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2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings

Jane D. Siegel, MD, Emily Rhinehart, RN, MPH, CIC, Marguerite Jackson, PhD, Linda Chiarello, RN, MS, for the Health Care Infection Control Practices Advisory Committee

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Harriett M. Pitt, MS, CIC, RN, Director, Epidemiology, Long Beach Memorial Medical Center

Keith M. Ramsey, MD, Professor of Medicine, Medical Director of Infection Control, Brody School of Medicine, East Carolina University

Nalini Singh, MD, MPH, Professor of Pediatrics, Epidemiology and International Health, George Washington University Children's National Medical Center

Kurt Brown Stevenson, MD, MPH Division of Infectious Diseases, Department of Internal Medicine, Ohio State University Medical Center

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Beth H. Stover, RN, Kosair Children's Hospital, Louisville, KY

Marjorie A. Underwood, RN, BSN CIC, Mt Diablo Medical Center, Concord, CA

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Michael L. Tapper, MD, Liaison to the Society for Health Care Epidemiology of America

Robert A. Wise, MD, Liaison to the Joint Commission on the Accreditation of Health Care Organizations

Authors' Associations

Jane D. Siegel, MD, Professor of Pediatrics, Department of Pediatrics, University of Texas Southwestern Medical Center

Emily Rhinehart, RN, MPH, CIC, CPHQ, Vice President, AIG Consultants, Inc

Marguerite Jackson, RN, PhD, CIC, Director, Administrative Unit, National Tuberculosis Curriculum Consortium, Department of Medicine, University of California San Diego

Linda Chiarello, RN, MS, Division of Health Care Quality Promotion, National Center for Infectious Diseases, Centers for Disease Control and Prevention

TABLE OF CONTENTS**Executive Summary****Abbreviations****Part I: Review of the Scientific Data Regarding Transmission of Infectious Agents in Health Care Settings**

I.A. Evolution of the 2007 Document

I.B. Rationale for Standard and Transmission-Based Precautions in Health Care Settings

I.B.1. Source of Infectious Agents

I.B.2. Susceptible Hosts

I.B.3. Modes of Transmission

I.B.3.a. Contact Transmission

I.B.3.a.i. Direct Contact Transmission

I.B.3.a.ii. Indirect Contact Transmission

I.B.3.b. Droplet Transmission

I.B.3.c. Airborne Transmission

I.B.3.d. Emerging Issues and Controversies Concerning Bioaerosols and Airborne Transmission of Infectious Agents

I.B.3.d.i. Transmission From Patients

I.B.3.d.ii. Transmission From the Environment

I.B.3.e. Other Sources of Infection

I.C. Infectious Agents of Special Infection Control Interest for Health Care Settings

I.C.1. Epidemiologically Important Organisms

I.C.1.a. *Clostridium difficile*

I.C.1.b. Multidrug-Resistant Organisms

I.C.2. Agents of Bioterrorism

I.C.3. Prions

I.C.4. Severe Acute Respiratory Syndrome (SARS)

I.C.5. Monkeypox

I.C.6. Noroviruses

I.C.7. Hemorrhagic Fever Viruses

I.D. Transmission Risks Associated With Specific Types of Health Care Settings

I.D.1. Hospitals

I.D.1.a. Intensive Care Units

I.D.1.b. Burn Units

I.D.1.c. Pediatrics

I.D.2. Nonacute Care Settings

I.D.2.a. Long-Term Care

I.D.2.b. Ambulatory Care

I.D.2.c. Home Care

I.D.2.d. Other Sites of Health Care Delivery

I.E. Transmission Risks Associated With Special Patient Populations

I.E.1. Immunocompromised Patients

I.E.2. Cystic Fibrosis Patients

I.F. New Therapies With Potential Transmissible Infectious Agents

I.F.1. Gene Therapy

I.F.2. Infections Transmitted Through Blood, Organs and Tissues

I.F.3. Xenotransplantation and Tissue Allografts

Part II. Fundamental Elements to Prevent Transmission of Infectious Agents in Health Care Settings

II.A. Health Care System Components That Influence the Effectiveness of Precautions to Prevent Transmission

- II.A.1. Administrative Measures
 - II.A.1.a. Scope of Work and Staffing Needs for Infection Control Professionals
 - II.A.1.a.i. Infection Control Liaison Nurse
 - II.A.1.b. Bedside Nurse Staffing
 - II.A.1.c. Clinical Microbiology Laboratory Support
- II.A.2. Institutional Safety Culture and Organizational Characteristics
- II.A.3. Adherence of Health Care Workers to Recommended Guidelines
- II.B. Surveillance for Health Care–Associated Infections
- II.C. Education of Health Care Workers, Patients, and Families
- II.D. Hand Hygiene
- II.E. Personal Protective Equipment for Health Care Workers
 - II.E.1. Gloves
 - II.E.2. Isolation Gowns
 - II.E.3. Face Protection: Masks, Goggles, Face Shields
 - II.E.3.a. Masks
 - II.E.3.b. Goggles and Face Shields
 - II.E.4. Respiratory Protection
- II.F. Safe Work Practices to Prevent Health Care Worker Exposure to Bloodborne Pathogens
 - II.F.1. Prevention of Needlesticks and Other Sharps-Related Injuries
 - II.F.2. Prevention of Mucous Membrane Contact
 - II.F.2.a. Precautions During Aerosol-Generating Procedures
- II.G. Patient Placement
 - II.G.1. Hospitals and Long-Term Care Settings
 - II.G.2. Ambulatory Care Settings
 - II.G.3. Home Care
- II.H. Transport of Patients
- II.I. Environmental Measures
- II.J. Patient Care Equipment, Instruments/Devices
- II.K. Textiles and Laundry
- II.L. Solid Waste
- II.M. Dishware and Eating Utensils
- II.N. Adjunctive Measures
 - II.N.1. Chemoprophylaxis
 - II.N.2. Immunoprophylaxis
 - II.N.3. Management of Visitors
 - II.N.3.a. Visitors as Sources of Infection
 - II.N.3.b. Use of Barrier Precautions by Visitors

Part III. HICPAC Precautions to Prevent Transmission of Infectious Agents

- III.A. Standard Precautions
 - III.A.1. New Standard Precautions for Patients

- III.A.1.a. Respiratory Hygiene/Cough Etiquette
- III.A.1.b. Safe Injection Practices
- III.A.1.c. Infection Control Practices for Special Lumbar Puncture Procedures
- III.B. Transmission-Based Precautions
 - III.B.1. Contact Precautions
 - III.B.2. Droplet Precautions
 - III.B.3. Airborne Infection Isolation Precautions
- III.C. Syndromic or Empiric Application of Transmission-Based Precautions
- III.D. Discontinuation of Precautions
- III.E. Application of Transmission-Based Precautions in Ambulatory and Home Care Settings
- III.F. Protective Environment

Part IV: Recommendations

Appendix A: Type and Duration of Precautions Needed for Selected Infections and Conditions

Glossary

References

Table 1. Recent history of guidelines for prevention of health care–associated infections

Table 2. Clinical syndromes or conditions warranting additional empiric transmission-based precautions pending confirmation of diagnosis

Table 3. Infection control considerations for high-priority (CDC category A) diseases that may result from bioterrorist attacks or are considered bioterrorist threats

Table 4. Recommendations for application of Standard Precautions for the care of all patients in all health care settings

Table 5. Components of a protective environment

Fig 1. Sequence for donning and removing personal protective equipment

EXECUTIVE SUMMARY

The *Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Health Care Settings 2007* updates and expands the *1996 Guideline for Isolation Precautions in Hospitals*. The following developments led to these revisions of the 1996 guideline:

1. The transition of health care delivery from primarily acute care hospitals to other health care settings (eg, home care, ambulatory care, free-standing specialty care sites, long-term care) created a need for recommendations that can be applied in all health care settings using common principles of infection control practice, yet can be modified to reflect setting-specific needs.

Accordingly, the revised guideline addresses the spectrum of health care delivery settings. Furthermore, the term “nosocomial infections” is replaced by “health care–associated infections” (HAIs), to reflect the changing patterns in health care delivery and difficulty in determining the geographic site of exposure to an infectious agent and/or acquisition of infection.

2. The emergence of new pathogens (eg, severe acute respiratory syndrome coronavirus [SARS-CoV] associated with SARS avian influenza in humans), renewed concern for evolving known pathogens (eg, *Clostridium difficile*, noroviruses, community-associated methicillin-resistant *Staphylococcus aureus* [CA-MRSA]), development of new therapies (eg, gene therapy), and increasing concern for the threat of bioweapons attacks, necessitates addressing a broader scope of issues than in previous isolation guidelines.
3. The successful experience with Standard Precautions, first recommended in the 1996 guideline, has led to a reaffirmation of this approach as the foundation for preventing transmission of infectious agents in all health care settings. New additions to the recommendations for Standard Precautions are respiratory hygiene/cough etiquette and safe injection practices, including the use of a mask when performing certain high-risk, prolonged procedures involving spinal canal punctures (eg, myelography, epidural anesthesia). The need for a recommendation for respiratory hygiene/cough etiquette grew out of observations during the SARS outbreaks, when failure to implement simple source control measures with patients, visitors, and health care workers (HCWs) with respiratory symptoms may have contributed to SARS-CoV transmission. The recommended practices have a strong evidence base. The continued occurrence of outbreaks of hepatitis B and hepatitis C viruses in ambulatory settings indicated a need to reiterate safe injection practice recommendations as part of Standard Precautions. The addition of a mask for certain spinal injections grew from recent evidence of an associated risk for developing meningitis caused by respiratory flora.
4. The accumulated evidence that environmental controls decrease the risk of life-threatening fungal infections in the most severely immunocompromised patients (ie, those undergoing allogeneic hematopoietic stem cell transplantation [HSCT]) led to the update on the components of the protective environment (PE).
5. Evidence that organizational characteristics (eg, nurse staffing levels and composition, establishment

of a safety culture) influence HCWs' adherence to recommended infection control practices, and thus are important factors in preventing transmission of infectious agents, led to a new emphasis and recommendations for administrative involvement in the development and support of infection control programs.

6. Continued increase in the incidence of HAIs caused by multidrug-resistant organisms (MDROs) in all health care settings and the expanded body of knowledge concerning prevention of transmission of MDROs created a need for more specific recommendations for surveillance and control of these pathogens that would be practical and effective in various types of health care settings.

This document is intended for use by infection control staff, health care epidemiologists, health care administrators, nurses, other health care providers, and persons responsible for developing, implementing, and evaluating infection control programs for health care settings across the continuum of care. The reader is referred to other guidelines and websites for more detailed information and for recommendations concerning specialized infection control problems.

PARTS I, II, AND III: REVIEW OF THE SCIENTIFIC DATA REGARDING TRANSMISSION OF INFECTIOUS AGENTS IN HEALTH CARE SETTINGS

Part I reviews the relevant scientific literature that supports the recommended prevention and control practices. As in the 1996 guideline, the modes and factors that influence transmission risks are described in detail. New to the section on transmission are discussions of bioaerosols and of how droplet and airborne transmission may contribute to infection transmission. This became a concern during the SARS outbreaks of 2003, when transmission associated with aerosol-generating procedures was observed. Also new is a definition of “epidemiologically important organisms” that was developed to assist in the identification of clusters of infections that require investigation (ie multidrug-resistant organisms, *C difficile*). Several other pathogens of special infection control interest (ie, norovirus, SARS, Centers for Disease Control and Prevention [CDC] category A bioterrorist agents, prions, monkeypox, and the hemorrhagic fever viruses) also are discussed, to present new information and infection control lessons learned from experience with these agents. This section of the guideline

also presents information on infection risks associated with specific health care settings and patient populations.

