disease (Trypanosoma cruzi) which causes disability and death. It affects some 17 million persons mainly in Latin America, with some 300,000 new cases and 45,000 deaths occurring annually. About 30% of affected persons develop severe heart disease. Brazil, which accounts for 40% of the cases prevalent in Latin America, achieved elimination of transmission in 1998, after Uruguay (1996) and Venezuela (1997) and followed by Argentina (1999). Elimination of transmission is projected by WHO by the year 2010.

Control is difficult, but control measures include reducing the animal host and vector insect population in its habitat by ecological and insectiside measures, education of the population in prevention by clothing, bednets, and repellents, and with chemotherapy for case management.

Other Parasitic Diseases

Amebiasis. Amebiasis is an infection with a protozoan parasite (Entamoeba histolytica) which exists as an infective cyst. Infestation may be asymptomatic or cause acute, severe diarrhea with blood and mucus, alternating with constipation.
Amebic colitis can be confused with ulcerative colitis. Diagnosis is by microscopic examination of fresh fecal specimens showing trophozoites or cysts. Transmission is generally via ingestion of fecal-contaminated food or water containing cysts, or by oral–anal sexual practices. Amebiasis is found worldwide. Sand filtration of community water supplies removes nearly all cysts. Suspect water should be boiled. Education regarding hygienic practices with safe food and water handling and disposal of human feces are the basis for control.

Ascariasis. Ascariasis is infestation of the small intestine with the roundworm *Ascaris lumbricoides*, which may appear in the stool, occasionally the nose or mouth, or may be coughed up from lung infestation. The roundworm is very common in tropical countries, where infestation may reach or exceed 50% of the population. Children aged 3–8 years are especially susceptible. Infestation can cause pulmonary symptoms and frequently contributes to malnutrition, especially iron deficiency anemia. Transmission is by ingestion of infective eggs, common among children playing in contaminated areas, or via the ingestion of uncooked products of infected soil. Eggs may remain viable in the soil for years. Vermox and other treatments are effective. Prevention is through education, adequate sanitary facilities for excretion, and improved hygienic practices, especially with food. Use of human feces for fertilizer, even after partial treatment, may spread the infestation. Mass treatment is indicated in high prevalence communities.

Pinworm Disease or Enterobiasis. Pinworm disease (oxyuriasis) is common worldwide in all socioeconomic classes; however, it is more widespread when crowded and unsanitary living conditions exist. The *Enterobius vermicularis* infestation of the intestine may be symptomless or may cause severe perianal itching or vulvovaginitis. It primarily affects schoolchildren and preschoolers. More severe complications may occur. Adult worms may be seen visually or identified by microscopic examination of stool specimens or perianal swabs. Transmission is by the oral–fecal ingestion of eggs. The larvae grow in the small intestine and upper colon. Prevention is by educating the public regarding hygiene and adequate sanitary facilities, as well as by treating cases and investigating contacts. Treatment is the same as for ascariasis. Mass treatment is indicated in high prevalence communities.

Ectoparasites. Ectoparasites include scabies (*Sarcoptes scabiei*), the common bed bug (*Cimex lectularius*), fleas, and lice, including the body louse (*Pediculus humanus*), pubic louse (*Phthirius pubis*), and the head louse (*Pediculus humanus capitis*). Their severity ranges from nuisance value to serious public health hazard. Head lice are common in schoolchildren worldwide and are mainly a distressing nuisance. The body louse serves as a vector for epidemic typhus, trench fever, and louse-borne relapsing fever. In disaster situations, disinfection and hygienic practices may be essential to prevent epidemic typhus. The flea plays an important role in the spread of the plague by transmitting the organism from the rat
to humans. Control of rats has reduced the flea population, but during war and disasters, rat and flea populations may thrive. Scabies, which is caused by a mite, is common worldwide and is transmitted from person to person. The mite burrows under the skin and causes intense itching. All of these ectoparasites are preventable by proper hygiene and the treatment of cases. The spread of these diseases is rapid and therefore warrants attention in school health and public health policy.

**LEGIONNAIRE'S DISEASE**

Legionnaire's disease (Legionellosis) is an acute bacterial disease caused by *Legionella*, a gram-negative group of bacilli, with 35 species and many serogroups. The first documented case was reported in the United States in 1947, and the first disease outbreak was reported in the United States in 1976 among participants of a war veterans convention. General malaise, anorexia, myalgia, and headache are followed by fever, cough, abdominal pain, and diarrhea. Pneumonia followed by respiratory failure may follow. The case fatality rate can be as high as 40% of hospitalized cases. A milder, nonpneumonic form of the disease (Pontiac fever) is associated with virtually no mortality.

The organism is found in water reservoirs and is transmitted through heating, cooling, and air conditioning systems, as well as from tap water, showers, saunas, and jaccuzi baths. The disease has been reported in Australia, Canada, South America, Europe, Israel, and on cruise ships. Prevention requires the cleaning of water towers and cooling systems, including whirlpool spas. Hyperchlorination of water systems and the replacement of filters is required where cases and/or organisms have been identified. Antibiotic treatment with erythromycin is effective.

**LEPROSY**

Leprosy (Hansen's disease) was widely prevalent in Europe and Mediterranean countries for many centuries, with some 19,000 leprosaria in the year 1300. Leprosy was largely wiped out during the Black Death in the fourteenth century, but continued in endemic form until the twentieth century. Leprosy is a chronic bacterial infection of the skin, peripheral nerves, and upper airway. In the lepromatous form, there is diffuse infiltration of the skin nodules and macules, usually bilateral and extensive. The tuberculoid form of the disease is characterized by clearly demarcated skin lesions with peripheral nerve involvement. Diagnosis is based on clinical examination of the skin and signs of peripheral nerve damage, skin scrapings, and skin biopsy.

