Chapter 7
The Role of Managerial Epidemiology in Infection Prevention and Control

Learning Outcomes

After completing this chapter, you will be able to:

1. Understand the roles and responsibilities of health care managers in infection prevention and control in health care organizations.
2. Apply epidemiologic principles to manage an outbreak of a transmissible disease in a health care setting.
3. Develop a strategy for infection prevention in a health care setting.

Keyterms Case-fatality rate • Epidemic • Health care-associated infection • Immunity • Incubation period • Outbreak • Pandemic • Pathogenicity • Virulence

Introduction

Infectious and parasitic diseases are the second leading cause of mortality worldwide, following mortality from cardiovascular disease (Fig. 1). Within the category of infectious and parasitic diseases in 2002, there were 31.1 million deaths worldwide from infectious diseases, with 2.7 million of those deaths due to HIV/AIDS, followed by diarrheal diseases, tuberculosis (TB), and malaria. The persistence of infectious diseases, epidemics, and infectious disease outbreaks is attributable to a number of factors including: crowding and migration (e.g., tuberculosis), international travel (e.g., Severe Acute Respiratory Syndrome, SARS), global commerce, resistance promoted by the widespread use of antimicrobials (e.g., increased use and resistance to fluroquinolones and increased rate and severity of *Clostridium difficile*-related disease, changes in medical practice requiring more invasive procedures and more aggressive procedures (e.g., increased bloodborne catheter infections), changes in the environment (e.g., flooding and increased fecal-oral disease, vector-borne disease, and rodent-borne disease), and changes in social and behavioral factors

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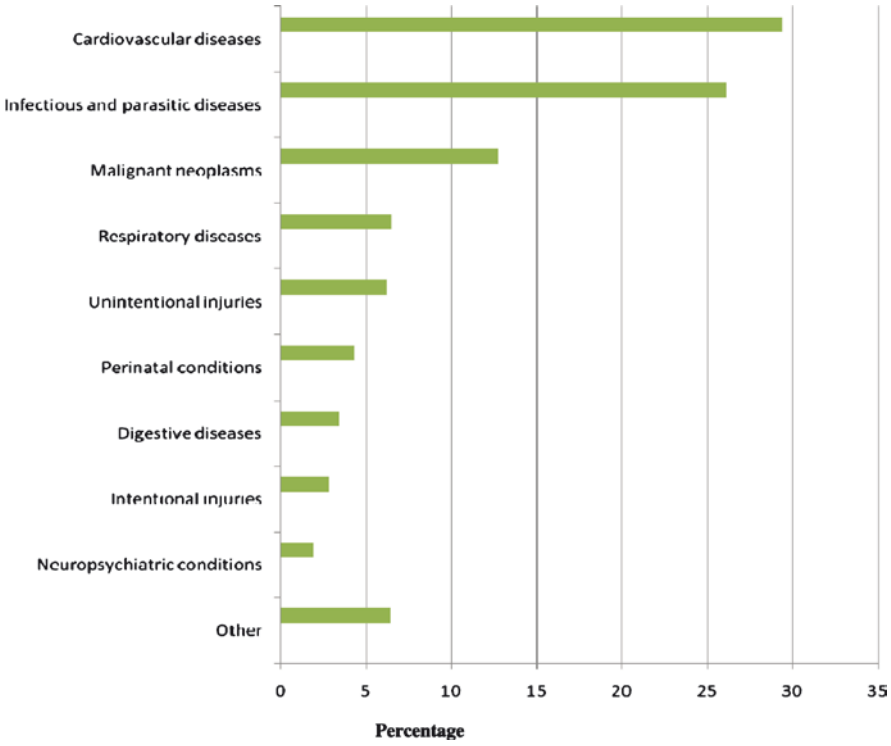

Fig. 1 Percentage distribution of mortality by condition, World, 2002 (Source: World Health Organization, 2004)

(e.g., exchange of sex for drugs) (Ahern et al., 2005; Lienhardt, 2001; McDonald et al., 2005; Newman et al., 2004; Olsen et al., 2003).

Health care-acquired infections contribute to increased lengths of hospital stays, readmission to hospitals, the potential for litigation, and affects the quality of life among individuals in skilled care facilities and hospices. The recognition of the impact of infectious conditions acquired in the hospital has reached national legislative attention because of its impact on federal health care spending. In the Deficit Reduction Act (DRA) of 2005, Section 5001(c) required the Secretary to identify, by October 1, 2007, at least two conditions that are (a) high cost or high volume or both, (b) result in the assignment of a case to a DRG that has a higher payment when present as a secondary diagnosis, and (c) could reasonably have been prevented through the application of evidence-based guidelines. For discharges occurring on or after October 1, 2008, hospitals will not receive additional payment for cases in which one of the selected Hospital-Acquired Conditions (HAC) was not present on admission and the case would be paid as though the secondary diagnosis was not present. Section 5001(c) provides that the Centers for Medicare and Medicaid Services (CMS) can revise the list of conditions from time to time. In the final FY 2008 IPPS rule, CMS identified three infectious HAC subject to this rule:

catheter-associated urinary tract infections, vascular catheter-associated blood stream infection, and surgical site infection (mediastinitis after coronary artery by-pass graft [CABG] surgery). Conditions being considered for fiscal year 2009 are ventilator-associated pneumonia and *Staphylococcus aureus* septicemia. This legislation will signal the era of intense focus on infection prevention and control and prevention efforts in health care facilities. The use and application of epidemiologic data and principles are fundamental to the success of these efforts.

Prevention of infection can span a wide variety of topics from animal to food to environment. The purpose of this chapter is to provide an introduction to the principles and practices of infectious disease epidemiology as they may be applied in health care services delivery settings.

Infectious Disease Concepts

There are five elements involved in the emergence of an infectious disease. These elements are: (1) characteristics of the infectious agent, (2) reservoir of the agent, (3) mode of transmission, (4) portal of entry/exit of the agent, and (5) the characteristics of the susceptible host.

Infectious Agent

An infectious agent is characterized in terms of its biological classification, incubation period, and manifestation in the host.

Biological agents relevant to human diseases are classified as viruses, bacteria, fungi, and parasites. Most human diseases caused by biological agents are due to bacteria or viruses. Biological agents are classified according to the presence or absence of specific traits. Bacteria are classified based on the mechanism of movement and features of the cell wall. Viruses are classified based on the type of nucleic acid and its size, shape, and mode of replication. Table 1 illustrates the major categories of microbial agents and their commonly associated disease. To determine whether a biological agent is causative in a disease, it must be isolated and identified in the host.

Each infectious agent has a unique incubation period. The incubation period is the time from the introduction of the agent into the host to the onset of the signs and symptoms of the disease. The incubation time is determined from a histogram of the onset of the signs and symptoms of illness by time unit. Commonly, the median or peak of the distribution from the histogram is the referent time unit from which to trace back in time the possible exposure source as ascertained from interviews of ill persons (Fig. 1). The incubation period may be hours, days, weeks, months, or even years. For example, microbial agents that cause food poisoning typically have an incubation period of 24–72 h; microbial agents that cause respiratory infections typically have an incubation period of 7–10 days. A group of subacute degenerative diseases such as bovine spongiform encephalopathy or “mad cow

Table 1 Common transmissible diseases according to medically important classification and associated biological agent

Classification	Transmissible disease	Biological agent
Bacterial disease: Bacteria with gram-positive cell wall structure	Tuberculosis	*Mycobacterium*
Bacteria disease: Bacteria with gram-negative cell wall structure	Gonorrhea	*Neisseria gonorrhoeae*
Bacterial disease: Bacteria with no cell walls	Pneumonia	*Mycoplasma pneumoniae*
Helminthiases	Trichinellosis	*Trichinella spiralis*
Mycoses	Ringworm	*Trichophyton*
Pediculosis, acariasis, other	Head lice	*Pediculus capitis*
Prion	Creutzfeldt-Jakob disease	Proteinaceous infectious particles
Protozoal disease	Trichomoniasis	*Trichomonas vaginalis*
Viral disease: Virus-DNA	Cervical cancer	Human papillomaviruses, Types 16 and 18
Viral disease Virus-RNA	Acquired Immunodeficiency Syndrome (AIDS)	Human immunodeficiency virus (HIV)

disease," kuru, and Creutzfeldt-Jakob disease can be from 15 months to over 30 years depending upon the route of exposure (Heymann, 2008).