Part II updates information on the basic principles of hand hygiene, barrier precautions, safe work practices, and isolation practices that were included in previous guidelines. However, new to this guideline is important information on health care system components that influence transmission risks, including those components under the influence of health care administrators. An important administrative priority that is described is the need for appropriate infection control staffing to meet the ever-expanding role of infection control professionals in the complex modern health care system. Evidence presented also demonstrates another administrative concern: the importance of nurse staffing levels, including ensuring numbers of appropriately trained nurses in intensive care units (ICUs) for preventing HAIs. The role of the clinical microbiology laboratory in supporting infection control is described, to emphasize the need for this service in health care facilities. Other factors that influence transmission risks are discussed, including the adherence of HCWs to recommended infection control practices, organizational safety culture or climate, and education and training.

Discussed for the first time in an isolation guideline is surveillance of health care–associated infections. The information presented will be useful to new infection control professionals as well as persons involved in designing or responding to state programs for public reporting of HAI rates.

Part III describes each of the categories of precautions developed by the Health Care Infection Control Practices Advisory Committee (HICPAC) and the CDC and provides guidance for their application in various health care settings. The categories of Transmission-Based Precautions are unchanged from those in the 1996 guideline: Contact, Droplet, and Airborne. One important change is the recommendation to don the indicated personal protective equipment (PPE—gowns, gloves, mask) on entry into the patient's room for patients who are on Contact and/or Droplet Precautions, because the nature of the interaction with the patient cannot be predicted with certainty, and contaminated environmental surfaces are important sources for transmission of pathogens. In addition, the PE for patients undergoing allogeneic HSCT, described in previous guidelines, has been updated.

TABLES, APPENDICES, AND OTHER INFORMATION

Five tables summarize important information. Table 1 provides a summary of the evolution of this

document. Table 2 gives guidance on using empiric isolation precautions according to a clinical syndrome. Table 3 summarizes infection control recommendations for CDC category A agents of bioterrorism. Table 4 lists the components of Standard Precautions and recommendations for their application, and Table 5 lists components of the PE.

A glossary of definitions used in this guideline also is provided. New to this edition of the guideline is a figure showing the recommended sequence for donning and removing PPE used for isolation precautions to optimize safety and prevent self-contamination during removal.

APPENDIX A: TYPE AND DURATION OF PRECAUTIONS RECOMMENDED FOR SELECTED INFECTIONS AND CONDITIONS

Appendix A provides an updated alphabetical list of most infectious agents and clinical conditions for which isolation precautions are recommended. A preamble to the appendix provides a rationale for recommending the use of 1 or more Transmission-Based Precautions in addition to Standard Precautions, based on a review of the literature and evidence demonstrating a real or potential risk for person-to-person transmission in health care settings. The type and duration of recommended precautions are presented, with additional comments concerning the use of adjunctive measures or other relevant considerations to prevent transmission of the specific agent. Relevant citations are included.

PREPUBLICATION OF THE GUIDELINE ON PREVENTING TRANSMISSION OF MDROS

New to this guideline is a comprehensive review and detailed recommendations for prevention of transmission of MDROs. This portion of the guideline was published electronically in October 2006 and updated in November 2006 (Siegel JD, Rhinehart E, Jackson M, Chiarello L and HICPAC. Management of multidrug-resistant organisms in health care settings, 2006; available from <http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf>), and is considered a part of the *Guideline for Isolation Precautions*. This section provides a detailed review of the complex topic of MDRO control in health care settings and is intended to provide a context for evaluation of MDRO at individual health care settings. A rationale and institutional requirements for developing an effective MDRO control program are summarized.

Table 1. History of guidelines for isolation precautions in hospitals*

Year (reference)	Document issued	Comments
1970 ¹⁰⁹⁵	<i>Isolation Techniques for Use in Hospitals</i> , 1 st ed	<ul style="list-style-type: none"> Introduced 7 isolation precaution categories with color-coded cards: strict, respiratory, protective, enteric, wound and skin, discharge, and blood. No user decision making required. Simplicity a strength; overisolation prescribed for some infections.
1975 ¹¹⁰⁰	<i>Isolation Techniques for Use in Hospitals</i> , 2 nd ed	<ul style="list-style-type: none"> Same conceptual framework as first edition.
1983 ¹⁰⁹⁷	<i>Guideline for Isolation Precautions in Hospitals</i>	<ul style="list-style-type: none"> Provided 2 systems for isolation: category-specific and disease-specific. Protective isolation eliminated; blood precautions expanded to include body fluids. Categories included strict, contact, respiratory, acid-fast bacteria, enteric, drainage/secretion, blood and body fluids. Emphasized decision making by users.
1985-88 ^{778, 894}	Universal Precautions	<ul style="list-style-type: none"> Developed in response to the HIV/AIDS epidemic. Dictated application of blood and body fluid precautions to all patients, regardless of infection status. Did not apply to feces, nasal secretions, sputum, sweat, tears, urine, or vomitus unless contaminated by visible blood. Added personal protective equipment to protect health care workers from mucous membrane exposures. Handwashing recommended immediately after glove removal. Added specific recommendations for handling needles and other sharp devices; concept became integral to the OSHA's 1991 rule on occupational exposure to blood-borne pathogens in health care settings.
1987 ¹⁰⁹⁸	Body Substance Isolation	<ul style="list-style-type: none"> Emphasized avoiding contact with all moist and potentially infectious body substances except sweat even if blood not present. Shared some features with Universal Precautions. Weak on infections transmitted by large droplets or by contact with dry surfaces. Did not emphasize need for special ventilation to contain airborne infections. Handwashing after glove removal not specified in the absence of visible soiling.
1996 ¹	<i>Guideline for Isolation Precautions in Hospitals</i>	<ul style="list-style-type: none"> Prepared by the Healthcare Infection Control Practices Advisory Committee. Melded major features of Universal Precautions and body substance isolation into Standard Precautions to be used with all patients at all times. Included 3 transmission-based precaution categories: Airborne, Droplet, and Contact. Listed clinical syndromes that should dictate use of empiric isolation until an etiologic diagnosis is established.

*Derived from Garner and Simmons.¹⁰⁹⁹

Although the focus of this guideline is on measures to prevent *transmission* of MDROs in health care settings, information concerning the judicious use of antimicrobial agents also is presented, because such practices are intricately related to the size of the reservoir of MDROs, which in turn influences transmission (eg, colonization pressure). Two tables summarize

recommended prevention and control practices using 7 categories of interventions to control MDROs: administrative measures, education of HCWs, judicious antimicrobial use, surveillance, infection control precautions, environmental measures, and decolonization. Recommendations for each category apply to and are adapted for the various health care settings.

Table 2. Clinical syndromes or conditions warranting empiric transmission-based precautions in addition to Standard Precautions pending confirmation of diagnosis*

Clinical syndrome or condition [†]	Potential pathogens [‡]	Empiric precautions (always includes Standard Precautions)
Diarrhea		
Acute diarrhea with a likely infectious cause in an incontinent or diapered patient	Enteric pathogens [§]	Contact Precautions (pediatrics and adult)
Meningitis	<i>Neisseria meningitidis</i>	Droplet Precautions for first 24 hours of antimicrobial therapy; mask and face protection for intubation
	Enteroviruses	Contact Precautions for infants and children
	<i>Mycobacterium tuberculosis</i>	Airborne Precautions if pulmonary infiltrate present
		Airborne Precautions plus Contact Precautions if potentially infectious draining body fluid present
Rash or exanthems, generalized, etiology unknown		
Petechial/ecchymotic with fever (general)	<i>Neisseria meningitidis</i>	Droplet Precautions for the first 24 hours of antimicrobial therapy
Positive history of travel to an area with an ongoing outbreak of VHF in the 10 days before onset of fever	Ebola, Lassa, Marburg viruses	Droplet Precautions plus Contact Precautions, with face/eye protection, emphasizing safety sharps and Barrier Precautions when blood exposure likely. N95 or higher-level respiratory protection when aerosol-generating procedure performed
Vesicular	Varicella-zoster, herpes simplex, variola (smallpox), vaccinia viruses	Airborne plus Contact Precautions
	Vaccinia virus	Contact Precautions only if herpes simplex, localized zoster in an immunocompetent host, or vaccinia virus likely
Maculopapular with cough, coryza, and fever	Rubeola (measles) virus	Airborne Precautions
Respiratory infections		
Cough/fever/upper lobe pulmonary infiltrate in an HIV-negative patient or a patient at low risk for HIV infection	<i>M. tuberculosis</i> , respiratory viruses, <i>Streptococcus pneumoniae</i> , <i>Staphylococcus aureus</i> (MSSA or MRSA)	Airborne Precautions plus Contact Precautions
Cough/fever/pulmonary infiltrate in any lung location in an HIV-infected patient or a patient at high risk for HIV infection	<i>M tuberculosis</i> , respiratory viruses, <i>S pneumoniae</i> , <i>S aureus</i> (MSSA or MRSA)	Airborne Precautions plus Contact Precautions; eye/face protection if aerosol-generating procedure performed or contact with respiratory secretions anticipated; Droplet Precautions instead of Airborne Precautions if tuberculosis unlikely and airborne infection isolation room and/or respirator unavailable (tuberculosis more likely in HIV-infected than in HIV-negative individuals)
Cough/fever/pulmonary infiltrate in any lung location in a patient with a history of recent travel (10 to 21 days) to countries with active outbreaks of SARS, avian influenza	<i>M tuberculosis</i> , severe acute respiratory syndrome virus (SARS-CoV), avian influenza	Airborne plus Contact Precautions plus eye protection; Droplet Precautions instead of Airborne Precautions if SARS and tuberculosis unlikely
Respiratory infections, particularly bronchiolitis and pneumonia, in infants and young children	Respiratory syncytial virus, parainfluenza virus, adenovirus, influenza virus, human metapneumovirus	Contact plus Droplet Precautions; discontinue Droplet Precautions if adenovirus and influenza ruled out
Skin or wound infection		
Abscess or draining wound that cannot be covered	<i>S aureus</i> (MSSA or MRSA), group A streptococcus	Contact Precautions, plus Droplet Precautions for the first 24 hours of appropriate antimicrobial therapy if invasive group A streptococcal disease suspected

*Infection control professionals should modify or adapt this table according to local conditions. To ensure that appropriate empiric precautions are implemented always, hospitals must have systems in place to evaluate patients routinely according to these criteria as part of their preadmission and admission care.

[†]Patients with the syndromes or conditions listed below may present with atypical signs or symptoms (eg, neonates and adults with pertussis may not have paroxysmal or severe cough). The clinician's index of suspicion should be guided by the prevalence of specific conditions in the community, as well as clinical judgment.

[‡]The organisms listed under the column "Potential Pathogens" are not intended to represent the complete, or even most likely, diagnoses, but rather possible etiologic agents that require additional precautions beyond Standard Precautions until they can be ruled out.

[§]These pathogens include enterohemorrhagic *Escherichia coli* O157:H7, *Shigella* spp, hepatitis A virus, noroviruses, rotavirus, and *Clostridium difficile*.