Transmission of the *Mycobacterium leprae* organism is by close contact from person to person, with incubation periods of between 9 months and 20 years (average of 4–8 years). Rifampicin and other medications make the patient noninfectious in a short time, so that ambulatory treatment is possible. Multidrug therapy (MDT) has been shown to be highly effective in combating the disease, with
4. COMMUNICABLE DISEASES

a very low relapse rate. Treatment with MDT ensures that the bacillus does not develop drug resistance. MDT is covering 91% of known cases in 1996, according to WHO reports, as compared to only 55% in 1994. The increase has been associated with improved case finding. BCG may be useful in reducing tuberculoid leprosy among contacts. Investigation of contacts over 5 years is recommended.

The disease is still highly endemic primarily in five countries, India, Brazil, Indonesia, Myanmar, and Bangladesh, and is still present in some 80 countries in Southeast Asia, including the Philippines and Burma, sub-Saharan Africa, the Middle East (Sudan, Egypt, Iran), and in some parts of Latin America (Mexico, Colombia) with isolated cases in the United States. World prevalence has declined from 10.5 million cases in 1980, 5.5 million in 1990, to less than 1 million cases in 1995. The World Health Organization expects to eliminate leprosy as a public health problem by the year 2000, defined as prevalence of less than 1 per 10,000 population, or less than 300,000 cases.

TRACHOMA

Trachoma is currently responsible for 6 million blind persons or 15% of total blindness in the world. The causative organism, *Chlamydia trachomatis*, is a bacterium which can survive only within a cell. It is spread through contact with eye discharges, usually by flies, or household items (e.g., handkerchiefs, washcloths). Trachoma is common in poor rural areas of Central America, Brazil, Africa, parts of Asia, and some countries in the eastern Mediterranean. The resulting infection leads to conjunctival scarring and if untreated, to blindness. WHO estimates there are 148 million cases of active disease in 46 endemic countries. Hygiene, vector control, and treatment with antibiotic eye ointments or simple surgery for scarring of eyelids and inturned eyelashes prevent the blindness. A new drug, azithromycin, is effective in curing the disease. The WHO is promoting a program for the global elimination of trachoma using azithromycin and hygiene education in endemic areas.

*Chlamydia (Chlamydia pneumonia)* is suspected of playing a role in coronary artery disease by intraarterial infection, with plaque formation and occlusion of the artery by thrombi consisting mainly of platelets. If borne out, this will provide potential for low cost intervention to reduce the burden of the leading worldwide cause of death.

SEXUALLY TRANSMITTED DISEASES

Sexually transmitted diseases (STDs) are widespread internationally with an estimated 330 million new cases per year, with 5.8 million new cases, over 30 million total cases, and 2.3 million deaths (1997), AIDS has captured world attention over the past decade. The global burden of STDs is enormous (Table 4.8), and the public health and social consequences are devastating in many countries.
Table 4.8 Estimated Worldwide Incidence of Major Sexually Transmitted Diseases, 1997

| Disease          | Organism responsible                  | New cases |
|------------------|---------------------------------------|-----------|
| Trichomoniasis   | *Trichomonas vaginalis*                | 170 million |
| Chlamydia, genital | *Chlamydia trachomatis*              | 89 million |
| Gonorrhea        | *Neisseria gonorrhoea*                | 62 million |
| Genital papilloma | Human papilloma virus                 | 30 million |
| Anogenital herpes | Herpes simplex virus                  | 20 million |
| Syphilis         | *Treponema pallidum*                  | 12 million |
| HIV              | *Human immunodeficiency virus* (HIV)  | 5.8 million |
| Chancroid        | Haemophilus ducreyi                   | 2 million |

Source: WHO, 1998, *World Health Report 1998*.

Sexually transmitted diseases, especially in women, may be asymptomatic, so that severe sequelae may occur before patients seek care. Infection by one STD increases risk of infection by other diseases in this group.

**Syphilis**

Syphilis is caused by the spirochete *Treponema pallidum*. After an incubation period of 10–90 days (mean = 21), primary syphilis develops as a painless ulcer or chancre on the penis, cervix, nose, mouth, or anus, lasting 4–6 weeks. The patient may first present with secondary syphilis 6–8 weeks (up to 12 weeks) after infection with a general rash and malaise, fever, hair loss, arthritis, and jaundice. These symptoms spontaneously disappear within weeks or up to 12 months later. Tertiary syphilis may appear 5–20 years after initial infection. Complications of tertiary syphilis include catastrophic cardiovascular and central nervous system conditions. Early antibiotic treatment is highly effective when given in a large initial dose, but longer term therapy may be needed if treatment is delayed.

**Gonorrhea**

Gonorrhea (GC) is caused by the bacterium *Neisseria gonorrhoeae*. The incubation period is 1–14 days. Gonorrhea is often associated with concurrent chlamydia infection. In women, GC may be asymptomatic or it may cause vaginal discharge, pain on urination, bleeding on intercourse, or lower abdominal pain. Untreated, it can lead to sterility. In men, GC causes urethral discharge and painful urination. Treatment with antibiotics ends infectivity, but untreated cases can be infectious for months. Drug resistance to penicillin and tetracycline has increased in many countries so that more expensive and often unavailable drugs are necessary for treatment. Prevention of gonococcal eye infection in newborns is based on routine use of antibiotic ointments in the eyes of newborns.

**Other Sexually Transmitted Diseases**

**Chancroid.** Chancroid is caused by *Haemophilus ducreyi*. In women chancroids may cause a painful, irregular ulcer near the vagina, resulting in pain on in-
tercourse, urination, and defecation, but it may be asymptomatic. In men it causes a painful, irregular ulcer on the penis. The incubation period is usually 3–5 days, but may be up to 14 days. An individual is infectious as long as there are ulcers, usually 1–3 months. Treatment is by erythromycin or azithromycin.