Manifestation in the host is described in terms of the agent's pathogenicity and virulence. Pathogenicity is the ability of the organism to alter normal cellular and physiological processes. Virulence is the invasive ability of an organism to produce clinically manifest disease because of damage to tissues. Virulence is another term used when describing the potential for an agent to cause morbidity and mortality. It can also be epidemiologically characterized in terms of the case-fatality rate (see Boxed Example 1). Noroviruses are highly virulent because they are highly contagious and quickly spread from person to person and "few as 100 virus particles thought to be sufficient to cause infection (http://www.cdc.gov)," but have low pathogenicity because symptoms last between 24 and 60 h and recovery is usually complete with no evidence of the emergence of any serious long-term adverse health problems.

The accurate identification of an infectious agent requires the following steps to ensure the integrity of the specimen: select the appropriate body area for collection of the clinical specimen(s) for testing; select an appropriate method of collection

Boxed Example 1 Interpreting the SARS Case Fatality Rate (Source: Karlberg et al., 2004)*

Problem: Severe Acute Respiratory Syndrome (SARS) is a novel coronavirus presenting with high fever (>38°Celsius/100.4°F) and coughing or breathing difficulty. Transmission is from person to person through direct contact with

(continued)

Boxed Example 1 (continued)

the secretions or droplets of suspect or probable cases with SARS. It is not well-established if susceptibility varies by age, gender or race.

Methods: Cases of SARS were determined by treating physicians according to patient clinical signs, a chest X-ray, and appropriate diagnostic tests or autopsy reports. The case-fatality rate is the number of persons dying from a particular disease in a specific period who were diagnosed with the disease within that same time period multiplied by 100 or 100%. Mortality data were from 42 Hong Kong Government hospitals from the period early March to September 22, 2004.

Data and Results: The case fatality rate for males was 170/776 × 100% = 21.9%. The case fatality rate for females was 129/979 × 100% = 13.2%. The difference between the two groups was $p < 0.0001$. The crude relative risk of death among males was 1.66 (21.9%/13.2%).

Managerial Epidemiology Interpretation: Males are more severely affected by SARS than females experience a risk of dying that is 1.66 times greater than females. Health care managers need to understand that some population subgroups may be at higher risk than others. Resource allocation for prevention efforts (e.g., workplace exposures, smoking cessation) or more thorough diagnosis (e.g., symptoms/signs overlooked in females) should be considered.

(e.g., oral swab, spinal puncture, etc.); a sufficient quantity of material to be tested; preparation of the sample for transport (e.g., icing) including proper labeling for patient identification number; date and time of collection of the specimen; and a timely and safe transport of the specimen to the laboratory. If multiple specimens are to be taken from the same patient or if the same type of specimen is to be obtained from multiple patients, prepare and secure one specimen at a time to avoid cross-contamination, change gloves between samples and patients, avoid splashing, spilling, or aerosolizing samples. Proper frequent disinfection of the work area, immediately cleaning up spills, and ensuring that biosafety cabinets/areas are available for specimen storage while awaiting transport to the laboratory. It is also important for the health care manager to ensure the facilities and equipment for proper specimen collection are readily available and that services are organized in a manner to ensure the timely and safe delivery of the specimen(s) (e.g., tube system, refrigerated transport services).

Reservoir of Infectious Agent

A reservoir is where the agent lives, grows, and multiplies. Reservoirs can be living (human, animal, arthropod, plant) or a substance (soil, water) or some combination

thereof. The agent depends on the conditions of the reservoir to survive and be transmitted to a susceptible host. Human reservoirs can be clinical cases or carriers. Clinical cases are those persons who manifest signs and/or symptoms of the disease. Carriers are individuals who are a source of the infection by harboring a specific infectious agent, but they themselves do not manifest any signs or symptoms of the disease. An individual may be a carrier during the incubatory, convalescent, or postconvalescent phases of a disease. Also a carrier may be asymptomatic during the entire course of the infection. The carrier state may be temporary, transient, or long term (chronic carrier) (Heymann, 2008).

Transmission of Infectious Disease

Transmission is the mechanism by which an infectious agent is spread from a source to a susceptible host. The modes of transmission are: (1) direct or contact, (2) indirect, and (3) airborne.

Direct or contact transmission involves physical contact, commonly through person-to-person, such as through biting, kissing, touching, sexual intercourse or through direct projection of droplet spray onto the mucous membranes from coughing, singing, spitting, sneezing, or close (within 3 ft) talking. Direct exposure of the susceptible host to an infectious agent can also occur from an animal bite, to contaminated soil, or transplacentally. Food and water are the most common vehicles for the transmission of infectious agents.

Indirect transmission is through vehicle-borne or vector-borne methods and is a means for transporting the infectious agent into the susceptible host. Vehicles for infectious disease transmission include but are not limited to inanimate objects or materials such as soiled bedding or clothes, door handles, eating utensils, objects of personal care (toothbrushes, shavers), water, milk, surgical instruments, wound dressings, or biological substances (e.g., transplanted organs, blood transfusion, etc.). Vector-borne transmission may be mechanical or biological. Mechanical transmission is the physical transmission of an infectious agent, which is not an essential element in its life cycle. Flies can transmit *Salmonella* on their appendages from contaminated feces to food, representing mechanical transmission. Biological transmission occurs when a vector harbors a pathogen within its body and delivers the pathogen to a host in an interactive manner, such as through propagation, a bite. Malaria is caused by the biological transmission from the bite of a female *Anopheles* mosquito infected with *Plasmodium falciparum*, a protozoan parasite into a susceptible host.

Some infections, such as Trachoma, can be transmitted by multiple mechanisms, including direct contact with ocular or nasopharyngeal discharges, indirectly through contact with fomites (contaminated objects) from infected people, or through vector-borne mechanical transmission by flies (Heymann, 2008). Knowing how a disease is transmitted aids in understanding how to break the cycle of infection and control its spread. Table 2 displays selected infectious diseases and the recommended associated transmission precautions.

Table 2 Selected infectious problems, type of transmission and transmission precautions

Infectious problem	Type of transmission	Transmission precautions
Acquired immunodeficiency syndrome (AIDS)	Sexual contact, percutaneous, permucosal, perinatal	Standard
Hepatitis B, Viral	Blood, blood products, saliva, cerebrospinal fluid, peritoneal, pleural, pericardial and synovial fluid, amniotic fluid, semen and vaginal secretions, other body fluid containing blood, unfixed or transplanted tissues and organs	Standard
Measles (rubeola)	Airborne by droplet spread, direct contact with nasal or throat secretions of infected persons	Airborne
Salmonella species	Person-to-person fecal oral or ingested of organisms in food or contaminated by feces of infected animal or person	Standard
Meningitis		
Aseptic	Direct contact, including respiratory droplets from nose and throat of infected persons	Standard, Contact for infants and young children
Bacterial		Standard
Small pox	Respiratory tract (droplet spread), skin inoculation, conjunctiva	Airborne, Contact

Portal of Exit/Portal of Entry of Infectious Agent

The portal of exit is where the infectious agent leaves the host. The portal of entry is the way the organism enters the host and invades the tissue. The portals of entry/exit are: gastrointestinal, genitourinary, respiratory, and integumentary (skin, mucous membranes). Often, the portal of exit is the same as the portal of entry. Staphylococcal disease in the community, a common bacterial skin lesion, manifests itself as folliculitis, carbuncles, abscesses, or infected lacerations, and is transmitted through contact with the person who has a draining or purulent lesion.

Host Susceptibility

Host susceptibility is not having sufficient resistance to protect against acquiring disease from an infectious agent if exposed to it. Susceptibility depends on age, genetic factors, general health and immunity. Decreasing age, especially before 11 years of age when the immune system reaches maturity, and increasing age, especially over 65 years, each are associated with increased susceptibility. General health is influenced by nutrition and the presence of comorbidities, with better health associated with a lower likelihood of developing infectious disease. HIV is a major risk factor for the progression from latent TB infection to TB disease.

Immunity is a biological defense primarily provided by two categories of circulating white blood cells: lymphocytes which produce antibodies (a humoral immunity secreting antibodies) or a through a cell-mediated immunity (detecting and destroying antigens or destruction of foreign cells), and monoctyes (a phagocytic response) which have a specific action on the microorganism or on its toxin. Immunity can be characterized as passive (natural or artificial) or active (natural or artificial). Passive natural immunity is the transplacental transfer of antibodies from mother to fetus. Passive artificial immunity is the inoculation of specific protective antibodies in globulin preparations. Passive artificial immunity has a short-term efficacy (less than 6 months). Active immunity is provided through a humoral mechanism can be natural, as in the case of acquiring an infection (with or without clinical manifestations of disease), or artificial in which the agent itself in a killed or modified form (via a vaccine) is injected to stimulate protective antibodies.