Table 3. Infection control considerations for high-priority (CDC category A) diseases that may result from bioterrorist attacks or are considered bioterrorist threats (see <http://www.bt.cdc.gov>)

Disease	Anthrax
Site(s) of infection; transmission mode	Cutaneous (contact with spores); RT (inhalation of spores); GIT (ingestion of spores [rare])
Cutaneous and inhalation disease have occurred in past bioterrorist incidents	Comment: Spores can be inhaled into the lower respiratory tract. The infectious dose of <i>Bacillus anthracis</i> in humans by any route is not precisely known. In primates, the LD ₅₀ for an aerosol challenge with <i>B anthracis</i> is estimated to be 8,000 to 50,000 spores; the infectious dose may be as low as 1 to 3 spores.
Incubation period	Cutaneous: 1 to 12 days; RT: Usually 1 to 7 days, but up to 43 days reported; GIT: 15 to 72 hours
Clinical features	Cutaneous: Painless, reddish papule that develops a central vesicle or bulla in 1 to 2 days; over the next 3 to 7 days, the lesion becomes pustular and then necrotic, with black eschar and extensive surrounding edema RT: Initial flu-like illness for 1 to 3 days with headache, fever, malaise, cough; by day 4, severe dyspnea and shock. Usually fatal (85% to 90%) if untreated; meningitis develops in 50% of RT cases. GIT: In intestinal form, necrotic, ulcerated edematous lesions develop in intestines with fever, nausea, and vomiting and progression to hematemesis and bloody diarrhea; 25% to 60% mortality
Diagnosis	Cutaneous: Swabs of lesion (under eschar) for IHC, PCR, and culture; punch biopsy for IHC, PCR, and culture; vesicular fluid aspirate for Gram's stain and culture; blood culture if systemic symptoms present; acute and convalescent sera for ELISA serology RT: CXR or CT demonstrating wide mediastinal widening and/or pleural effusion and hilar abnormalities; blood for culture and PCR; pleural effusion for culture, PCR, and IHC; CSF (if meningeal signs present) for IHC, PCR, and culture; acute and convalescent sera for ELISA serology; pleural and/or bronchial biopsy specimens for IHC GIT: Blood and ascites fluid, stool samples, rectal swabs, and swabs of oropharyngeal lesions, if present, for culture, PCR, and IHC
Infectivity	Cutaneous: Person-to-person transmission from contact with lesion of untreated patient is possible but rare RT and GIT: Person-to-person transmission does not occur
Recommended precautions	Aerosolized powder, environmental exposures: Highly infectious if aerosolized Cutaneous: Standard Precautions; Contact Precautions if uncontained copious drainage present RT and GIT: Standard Precautions. Aerosolized powder, environmental exposures: Respirator (N95 mask or powered air-purifying respirator), protective clothing; decontamination of persons with powder on them (see http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5135a3.htm) Hand hygiene: Handwashing for 30 to 60 seconds with soap and water or 2% chlorhexidine gluconate after spore contact; alcohol hand rubs are inactive against spores. ⁹⁸¹ Postexposure prophylaxis after environmental exposure: A 60-day course of antimicrobials (doxycycline, ciprofloxacin, or levofloxacin) and postexposure vaccine under IND.
Disease	Botulism
Site(s) of infection; transmission mode	GIT: Ingestion of toxin-containing food; RT: Inhalation of toxin containing aerosol. Comment: Toxin ingested or potentially delivered by aerosol in bioterrorist incidents. LD ₅₀ for type A is 0.001 µg/mL/kg.
Incubation period	1 to 5 days.
Clinical features	Ptosis, generalized weakness, dizziness, dry mouth and throat, blurred vision, diplopia, dysarthria, dysphonia, and dysphagia, followed by symmetrical descending paralysis and respiratory failure.
Diagnosis	Clinical diagnosis: identification of toxin in stool, serology, unless toxin-containing material available for toxin neutralization bioassays.
Infectivity	Not transmitted from person to person; exposure to toxin necessary for disease.
Recommended precautions	Standard Precautions.
Disease	Ebola Hemorrhagic Fever
Site(s) of infection; transmission mode	As a rule, infection develops after exposure of mucous membranes or RT, or through broken skin or percutaneous injury.
Incubation period	2 to 19 days, usually 5 to 10 days
Clinical features	Febrile illnesses with malaise, myalgias, headache, vomiting, and diarrhea that are rapidly complicated by hypotension, shock, and hemorrhagic features. Massive hemorrhage in < 50% of patients.
Diagnosis	Etiologic diagnosis can be made using reverse-transcription-PCR, serologic detection of antibody and antigen, pathologic assessment with immunohistochemistry, and viral culture with electromicroscopic confirmation of morphology.
Infectivity	Person-to-person transmission occurs primarily through unprotected contact with blood and body fluids; percutaneous injuries (eg, needlestick) are associated with a high rate of transmission. Transmission in health care settings has been reported but can be prevented by use of Barrier Precautions.
Recommended precautions	Hemorrhagic fever-specific Barrier Precautions: If disease is believed to be related to intentional release of a bioweapon, then the epidemiology of transmission is unpredictable pending observation of disease transmission. Until the nature of the pathogen is understood and its transmission pattern confirmed, Standard, Contact, and Airborne Precautions should be used. Once the pathogen is characterized, if the epidemiology of transmission is consistent with natural disease, then Droplet Precautions can be substituted for Airborne Precautions. Emphasize the following: (1) use of sharps safety devices and safe work practices, (2) proper hand hygiene, (3) barrier protection against blood and body fluids on entry into room (single gloves and fluid-resistant or impermeable gown, face/eye protection with masks, goggles or face shields), and (4) appropriate waste handling. Use N95 or higher respirators when performing aerosol-generating procedures. In settings where AIIRs are unavailable or the large numbers of patients cannot be accommodated by existing AIIRs, observe Droplet Precautions (plus Standard and Contact Precautions) and segregate patients from those not suspected as having VHF infection. Limit blood draws to those essential to care. See the text for discussion and Appendix A for recommendations for naturally occurring VHFs.

Continued

Table 3. Continued

Disease	Plague*
Site(s) of infection; transmission mode	RT: Inhalation of respiratory droplets. Comment: Pneumonic plague is most likely when used as a biological weapon, but some cases of bubonic and primary septicemia also may occur. Infective dose, 100 to 500 bacteria.
Incubation period	1 to 6 days, usually 2 to 3 days.
Clinical features	Pneumonic: Fever, chills, headache, cough, dyspnea, rapid progression of weakness, and, in later stages, hemoptysis, circulatory collapse, and bleeding diathesis.
Diagnosis	Presumptive is diagnosis from Gram's stain or Wayson's stain of sputum, blood, or lymph node aspirate; definitive diagnosis is from cultures of same material or paired acute/convalescent serology.
Infectivity	Person-to-person transmission occurs through respiratory droplets. Risk of transmission is low during the first 20 to 24 hours of illness and requires close contact. Respiratory secretions probably are not infectious within a few hours after initiation of appropriate therapy.
Recommended precautions	Standard and Droplet Precautions until patients have received 48 hours of appropriate therapy. Chemoprophylaxis: Consider antibiotic prophylaxis for HCWs with close contact exposure.

Disease	Smallpox
Site(s) of infection; transmission mode	RT Inhalation of droplet or, rarely, aerosols; and skin lesions (contact with virus). Comment: If used as a biological weapon, natural disease (which has not occurred since 1977) likely will result.
Incubation period	7 to 19 days (mean, 12 days).
Clinical features	Fever, malaise, backache, headache, and often vomiting for 2 to 3 days, followed by generalized papular or maculopapular rash (more on face and extremities), which becomes vesicular (on day 4 or 5) and then pustular; lesions all in same stage.
Diagnosis	Electron microscopy of vesicular fluid or culture of vesicular fluid by a World Health Organization–approved laboratory (CDC); detection by PCR available only at select LRN laboratories, the CDC, and US Army Medical Research Institute of Infectious Diseases.
Infectivity	Secondary attack rates up to 50% in unvaccinated persons. Infected persons may transmit disease from the time that rash appears until all lesions have crusted over (about 3 weeks). Infectivity is greatest during the first 10 days of rash.
Recommended precautions	Combined use of Standard, Contact, and Airborne Precautions should be maintained until all scabs have separated (3 to 4 weeks). [†] Only immune HCWs should care for patients. Postexposure vaccine should be provided within 4 days. Vaccinia [‡] : HCWs to cover vaccination site with gauze and semipermeable dressing until scab separates ($\geq$ 21 days). Hand hygiene should be observed. Adverse events with virus-containing lesions: Standard Precautions plus Contact Precautions until all lesions are crusted.

Disease	Tularemia
Site(s) of infection; transmission mode	RT: Inhalation of aerosolized bacteria; GIT: Ingestion of food or drink contaminated with aerosolized bacteria. Comment: Pneumonic or typhoidal disease likely to occur after bioterrorist event using aerosol delivery. Infective dose, 10 to 50 bacteria.
Incubation period	2 to 10 days; usually 3 to 5 days.
Clinical features	Pneumonic: malaise, cough, sputum production, dyspnea. Typhoidal: fever, prostration, weight loss and frequently an associated pneumonia.
Diagnosis	Diagnosis usually made with serology on acute and convalescent serum specimens; bacterium can be detected by PCR (LRN) or isolated from blood and other body fluids on cysteine-enriched media or mouse inoculation.
Infectivity	Person-to-person spread is rare. Laboratory workers who encounter/handle cultures of this organism are at high risk for disease if exposed.
Recommended precautions	Standard Precautions

AIIR, airborne infection isolation room; *BSL*, biosafety level; *CSF*, cerebrospinal fluid; *CT*, computed tomography; *CXR*, chest x-ray; *ELISA*, enzyme-linked immunosorbent assay; *GIT*, gastrointestinal tract; *HCW*, health care worker; *IHC*, immunohistochemistry; *LD₅₀*, lethal dose for 50% of experimental animals; *LRN*, Laboratory Response Network; *PAPR*, powered air-purifying respirator; *PCR*, polymerase chain reaction; *RT*, respiratory tract; *VHF*, viral hemorrhagic fever.

*Pneumonic plague is not as contagious as is often thought. Historical accounts and contemporary evidence indicate that persons with plague usually transmit the infection only when the disease is in the end stage. These persons cough copious amounts of bloody sputum that contains many plague bacteria. Patients in the early stage of primary pneumonic plague (approximately the first 20 to 24 hours) apparently pose little risk (Wu L-T. A treatise on pneumonic plague. Geneva, Switzerland: League of Nations; 1926; Kool JL. Risk of person-to-person transmission of pneumonic plague. *Clin Infect Dis* 2005;40:1166-72). Antibiotic medication rapidly clears the sputum of plague bacilli, so that a patient generally is not infective within hours after initiation of effective antibiotic treatment (Butler TC. Plague and other *Yersinia* infections. In: Greenough VVB, editor. Current topics in infectious disease. New York: Plenum; 1983). This means that in modern times, many patients will never reach a stage where they pose a significant risk to others. Even in the end stage of disease, transmission occurs only after close contact. Simple protective measures, such as wearing masks, maintaining good hygiene, and avoiding close contact, have been effective in interrupting transmission during many pneumonic plague outbreaks; in the United States, the last known case of person-to-person transmission of pneumonic plague occurred in 1925 (Kool JL. Risk of person-to-person transmission of pneumonic plague. *Clin Infect Dis* 2005;40:1166-72).

[†]Transmission by the airborne route is a rare event. Airborne Precautions are recommended when possible, but in the event of mass exposures, Barrier Precautions and containment within a designated area are most important.^{204,212}

[‡]Vaccinia adverse events with lesions containing infectious virus include inadvertent autoinoculation, ocular lesions (blepharitis, conjunctivitis), generalized vaccinia, progressive vaccinia, and eczema vaccinatum. Bacterial superinfection also requires addition of Contact Precautions if exudates cannot be contained.^{216, 217}

Table 4. Recommendations for application of Standard Precautions for the care of all patients in all healthcare settings (see Sections II.D to II.J and III.A.1)

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, mucous membranes, and nonintact skin
Gown	During procedures 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*	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 others and to the environment; wear gloves if visibly contaminated; perform hand hygiene
Environmental 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
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 after infection
Respiratory hygiene/cough etiquette (source containment of infectious respiratory secretions in symptomatic patients, beginning at initial point of encounter, eg, 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 if possible.

*During aerosol-generating procedures on patients with suspected or proven infections transmitted by respiratory aerosols (eg, severe acute respiratory syndrome), wear a fit-tested N95 or higher respirator in addition to gloves, gown, and face/eye protection.