*Herpes Simplex.* Herpes simplex is caused by herpes simplex virus types 1 and 2 and has an incubation period of 2–12 days. Genital herpes causes painful blisters around the mouth, vagina, penis, or anus. The genital lesions are infectious for 7–12 days. Herpes may lead to central nervous system meningoencephalitis infection. It can be transmitted to newborns during vaginal delivery, causing infection, encephalitis, and death. Cesarian delivery is therefore necessary when a mother is infected. Anti-viral drugs are used in treatment, orally, topically, or intravenously.

*Chlamydia.* Chlamydia is caused by *Chlamydia trachomatis*. In women, it is usually asymptomatic but may cause vaginal discharge, spotting, pain on urination, lower abdominal pain, and pelvic inflammatory disease (PID). In newborns, chlamydia may cause eye and respiratory infections. In men, chlamydia causes urethral discharge and pain on urination. The incubation period is 7–21 days and the infectious period is unknown. Treatment for chlamydia is doxycycline, azithromycin, or erythromycin. Chlamydia infection, not necessarily venereal in transmission, may be transmitted to newborns of infected mothers. *Chlamydia pneumoniae*, presently under investigation as a possible cause or contributor to coronary heart disease, and is widespread in poor hygienic conditions.

*Trichomoniasis.* Trichomoniasis is caused by *Trichomonas vaginalis*. The incubation period is 4–20 days (mean = 7). In women, trichomoniasis may be asymptomatic or may cause a frothy vaginal discharge with foul odor, and painful urination and intercourse. In men, the disease is usually mild, causing pain on urination. Treatment is by metronidazole taken orally. Without treatment, the disease may persist and remain infectious for years.

*Condyloma.* Condyloma or viral wart is caused by human papilloma virus (HPV). It is a sporadic disease which may be associated with cervical neoplasia and cancer of the cervix. HPV includes many types associated with a variety of conditions. The search for a HPV vaccine to prevent cancer of the cervix looks promising.

**Control of Sexually Transmitted Infections**

In areas where a full range of diagnostic services is lacking, a “syndromic approach” is recommended for the control of STDs. The diagnosis is based on a group of symptoms and treatment on a protocol addressing all the diseases that could possibly cause those symptoms, without expensive laboratory tests and repeated visits. Early treatment without laboratory confirmation helps to cure persons who might not return for follow-up, or may place them in a noninfective stage so that even without follow-up they will not transmit the disease. STD incidence between 1950 and 1996 is shown in Table 4.9, with decline overall except around 1990, with subsequent further fall in incidence.

Screening in prenatal and family planning clinics, prison medical services, and
in clinics serving prostitutes, homosexuals, or other potential risk groups will detect subclinical cases of various STDs. Treatment can be carried out cheaply and immediately. For instance, the screening test for syphilis costs $0.10 and the treatment with benzathine penicillin injection costs about $0.40 in 1998. Partner notification is a controversial issue, but may be needed to identify contacts who may be the source of transmission to others.

Control of STDs through a syndrome approach based on primary care providers is being promoted by WHO. Health education directed at high risk target groups is essential. Providing easy and cost-free access to acceptable, nonthreatening treatment is vital in promoting the early treatment of cases and thereby reducing the risk of transmission.

Promoting prevention through the use of condoms and/or monogamy requires long-term educational efforts that are now fostered by the HIV/AIDS pandemic. Increased use of condoms for HIV prevention is associated with reduced risk of other STDs. Training medical care providers in STD awareness should be stressed in undergraduate and continuing educational efforts including personal protection as care givers.

HIV/AIDS

Human immunodeficiency virus (HIV) is a retrovirus that infects various cells of the immune system, and also affects the central nervous system. Two types have been identified: HIV1, worldwide in distribution, and the less pathogenic HIV2, found mainly in West Africa. HIV is transmitted by sexual contact, exposure to blood and blood products, perinatally, and via breast milk. The period of communicability is unknown, but studies indicate that infectiousness is high, both during the initial period after infection and later in the disease. Antibodies to HIV usually appear within 1–3 months.

Within several weeks to months of the infection, many persons develop an acute self-limited flulike syndrome. They may then be free of any signs or symptoms for months to more than 10 years. Onset of illness is usually insidious with nonspecific symptoms, including sweats, diarrhea, weight loss, and fatigue. AIDS
4. Communicable Diseases

represents the later clinical stage of HIV infection. According to the revised CDC case definition (1993), AIDS involves any one or more of the following: low CD4 count, severe systematic symptoms, opportunistic infections such as pneumocystis pneumonia or TB, aggressive cancers such as Kaposi's sarcoma or lymphoma, and/or neurological manifestations, including dementia and neuropathy. The WHO case definition is more clinically oriented, relying less on often unavailable laboratory diagnoses for indicator diseases.

AIDS was first recognized clinically in 1981 in Los Angeles and New York. By mid-1982 it was considered an epidemic in those and other U.S. cities. It was primarily seen among homosexual men and recipients of blood products. After initial errors, testing of blood and blood products became standard and has subsequently closed off this method of transmission. Transmission has changed markedly since the initial onslaught of the disease, with needle sharing among intravenous drug users, heterosexual, and maternal–fetal transmission becoming major factors. Comorbidity with other STDs apparently increases HIV infectivity and may have helped to convert the epidemiology to a greater degree of heterosexual transmission.

The disease grew exponentially in the United States (Table 4.10), but incidence of new cases has declined since 1993. AIDS has become a major public health problem in most developed and developing countries, reaching catastrophic proportions in some sub-Saharan African countries affecting up to 30% of the population.