Epidemics

The occurrence of a disease in excess of what is expected is called an epidemic. The existence of an epidemic is determined in different manners depending upon epidemiologic data on the frequency of its natural occurrence and seasonal variation. Influenza epidemics are defined as rates occurring in excess of one standard deviation above historical trends. Epidemics occurring where the frequency of a disease is expected to be low are determined through a graphical method or the construction of an epidemic curve. A point source epidemic curve follows a bell-shaped distribution of a histogram plotting the number of cases occurring on each date when a case became ill. The peak of the histogram represents the date where the median number of cases became ill. Knowing the suspect infection agent and tracing the incubation time from the date associated with the peak of the histogram an estimate of the time of exposure to the agent can be obtained. A propagated epidemic curve is illustrated by a histogram of the onset of the disease demonstrating repeated peaks of occurrence (Fig. 2a). Epidemics can also be cyclic, recurring according to certain time periods. Influenza and pneumonia-associated deaths typically occur as a cyclic epidemic, with the epidemic threshold exceeded during winter months (Fig. 2b). Epidemics can occur in any setting, in the community or in any setting where populations are in congregate settings (hospitals, prisons, skilled care facilities, schools, etc.). A pandemic is an epidemic that is an epidemic manifest world-wide. The severity of pandemic disease can vary over the phases of its course. Miller et al. (2009) describe the signature features of past pandemics, including a shift in the virus sub-type, a shift toward increased mortality in younger age groups, multiple successive lethal waves, and high susceptibility of populations resulting in increased transmissibility. Depending upon the features of the pandemic including its potential for animal-human transmission and the extent of countries and regions involved, the World Health Organization (2009) proposed a scheme of phases guiding the deployment of different levels of resources, interventions, and communications for disease control. The determination of an epidemic or pandemic requires the mobilization of many

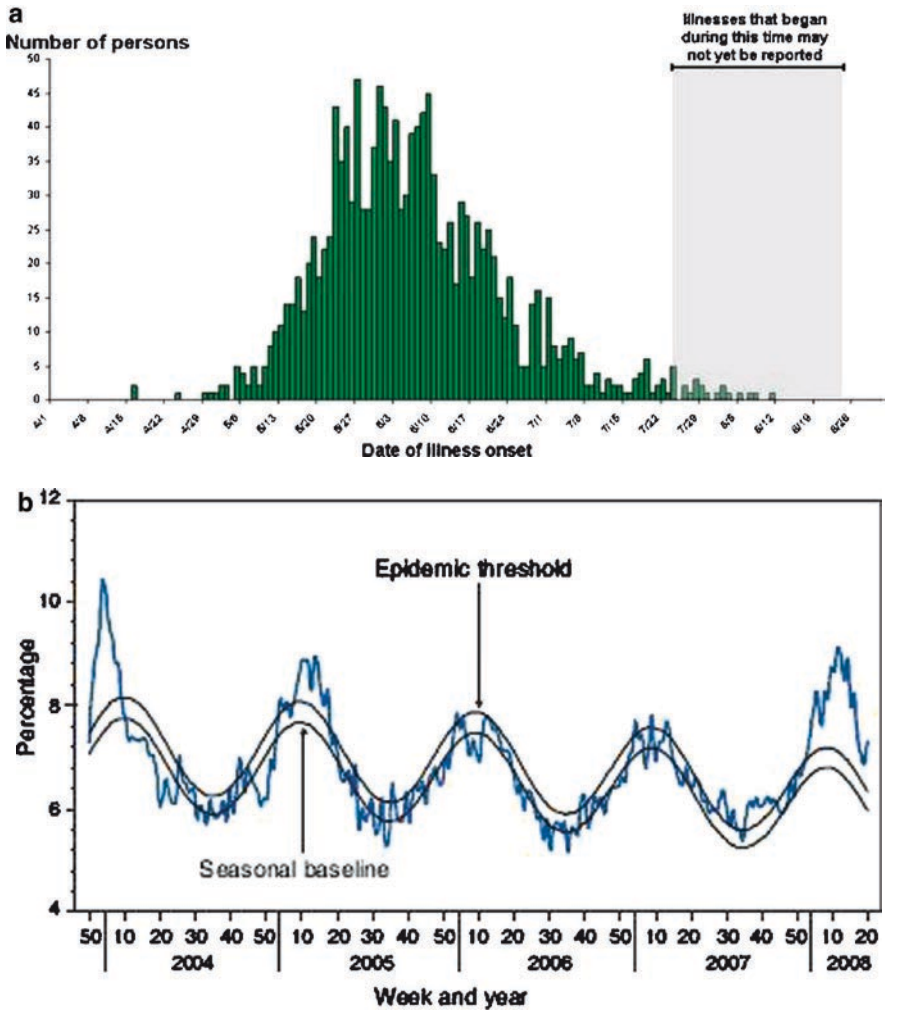

Fig. 2 (**a**) Propagated epidemic curve – Outbreak of Salmonella. From National Center for Zoonotic, Vector-Borne, and Enteric Diseases, http://www.cdc.gov/salmonella/saintpaul/epidemic_curve.html (2008). (**b**) Cyclic epidemic (Source: Centers for Disease Control and Prevention, 2008)

resources within the organization, locally, and even nationally to monitor the progress of an epidemic and to institute appropriate control and prevention measures.

An outbreak is an epidemic confined to a particular geographical area, such as a community, or organizational entity (e.g., school, hospital, jail). Outbreaks and epidemics require the same investigative process to investigate the cause and control the disease spread. The steps in this process are: (1) defining the case, (2) collecting information in the field regarding the signs and symptoms of case to determine who is ill and who is not ill, (3) collecting risk factor information, (4) analyzing the data graphically and statistically to identify associations between exposure and disease, (5) obtaining specimens for laboratory confirmation from

cases and potential sources of the illness, (6) confirming the transmissible agent, (7) disseminating the results of the findings to those who need to know, and (8) developing surveillance and other systems as appropriate to prevent the spread of the infectious disease and its future reoccurrence.

To develop an infectious disease, an individual must be both susceptible and exposed. An exposure is a factor that, in the case of infectious disease transmission, is harmful and is the circumstance that allows for entry or interaction between the host and the organism to produce harmful effects or clinical disease. The circumstances of the exposure are its frequency, duration, dose, distance, and degree of intimacy. The degree of susceptibility of the host (e.g., older age plus comorbidities) also determines if the circumstances of the exposure will result in an infectious disease. An epidemic or outbreak may occur if a large number individuals are exposed who do not possess adequate immunity or are not protected in terms of herd immunity. Herd immunity is the protection of an individual(s) because a sufficient number of individuals in the geographic area are immune from the disease. There are various theories on determining the size of the population to protect any one individual, but the reader should consult other resources.

Control of Infectious Disease

Control of infectious disease, in the health care setting or in the community, is the responsibility of all health care professionals. The areas of responsibility are described below.

Knowledge of the Epidemiology of Common Infectious Problems in Health Care Settings

Knowledge of the epidemiology of infectious problems in health care settings is key to developing prevention measures. There are two populations at risk in this framework, health care workers and patients. Infectious diseases that health care workers are at greatest risk for are:

Hepatitis B, Hepatitis C, and HIV via blood/body fluid exposure and influenza other respiratory conditions transmitted through airborne exposures. Table 3 summarizes the epidemiology of Hepatitis B as an example of the core knowledge that a health care manager should possess when confronted with either planning for or responding to an outbreak or epidemic.