With the increasing incidence and prevalence of MDROs, all health care facilities must prioritize effective control of MDRO transmission. Facilities should identify prevalent MDROs at the facility, implement control measures, assess the effectiveness of control programs, and demonstrate decreasing MDRO rates. A set of intensified MDRO prevention interventions is to be added if the incidence of transmission of a target MDRO is not decreasing despite implementation of basic MDRO infection control measures, and when the first case of an epidemiologically

important MDRO is identified within a health care facility.

SUMMARY

This updated guideline responds to changes in health care delivery and addresses new concerns about transmission of infectious agents to patients and HCWs in the United States and infection control. The primary objective of the guideline is to improve the safety of the nation's health care delivery system by reducing the rates of HAIs.

Table 5. Components of a protective environment

I. Patients: allogeneic hematopoietic stem cell transplantation only	
● Maintain in protective environment (PE) room except for required diagnostic or therapeutic procedures that cannot be performed in the room (eg, radiology, surgery)	
● Respiratory protection (eg, N95 respirator) for the patient when leaving PE during periods of construction	
II. Standard and Expanded Precautions	
● Hand hygiene observed before and after patient contact	
● Gown, gloves, mask not required for health care workers (HCWs) or visitors for routine entry into the room	
● Use of gown, gloves, and mask by HCWs and visitors according to Standard Precautions and as indicated for suspected or proven infections for which transmission-based precautions are recommended	
III. Engineering	
● Central or point-of-use high-efficiency particulate air (HEPA) filters (99.97% efficiency) filters capable of removing particles 0.3 μm in diameter in supply (incoming) air	
● Well-sealed rooms:	
- Proper construction of windows, doors, and intake and exhaust ports	
- Ceilings: smooth, free of fissures, open joints, crevices	
- Walls sealed above and below the ceiling	
- If leakage detected, locate source and make necessary repairs	
● Ventilation to maintain ≥ 12 air changes/hour	
● Directed air flow; air supply and exhaust grills located so that clean, filtered air enters from one side of the room, flows across the patient's bed, and exits on opposite side of the room	
● Positive room air pressure in relation to the corridor; pressure differential of >2.5 Pa (0.01-inch water gauge)	
● Air flow patterns monitored and recorded daily using visual methods (eg, flutter strips, smoke tubes) or a hand-held pressure gauge	
● Self-closing door on all room exits	
● Back-up ventilation equipment (eg, portable units for fans or filters) maintained for emergency provision of ventilation requirements for PE areas, with immediate steps taken to restore the fixed ventilation system	
● For patients who require both a PE and an airborne infection isolation room (AIIR), use an anteroom to ensure proper air balance relationships and provide independent exhaust of contaminated air to the outside, or place a HEPA filter in the exhaust duct. If an anteroom is not available, place patient in an AIIR and use portable ventilation units, industrial-grade HEPA filters to enhance filtration of spores.	
IV. Surfaces	
● Daily wet-dusting of horizontal surfaces using cloths moistened with EPA-registered hospital disinfectant/detergent	
● Avoid dusting methods that disperse dust	
● No carpeting in patient rooms or hallways	
● No upholstered furniture and furnishings	
V. Other	
● No flowers (fresh or dried) or potted plants in PE rooms or areas	
● Vacuum cleaner equipped with HEPA filters when vacuum cleaning is necessary	

Adapted from Centers for Disease Control and Prevention.¹¹**ABBREVIATIONS USED IN THE GUIDELINE**

AIA	American Institute of Architects	ICP	Infection prevention and control professional
AIIR	Airborne infection isolation room	ICU	Intensive care unit
CDC	Centers for Disease Control and Prevention	LTCF	Long-term care facility
CF	Cystic fibrosis	MDR-GNB	Multidrug-resistant gram-negative bacilli
CJD	Creutzfeld-Jakob Disease	MDRO	Multidrug-resistant organism
ESBL	Extended-spectrum beta-lactamase	MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
FDA	Food and Drug Administration	MSSA	Methicillin-susceptible <i>Staphylococcus aureus</i>
HAI	Health care–associated infection	NICU	Neonatal intensive care unit
HBV	Hepatitis B virus	NIOSH	National Institute for Occupational Safety and Health
HCV	Hepatitis C virus	NNIS	National Nosocomial Infection Surveillance
HEPA	High-efficiency particulate air	NSSP	Nonsusceptible <i>Streptococcus pneumoniae</i>
HICPAC	Health Care Infection Control Practices Advisory Committee	OSHA	Occupational Safety and Health Administration
HIV	Human immunodeficiency virus	PCR	Polymerase chain reaction
HCW	Health care worker	PE	Protective environment
HFV	Hemorrhagic fever virus	PFGE	Pulsed-field gel electrophoresis
HSCT	Hematopoietic stem cell transplantation	PICU	Pediatric intensive care unit

PPE	Personal protective equipment
RSV	Respiratory syncytial virus
SARS	Severe acute respiratory syndrome
vCJD	variant Creutzfeld-Jakob disease
VISA	Vancomycin-intermediate/resistant <i>Staphylococcus aureus</i>
VRE	Vancomycin-resistant enterococci
VRSA	Vancomycin-resistant <i>Staphylococcus aureus</i>
WHO	World Health Organization

PART I: REVIEW OF SCIENTIFIC DATA REGARDING TRANSMISSION OF INFECTIOUS AGENTS IN HEALTH CARE SETTINGS

I.A. Evolution of the 2007 Document

The *Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Health care Settings 2007* builds on a series of isolation and infection prevention documents promulgated since 1970. These previous documents are summarized and referenced in Table 1 and in Part I of the *1996 Guideline for Isolation Precautions in Hospitals*.¹

I.A.1. Objectives and Methods. The objectives of this guideline are to (1) provide infection control recommendations for all components of the health care delivery system, including hospitals, long-term care facilities, ambulatory care, home care, and hospice; (2) reaffirm Standard Precautions as the foundation for preventing transmission during patient care in all health care settings; (3) reaffirm the importance of implementing Transmission-Based Precautions based on the clinical presentation or syndrome and likely pathogens until the infectious etiology has been determined (Table 2); and (4) provide epidemiologically sound and, whenever possible, evidence-based recommendations.

This guideline is designed for use by individuals who are charged with administering infection control programs in hospitals and other health care settings. The information also will be useful for other HCWs, health care administrators, and anyone needing information about infection control measures to prevent transmission of infectious agents. Commonly used abbreviations are provided, and terms used in the guideline are defined in the Glossary.

Medline and PubMed were used to search for relevant studies published in English, focusing on those published since 1996. Much of the evidence cited for preventing transmission of infectious agents in health care settings is derived from studies that used “quasi-experimental designs,” also referred to as nonrandomized preintervention and postintervention study designs.² Although these types of studies can provide valuable information regarding the effectiveness of various interventions, several factors decrease the certainty of attributing improved outcome to a specific

intervention. These include: difficulties in controlling for important confounding variables, the use of multiple interventions during an outbreak, and results that are explained by the statistical principle of regression to the mean (eg, improvement over time without any intervention).³ Observational studies remain relevant and have been used to evaluate infection control interventions.^{4,5} The quality of studies, consistency of results, and correlation with results from randomized controlled trials, when available, were considered during the literature review and assignment of evidence-based categories (see Part IV: Recommendations) to the recommendations in this guideline. Several authors have summarized properties to consider when evaluating studies for the purpose of determining whether the results should change practice or in designing new studies.^{2,6,7}

I.A.2. Changes or Clarifications in Terminology. This guideline contains 4 changes in terminology from the 1996 guideline:

1. The term “nosocomial infection” is retained to refer only to infections acquired in hospitals. The term “health care–associated infection” (HAI) is used to refer to infections associated with health care delivery in any setting (eg, hospitals, long-term care facilities, ambulatory settings, home care). This term reflects the inability to determine with certainty where the pathogen was acquired, because patients may be colonized with or exposed to potential pathogens outside of the health care setting before receiving health care, or may develop infections caused by those pathogens when exposed to the conditions associated with delivery of health care. In addition, patients frequently move among the various settings within the health care system.⁸
2. A new addition to the practice recommendations for Standard Precautions is *respiratory hygiene/cough etiquette*. Whereas Standard Precautions generally apply to the recommended practices of HCWs during patient care, respiratory hygiene/cough etiquette applies broadly to all persons who enter a health care setting, including HCWs, patients, and visitors. These recommendations evolved from observations during the SARS epidemic that failure to implement basic source control measures with patients, visitors, and HCWs with signs and symptoms of respiratory tract infection may have contributed to SARS-CoV transmission. This concept has been incorporated into CDC planning documents for SARS and pandemic influenza.^{9,10}
3. The term “Airborne Precautions” has been supplemented by the term “Airborne Infection Isolation Room” (AIIR), to achieve consistency with the *Guidelines for Environmental Infection Control in*

Health Care Facilities,¹¹ the *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health Care Settings 2005*,¹² and the American Institute of Architects (AIA) 2006 guidelines for design and construction of hospitals.¹³

4. A set of prevention measures known as the *protective environment* (PE) has been added to the precautions for preventing HAIs. These measures, which have been defined in previous guidelines, consist of engineering and design interventions aimed at decreasing the risk of exposure to environmental fungi for severely immunocompromised patients undergoing allogeneic HSCT during the times of highest risk, usually the first 100 days posttransplantation or longer in the presence of graft-versus-host disease.^{11,13-15} Recommendations for a PE apply only to acute care hospitals that provide care to patients undergoing HSCT.

I.A.3. Scope. This guideline, like its predecessors, focuses primarily on interactions between patients and health care providers. The *Guidelines for the Prevention of MDRO Infection* were published separately in November 2006 and are available online at <http://www.cdc.gov/ncidod/dhqp/index.html>. Several other HICPAC guidelines to prevent transmission of infectious agents associated with health care delivery are cited, including *Guideline for Hand Hygiene*, *Guideline for Environmental Infection Control*, *Guideline for Prevention of Health Care–Associated Pneumonia*, and *Guideline for Infection Control in Health Care Personnel*.^{11,14,16,17} In combination, these provide comprehensive guidance on the primary infection control measures for ensuring a safe environment for patients and HCWs.

This guideline does not discuss in detail specialized infection control issues in defined populations that are addressed elsewhere (eg, *Recommendations for Preventing Transmission of Infections Among Chronic Hemodialysis Patients*, *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health Care Facilities 2005*, *Guidelines for Infection Control in Dental Health Care Settings*, and *Infection Control Recommendations for Patients With Cystic Fibrosis*.^{12,18-20} An exception has been made by including abbreviated guidance for a PE used for allogeneic HSCT recipients, because components of the PE have been defined more completely since publication of the *Guidelines for Preventing Opportunistic Infections Among HSCT Recipients in 2000* and the *Guideline for Environmental Infection Control in Health Care Facilities*.^{11,15}

I.B. Rationale for Standard and Transmission-Based Precautions in Health Care Settings

Transmission of infectious agents within a health care setting requires 3 elements: a source (or reservoir)

of infectious agents, a susceptible host with a portal of entry receptive to the agent, and a mode of transmission for the agent. This section describes the interrelationship of these elements in the epidemiology of HAIs.