HIV-related deaths were the eighth leading cause of all deaths in 1993 in the U.S., the leading cause among men aged 25–44 years of age, and the fourth leading cause for women in this age group. By 1996, AIDS had been diagnosed in 548,000 persons and 343,000 had died. It is estimated that up to 1 million persons are HIV infected in the United States.

Globally, deaths from AIDS totalled 2.3 million in 1997, with an estimated 11.7 million persons having died from this pandemic up to 1997. In 1998, an estimated 3.1 million persons were HIV infected with 5.8 million new infection in 1997.

The declining incidence of new cases in the industrialized countries may be the result of greater awareness of the disease and methods of prevention of transmission. Improving early diagnosis and access to care, especially the combined therapy programs that are very effective in delaying onset of symptoms, are important parts of public health management of the AIDS crisis. Until an effective vaccine is available, preventive reliance will continue to be on behavior risk-reduction and other prevention strategies such as needle and condom distribution among high risk population groups.

Throughout the world, HIV continues to spread rapidly, especially in poor countries in Africa, Asia, and South and Central America. The United Nations reports that 21 million persons are living with HIV/AIDS, 90% of them in developing countries, where transmission is 85% by heterosexual contact. Every day, more than 8500 persons are infected, including 1000 children. In Thailand, 1 person in 50 is now infected. In sub-Saharan Africa 1 person in 40 is infected, and in some cities as many as 1 person in 3 carries the virus. Estimations of new infections per
| Group         | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Total        | 8.2  | 13.1 | 21.1 | 30.7 | 33.6 | 41.7 | 43.7 | 45.8 | 102.4| 77.4 | 71.3 | 66.7 | 30.2 |
| Males ≥ 13   | 7.5  | 12.0 | 19.1 | 27.1 | 29.6 | 36.3 | 37.6 | 39.1 | 85.4 | 62.9 | 57.2 | 52.8 | 23.3 |
| Women ≥ 13   | 0.5  | 1.0  | 1.7  | 3.0  | 3.4  | 4.5  | 5.3  | 6.0  | 16.0 | 13.3 | 13.1 | 13.2 | 6.6  |
| Children < 13| 0.1  | 0.2  | 0.3  | 0.6  | 0.6  | 0.7  | 0.7  | 0.7  | 0.9  | 1.0  | 0.7  | 0.7  | 0.3  |

Source: *Health United States, 1998.*

*The CDC expanded its criteria for AIDS case definition in 1985, 1987, and 1993. This accounts for some of the increases in cases (especially among women in 1993).

b*The year 1997 includes cases reported up to June 30, 1997.

*Children includes both sexes up to 13 years of age. Numbers are rounded.*
year in sub-Saharan Africa range from 1 to 2 million persons, while in Asia the range is from 1.2 to 3.5 million new infected persons per year.

Lessons are still being learned from the AIDS pandemic. The explosive spread of this infection, from an estimated 100,000 people in 1980 to an anticipated 40 million persons HIV infected, shows that the world is still vulnerable to pandemics of "new" infectious diseases. Enormous movements of tourists, business people, truck drivers, migrants, soldiers, and refugees promote the spread of such diseases. Widespread sexual exchange, traffic in blood products, and illicit drug use all promote the international potential for pandemics. War and massive refugee situations promote rape and prostitution, worsening the AIDS situation in some settings in Africa.

HIV has arrived in almost every country. However, there is the somewhat hopeful indication that the rate of increase, has slowed in the United States. This may be an indication either of higher levels of self-protective behavior, or that the most susceptible population groups have already been affected and the spread into the general population is at a slower rate. It is also possible that this may yet prove to be only a lull in the storm, as heterosexual contact becomes a more important mode of transmission.

The Eleventh International Conference on AIDS, held in Vancouver, Canada, in July 1996, reported signs that combinations of several drugs from among a number of antiretroviral medications are showing promise to suppress the AIDS virus in infected people. At a current annual price of $10,000–15,000 per patient, these sums well beyond the capacity of most developing countries. Development of methods of measuring the HIV viral load have allowed for better evaluation of potential therapies and monitoring of patients receiving therapy. In developed countries, transmission by blood products has been largely controlled by screening tests; transmission among homosexuals has been reduced by safe sex practices; transmission to newborns has been reduced by recent therapeutic advances. Safe sex practices and condom use may have helped in reducing heterosexual transmission. Further advances in therapy and prevention with a vaccine are expected over the next decade.

The HIV/AIDS pandemic is one of the great challenges to public health for the 21st century due to its complexity, its international spread, its sexual and other modes of transmission, its devastating and costly clinical effects, and its impact on parallel diseases such as tuberculosis, respiratory infections, and cancer. The cost of care for the AIDS patient can be very high. Needed programs include home care and community health workers to improve nutrition and self-care, and mutual help among HIV carriers and AIDS patients. The ethical issues associated with AIDS are also complex regarding screening of pregnant women, newborns, partner notification, reporting, and contact tracing, as well as financing the cost of care.

**DIARRHEAL DISEASES**

Diarrheal diseases are caused by a wide variety of bacteria, parasites, and viruses (Table 4.11) infecting the intestinal tract and causing secretion of fluids and dis-
solved salts into the gut with mild to severe or fatal complications. In developing countries, diarrheal diseases account for half of all morbidity and a quarter of all mortality. Diarrhea itself does not cause death, but the dehydration resulting from fluid and electrolyte loss is one of the most common causes of death in children worldwide. Deaths from dehydration can be prevented by use of oral rehydration therapy (ORT), an inexpensive and simple method of intervention easily used by a nonmedical primary care worker and by the mother of the child as a home intervention. In 1983, diarrheal diseases were the cause of almost 4 million child deaths, but by 1996 this had declined to 2.4 million, largely under the impact of increased use of ORT.