Patients are also at risk for a variety of transmissible diseases in any health care setting. Risk of infectious disease transmission varies by health care setting (Siegel et al., 2007). It is also important to protect patients from diseases transmitted by health care workers. Hence, health care facilities should have policies and procedures in place regarding when workers have become exposed and/or are ill with transmissible diseases (e.g., remain home if have a fever above 101°F). Policies may involve

Table 3 Epidemiology of acute Viral Hepatitis B

Agent:	Hepatitis B virus (HBV) a hepadnavirus, partially double-stranded DNA virus
Classification codes:	ICD-9 070.3; ICD-10 B16
Signs and symptoms:	Jaundice (70%), fatigue, abdominal pain, loss of appetite, nausea, vomiting, joint pain (30% have no signs or symptoms)
Incidence rates (US, 2006):	Overall: trend declining (81% since 1990); 1.6 per 100,000; Race/ethnicity highest among blacks: 2.3 per 100,000; Highest age group: 25–44 years (3.1 per 100,000); Highest rates in the South; Male to female ratio 1.8:1
Clinical course:	40% of cases hospitalized; 0.8% died; increased rate of hospitalization with increasing age
Reservoir:	Man
Mode of transmission:	Infected blood or blood products or any other body fluids containing blood or unfixed tissues or organs
Risk groups:	• Sex contacts with infected persons • Men who have sex with men • Diagnosis of a sexually transmitted disease • Individuals having sex with multiple partners • Household contacts of chronically infected persons • Infants born to infected mothers • Infants/children of immigrants from areas with high rates of HBV infection (Southeast Asia, China, Korea, Indonesia, and the Philippines; the Middle East, except Israel; South and Western Pacific islands; the interior Amazon River basin; Haiti and the Dominican Republic) • IV drug users • Health care and public safety workers with exposure to blood • Hemodialysis patients

ICD = International Classification of Disease

active screening of employees to protect patients against this risk. Screening may include: measles and hepatitis B titre levels and skin testing for latent TB infection. Guidelines for targeted tuberculin testing of health care providers are available through the Centers for Disease Control and Prevention (CDC, 2005). The magnitude and type risk to infectious disease of patients in health care settings varies according to the specific patient population (e.g., adult, pediatric, geriatric, etc.), types of exposures to devices, and types of invasive procedures performed.

In *hospitals*, there are three areas of concern for transmission risk. Intensive care units (ICU) care for patients with life threatening diseases and trauma who are treated with invasive technology often with extended antibiotic use and long stays. ICU patients are at risk for multidrug resistant organisms and various *Candida* species. Over 20% of hospital-acquired infections are likely to arise in ICUs. Burn unit patients are susceptible to infection in proportion to the amount of total body surface exposed. Prevalent organisms in burn units include methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), gram-negative bacteria, and various *Candida and Aspergillus* species. Pediatric unit patients are at risk of transmission of

community-acquired infections because these patients do not have fully developed immune systems, are low birthweight, have incomplete immunization series, or because of seasonal epidemics occurring in the community. Organisms common in pediatric units include: *Bordetella pertussis* [pertussis], respiratory viral infections including those caused by respiratory syncytial viruses (RSV), influenza viruses, parainfluenza virus, human metapneumovirus, adenoviruses, rubeola [measles], varicella [chicken-pox], and rotaviral enteritis (Boxed Example 2).

Long term care facilities (LTC) (skilled nursing facilities, in-patient rehabilitation centers, in-patient behavioral health centers, assisted breathing centers, homes for the developmentally disabled, hospices) are a source of risk for transmissible disease because their residents may have limitations in or impaired mobility or cognition, share common areas for extended periods of time, and/or have chronic illnesses. The rate of health care-acquired infections has been reported to range from 3 to 7 per 1,000 resident-care days in the more rigorous studies (Siegel et al., 2007). In LTC facilities, transmissible organisms of concern are: various viruses (e.g., influenza virus,

Boxed Example 2 Catheter-related Bloodstream Infection:Effectiveness of an Intervention

Problem: In intensive care units, catheter-related bloodstream infections are common and potentially lethal.

Methods: A cohort study compared infection rates before, during, and up to 18 months after implementation of study intervention. The Michigan Health and Hospital Association (MHA) promoted hospital involvement to use interventions (hand washing, full-barrier precautions during the insertion of central venous catheters, cleaning the skin with chlorhexidine, avoiding the femoral site, and removing unnecessary catheters) as part of a statewide safety initiative in ICUs (the MHA Keystone: ICU Project). The National Nosocomial Infections Surveillance System definition of catheter-related blood-stream infection was used which included clinical signs and/or cultures of blood or other infection sites.

Data and Results (Sources: Pronovost et al., 2006; Goeschel et al., 2006):

Study period	Incidence-rate ratio (IRR) (95% CI)	*p*-value
Baseline	1.00	
During implementation	0.76 (0.57–1.01)	0.063
After implementation		
0–3 months	0.62 (0.47–0.81)	0.001
7–9 months	0.47 (0.34–0.65)	<0.001
16–18 months	0.34 (0.23–0.50)	<0.001

Managerial Epidemiology Interpretation: A risk ratio less than 1.0 indicates that the outcome is less likely the study period than in the baseline period. The significant (a *p*-value of less than 0.001) "protective (or reduction)" effect (IRR = 0.34) of intervention reducing catheter-related bloodstream infections persisted as long as 18 months after the introduction of the intervention (incidence rate ratio of 0.34, 95% CI: 0.23–0.50, $p < 0.001$).

rhinovirus, adenovirus [conjunctivitis], norovirus) and bacteria, including group A streptococcus, *B. pertussis*, nonsusceptible *S. pneumoniae*, various other multidrug resistant organisms, and *Clostridium difficile.*

In *ambulatory care settings*, the risk of disease transmission is largely influenced by seasonal epidemic trends in the community as well as the types of patient populations served and their treatments. Transmission of bloodborne pathogens (Hepatitis B, Hepatitis C, HIV/AIDS) and transmission of airborne pathogens (M. tuberculosis, measles, rubella varicella-zoster virus) have been reported in ambulatory settings. M. tuberculosis and measles transmission have been most frequently reported in emergency departments, where measles virus transmission has been most frequently reported in physician offices (Siegel et al., 2007). Another common source of transmissible disease in ambulatory settings are contaminated equipment, and failure to use safe injection practices or aseptic technique. Cohorting patients presenting to ambulatory care settings (e.g., a well-child area and sick-child area in a waiting room, negative pressure rooms in the emergency department for persons suspected of serious airborne disease transmission) is a strategy for minimizing the chances of health care-acquired infectious.

In *nontraditional settings* for health care delivery, health care may be provided such as workplaces with occupational health clinics, adult day care centers, assisted living facilities, homeless shelters, jails and prisons, and school clinics. Each setting faces unique challenges and organisms because of the patient populations served (e.g., HIV/AIDS and TB in incarcerated populations and homeless shelters) requiring the health care management to seek guidance from local health authorities.

Reporting

Ideally, all health care facilities should have dedicated infection control professional (ICP) whose primary responsibility is the prevention of infection. The ICP is responsible for having the knowledge of which infectious diseases must be reported by state legislation or regulation to the local or state health department. In the absence of an ICP, the designated manager is responsible for the reporting. The general categories of conditions reported are communicable diseases, sexually transmitted diseases, TB, and vaccine preventable disease. Notifiable diseases vary somewhat by state although all states require reporting of diseases subject to quarantine (cholera, plague, and yellow fever) according to the World Health Organization's International Health Regulations. The responsibility for reporting diseases to the local health authority depends upon the requirements set forth by that authority. A report to the local health authority in whose jurisdiction the reporter is located is required by any person having knowledge of a known or suspected case or carrier of communicable disease or a death caused by a communicable disease determined notifiable by the local health authority. Among those required to report include: physicians, nurses, nurse aides, dentists, laboratory personnel, school personnel, long-term care personnel, day care personnel, and college/university personnel. Health care providers may disclose individually identifiable health information for

use in public health to public health authorities without individual consent without violating HIPAA regulation. The specific data required for reporting includes patient information (name, address, date of birth, gender, race, ethnicity) and testing information (name of test and test result). The Centers for Disease and Control website should be consulted for the latest listing of notifiable diseases in the USA which is revised periodically depending upon the emergence of new pathogens or a decline or elimination of an existing pathogen (Table 4). Even under the best of circumstances, it may take 2–3 weeks to confirm a patient's illness was part of an outbreak because of the time to contact the health system, the timing of the collection of the specimen, clinical laboratory identification of the agent, shipping time of the specimen to the public health lab, and confirmation by the public lab. Thus, cases

Table 4 Notifiable communicable diseases in the United States, 2008 (Source: Centers for Disease Control and Prevention, 2008)