I.B.1. Sources of Infectious Agents. Infectious agents transmitted during health care derive primarily from human sources but inanimate environmental sources also are implicated in transmission. Human reservoirs include patients,²⁰⁻²⁸ HCWs,^{17,29-39} and household members and other visitors.⁴⁰⁻⁴⁵ Such source individuals may have active infections, may be in the asymptomatic and/or incubation period of an infectious disease, or may be transiently or chronically colonized with pathogenic microorganisms, particularly in the respiratory and gastrointestinal tracts. Other sources of HAIs are the endogenous flora of patients (eg, bacteria residing in the respiratory or gastrointestinal tract).⁴⁶⁻⁵⁴

I.B.2. Susceptible Hosts. Infection is the result of a complex interrelationship between a potential host and an infectious agent. Most of the factors that influence infection and the occurrence and severity of disease are related to the host. However, characteristics of the host-agent interaction as it relates to pathogenicity, virulence, and antigenicity also are important, as are the infectious dose, mechanisms of disease production, and route of exposure.⁵⁵ There is a spectrum of possible outcomes after exposure to an infectious agent. Some persons exposed to pathogenic microorganisms never develop symptomatic disease, whereas others become severely ill and even die. Some individuals are prone to becoming transiently or permanently colonized but remain asymptomatic. Still others progress from colonization to symptomatic disease either immediately after exposure or after a period of asymptomatic colonization. The immune state at the time of exposure to an infectious agent, interaction between pathogens, and virulence factors intrinsic to the agent are important predictors of an individual's outcome. Host factors such as extremes of age and underlying disease (eg, diabetes^{56,57}, human immunodeficiency virus/acquired immune deficiency syndrome [HIV/AIDS],^{58,59} malignancy, and transplantation^{18,60,61}) can increase susceptibility to infection, as can various medications that alter the normal flora (eg, antimicrobial agents, gastric acid suppressors, corticosteroids, antirejection drugs, antineoplastic agents, immunosuppressive drugs). Surgical procedures and radiation therapy impair defenses of the skin and other involved organ systems. Indwelling devices, such as urinary catheters, endotracheal tubes, central venous and arterial catheters,⁶²⁻⁶⁴ and synthetic implants, facilitate development of HAIs by allowing potential pathogens to bypass local defenses that ordinarily would impede their invasion and by providing surfaces for development of biofilms that may facilitate adherence of

microorganisms and protect from antimicrobial activity.⁶⁵ Some infections associated with invasive procedures result from transmission within the health care facility; others arise from the patient's endogenous flora.⁴⁶⁻⁵⁰ High-risk patient populations with noteworthy risk factors for infection are discussed further in Sections I.D, I.E, and I.F.

I.B.3. Modes of Transmission. Several classes of pathogens can cause infection, including bacteria, viruses, fungi, parasites, and prions. The modes of transmission vary by type of organism, and some infectious agents may be transmitted by more than 1 route. Some are transmitted primarily by direct or indirect contact, (eg, herpes simplex virus [HSV], respiratory syncytial virus, *S aureus*), others by the droplet, (eg, influenza virus, *Bordetella pertussis*) or airborne routes (eg, *Mycobacterium tuberculosis*). Other infectious agents, such as bloodborne viruses (eg, hepatitis B virus [HBV], hepatitis C virus [HCV], HIV), are rarely transmitted in health care settings through percutaneous or mucous membrane exposure. Importantly, not all infectious agents are transmitted from person to person; these are listed in Appendix A. The 3 principal routes of transmission—contact, droplet, and airborne—are summarized below.

I.B.3.a. Contact Transmission. The most common mode of transmission, contact transmission is divided into 2 subgroups: direct contact and indirect contact.

I.B.3.a.i. Direct Contact Transmission. Direct transmission occurs when microorganisms are transferred from an infected person to another person without a contaminated intermediate object or person. Opportunities for direct contact transmission between patients and HCWs have been summarized in HICPAC's *Guideline for Infection Control in Health Care Personnel, 1998*¹⁷ and include the following:

- Blood or other blood-containing body fluids from a patient directly enters a HCW's body through contact with a mucous membrane⁶⁶ or breaks (ie, cuts, abrasions) in the skin.⁶⁷
- Mites from a scabies-infested patient are transferred to a HCW's skin while he or she is in direct ungloved contact with the patient's skin.^{68,69}
- A HCW develops herpetic whitlow on a finger after contact with HSV when providing oral care to a patient without using gloves, or HSV is transmitted to a patient from a herpetic whitlow on an ungloved hand of a HCW.^{70,71}

I.B.3.a.ii. Indirect Contact Transmission. Indirect transmission involves the transfer of an infectious agent through a contaminated intermediate object or person. In the absence of a point-source outbreak, it is difficult to determine how indirect transmission occurs. However, extensive evidence cited in the *Guideline*

for Hand Hygiene in Health Care Settings suggests that the contaminated hands of HCWs are important contributors to indirect contact transmission.¹⁶ Examples of opportunities for indirect contact transmission include the following:

- A HCWs' hands may transmit pathogens after touching an infected or colonized body site on 1 patient or a contaminated inanimate object, if hand hygiene is not performed before touching another patient.^{72,73}
- Patient-care devices (eg, electronic thermometers, glucose monitoring devices) may transmit pathogens if devices contaminated with blood or body fluids are shared between patients without cleaning and disinfecting between patients.⁷⁴⁻⁷⁷
- Shared toys may become a vehicle for transmitting respiratory viruses (eg, respiratory syncytial virus [RSV]^{24,78,79} or pathogenic bacteria (eg, *Pseudomonas aeruginosa*⁸⁰) among pediatric patients.
- Instruments that are inadequately cleaned between patients before disinfection or sterilization (eg, endoscopes or surgical instruments)⁸¹⁻⁸⁵ or that have manufacturing defects that interfere with the effectiveness of reprocessing^{86,87} may transmit bacterial and viral pathogens.

Clothing, uniforms, laboratory coats, or isolation gowns used as PPE may become contaminated with potential pathogens after care of a patient colonized or infected with an infectious agent, (eg, MRSA,⁸⁸ vancomycin-resistant enterococci [VRE],⁸⁹ and *C difficile*⁹⁰). Although contaminated clothing has not been implicated directly in transmission, the potential exists for soiled garments to transfer infectious agents to successive patients.

I.B.3.b. Droplet Transmission. Droplet transmission is technically a form of contact transmission; some infectious agents transmitted by the droplet route also may be transmitted by direct and indirect contact routes. However, in contrast to contact transmission, respiratory droplets carrying infectious pathogens transmit infection when they travel directly from the respiratory tract of the infectious individual to susceptible mucosal surfaces of the recipient, generally over short distances, necessitating facial protection. Respiratory droplets are generated when an infected person coughs, sneezes, or talks^{91,92} or during such procedures as suctioning, endotracheal intubation,⁹³⁻⁹⁶ cough induction by chest physiotherapy,⁹⁷ and cardiopulmonary resuscitation.^{98,99} Evidence for droplet transmission comes from epidemiologic studies of disease outbreaks,¹⁰⁰⁻¹⁰³ from experimental studies,¹⁰⁴ and from information on aerosol dynamics.^{91,105} Studies have shown that the nasal mucosa, conjunctivae, and, less frequently, the mouth are susceptible portals of entry for respiratory viruses.¹⁰⁶ The maximum

distance for droplet transmission is currently unresolved; pathogens transmitted by the droplet route have not been transmitted through the air over long distances, in contrast to the airborne pathogens discussed below. Historically, the area of defined risk has been a distance of < 3 feet around the patient, based on epidemiologic and simulated studies of selected infections.^{103,104} Using this distance for donning masks has been effective in preventing transmission of infectious agents through the droplet route. However, experimental studies with smallpox^{107,108} and investigations during the global SARS outbreaks of 2003¹⁰¹ suggest that droplets from patients with these 2 infections could reach persons located 6 feet or more from their source. It is likely that the distance that droplets travel depends on the velocity and mechanism by which respiratory droplets are propelled from the source, the density of respiratory secretions, environmental factors (eg, temperature, humidity), and the pathogen's ability to maintain infectivity over that distance.¹⁰⁵ Thus, a distance of < 3 feet around the patient is best considered an example of what is meant by "a short distance from a patient" and should not be used as the sole criterion for determining when a mask should be donned to protect from droplet exposure. Based on these considerations, it may be prudent to don a mask when within 6 to 10 feet of the patient or on entry into the patient's room, especially when exposure to emerging or highly virulent pathogens is likely. More studies are needed to gain more insight into droplet transmission under various circumstances.

Droplet size is another variable under investigation. Droplets traditionally have been defined as being > 5 μm in size. Droplet nuclei (ie, particles arising from desiccation of suspended droplets) have been associated with airborne transmission and defined as < 5 μm in size,¹⁰⁵ a reflection of the pathogenesis of pulmonary tuberculosis that is not generalizable to other organisms. Observations of particle dynamics have demonstrated that a range of droplet sizes, including those of diameter $\geq 30 \mu\text{m}$, can remain suspended in the air.¹⁰⁹ The behavior of droplets and droplet nuclei affect recommendations for preventing transmission. Whereas fine airborne particles containing pathogens that are able to remain infective may transmit infections over long distances, requiring AIIR to prevent its dissemination within a facility; organisms transmitted by the droplet route do not remain infective over long distances and thus do not require special air handling and ventilation. Examples of infectious agents transmitted through the droplet route include *B pertussis*,¹¹⁰ influenza virus,²³ adenovirus,¹¹¹ rhinovirus,¹⁰⁴ *Mycoplasma pneumoniae*,¹¹² SARS-CoV,^{21,96,113} group A streptococcus,¹¹⁴ and *Neisseria meningitidis*.^{95,103,115} Although RSV may be transmitted by the droplet route, direct contact with

infected respiratory secretions is the most important determinant of transmission and consistent adherence to Standard Precautions plus Contact Precautions prevents transmission in health care settings.^{24,116,117}

Rarely, pathogens that are not transmitted routinely by the droplet route are dispersed into the air over short distances. For example, although *S aureus* is transmitted most frequently by the contact route, viral upper respiratory tract infection has been associated with increased dispersal of *S aureus* from the nose into the air for a distance of 4 feet under both outbreak and experimental conditions; this is known as the "cloud baby" and "cloud adult" phenomenon.¹¹⁸⁻¹²⁰

I.B.3.c. Airborne Transmission. Airborne transmission occurs by dissemination of either airborne droplet nuclei or small particles in the respirable size range containing infectious agents that remain infective over time and distance (eg, spores of *Aspergillus* spp and *M tuberculosis*). Microorganisms carried in this manner may be dispersed over long distances by air currents and may be inhaled by susceptible individuals who have not had face-to-face contact with (or even been in the same room with) the infectious individual.¹²¹⁻¹²⁴ Preventing the spread of pathogens that are transmitted by the airborne route requires the use of special air handling and ventilation systems (eg, AIIRs) to contain and then safely remove the infectious agent.^{11,12} Infectious agents to which this applies include *M tuberculosis*,¹²⁴⁻¹²⁷ rubeola virus (measles),¹²² and varicella-zoster virus (chickenpox).¹²³ In addition, published data suggest the possibility that variola virus (smallpox) may be transmitted over long distances through the air under unusual circumstances, and AIIRs are recommended for this agent as well; however, droplet and contact routes are the more frequent routes of transmission for smallpox.^{108,128,129} In addition to AIIRs, respiratory protection with a National Institute for Occupational Safety and Health (NIOSH)-certified N95 or higher-level respirator is recommended for HCWs entering the AIIR, to prevent acquisition of airborne infectious agents such as *M tuberculosis*.¹²

For certain other respiratory infectious agents, such as influenza^{130,131} and rhinovirus,¹⁰⁴ and even some gastrointestinal viruses (eg, norovirus¹³² and rotavirus¹³³), there is some evidence that the pathogen may be transmitted through small-particle aerosols under natural and experimental conditions. Such transmission has occurred over distances > 3 feet but within a defined air space (eg, patient room), suggesting that it is unlikely that these agents remain viable on air currents that travel long distances. AIIRs are not routinely required to prevent transmission of these agents. Additional issues concerning small-particle aerosol transmission of agents that are most frequently transmitted by the droplet route are discussed below.