Diarrheal diseases are transmitted by water, food, and directly from person to person via oral–fecal contamination. Diarrheal diseases occur in epidemics in situations of food poisoning or contaminated water sources, but can also be present at high levels when common source contamination is not found. Contamination of drinking water by sewage and poor management of water supplies are also major causes of diarrheal disease. The use of sewage for the irrigation of vegetables is a common cause of diarrheal disease in many areas.

**Salmonella**

Salmonella are a group of bacterial organisms causing acute gastroenteritis, associated with generalized illness including headache, fever, abdominal pains, and dehydration. There are over 2000 serotypes of salmonella, many of which are pathogenic in humans, the most common of which are *Salmonella typhimurium*, *S. enteritidis*, and *S. typhi*. Transmission is by ingestion of the organisms in food, derived from fecal material from animal or human contamination. Common sources include raw or uncooked eggs, raw milk, meat, poultry and its products, as well as pet turtles or chicks. Fecal–oral transmission from person to person is common. Prevention is in safe animal and food handling, refrigeration, sanitary preparation and storage, protection against rodent and insect contamination, and the use of sterile techniques during patient care. Antibiotics may not eliminate the carrier state and may produce resistant strains.
Shigella

Shigella are a group of bacteria that are pathogenic in man, with four groups: Type A = *Shigella dysenteriae*, Type B = *S. flexneri*, Type C = *S. boydii*, and Type D = *S. sonnei*. Types A, B, and C are each further divided into a total of 40 serotypes. Shigella are transmitted by direct or indirect fecal-oral methods from a patient or carrier, and illness follows ingestion of even a few organisms. Water and milk transmission occurs as a result of contamination. Flies can transmit the organism, and in nonrefrigerated foods the organism may multiply to an infectious dose. Control is in hygienic practices and in the safe handling of water and food.

*Escheria coli*

*E. coli* are common fecal contaminants of inadequately prepared and cooked food. Particularly virulent strains such as O157:H17 can cause explosive outbreaks of severe (enterohemorrhagic) diarrhoeal disease with a hemolytic-uremic syndrome and death, as occurred in Japan in 1998 with cases and deaths due to a food-borne epidemic. Other milder strains cause travellers diarrhoea and nursery infections. Inadequately cooked hamburger, unpasturized milk, and other food vectors are discussed under food safety in Chapter 8.

*Cholera*

Cholera is an acute bacterial enteric disease caused by *Vibrio cholerae*, with sudden onset, profuse painless watery stools, occasional vomiting, and, if untreated, rapid dehydration, and circulatory collapse, and death. Asymptomatic infection or carrier status, and mild cases are common. In severe, untreated cases, mortality is over 50%, but with adequate treatment, mortality is under 1%. Diagnosis is based on clinical signs, epidemiologic, serologic and bacteriologic confirmation by culture. The two types of cholera are the classic and el Tor (with Inaba and Ogawa serotypes).

In 1991, a large scale epidemic of cholera spread through much of South America. It was imported via a Chinese freighter, whose sewage contaminated shellfish in Lima harbor in Peru (Box 4.12). The South American cholera epidemic has caused hundreds of thousands of cases and thousands of deaths since 1991.

Prevention requires sanitation, particularly the chlorination of drinking water, prohibiting the use of raw sewage for the irrigation of vegetable crops, and high standards of community, food, and personal hygiene. Treatment is prompt fluid therapy with electrolytes in large volume to replace all fluid loss. Oral rehydration should be accomplished using standard ORT. Tetracycline shortens the duration of the disease, and chemoprophylaxis for contacts following stool samples may help in reducing its spread. A vaccine is available but is of no value in the prevention of outbreaks.

Viral Gastroenteritis

Viral gastroenteritis can occur in sporadic or epidemic forms, in infants, children, or adults. Some viruses, such as the rotaviruses and enteric adenoviruses, af-
Box 4.12 THE CHOLERA PANDEMIC IN SOUTH AMERICA, 1991–1998

In the 1980s, Peruvian officials stopped the chlorination of community water supplies because of concern over possible carcinogenic effects of trihalomethanes, a view encouraged by officials of the U.S. Environmental Protection Agency (EPA) and the U.S. Public Health Service. In January 1991, a Chinese freighter arrived in Lima, Peru, and dumped bilge (sewage) in the harbor, apparently contaminating local shellfish. Consumption of raw shellfish is a popular local delicacy (ceviche) and associated with cases of cholera seen in local hospitals.

Contamination of local water supplies from sewage resulted in the geometric increase in cases, and by the end of 1992 the Pan American Health Organization (PAHO) reported an epidemic of 391,000 cases and 4002 deaths. The epidemic spread to 21 countries, and in 1992 there were a further 339,000 cases and 2321 deaths spreading over much of South America, continuing in 1999.

In the United States, 102 cases of cholera were reported in 1992; of these, 75 cases and 1 death were among passengers of an airplane flying from South America to Los Angeles in which contaminated seafood was served. In 1993, 91 cases of cholera were reported in the United States which were unrelated to international travel. These occurred mostly among persons consuming shellfish from the Gulf coast with a strain of cholera similar to the South American strain, also possibly introduced in ship ballast. Cholera organisms are reported in harbor waters in other parts of the United States (Promed, 1999).

Sources: Anderson, C. 1991. Cholera epidemic traced to risk miscalculation. *Nature*, 354:255; CDC. 1993. Update cholera—Western hemisphere, 1992. *MMWR*, 42:89–91; CDC. 1993. Isolation of *Vibrio cholerae* O1 from Oysters—Mobile Bay, 1991–1992. *MMWR*, 42:91–93; Promed, 1999.

fect mainly infants and young children, and may be severe enough to cause hospitalization for dehydration. Others such as Norwalk and Norwalk-like viruses affect older children and adults in self-limited acute gastroenteritis in family, institution, or community outbreaks.