Acquired immunodeficiency syndrome (AIDS)	Novel influenza A virus infection
Anthrax	Pertussis
Arboviral neuroinvasive and nonneuroinvasive diseases (e.g., St. Louis encephalitis, West Nile virus disease)	Plague
Botulism	Poliomyelitis, paralytic and nonparalytic
Brucellosis	Psittacosis
Chlamydia trachomatis, genital infection	Q Fever
Cholera	Rabies, animal and human
Coccidioidomycosis	Rocky Mountain spotted fever
Cryptosporidiosis	Rubella, including congenital syndrome
Cyclosporiasis	Salmonellosis
Diptheria	Severe Acute Respiratory Syndrome-associated Coronavirus (SARS-CoV) disease
Ehrlichiosis/Anaplasmosis	Shiga toxin-producing *Escherichia coli* (STEC)
Giardiasis	Shigellosis
Gonorrhea	Smallpox
Haemophilus influenza, invasive disease	Streptococcal disease, invasive, Group A or toxic-shock syndrome
Hepatitis A, acute	*Streptococcus pneumoniae*, drug resistant invasive disease or nondrug resistant invasive disease in children less than 5 years of age
Hansen disease (leprosy)	Syphilis, including congenital
Hantavirus pulmonary syndrome	Tetanus
Hemolytic uremic syndrome, postdiarrheal	Toxic-shock syndrome (other than Streptococcal)
Hepatitis, viral, acute and chronic (Hepatitis A, Hepatitis, B, Hepatitis C)	Trichinellosis (Trichinosis)
HIV Infection (adult or pediatric)	Tuberculosis

(continued)

Table 4 (continued)

Influenza-associated pediatric mortality	Tularemia
Legionellosis	Typhoid fever
Listeriosis	Vancomycin intermediate or resistant *Staphylococcus aureus*
Lyme disease	Syphilis
Malaria	Varicella (morbidity or mortality)
Measles	Vibriosis
Meningococcal disease	Yellow fever
Mumps	

enumerated by signs and symptoms while an outbreak of a disease is occurring should be considered preliminary until confirmed by laboratory findings.

Surveillance

Surveillance is the systematic collection of data pertaining to defined cases or behaviors related to a disease (infectious in this discussion), analysis, evaluation, and the dissemination of results to those who are in a position to initiate control measures. To prevent outbreaks, local health authorities rely on communicable disease reported to surveillance systems. Data collection may range from computerized reports of syndromes, compilation of reports from systematic field studies/or surveys, adverse events (e.g., needle stick injury), or environmental factors (surveillance of dead birds in association with West Nile disease) (Patnaik et al., 2007). A more detailed discussion of surveillance systems is in chapter "Screening and Surveillance for Promoting Population Health." Health care workers need to be active in surveillance efforts through participation in the reporting and utilization of data from surveillance systems to plan and evaluate control efforts.

Vaccines

Vaccination is the conferring of active immunity through the administration of an antigen that is not pathogenic. The principle of vaccination is to stimulate the antibody (B-cell) response and cell-mediated response (T-cell) such that the immune system will mount an immediate, sustained and sufficiently powerful attack against exposure to the pathogen invading the host. Vaccination should have long-term, lasting protection. Table 5 lists diseases that are preventable through available vaccines.

However, there are limitations to the value of existing vaccinations. The protective effective of the vaccination may take longer than the time between exposure and onset of disease, many vaccines require multiple doses to achieve a protective immune response, not all persons mount an immune response subsequent to the vaccination, and finally, persons with impaired immunity either

Table 5 Vaccine preventable diseases

Anthrax	Pertussis (Whooping Cough)
Cervical cancer	Pneumococcal infection
Diptheria	Poliomyelitis (Polio)
Hepatitis A	Rabies
Hepatitis B	Rotavirus
Haemophilus influenzae type b (Hib)	Rubella (German Measles)
Human Papillomavirus (HPV)	Shingles (Herpes Zoster)
Influenza (Flu)	Smallpox
Japanese Encephalitis (JE)	Tetanus (Lockjaw)
Lyme disease	Tuberculosis (TB)
Measles	Typhoid fever
Meningococcal infection	Varicella (Chickenpox)
Monkeypox	Yellow Fever
Mumps	

cannot generate an immune response to the vaccine or may experience side effects to the vaccine. Vaccines, as with any therapeutic product, may have side effects. Most side effects may be minor (injection site swelling, fever, malaise). Major side effects may include allergic reactions because of the medium the vaccine was grown in (egg or tissue culture) or additives or the disease itself from the administration of a live virus.

There are recommended vaccinations and vaccination schedules not only for children, but also for adults and health care workers (Centers for Disease Control and Prevention, 2007; Centers for Disease Control and Prevention, 2009a, b). The purpose of immunization of health care workers is not only to protect themselves, but also to promote patient safety by "doing no harm," that is, not being a potential source of hospital-acquired infection. Immunization of health care workers additionally contributes to providing herd immunity. Herd immunity is the protection from an infectious agent afforded to a population as a whole because large numbers of its members are immune to an infectious problem and do not harbor it. Following current recommendations for vaccination is a responsibility of all health care providers as it is one aspect of promoting patient safety. The major cost savings to health care organizations are to promote the wide-spread coverage of influenza vaccination among its employees. The prevalence of employees obtaining influenza vaccination will be an important component of hospital infection prevention and control programs to meet new CMS (2007) Guidelines. In 2003, the prevalence of health care workers who received influenza vaccination was only 40%.

Passive antibody administration conferring rapid immunity through humoral mechanisms (e.g., Anthrax vaccination), regardless of the immunity level of the individual, has been proposed as a specific defense against biological weapons and would be useful to health care workers, first responders, and military personnel who are at risk for exposure to biological weapons (Casadevall, 2002). However, the cost of the development and administration of such vaccinations is questionable if readily available drug therapy is available.

Managerial Responsibilities in the Control of Infectious Diseases

Health care managers are responsible for coordinating the general effort of the prevention and control of transmissible diseases in health care organization. Areas of responsibility are described below.

Administrative Controls

Administrative controls are the development and use of policies, procedures, and protocols regarding the prevention and rapid detection, isolation, treatment, and spread of infectious disease within a health care facility. Administrative controls are aimed at the environment as well as employee and patient behaviors. Evidence from the recent literature, epidemiologic principles of infectious disease, national priorities, and accreditation agency criteria, state, or local regulations should guide in the development of administration controls. The Joint Commission on Accreditation of Healthcare Organizations (2008) has targeted selected infections and infection prevention and control activities to be included in its *2008 National Patient Safety Goals*. These are displayed in Table 6. The increasing costs associated with hospital-acquired infection have prompted the implementation of federal standards aimed at hospital responsibilities for infection prevention and control practices. The CMS Guidelines mandate hospitals to have active programs for the prevention, control, and investigations of infections and communicable diseases. The Guidelines further require that an infection prevention and control officer or officers are designated in writing, a log of all incidents related to infections

Table 6 2008 National patient safety goals pertaining to infection prevention and control (Source: Joint Commission for Accreditation of Healthcare Organizations, 2008)

Goal 7 Reduce the risk of health care-associated infections
7A Comply with current World Health Organization (WHO) Hand Hygiene Guidelines or Centers for Disease Control and Prevention (CDC) hand hygiene guidelines [Ambulatory, Assisted Living, Behavioral Health Care, Critical Access Hospital, Disease-Specific Care, Home Care, Hospital, Lab, Long Term Care, Office-Based Surgery]
7B Manage as sentinel events all identified cases of unanticipated death or major permanent loss of function associated with a health care-associated infection [Ambulatory, Assisted Living, Behavioral Health Care, Critical Access Hospital, Disease-Specific Care, Home Care, Hospital, Lab, Long Term Care, Office-Based Surgery]
Goal 10 Reduce the risk of influenza and pneumococcal disease in institutionalized older adults
10A Develop and implement a protocol for administration and documentation of the flu vaccine [Assisted Living, Disease-Specific Care, Long-Term Care]
10B Develop and implement a protocol for administration and documentation of the pneumococcus vaccine [Assisted Living, Disease-Specific Care, Long-Term Care]
10C Develop and implement a protocol to identify new cases of influenza and to manage an outbreak [Assisted Living, Disease-Specific Care, Long-Term Care]

and communicable disease among both patients and staff, the CEO, medical staff, and nursing director assume the responsibility for addressing problems identified by infection prevention and control officer(s) in quality assurance and training programs, and that corrective action plans are in place for problems identified by the infection prevention and control officer(s) (CMS, 2007).