I.B.3.d. Emerging Issues Concerning Airborne Transmission of Infectious Agents.

I.B.3.d.i. Transmission From Patients. The emergence of SARS in 2002, the importation of monkeypox into the United States in 2003, and the emergence of avian influenza present challenges to the assignment of isolation categories due to conflicting information and uncertainty about possible routes of transmission. Although SARS-CoV is transmitted primarily by contact and/or droplet routes, airborne transmission over a limited distance (eg, within a room) has been suggested, although not proven.¹³⁴⁻¹⁴¹ This is true of other infectious agents as well, such as influenza virus¹³⁰ and noroviruses.^{132,142,143} Influenza viruses are transmitted primarily by close contact with respiratory droplets,^{23,102} and acquisition by HCWs has been prevented by Droplet Precautions, even when positive-pressure rooms were used in one center.¹⁴⁴ However, inhalational transmission could not be excluded in an outbreak of influenza in the passengers and crew of an aircraft.¹³⁰ Observations of a protective effect of ultraviolet light in preventing influenza among patients with tuberculosis during the influenza pandemic of 1957–1958 have been used to suggest airborne transmission.^{145,146}

In contrast to the strict interpretation of an airborne route for transmission (ie, long distances beyond the patient room environment), short-distance transmission by small-particle aerosols generated under specific circumstances (eg, during endotracheal intubation) to persons in the immediate area near the patient also has been demonstrated. Aerosolized particles < 100 µm in diameter can remain suspended in air when room air current velocities exceed the terminal settling velocities of the particles.¹⁰⁹ SARS-CoV transmission has been associated with endotracheal intubation, noninvasive positive pressure ventilation, and cardiopulmonary resuscitation.^{93,94,96,98,141} Although the most frequent routes of transmission of noroviruses are contact and foodborne and waterborne routes, several reports suggest that noroviruses also may be transmitted through aerosolization of infectious particles from vomitus or fecal material.^{142,143,147,148} It is hypothesized that the aerosolized particles are inhaled and subsequently swallowed.

Roy and Milton have proposed a new classification for aerosol transmission when evaluating routes of SARS transmission:

- Obligate. Under natural conditions, disease occurs after transmission of the agent only through inhalation of small-particle aerosols (eg, tuberculosis).
- Preferential. Natural infection results from transmission through multiple routes, but small-particle aerosols are the predominant route (eg, measles, varicella).
- Opportunistic. Under special circumstances, agents that naturally cause disease through other routes

may be transmitted through small-particle aerosols.¹⁴⁹

This conceptual framework can explain rare occurrences of airborne transmission of agents that are transmitted most frequently by other routes (eg, smallpox, SARS, influenza, noroviruses). Concerns about unknown or possible routes of transmission of agents associated with severe disease and no known treatment often result in the adoption of overextreme prevention strategies, and recommended precautions may change as the epidemiology of an emerging infection becomes more well defined and controversial issues are resolved.

I.B.3.d.ii. Transmission From the Environment. Some airborne infectious agents are derived from the environment and do not usually involve person-to-person transmission; for example, anthrax spores present in a finely milled powdered preparation can be aerosolized from contaminated environmental surfaces and inhaled into the respiratory tract.^{150,151} Spores of environmental fungi (eg, *Aspergillus* spp) are ubiquitous in the environment and may cause disease in immunocompromised patients who inhale aerosolized spores (through, eg, construction dust).^{152,153} As a rule, neither of these organisms is subsequently transmitted from infected patients; however, there is 1 well-documented report of person-to-person transmission of *Aspergillus* sp in the ICU setting that was most likely due to the aerosolization of spores during wound debridement.¹⁵⁴ The PE involves isolation practices designed to decrease the risk of exposure to environmental fungal agents in allogeneic HSCT patients.^{11,14,15,155-158}

Environmental sources of respiratory pathogens (eg, *Legionella*) transmitted to humans through a common aerosol source is distinct from direct patient-to-patient transmission.

I.B.3.e. Other Sources of Infection. Sources of infection transmission other than infectious individuals include those associated with common environmental sources or vehicles (eg, contaminated food, water, or medications, such as intravenous fluids). Although *Aspergillus* spp have been recovered from hospital water systems,¹⁵⁹ the role of water as a reservoir for immunosuppressed patients remains unclear. Vectorborne transmission of infectious agents from mosquitoes, flies, rats, and other vermin also can occur in health care settings. Prevention of vectorborne transmission is not addressed in this document.

I.C. Infectious Agents of Special Infection Control Interest for Health Care Settings

This section discusses several infectious agents with important infection control implications that either were not discussed extensively in previous isolation

guidelines or have emerged only recently. Included are epidemiologically important organisms (eg, *C difficile*), agents of bioterrorism, prions, SARS-CoV, monkeypox, noroviruses, and the hemorrhagic fever viruses (HFVs). Experience with these agents has broadened the understanding of modes of transmission and effective preventive measures. These agents are included for information purposes and, for some (ie, SARS-CoV, monkeypox), to highlight the lessons that have been learned about preparedness planning and responding effectively to new infectious agents.

I.C.1. Epidemiologically Important Organisms. Under defined conditions, any infectious agent transmitted in a health care setting may become targeted for control because it is epidemiologically important. *C difficile* is specifically discussed below because of its current prevalence and seriousness in US health care facilities. In determining what constitutes an "epidemiologically important organism," the following criteria apply:

- A propensity for transmission within health care facilities based on published reports and the occurrence of temporal or geographic clusters of more than 2 patients, (eg, *C difficile*, norovirus, RSV, influenza, rotavirus, *Enterobacter* spp, *Serratia* spp, group A streptococcus). A single case of health care-associated invasive disease caused by certain pathogens (eg, group A streptococcus postoperatively,¹⁶⁰ in a burn unit,¹⁶¹ or in a LTCF;¹⁶² *Legionella* spp,^{14,163} *Aspergillus* spp¹⁶⁴) is generally considered a trigger for investigation and enhanced control measures because of the risk of additional cases and the severity of illness associated with these infections. Antimicrobial resistance can have the following characteristics:
- Resistance to first-line therapies (eg, MRSA, vancomycin-intermediate/resistant *S aureus* [VISA], vancomycin-resistant *S aureus* [VRSA], VRE, extended-spectrum beta-lactamase [ESBL]-producing organisms)
- Common and uncommon microorganisms with unusual patterns of resistance within a facility (eg, the first isolate of *Burkholderia cepacia* complex or *Ralstonia* spp in non-CF patients or a quinolone-resistant strain of *P aeruginosa* in a facility)
- Difficult to treat because of innate or acquired resistance to multiple classes of antimicrobial agents (eg, *Stenotrophomonas maltophilia*, *Acinetobacter* spp)
- Association with serious clinical disease, and increased morbidity and mortality (eg, MRSA and methicillin-susceptible *S aureus* [MSSA], group A streptococcus)
- A newly discovered or reemerging pathogen.

I.C.1.a. Clostridium difficile. *C difficile* is a spore-forming gram-positive anaerobic bacillus that was first

isolated from stools of neonates in 1935¹⁶⁵ and identified as the most frequent causative agent of antibiotic-associated diarrhea and pseudomembranous colitis in 1977.¹⁶⁶ This pathogen is a major cause of health care-associated diarrhea and has been responsible for many large outbreaks in health care settings that have proven extremely difficult to control. Important factors contributing to health care-associated outbreaks include environmental contamination, persistence of spores for prolonged periods, resistance of spores to routinely used disinfectants and antiseptics, hand carriage by HCWs to other patients, and exposure of patients to frequent courses of antimicrobial agents.¹⁶⁷ Antimicrobials most frequently associated with increased risk of *C difficile* include third-generation cephalosporins, clindamycin, vancomycin, and fluoroquinolones.

Since 2001, outbreaks and sporadic cases of *C difficile* with increased morbidity and mortality have occurred in several US states, Canada, England, and the Netherlands.¹⁶⁸⁻¹⁷² The same strain of *C difficile* has been implicated in all of these outbreaks;¹⁷³ this strain, toxinotype III, North American pulsed-field gel electrophoresis (PFGE) type 1, and polymerase chain reaction (PCR)-ribotype 027 (NAP1/027), has been found to hyperproduce toxin A (a 16-fold increase) and toxin B (a 23-fold increase) compared with isolates from 12 other PFGE types. A recent survey of US infectious disease physicians found that 40% of the respondents perceived recent increases in the incidence and severity of *C difficile* disease.¹⁷⁴ Standardization of testing methodology and surveillance definitions is needed for accurate comparisons of trends in rates among hospitals.¹⁷⁵ It is hypothesized that the incidence of disease and apparent heightened transmissibility of this new strain may be due, at least in part, to the greater production of toxins A and B, increasing the severity of diarrhea and producing more environmental contamination. Considering the greater morbidity, mortality, length of stay, and costs associated with *C difficile* disease in both acute care and long-term care facilities, control of this pathogen is becoming increasingly important.

Prevention of transmission focuses on syndromic application of Contact Precautions for patients with diarrhea, accurate identification of affected patients, environmental measures (eg, rigorous cleaning of patient rooms), and consistent hand hygiene. Using soap and water rather than alcohol-based handrubs for mechanical removal of spores from hands and using a bleach-containing disinfectant (5000 ppm) for environmental disinfection may be valuable in cases of transmission in health care facilities. Appendix A provides for recommendations.

I.C.1.b. Multidrug-Resistant Organisms. In general, MDROs are defined as microorganisms—predominantly bacteria—that are resistant to 1 or more classes of antimicrobial agents.¹⁷⁶ Although the names of certain MDROs suggest resistance to only a single agent (eg, MRSA, VRE), these pathogens are usually resistant to all but a few commercially available antimicrobial agents. This latter feature defines MDROs that are considered to be epidemiologically important and deserve special attention in health care facilities.¹⁷⁷ Other MDROs of current concern include multidrug-resistant *Streptococcus pneumoniae*, which is resistant to penicillin and other broad-spectrum agents such as macrolides and fluoroquinolones, multidrug-resistant gram-negative bacilli (MDR-GNB), especially those producing ESBLs; and strains of *S aureus* that are intermediate or resistant to vancomycin (ie, VISA and VRSA).¹⁷⁸⁻¹⁹⁸

MDROs are transmitted by the same routes as antimicrobial susceptible infectious agents. Patient-to-patient transmission in health care settings, usually via hands of HCWs, has been a major factor accounting for the increase in MDRO incidence and prevalence, especially for MRSA and VRE in acute care facilities.¹⁹⁹⁻²⁰¹ Preventing the emergence and transmission of these pathogens requires a comprehensive approach that includes administrative involvement and measures (eg, nurse staffing, communication systems, performance improvement processes to ensure adherence to recommended infection control measures), education and training of medical and other HCWs, judicious antibiotic use, comprehensive surveillance for targeted MDROs, application of infection control precautions during patient care, environmental measures (eg, cleaning and disinfection of the patient care environment and equipment, dedicated single-patient use of noncritical equipment), and decolonization therapy when appropriate.

The prevention and control of MDROs is a national priority, one that requires that all health care facilities and agencies assume responsibility and participate in community-wide control programs.^{176,177} A detailed discussion of this topic and recommendations for prevention published in 2006 is available at <http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf>.

I.C.2. Agents of Bioterrorism. The CDC has designated the agents that cause anthrax, smallpox, plague, tularemia, viral hemorrhagic fevers, and botulism as category A (high priority), because these agents can be easily disseminated environmentally and/or transmitted from person to person, can cause high mortality and have the potential for major public health impact, might cause public panic and social disruption, and necessitate special action for public health preparedness.²⁰² General information relevant to infection

control in health care settings for Category A agents of bioterrorism is summarized in Table 3. (See <http://www.bt.cdc.gov> for additional, updated Category A agent information as well as information concerning Category B and C agents of bioterrorism and updates.) Category B and C agents are important but are not as readily disseminated and cause less morbidity and mortality than Category A agents.