*Rotaviruses.* Rotaviruses cause acute gastroenteritis in infants and young children, with fever and vomiting, followed by watery diarrhea and occasionally severe dehydration and death if not adequately treated. Diagnosis is by examination of stool or rectal swabs with commercial immunologic kits. In both developed and developing countries, rotavirus is the cause of about one-third of all hospitalized cases for diarrheal diseases in infants and children up to age 5. Most children
in developing countries experience this disease by the age of 4 years, with the majority of cases between 6 and 24 months. In developing countries, rotaviruses are estimated to cause over 800,000 deaths per year. The virus is found in temperate climates in the cooler months and in tropical countries throughout the year. Breastfeeding does not prevent the disease but may reduce its severity. Oral rehydration therapy is the key treatment. A live attenuated vaccine was approved by the FDA in 1998 and adopted in the 1999 U.S. recommended routine vaccination programs for infants.

**Adenoviruses.** Adenoviruses, Norwalk, and a variety of other viruses (including astrovirus, calcivirus, and other groups) cause sporadic acute gastroenteritis worldwide, mostly in outbreaks. Spread is by the oral–fecal route, often in hospital or other communal settings, with secondary spread among family contacts. Food-borne and waterborne transmission are both likely. These can be a serious problem in disaster situations. No vaccines are available. Management is with fluid replacement and hygienic measures to prevent secondary spread.

**Parasitic Gastroenteritis**

**Giardiasis.** Giardiasis (caused by *Giardia lamblia*) is a protozoan parasitic infection of the upper small intestine, usually asymptomatic, but sometimes associated with chronic diarrhea, abdominal cramps, bloating, frequent loose greasy stools, fatigue, and weight loss. Malabsorption of fats and vitamins may lead to malnutrition. Diagnosis is by the presence of cysts or other forms of the organism in stools, duodenal fluid, or in intestinal mucosa from a biopsy. This disease is prevalent worldwide and affects mostly children. It is spread in areas of poor sanitation and in preschool settings and swimming pools, and is of increasing importance as a secondary infection among immunocompromised patients, especially those with AIDS.

Waterborne giardia was recognized as a serious problem in the United States in the 1980s and 1990s, since the protozoa is not readily inactivated by chlorine, but requires adequate filtration before chlorination. Person-to-person transmission in day-care centers is common, as is transmission by unfiltered stream or lake water where contamination by human or animal feces is to be expected. An asymptomatic carrier state is common. Prevention relies on careful hygiene in settings such as day-care centers, filtration of public water supplies and the boiling of water in emergency situations.

**Cryptosporidium.** Cryptosporidium parvum is a parasitic infection of the gastrointestinal tract in man, small and large mammals and vertebrates. Infection may be asymptomatic or cause a profuse, watery diarrhea, abdominal cramps, general malaise, fever, anorexia, nausea, and vomiting. In immunosuppressed patients, such as persons with AIDS, it can be a serious problem. The disease is most common in children under 2 years of age and those in close contact with them, as well as in homosexual men. Diagnosis is by identification of the cryptosporidium or-
ganism cysts in stools. The disease is present worldwide. In Europe and the United States, the organism has been found in <1 to 4.5% of individuals sampled. Spread is common by person-to-person contact by fecal–oral contamination, especially in such settings as day-care centers. Raw milk and waterborne outbreaks have also been identified in recent years. A large waterborne disease outbreak due to cryptosporidium occurred in Milwaukee in 1986 described in Chapter 9. Management is by rehydration and prevention is by careful hygiene in food and water safety.

*Helicobacter pylori.* *Helicobacter pylori,* first identified in 1986, is a bacterium causally linked to duodenal ulcers and gastritis, contributing to high rates of gastric cancer (Chapter 5). It is an important example of the link between infection and chronic disease. This has enormous implications for prevention of cancer of the stomach, chronic peptic ulcers and large-scale use of hospitals and other medical resources (see Chapter 5).

**A Program Approach to Diarrhoeal Disease Control**

The control of diarrhoeal diseases requires a comprehensive program involving a wide range of activities, including good management of food and water supplies, education in hygiene, and, particularly where morbidity and mortality are high, education in the use of Oral Rehydration Therapy (ORT).

Oral rehydration therapy (ORT) is considered by UNICEF and WHO to have resulted in the saving of 1 million lives each year in the 1990s. Proper management of an episode of diarrhea by ORT (Table 4.12), along with continued feeding, not only saves the child from dehydration and immediate death, but also contributes to early restoration of nutritional adequacy, sparing the child the prolonged effects of malnutrition.

The World Summit for Children (WSC) in 1990 called for a reduction in child deaths from diarrhoeal diseases by one-third and malnutrition by one-half, with em-

| Table 4.12 WHO Formula for Oral Rehydration Therapy (ORT) |
|---------------------------------------------------------|
| **Ingredients**                                        | **Amount (g/liter)** | **Concentration Ion** | **(mmol/liter)** |
| Sodium chloride (NaCl)                                 | 3.5                  | Sodium                | 90               |
| Trisodium citrate, dihydrate, or sodium bicarbonate (NaHCO₃) | 2.9 (or 2.5)         | Citrate<sup>a</sup> | 20 citrate<sup>b</sup> |
| Potassium chloride (KCl)                               | 1.5                  | Potassium             | 10 of potassium 80 of chloride |
| Glucose (anhydrous)                                    | 20.0                 | Glucose               | 111              |

<sup>a</sup>Or 2.5 g sodium bicarbonate.  
<sup>b</sup>Or 30 mmol bicarbonate.