Increasingly, the use of evidence-based guidelines and protocols is used to improve outcomes and/or prevent infections (Hauck et al., 2004; Pronovost et al., 2006). The Michigan Health and Hospital Association Keystone ICU Project promoted the use of evidence-based protocol by a hospital's ICU implementation team which had the goals of eliminating bloodstream infections and ventilator-associated pneumonia. The Project had many successful outcomes including patient lives, hospital days, and health care dollars saved (see Boxed Example 2) (Michigan Health and Hospital Association, 2008).

Employee risk assessment and education are administrative control measures. The first step is to classify all employees according to risk of exposure to bloodborne pathogens or airborne disease transmission. Volunteers and students should also be assessed of their risk. Risk assessment for bloodborne disease is according to three levels: Level I, individuals at highest risk because they work with blood or blood products, sharps, perform invasive tasks, or work with equipment which may be contaminated with blood or bodily fluids (e.g., lab technician, nurse); Level II individuals are at medium exposure due to limited contact with patients, blood, or body fluids (e.g., dietary workers); and, Level III individuals have no direct patient contact and no contact with contaminated items such as sharps (e.g., accounting personnel). The next steps involve the communication of the risk to the affected persons, monitoring the exposures, and offering exposure reduction plans to employees (e.g., on site availability of Hepatitis B vaccine series) and training on risk reduction and infection prevention and control practices at orientation and annually.

Administrative controls also include the establishment of an infection prevention and control program and credentials of its personnel should follow the practice standards adopted by the Boards of the Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) (http://www.apic.org). APIC promotes guidelines, based upon epidemiologic principles, for the development and staffing for infection control programs within health care organizations. Criteria for staffing include a consideration of number of occupied beds (average daily census), complexity of health system, patient population, and diagnostic and therapeutic interventions used in the setting (O'Boyle et al., 2002). Elements of an infection prevention and control program are listed in Table 7. Even if the health care facility has an infection prevention and control program, it is the responsibility of each employee to be engaged in the control of transmissible disease. Management responsibilities regarding infection prevention and control are displayed in Table 8.

Other administrative controls involve patient placement (e.g., cohorting ill patients in waiting rooms or air pressure negative rooms), transportation procedures (specimen and patient), handling of laundry, management of solid waste disposal, handling of dietary materials, and the management of visitors.

Table 7 Elements of an infection prevention and control program

1. Establish authority of infection prevention and control, organizational position, reporting relationships, and staffing
2. Construct an exposure matrix for all employee job classifications
3. Plan, develop, implement, and operate method(s) for infection surveillance:
   a. Targeted (e.g., high risk patients: immobile, ICU)
   b. Active (e.g., encourage or require reporting of needle stick injuries, culturing for a specific organism, Staphylococci)
   c. Passive (e.g., monitor microbiological reports of Assisted Breathing Unit)
   d. Periodic (e.g., rotating sampling of reports or specimens among wards)
4. Develop policies and procedures in accordance with regulatory bodies, credentialing bodies, the current literature, and the types of exposures anticipated among the health care workforce
5. Establish mechanisms and procedures for communicable disease reporting, within organization and to local health authority
6. Conduct preemployment testing and mandatory immunizations
7. Conduct education for all new employees and annually thereafter on latest CDC recommendations for infection prevention and control
8. Conduct periodic employee screenings (e.g., for tuberculosis)
9. Provide recommended immunizations for employees (hepatitis B, influenza)
10. Provide treatment for workplace exposures if indicated (e.g., chemotherapy for post HIV/AIDS exposure)
11. Provide support for personnel employee health (e.g., smoking cessation programs, asthma awareness)
12. Disseminate feedback to staff on organizational progress in infection prevention and control

Table 8 Healthcare manager responsibilities regarding infection prevention and control

Prevention

1. Classify work activity and exposure levels for all job titles
2. Develop policies and procedures for workplace exposure control
3. Provide training an education in infection prevention and control
4. Develop procedures to ensure and monitor compliance to infection prevention and control policies and procedures
5. Provide access to Hepatitis B vaccination
6. Establish an annual influenza vaccination program that includes at least staff and licensed independent practitioners
   - Provide access to influenza vaccinations on-site
   - Education staff and licensed independent practitioners about flu vaccination, diagnosis and transmission, and impact of diagnosis and nonvaccination control measures (e.g., cohorting of patients, protect sneezes and coughs, prevent hand mucous membrane contact)
   - Annually evaluate vaccination rates and reasons for nonparticipation in the organization's immunization program
   - Implement enhancements to the program to increase participation

Workplace environment

1. Provide for safe needles and sharps disposal
2. Install hand washing facilities and redundant systems for hand hygiene (e.g., alcohol-based hand sanitizers)

(continued)

Table 8 (continued)

3. Supply approved cleaning, disinfecting, sterilizing equipment materials
4. Fit and provide personal protective equipment and training in its use
5. Arrange for safe disposal of biological waste
6. Maintain proper airflow in isolation rooms
7. Ensure timely and protected transport of biological specimens within and out of facility

Medical response to individual exposure

1. Provide baseline assessment and appropriate laboratory testing at time of exposure
2. Secure documentation of exposure circumstances (work tasks, protective equipment, exposure source, and features)
3. Arrange for follow-up assessments, testing, and treatment for symptomatic disease emerging related to exposure
4. Institute workplace restrictions or duty-reassignment for workers highly susceptible to transmissible disease depending upon employee's physician

General operations

1. Report exposure and subsequent exposure-related disease to OSHA and as appropriate to local health authority
2. Communicate with local authorities in the event of intentional exposure of employees or patients to biologic agents (e.g., evidence of aerosolized anthrax in health care facilities)
3. Communicate with employees and/or patients in the event of accidental or intentional exposure of employees or patients to biological agents (e.g., contaminated surgical equipment)

Engineering Controls

Engineering controls are modifications to the environment or devices that remove the hazard or reduce the exposure in the workplace. Examples are: sharps containers that are leak-proof and puncture resistant, needle-less intravenous connections, mouth-to-mouth, resuscitation mouthpieces, and nitrile gloves. Structural features such as certified biological safety cabinets and laminar flow rooms are engineering measures aimed at infection prevention and control. Cost-effectiveness analysis guides the manager in selecting engineering measures which are typically more expensive control options than either the use of administrative controls or personal protective equipment (PPE).

Personal Protective Equipment

Health care managers must assure that PPE is available to employees as appropriate, in addition to administrative controls. PPE consists of items to protect patients and staff from exposures during work tasks. In particular, PPE is designed to reduce the risk of a health care worker's exposure through the skin, mucous membranes, or respiratory system. Examples of PPE include gloves, gowns, masks, eyeglasses, face shields, shoe covers, goggles, and respirators. The sequence of donning and removing PPE is extremely important an infection prevention process and the recommended sequences are displayed in Fig. 3.