Health care facilities confront a different set of issues when dealing with a suspected bioterrorism event compared with other communicable diseases. An understanding of the epidemiology, modes of transmission, and clinical course of each disease, as well as carefully drafted plans that specify an approach and relevant websites and other resources for disease-specific guidance to health care, administrative, and support personnel, are essential for responding to and managing a bioterrorism event. Infection control issues to be addressed include (1) identifying persons who may be exposed or infected; (2) preventing transmission among patients, HCWs, and visitors; (3) providing treatment, chemoprophylaxis, or vaccine to potentially large numbers of people; (4) protecting the environment, including the logistical aspects of securing sufficient numbers of AIIRs or designating areas for patient cohorts when an insufficient number of AIIRs is available; (5) providing adequate quantities of appropriate PPE; and (6) identifying appropriate staff to care for potentially infectious patients (eg, vaccinated HCWs for care of patients with smallpox). The response is likely to differ for exposures resulting from an intentional release compared with a naturally occurring disease because of the large number of persons that can be exposed at the same time and possible differences in pathogenicity.

Various sources offer guidance for the management of persons exposed to the most likely agents of bioterrorism. Federal agency websites (eg, <http://www.usamriid.army.mil/publications/index.html> and <http://www.bt.cdc.gov>) and state and county health department websites should be consulted for the most up-to-date information. Sources of information on specific agents include anthrax,²⁰³ smallpox,²⁰⁴⁻²⁰⁶ plague,^{207,208} botulinum toxin,²⁰⁹ tularemia,²¹⁰ and hemorrhagic fever viruses.^{211,212}

I.C.2.a. Pre-Event Administration of Smallpox (Vaccinia) Vaccine to Health Care Workers. Vaccination of HCWs in preparation for a possible smallpox exposure has important infection control implications.²¹³⁻²¹⁵ These include the need for meticulous screening for vaccine contraindications in persons at increased risk for adverse vaccinia events; containment and monitoring of the vaccination site to prevent transmission in the health care setting and at home; and management of patients with vaccinia-related

adverse events.^{216,217} The pre-event US smallpox vaccination program of 2003 is an example of the effectiveness of carefully developed recommendations for both screening potential vaccinees for contraindications and vaccination site care and monitoring. Between December 2002 and February 2005, approximately 760,000 individuals were vaccinated in the Department of Defense and 40,000 in the civilian or public health populations, including approximately 70,000 who worked in health care settings. No cases of eczema vaccinatum, progressive vaccinia, fetal vaccinia, or contact transfer of vaccinia were reported in health care settings or in military workplaces.^{218,219} Outside the health care setting, there were 53 cases of contact transfer from military vaccinees to close personal contacts (eg, bed partners or contacts during participation in sports such as wrestling²²⁰). All contact transfers were from individuals who were not following recommendations to cover their vaccination sites. Vaccinia virus was confirmed by culture or PCR in 30 cases, 2 of which resulted from tertiary transfer. All recipients, including 1 breast-fed infant, recovered without complications. Subsequent studies using viral culture and PCR techniques have confirmed the effectiveness of semipermeable dressings to contain vaccinia.²²¹⁻²²⁴ This experience emphasizes the importance of ensuring that newly vaccinated HCWs adhere to recommended vaccination site care, especially those caring for high-risk patients. Recommendations for pre-event smallpox vaccination of HCWs and vaccinia-related infection control recommendations are published in the *Morbidity and Mortality Weekly Report*,^{216,225} with updates posted on the CDC's bioterrorism website.²⁰⁵

I.C.3. Prions. Creutzfeldt-Jakob disease (CJD) is a rapidly progressive, degenerative neurologic disorder of humans, with an incidence in the United States of approximately 1 person/million population/year.^{226,227} CJD is believed to be caused by a transmissible proteinaceous infectious agent known as a *prion*. Infectious prions are isoforms of a host-encoded glycoprotein known as the prion protein. The incubation period (ie, time between exposure and onset of symptoms) varies from 2 years to many decades. However, death typically occurs within 1 year of the onset of symptoms. Approximately 85% of CJD cases occur sporadically with no known environmental source of infection, and 10% of cases are familial. Iatrogenic transmission has occurred, with most cases resulting from treatment with human cadaver pituitary-derived growth hormone or gonadotropin,^{228,229} from implantation of contaminated human dura mater grafts,²³⁰ or from corneal transplants.²³¹ Transmission has been linked to the use of contaminated neurosurgical instruments or stereotactic electroencephalogram electrodes.²³²⁻²³⁵

Prion diseases in animals include scrapie in sheep and goats, bovine spongiform encephalopathy (BSE, or "mad cow disease") in cattle, and chronic wasting disease in deer and elk.²³⁶ BSE, first recognized in the United Kingdom in 1986, was associated with a major epidemic among cattle that had consumed contaminated meat and bone meal. The possible transmission of BSE to humans causing variant CJD (vCJD) was first described in 1996 and was subsequently found to be associated with consumption of BSE-contaminated cattle products primarily in the United Kingdom. There is strong epidemiologic and laboratory evidence for a causal association between the causative agent of BSE and vCJD.²³⁷ Although most cases of vCJD have been reported from the United Kingdom, a few cases also have been reported from Europe, Japan, Canada, and the United States. Most persons affected with vCJD worldwide lived in or visited the United Kingdom during the years of a large outbreak of BSE (1980-1996) and may have consumed contaminated cattle products during that time (see <http://www.cdc.gov/ncidod/diseases/cjd/cjd.htm>). Although there has been no indigenously acquired vCJD in the United States, the sporadic occurrence of BSE in cattle in North America has heightened awareness of the possibility that such infections could occur and have led to increased surveillance activities. Updated information may be found at <http://www.cdc.gov/ncidod/diseases/cjd/cjd.htm>. The public health impact of prion diseases has been reviewed previously.²³⁸

vCJD in humans has different clinical and pathologic characteristics than sporadic or classic CJD,²³⁹ including (1) younger median age at death (28 [range, 16 to 48] vs 68 years), (2) longer median duration of illness (14 months vs 4 to 6 months), (3) increased frequency of sensory symptoms and early psychiatric symptoms with delayed onset of frank neurologic signs; and (4) detection of prions in tonsillar and other lymphoid tissues, not present in sporadic CJD.²⁴⁰ Similar to sporadic CJD, there have been no reported cases of direct human-to-human transmission of vCJD by casual or environmental contact, droplet, or airborne routes. Ongoing blood safety surveillance in the United States has not detected sporadic CJD transmission through blood transfusion;²⁴¹⁻²⁴³ however, bloodborne transmission of vCJD is believed to have occurred in 2 patients in the United Kingdom.^{244,245} The following FDA websites provide information on steps currently being taken in the United States to protect the blood supply from CJD and vCJD: <http://www.fda.gov/cber/gdlns/cjdvcjd.htm> and <http://www.fda.gov/cber/gdlns/cjdvcjdqa.htm>.

Standard Precautions are used when caring for patients with suspected or confirmed CJD or vCJD. However, special precautions are recommended for tissue handling in the histology laboratory and for conducting

an autopsy, embalming, and coming into contact with a body that has undergone autopsy.²⁴⁶ Recommendations for reprocessing surgical instruments to prevent transmission of CJD in health care settings have been published by the World Health Organization (WHO) and are currently under review at the CDC.

Questions may arise concerning notification of patients potentially exposed to CJD or vCJD through contaminated instruments and blood products from patients with CJD or vCJD or at risk of having vCJD. The risk of transmission associated with such exposures is believed to be extremely low but may vary based on the specific circumstance. Therefore, consultation on appropriate options is advised. The United Kingdom has developed several documents that clinicians and patients in the United States may find useful (see http://www.hpa.org.uk/infections/topics_az/cjd/information_documents.htm).

I.C.4. Severe Acute Respiratory Syndrome. SARS is a newly discovered respiratory disease that emerged in China late in 2002 and spread to several countries.^{135,140} In particular, mainland China, Hong Kong, Hanoi, Singapore, and Toronto have been significantly affected. SARS is caused by SARS-CoV, a previously unrecognized member of the coronavirus family.^{247,248} The incubation period from exposure to the onset of symptoms is typically 2 to 7 days, but can be as long as 10 days and in rare cases even longer.²⁴⁹ The illness is initially difficult to distinguish from other common respiratory infections. Signs and symptoms usually include fever above 38.0°C and chills and rigors, sometimes accompanied by headache, myalgia, and mild to severe respiratory symptoms. A radiographic profile of atypical pneumonia is an important clinical indicator of possible SARS. Compared with adults, children are affected less frequently, have milder disease, and are less likely to transmit SARS-CoV.^{135,249-251} The overall case fatality rate is approximately 6%; underlying disease and advanced age increase the risk of mortality (see http://www.who.int/csr/sarsarchive/2003_05_07a/en/).

Outbreaks in health care settings, with transmission to large numbers of HCWs and patients, have been a striking feature of SARS; undiagnosed infectious patients and visitors have been important initiators of these outbreaks.^{21,252-254} The relative contribution of potential modes of transmission is not known precisely. There is ample evidence for droplet and contact transmission;^{96,101,113} however, opportunistic airborne transmission cannot be excluded.^{101,135-139,149, 254} For example, exposure to aerosol-generating procedures (eg, endotracheal intubation, suctioning) has been associated with transmission of infection to large numbers of HCWs outside of the United States.^{93,94,96,98,253} Therefore, aerosolization of small infectious particles generated during these and other similar procedures

could be a risk factor for transmission to others within a multibed room or shared airspace. A review of the infection control literature generated from the SARS outbreaks of 2003 concluded that the greatest risk of transmission is to those who have close contact, are not properly trained in use of protective infection control procedures, and do not consistently use PPE, and that N95 or higher-level respirators may offer additional protection to those exposed to aerosol-generating procedures and high-risk activities.^{255,256} Organizational and individual factors that affect adherence to infection control practices for SARS also were identified.²⁵⁶

Control of SARS requires a coordinated, dynamic response by multiple disciplines in a health care setting.⁹ Early detection of cases is accomplished by screening persons with symptoms of a respiratory infection for history of travel to areas experiencing community transmission or contact with SARS patients, followed by implementation of respiratory hygiene/cough etiquette (ie, placing a mask over the patient's nose and mouth) and physical separation from other patients in common waiting areas. The precise combination of precautions to protect HCWs has not yet been determined. At the time of this publication, the CDC recommends Standard Precautions, with emphasis on the use of hand hygiene; Contact Precautions, with emphasis on environmental cleaning due to the detection of SARS-CoV RNA by PCR on surfaces in rooms occupied by SARS patients;^{138,254,257} and Airborne Precautions, including use of fit-tested NIOSH-approved N95 or higher-level respirators and eye protection.²⁵⁸ In Hong Kong, the use of Droplet and Contact Precautions, including the use of a mask but not a respirator, was effective in protecting HCWs.¹¹³ However, in Toronto, consistent use of an N95 respirator was found to be slightly more protective than a mask.⁹³ It is noteworthy that no transmission of SARS-CoV to public hospital workers occurred in Vietnam despite inconsistent use of infection control measures, including use of PPE, which suggests other factors (eg, severity of disease, frequency of high-risk procedures or events, environmental features) may influence opportunities for transmission.²⁵⁹

SARS-CoV also has been transmitted in the laboratory setting through breaches in recommended laboratory practices. Research laboratories in which SARS-CoV was under investigation were the source of most cases reported after the first series of outbreaks in the winter and spring of 2003.^{260,261} Studies of the SARS outbreaks of 2003 and transmissions occurring in the laboratory reaffirm the effectiveness of recommended infection control precautions and highlight the importance of consistent adherence to these measures.