Source: World Health Organization, 1992, *Readings on Diarrhoea: Student Manual*; Benenson, 1995, *Control of Communicable Diseases Manual*.
phasis on the widest possible availability, education for, and use of ORT. This requires a programmatic approach. Public health leadership must train primary care doctors, pediatricians, pharmacists, drug manufacturers, and primary care health workers of all kinds in ORT principles and usage. They must be backed by the widest possible publicity to raise awareness among parents.

Oral rehydration therapy is an important public health modality in developed countries as well as in developing countries. Diarrheal disease may not cause death as frequently in developed countries, but it is still a significant factor in infant and child health and, even under the most optimal conditions, can cause setbacks in the nutritional state and physical development of a child. Use of ORT does not prevent the disease (i.e., it is not a primary prevention), but it is excellent in secondary prevention, by preventing complications from diarrhoea, and should be available in every home for symptomatic treatment of diarrheal diseases.

An adaptation of ORT has found its place in popular culture in the United States. A form of ORT, marketed as “sports drinks,” is used in sports where athletes lose large quantities of water and salts in sweat and insensible loss from the respiratory tract. The wider application of the principles of ORT for use in adults in dry hot climates and in adults under severe physical exertion with inadequate fluid/salt intake situations requires further exploration.

Management of diarrheal diseases should be part of a wider approach to child nutrition. The child who goes through an episode of diarrheal disease may have a faltering in growth and development. Supportive measures may be needed following the episode as well as during it. This involves providing primary care services that are attuned to monitoring individual infant and child growth. Growth monitoring surveillance is important to assess the health status of the individual child and the child population. Supplementation of infant feeding with vitamins A and D, and iron to prevent anemia are important for routine infant and child care, and more so for conditions affecting total nutrition such as a diarrheal disease.

ACUTE RESPIRATORY INFECTIONS

In the developing world, respiratory infections account for over one-quarter of all deaths and illnesses in children. As diarrheal disease deaths are reduced, the major cause of death among infants in developing countries is becoming acute respiratory infections (ARIs). In industrialized countries, ARIs are important for their potentially devastating effects on the elderly and chronically ill. They are also the major cause of morbidity in infants in developed countries, causing much anxiety to parents even in areas with good living conditions. Cigarette smoking, chronic bronchitis, poorly controlled diabetes or congestive heart failure, and chronic liver and kidney disease increase susceptibility to ARIs. ARIs place a heavy burden on health care systems and individual families. Improved methods of management of such chronic diseases are needed to reduce the associated toll of morbidity, mortality, and the considerable expenses of health care.
Acute respiratory infections are due to a broad range of viral and, to a lesser extent, bacterial infections. It is the latter which can progress to pneumonia with mortality rates of 10–20%. Acute viral respiratory diseases include those affecting the upper respiratory tract, such as acute viral rhinitis, pharyngitis, and laryngitis, as well as those affecting the lower respiratory tract, tracheobronchitis, bronchitis, bronchiolitis, and pneumonia. ARIs are frequently associated with vaccine-preventable diseases, including measles, varicella, and influenza. They are caused by a large number of viruses, producing a wide spectrum of acute respiratory illness. Some organisms affect any part of the respiratory tract, while others affect specific parts and all predispose to bacterial secondary infection. While children and the elderly are especially susceptible to morbidity and mortality from acute respiratory disease, the vast numbers of respiratory illnesses among adults cause large-scale economic loss from work absence.

Bacterial agents causing upper respiratory tract infection include group A streptococcus, mycoplasma pneumonia, pertussis, and parapertussis. Pneumonia or acute bacterial infection of the lower respiratory tract and lung tissue may be due to pneumococcal infection with *Streptococcus pneumoniae*. There are 83 known types of this organism, distinguished by capsule characteristics; 23 account for 88% of pneumococcal infections in the United States. An excellent polyvalent vaccine based on these types is available for high risk groups such as the elderly, immunodeficient patients, and persons with chronic heart, lung, liver, blood disorders, or diabetes.

Opportunistic infections attack the chronically ill, especially those with compromised immune systems, often with life-threatening ARIs. Mycoplasma (primary atypical pneumonia) is a lower respiratory tract infection which sometimes progresses to pneumonia. TB and *Pneumocytis carinii* are especially problematic for AIDS patients. Other organisms causing pneumonias include *Chlamydia pneumoniae*, *H. influenza*, *klebsiella pneumonia*, *Escherichia coli*, Staphylococcus, rickettsia (Q fever), and *Legionella*. Parasitic infestation of lungs may occur with nematodes (e.g., ascariasis). Fungal infections of the lung may be caused by aspergillosis, histoplasmosis, and coccidiomycosis, often as a complication of antibiotic therapy.

Access to primary care and early institution of treatment are vital to control excess mortality from ARIs. In developed countries, ARIs as contributors to infant deaths are largely a problem in minority and deprived population groups. Because these groups contribute disproportionately to childhood mortality, infant mortality reduction has been slower in countries such as the United States and Russia than in other industrialized countries. The continuing gap in mortality rates between white and black children in the United States can, to a large extent, be attributed to ARIs and less access to organized primary care. Children are brought to emergency rooms for care when the disease process is already advanced and more dangerous than had it been attended to professionally earlier in the process. Many field trials of ARI prevention programs have been proved successful involving parent education and training of primary care workers in early assessment and, if necessary, initiation of treatment. This needs field testing in multiple settings.
Reliance on vaccines to prevent respiratory infectious diseases is not currently feasible. ARIs are caused by a very wide spectrum of viruses, and the development of vaccines in this field has been slow and limited. The vaccine for pneumococcal pneumonia has been an important breakthrough, but it is still inadequately utilized by the chronically ill because of its limitations, costs, and lack of sufficient awareness, and it is too expensive for developing countries. Improvements in bacterial and viral vaccine development will potentially help to reduce the burden of ARIs. A programmatic approach with clinical guidelines and education of family and care givers is currently the only feasible way to reduce the still enormous morbidity and mortality from ARIs on the young and the elderly.