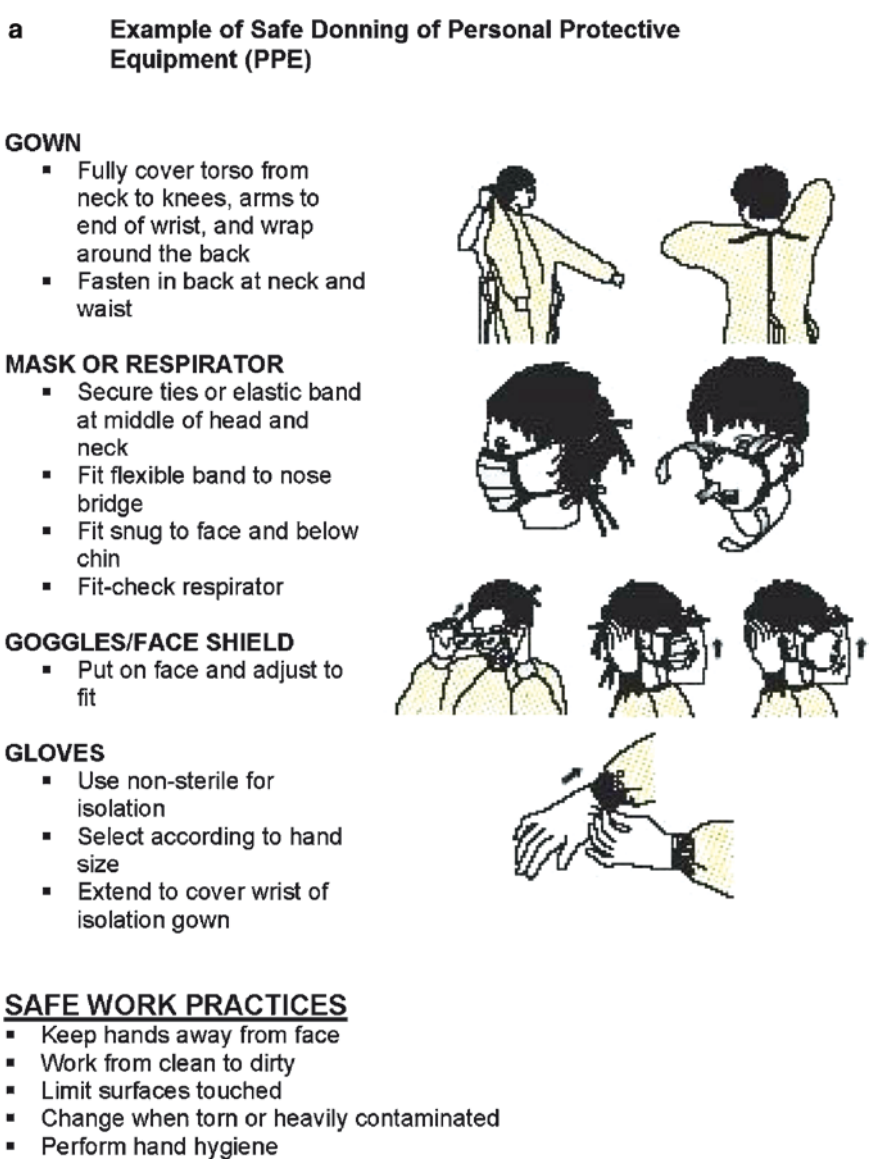

Fig. 3 (**a**) Sequence for donning personal protective equipment (PPE)

Managing Disease Outbreaks 484

There are circumstances, despite the most comprehensive administrative efforts, that 485
a disease outbreak or epidemic will occur in a health care facility. An epidemic is 486
the occurrence of cases of a condition occurring in excess of what would be expected 487

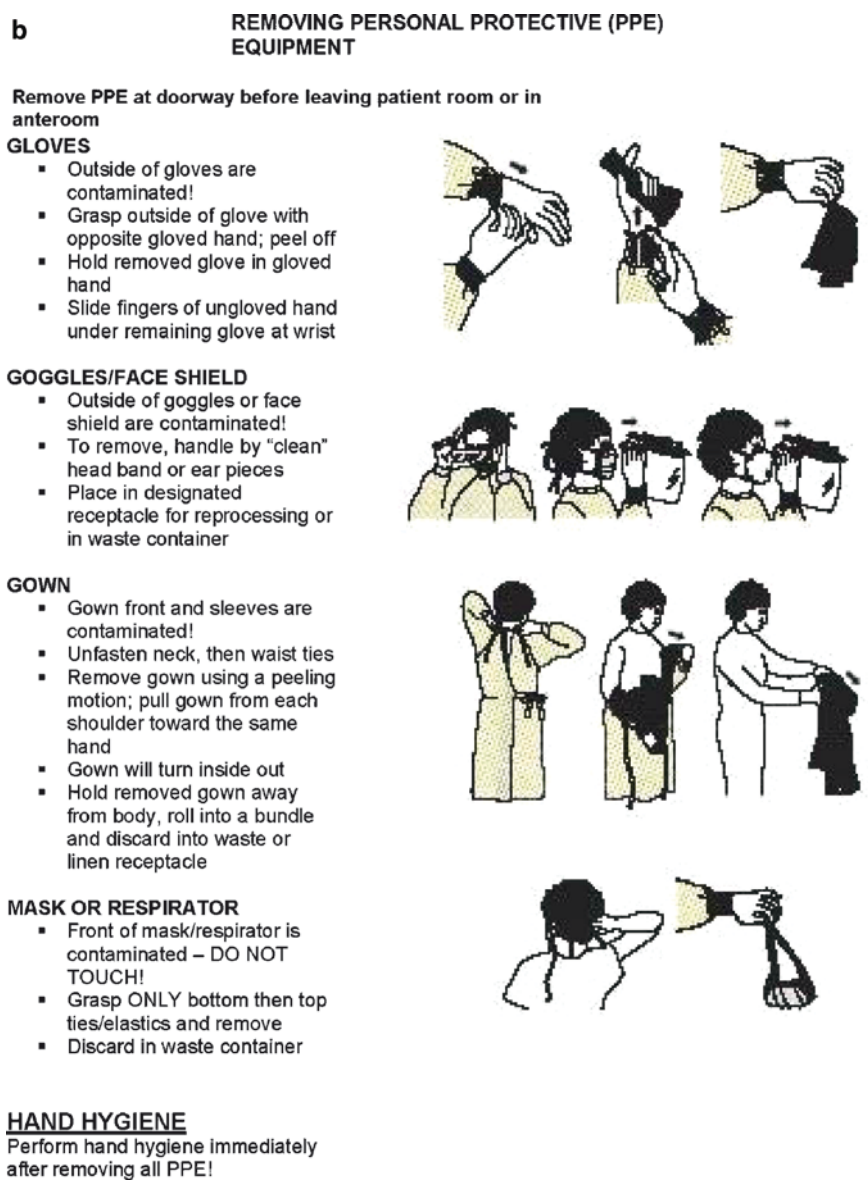

Fig. 3 (**b**) Sequence for removing PPE (From: Centers for Disease Control and Prevention, 2007)

during the same time interval during the same season of the year. A disease outbreak is the occurrence of cases of disease in excess of what would normally be expected in a short-time period in a defined population, community, geographical area, or season. An outbreak may occur in a restricted geographical area, or extend over several countries within the same few days, weeks, or years. According to the World Health Organization (2007), "A single case of a communicable disease long absent

from a population, or caused by an agent (e.g., bacterium or virus) not previously recognized in that community or area, or the emergence of a previously unknown disease, may also constitute an outbreak and should be reported and investigated." The actual number of cases constituting an epidemic depends upon the infectious agent and the circumstances of the case presentation. Two cases of botulism occurring among patrons of a restaurant may be considered an epidemic. An epidemic may arise for several reasons, including: (1) an increase in the number of susceptible persons; (2) the emergence of a new organism; (3) changes in the environment; (4) changes in human behavior; (5) new media for the growth of organisms; (6) the migration of infected persons, animals, birds, or insects into an area; (7) change in the virulence of an organism; (8) inadequate immunization levels in a population; (9) improper sanitation or sanitary practices; or, (10) the intentional introduction of an infectious agent. A clue, if the epidemic is due to the intentional introduction of an infectious agent, is when a case is found to have developed the disease not through usual route of transmission or reservoir. For example, the development of anthrax in the respiratory system is not consistent with the common mode of transmission, namely direct contact with the tissues of animals dying of the disease.

Health care settings are susceptible to epidemics and outbreaks. In theses setting, both the patient population and health care employees are at risk including because of the closeness of contact, the immunocompromised state of many patients from diseases, inadequate vaccination levels. During the SARS epidemic, there were a large number of health care workers documented as having acquired the disease from exposure to patients. The health care organization must be proactive and reactive, responding in a quick manner to decrease further infectious disease spread. This requires an organized effort by the organization.

In the event an outbreak occurs in a health care facility, the role of the health care manager is to initiate an organized strategy for its control. The action steps then taken by the manager would include the deployment of the personnel and resources to: (1) define the case; (2) screen all persons potentially exposed with laboratory studies to define the magnitude of the outbreak; (3) characterize the demographics of the cases, place of onset of disease, and time of onset of signs and symptoms; (4) isolate the infected cases and the source, if known; (5) disinfect portals of exit; (6) break identified chains of entry; (7) defend portals of entry; (8) arrange for the immunization and/or treatment of other susceptible persons, if indicated; (9) promote the investigation of risk factors (optimally using a case-control design); and (10) establish and maintain surveillance that serves to identify the potential for future outbreaks and gauges the efficacy of control measures. Of these steps, rapid detection is probably the most important and a responsibility of all health care professionals in the facility.

Health Care Manager Responsibilities in Infection Prevention

Health care managers in practice should support the use of a combination of control measures, both in terms of organizational structure as well as policies and procedures.