COMMUNICABLE DISEASE CONTROL IN THE NEW PUBLIC HEALTH

The success of sanitation vaccines and antibiotics led many to assume that all infectious diseases would sooner or later succumb to public health and medical technology. Unfortunately, this is a premature and even dangerous assumption. Despite the longstanding availability of an effective and inexpensive vaccine, the persistence of measles as a major killer of 1 million children per year represents a failure in effective use of both the vaccine and the health system. The resurgence of TB and malaria have led to new strategies, such as managed or directly observed care, with community health workers to assure compliance needed to render the patient noninfectious to others and to reduce the pool of carriers of the disease.

Current successes in reducing poliomyelitis, dracunculiasis, onchocerciasis, and other diseases to the point of eradication has raised hopes for similar success in other fields. But there are many infectious diseases of importance in developed and developing countries where existing technologies are not fully utilized. Oral rehydration therapy (ORT) is one of the most cost-effective methods of preventing excess mortality from ordinary diarrheal diseases, and yet is not used on sufficient scale.

Biases in the financing and management of medical insurance programs can result in underutilization of available effective vaccines. Hospital-based infections cause large-scale increases in lengths of stay and expenditures, although application of epidemiologic investigation and improved quality in hospital practices could reduce this burden. Control of the spread of AIDS using combined medical therapies is not financially or logistically possible in many countries, but education for “safe sex” is effective. Community health worker programs can greatly enhance tuberculosis, malaria, and STD control, or in AIDS care, promote prevention and appropriate treatment.

In the industrialized and mid-level developing countries, epidemiologic and demographic shifts have created new challenges in infectious disease control. Prevention and early treatment of infectious disease among the chronically ill and the elderly is not only a medical issue, it is also an economic one. Patients with chronic obstructive lung disease (COPD), chronic liver or kidney disease, or congestive
heart failure are at high risk of developing an infectious disease followed by prolonged hospitalization.

SUMMARY

Public health has addressed, and will continue to stress the issues of communicable disease as one of its key issues in protecting individual and population health. Methods of intervention include classic public health through sanitation, immunization, and well beyond that into nutrition, education, case finding, and treatment, and changing human behavior. The knowledge, attitudes, beliefs, and practices of policy makers, health care providers, and parents is as important in the success of communicable disease control as are the technology available and methods of financing health systems. Together, these encompass the broad programmatic approach of the New Public Health to control of communicable diseases.

In a world of rapid international transport and contact between populations, systems are needed to monitor the potential explosive spread of pathogens that may be transferred from their normal habitat. The potential for the international spread of new or reinvigorated infectious diseases constitute threat to mankind akin to ecological and other man-made disasters.

The eradication of smallpox paved the way for the eradication of poliomyelitis, and perhaps measles, in the foreseeable future. New vaccines are showing the capacity to reduce important morbidity from rubella syndrome, mumps, meningitis, and hepatitis. Other new vaccines on the horizon will continue the immunologic revolution into the twenty-first century.

As the triumphs of control or elimination of infectious diseases of children continue, the scourge of HIV infection continues with distressingly slow progress an effective vaccine or cure for the disease it engenders. Partly as a result of the HIV/AIDS, TB staged a comeback in many countries where it was thought to be merely a residual problem. At the same time an old/new method of intervention using directly observed short-term therapy has shown great success in controlling the TB epidemic. The resurgence of TB is more dangerous in that MDRTB has become a widespread problem. This issue highlights the difficulty of keeping ahead of drug resistance in the search for new generations of antibiotics, posing a difficult challenge for the pharmaceutical industry, basic scientists as well as public health workers.

The burden of infectious diseases has receded as the predominant public health problem in the developed countries but remains large in the developing countries. With increases in longevity and increased importance of chronic disease in the health status of the industrial and mid-level developing nations, the effects of infectious disease on the care of the elderly and chronically ill is of great importance in the New Public Health. Long-term management of chronic disease needs to address the care of vulnerable groups, promoting the use of existing vaccines and antibiotics. Most important is the development of health systems that provide
close monitoring of groups at special risk for infectious disease, especially patients with chronic diseases, the immunocompromised, and the elderly. The combination of traditional public health with direct medical care needed for effective control and eradication of communicable diseases is an essential element of the New Public Health. The challenge is to apply a comprehensive approach and management of resources to define and reach achievable targets in communicable disease control.

**ELECTRONIC MEDIA**

Access to e-mail and the Internet are vital to current practice of public health and nowhere is this more important than in communicable diseases. There are many such information sites and these will undoubtedly expand in the coming years. Several sites are given as examples. The Internet has great practical implications for keeping up to date with rapidly occurring events in this field.

*Eurosurveillance Weekly* is available at eurowkly@euroserv.org or at website http://www.euroserv.org

Gideon, outstanding encyclopedia database on infectious diseases (available via mdcassoc@ix.netcom.com at reduced price for Promed users, and free to sub-Saharan African sites); website http://www.cyinfo.com

Infectious disease early warning system via wilsonml@biology.isa.umich.edu or web server http://eotest2.gsfc.nasa.gov/IDP/form.html (NB: Capitalized letters must be capitalized)

*Morbidity and Mortality Weekly Reports* is available on the Internet via the CDC home page and may be downloaded; consult CDC’s home page at www.cdc.gov

Promed is an excellent, free report on current events in communicable diseases internationally; join via owner-promed@usa.healthnet.org

*Weekly Epidemiologic Bulletin* of the WHO is available on the World Wide Web via http://www.who.ch/programmes/emc/news.htm

World Health Organization, Diseases and Vaccines website, http://www.who.int/gpv-dvacc and http://www.who.int/gpv-surv/country/

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