The mandated use of "Standard Precautions" in a health care setting is an example of a combination of control measures. Standard precautions emphasize administrative controls and the use of PPE. The epidemiologic principle behind this is twofold. First, excluding sweat, all body fluids, secretions, excretions, mucous membranes, and nonintact skin are presumed to be potentially infectious so that contact with these portals of exit and bodily fluids should be avoided. Second, health care settings often have a high prevalence of patients who are immunocompromised and therefore Standard Precautions should be used in the care of all patients (Table 9). Although for most communicable diseases, Standard Precautions are recommended, there are also Airborne, Contact, and Droplet Precautions which may be indicated for selected infections and conditions (Siegel et al., 2007). The U.S. Department of Labor, Occupational Health and Safety Administration (OSHA) provides information

Table 9 Recommendations for application of standard precautions for the care of all patients in all healthcare settings (Source: Siegel et al., 2007)

Standard precautions component	Recommendations
Hand hygiene	After touching blood, body fluids, secretions, excretions, contaminated items; immediately after removing gloves; between patient contacts
Personal protective equipment (PPE):	
Gloves	For touching blood, body fluids, secretions, excretions, contaminated items; for touching mucous membranes and nonintact skin
Gown	During procedure and patient-care activities when contact of clothing/exposed skin with blood/body fluids, secretions, and excretions is anticipated
Mask, eye protection (goggles), face shield[a]	During procedures and patient-care activities likely to generate splashes or sprays of blood, body fluids, secretions, especially suctioning, endotracheal intubation
Soiled patient-care equipment	Handle in a manner that prevents transfer of microorganisms to other and to the environment; wear gloves if visibly contaminated; perform hand hygiene
Environment control	Develop procedures for routine care, cleaning, and disinfection of environmental surfaces, especially frequently touched surfaces in patient-care areas
Textiles and laundry	Handle in a manner that prevents transfer of microorganisms to others and to the environment
Needles and other sharps	Do not recap, bend, break, or hand-manipulate used needles; if recapping is required, use a one-handed scoop technique only; use safety features when available; place used sharps in puncture-resistant container
Patient resuscitation	Use mouthpiece, resuscitation bag, other ventilation devices to prevent contact with mouth and oral secretions

(continued)

Table 9 (continued)

Standard precautions component	Recommendations
Patient placement	Prioritize for single-patient room if patient is at increased risk of transmission, is likely to contaminate the environment, does not maintain appropriate hygiene, or is at increased risk of acquiring infection or developing adverse outcome following infection
Respiratory hygiene/cough etiquette (source containment of infectious respiratory secretions in symptomatic patients, beginning at initial point of encounter e.g., triage and reception areas in emergency departments and physician offices)	Instruct symptomatic persons to cover mouth/nose when sneezing/coughing; use tissues and dispose in no-touch receptacle; observe hand hygiene after soiling of hands with respiratory secretions; wear surgical mask if tolerated or maintain spatial separation, >3 feet possible

[a]During aerosol-generating procedures on patients with suspected or proven infection transmitted by highly pathogenic respiratory aerosols (e.g., SARS, tuberculosis), wear a fit-tested N95 or higher respirator in addition to gloves, gown, and face/eye protection

on assessing the risk of various exposures to biological agents (e.g., anthrax) and procedures for clean-up of the workplace after contamination http://www.osha.gov/SLTC/biologicalagents/index.html.

Outbreak, Hazard, and Communicable Disease Rate Communication

Communication is an essential management responsibility. Hazard communication involves not only written policies and procedures, but also communication in terms of signage and training. Warning labels affixed to biohazardous waste containers, refrigerators, and biohazardous waste bags identified by red color as signage on patients' doors are examples of hazard communication. Training given to employees on their risk level to bloodborne disease and other occupational exposures at orientation and annual retraining is another form of communication. Communication in the event of outbreaks is essential not only to employees, but also to patients and the community. The World Health Organization (WHO, 2005) identified a list of best practices in communicating with the public during outbreaks which apply in any culture, political system, or developmental state of a nation. According to the WHO, the communications of the existence of an outbreak should include the following elements: trust-building; announcing early; transparency (candid, easily understood, complete, accurate); an understanding of the public's beliefs, opinions and knowledge about risks; and, a preparedness plan. It is felt that greater cooperation by the public in participating with control measures will result with effective communication.

There is growing interest by public groups for information regarding the morbidity and mortality rates of infectious diseases in health care facilities.

The Consumers Union (2007) is one of several new organizations taking web-based action to promote the reporting of hospital infection rates, and hence consumer awareness, as a means of reducing the likelihood of hospital infection. Recognizing the need for greater transparency of communication, governmental agencies are also responding to consumers' interest in quality data. The Hospital Compare web-based quality tool provides information of selected conditions and procedures related to hospital-acquired infection (http://www.hospitalcompare.hhs.gov). The Michigan Quality Improvement Consortium publishes annual reports on procedures and preventive practices among members in Michigan health plans, commercial and Medicaid participants. Reports of indicators include: immunizations, appropriate testing for childhood pharyngitis, and *Chlamydia* screening (http://www.mqic.org). Health care managers need to understand the computation of the epidemiologic measures and data collection procedures of reports published by private and public organizations to prepare appropriate responses to members of the community's need for communication and information. Internet social media websites (e.g., Facebook, Twitter) and Really Simple Syndication (RSS) web feeds along with blogs are used with increasing frequency to transmit critical updates to as many people as possible news and information pertaining to emerging outbreaks and epidemics.

Summary

Infection prevention is a continuing priority in health care services. Not only is there the potential for litigation for health care-acquired infections (HAI), but the direct and indirect costs associated with the treatment of HAI's including risks of lost reimbursement, compel health care managers to scrutinize each step of the health care delivery process to ensure safeguards for infection prevention. Tasks as simple as the regular cleansing of public surfaces in health care institutions to monitoring the health of employees, volunteers, and students in the setting. Knowledge of the epidemiology of transmissible diseases common in health care settings is fundamental to the development, implementation, and evaluation of any infection prevention program.

Discussion Questions

Q.1. Compare and contrast the case-fatality rate from SARS described in Boxed Example 1 to the case-fatality rates of three other infectious diseases (e.g., AIDS, Ebola, etc.). Comment on the challenges in specifying the definitions of the numerator and the denominator used in calculating each rate.

Q.2. Outline an alternate study design to evaluate the effectiveness of intervention to reduced bloodborne catheter infection than the one described in Boxed Example 2.

Q.3. Propose alternative methods to those described in Boxed Example 3 for improving health care worker compliance to participation in an influenza vaccination program.

Q.4. You are an administrator of a nursing program offered through a university with residence halls. You find out that many of the nursing students have called in sick to their instructors of their clinical rotations. The students have reported

Boxed Example 3 Improving Influenza Vaccination Coverage in Health Care Workers (Source: Kimura et al., 2005)

Problem: In 2003, influenza vaccination coverage was only 40% among health care workers (HCW). HCW can transmit influenza to patients. CMS (2007) is mandating infection prevention and control programs that include both patient and employee populations.

Methods: A controlled study in 70 southern California nursing homes during the 2002–2003 influenza season. Nursing homes were selected by convenience sample and were assigned to one of four groups: (1) group A ($n = 25$), which conducted no interventions; (2) group B ($n = 15$), which conducted an educational campaign; (3) group C ($n = 15$), which held [influenza] Vaccine Days; and (4) group D ($n = 15$), which conducted both an educational campaign and held Vaccine Days.

Data and Results: The control group (group A) had 27% vaccination coverage. Vaccine Days when implemented in combination with the educational campaign (group D) had 53% coverage; adjusted odds ratio [AOR] = 3.54; 95% confidence interval [CI] = 2.17–5.72) and when implemented alone (group C) (45%; AOR = 2.28; CI = 1.30–3.98). The educational campaign alone (group B) had a vaccination coverage of 34% (AOR = 1.31; CI = 0.76–2.25).

Managerial Epidemiologic Interpretation: The control group in an intervention study is the referent. The higher AOR for the educational campaign alone was not significantly different from the control group because the 95% CI contained 1.0. The Vaccine Days intervention alone was effective in increasing the prevalence of vaccination coverage because the CI lower limit (1.30) was greater than 1.0. Vaccine days offered in combination with an educational campaign yielded a significantly higher coverage than the control group (AOR = 3.54) and was the most effective strategy. Considering the national prevalence of health care worker (HCW) influenza vaccination coverage rate is 40% in 2003, a multi-component intervention will be necessary to increase the rate in HCWs.

to their instructors a variety of gastrointestinal problems including acute-onset vomiting, watery nonbloody diarrhea with abdominal cramps, and nausea. How would you respond to this situation?

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