Lessons learned from the SARS outbreaks are useful in devising plans to respond to future public health crises, such as pandemic influenza and bioterrorism events. Surveillance for cases among patients and HCWs, ensuring availability of adequate supplies and staffing, and limiting access to health care facilities were important factors in the response to SARS.⁹ Guidance for infection control precautions in various settings is available at <http://www.cdc.gov/ncidod/sars>.

I.C.5. Monkeypox. Monkeypox is a rare viral disease found mostly in the rain forest countries of Central and West Africa. The disease is caused by an orthopoxvirus that is similar in appearance to smallpox but causes a milder disease. The only recognized outbreak of human monkeypox in the United States was detected in June 2003, after several people became ill after contact with sick pet prairie dogs. Infection in the prairie dogs was subsequently traced to their contact with a shipment of animals from Africa, including giant Gambian rats.²⁶² This outbreak demonstrates the importance of recognition and prompt reporting of unusual disease presentations by clinicians to enable prompt identification of the etiology, as well as the potential of epizootic diseases to spread from animal reservoirs to humans through personal and occupational exposure.²⁶³

Only limited data on transmission of monkeypox are available. Transmission from infected animals and humans is believed to occur primarily through direct contact with lesions and respiratory secretions; airborne transmission from animals to humans is unlikely but cannot be excluded, and may have occurred in veterinary practices (eg, during administration of nebulized medications to ill prairie dogs²⁶⁴). In humans, 4 instances of monkeypox transmission in hospitals have been reported in Africa among children, usually related to sharing the same ward or bed.^{265,266} Additional recent literature documents transmission of Congo Basin monkeypox in a hospital compound for an extended number of generations.²⁶⁷

There has been no evidence of airborne or any other person-to-person transmission of monkeypox in the United States, and no new cases of monkeypox have been identified since the outbreak in June 2003.²⁶⁸ The outbreak strain is a clade of monkeypox distinct from the Congo Basin clade and may have different epidemiologic properties (including human-to-human transmission potential) from monkeypox strains of the Congo Basin,²⁶⁹ this awaits further study. Smallpox vaccine is 85% protective against Congo Basin monkeypox.²⁷⁰ Because there is an associated case fatality rate of < 10%, administration of smallpox vaccine within 4 days to individuals who have had direct exposure to patients or animals with monkeypox is a reasonable policy.²⁷¹ For the most current information

on monkeypox, see <http://www.cdc.gov/ncidod/monkeypox/clinicians.htm>.

I.C.6. Noroviruses. Noroviruses, formerly referred to as Norwalk-like viruses, are members of the *Caliciviridae* family. These agents are transmitted via contaminated food or water and from person to person, causing explosive outbreaks of gastrointestinal disease.²⁷² Environmental contamination also has been documented as a contributing factor in ongoing transmission during outbreaks.^{273,274} Although noroviruses cannot be propagated in cell culture, DNA detection by molecular diagnostic techniques has brought a greater appreciation of their role in outbreaks of gastrointestinal disease.²⁷⁵ Reported outbreaks in hospitals,^{132,142,276} nursing homes,^{274,277-282} cruise ships,^{283,284} hotels,^{143,147} schools,¹⁴⁸ and large crowded shelters established for hurricane evacuees²⁸⁵ has demonstrated their highly contagious nature, their potentially disruptive impact in health care facilities and the community, and the difficulty of controlling outbreaks in settings in which people share common facilities and space. Of note, there is nearly a 5-fold increase in the risk to patients in outbreaks when a patient is the index case compared with exposure of patients during outbreaks when a staff member is the index case.²⁸⁶

The average incubation period for gastroenteritis caused by noroviruses is 12 to 48 hours, and the clinical course lasts 12 to 60 hours.²⁷² Illness is characterized by acute onset of nausea, vomiting, abdominal cramps, and/or diarrhea. The disease is largely self-limited; rarely, death due to severe dehydration can occur, particularly in elderly persons with debilitating health conditions.

The epidemiology of norovirus outbreaks shows that even though primary cases may result from exposure to a fecally contaminated food or water, secondary and tertiary cases often result from person-to-person transmission facilitated by contamination of fomites^{272,287} and dissemination of infectious particles, especially during the process of vomiting.^{132,142,143,147,148,272, 278,279} Widespread, persistent, and inapparent contamination of the environment and fomites can make outbreaks extremely difficult to control.^{147,274,283} These clinical observations and the detection of norovirus DNA on horizontal surfaces 5 feet above the level that might be touched normally suggest that under certain circumstances, aerosolized particles may travel distances beyond 3 feet.¹⁴⁷ It is hypothesized that infectious particles may be aerosolized from vomitus, inhaled, and swallowed. In addition, individuals who are responsible for cleaning the environment may be at increased risk of infection. Development of disease and transmission may be facilitated by the low infectious dose (ie, < 100 viral particles)²⁸⁸ and the resistance of these viruses to the usual cleaning and disinfection agents

(ie, they may survive < 10 ppm chlorine).²⁸⁹⁻²⁹¹ An alternate phenolic agent that was shown to be effective against feline calicivirus was used for environmental cleaning in one outbreak.^{275,292} There are insufficient data to determine the efficacy of alcohol-based hand rubs against noroviruses when the hands are not visibly soiled.²⁹³ Absence of disease in certain individuals during an outbreak may be explained by protection from infection conferred by the B histo-blood group antigen.²⁹⁴ Consultation on outbreaks of gastroenteritis is available through the CDC's Division of Viral and Rickettsial Diseases.²⁹⁵

I.C.7. Hemorrhagic Fever Viruses. HFV is a mixed group of viruses that cause serious disease with high fever, skin rash, bleeding diathesis, and, in some cases, high mortality; the resulting disease is referred to as viral hemorrhagic fever (VHF). Among the more commonly known HFVs are Ebola and Marburg viruses (*Filoviridae*), Lassa virus (*Arenaviridae*), Crimean-Congo hemorrhagic fever and Rift Valley Fever virus (*Bunyaviridae*), and Dengue and Yellow fever viruses (*Flaviviridae*).^{212,296} These viruses are transmitted to humans through contact with infected animals or via arthropod vectors. Although none of these viruses is endemic in the United States, outbreaks in affected countries provide potential opportunities for importation by infected humans and animals. Furthermore, there is a concern that some of these agents could be used as bioweapons.²¹² Person-to-person transmission has been documented for Ebola, Marburg, Lassa, and Crimean-Congo HFVs. In resource-limited health care settings, transmission of these agents to HCWs, patients, and visitors has been described and in some outbreaks has accounted for a large proportion of cases.²⁹⁷⁻²⁹⁹ Transmission within households also has been documented in individuals who had direct contact with ill persons or their body fluids, but not in those who did not have such contact.³⁰⁰

Evidence concerning the transmission of HFVs has been summarized previously.^{212,301} Person-to-person transmission is associated primarily with direct blood and body fluid contact. Percutaneous exposure to contaminated blood carries a particularly high risk for transmission and increased mortality.^{302,303} The finding of large numbers of Ebola viral particles in the skin and the lumina of sweat glands has raised concerns that transmission could occur from direct contact with intact skin, although epidemiologic evidence to support this is lacking.³⁰⁴ Postmortem handling of infected bodies is an important risk for transmission.^{300,305,306} In rare situations, cases in which the mode of transmission was unexplained among individuals with no known direct contact have led to speculation that airborne transmission could have occurred.²⁹⁷ However, airborne transmission of naturally occurring

HFVs in humans has not been documented. A study of airplane passengers exposed to an in-flight index case of Lassa fever found no transmission to any passengers.³⁰⁷

In the laboratory setting, animals have been infected experimentally with Marburg or Ebola virus through direct inoculation of the nose, mouth, and/or conjunctiva^{308,309} and by using mechanically generated virus-containing aerosols.^{310, 311} Transmission of Ebola virus among laboratory primates in an animal facility has been described.³¹² The secondarily infected animals were in individual cages separated by approximately 3 meters. Although the possibility of airborne transmission was suggested, the investigators were not able to exclude droplet or indirect contact transmission in this incidental observation.

Guidance on infection control precautions for HFVs transmitted person-to-person have been published by the CDC^{1,211} and by the Johns Hopkins Center for Civilian Biodefense Strategies.²¹² The most recent recommendations at the time of publication of this document were posted on the CDC website on May 19, 2005.³¹³ Inconsistencies among the various recommendations have raised questions about the appropriate precautions to use in US hospitals. In less developed countries, outbreaks of HFVs have been controlled with basic hygiene, barrier precautions, safe injection practices, and safe burial practices.^{298,305} The preponderance of evidence on HFV transmission indicates that Standard, Contact, and Droplet Precautions with eye protection are effective in protecting HCWs and visitors coming in contact with an infected patient. Single gloves are adequate for routine patient care; double-gloving is advised during invasive procedures (eg, surgery) that pose an increased risk of blood exposure. Routine eye protection (ie goggles or face shield) is particularly important. Fluid-resistant gowns should be worn for all patient contact. Airborne Precautions are not required for routine patient care; however, use of AIIRs is prudent when procedures that could generate infectious aerosols are performed (eg, endotracheal intubation, bronchoscopy, suctioning, autopsy procedures involving oscillating saws). N95 or higher-level respirators may provide added protection for individuals in a room during aerosol-generating procedures (Table 3, Appendix A). When a patient with a syndrome consistent with hemorrhagic fever also has a history of travel to an endemic area, precautions are initiated on presentation and then modified as more information is obtained (Table 2). Patients with hemorrhagic fever syndrome in the setting of a suspected bioweapons attack should be managed using Airborne Precautions, including AIIRs, because the epidemiology of a potentially weaponized hemorrhagic fever virus is unpredictable.

I.D. Transmission Risks Associated With Specific Types of Health Care Settings

Numerous factors influence differences in transmission risks among the various health care settings. These factors include the population characteristics (eg, increased susceptibility to infections, type and prevalence of indwelling devices), intensity of care, exposure to environmental sources, length of stay, and frequency of interaction between patients/residents with each other and with HCWs. These factors, as well as organizational priorities, goals, and resources, influence how different health care settings adapt transmission prevention guidelines to meet their specific needs.^{314,315} Infection control management decisions are informed by data regarding institutional experience/Epidemiology; trends in community and institutional HAIs; local, regional, and national Epidemiology; and emerging infectious disease threats.

I.D.1. Hospitals. Infection transmission risks are present in all hospital settings. However, certain hospital settings and patient populations have unique conditions that predispose patients to infection and merit special mention. These are often sentinel sites for the emergence of new transmission risks that may be unique to that setting or present opportunities for transmission to other settings in the hospital.

I.D.1.a. Intensive Care Units. Intensive care units (ICUs) serve patients who are immunocompromised by disease state and/or by treatment modalities, as well as patients with major trauma, respiratory failure, and other life-threatening conditions (eg, myocardial infarction, congestive heart failure, overdose, stroke, gastrointestinal bleeding, renal failure, hepatic failure, multiorgan system failure, and extremes of age). Although ICUs account for a relatively small proportion of hospitalized patients, infections acquired in these units account for > 20% of all HAIs.³¹⁶ In the National Nosocomial Infection Surveillance (NNIS) system, 26.6% of HAIs were reported from ICU and high-risk nursery (neonatal ICU [NICU]) patients in 2002 (NNIS, unpublished data). This patient population has increased susceptibility to colonization and infection, especially with MDROs and *Candida* spp,^{317,318} because of underlying diseases and conditions, the invasive medical devices and technology used in their care (eg central venous catheters and other intravascular devices, mechanical ventilators, extracorporeal membrane oxygenation, hemodialysis/filtration, pacemakers, implantable left-ventricular assist devices), the frequency of contact with HCWs, prolonged lengths of stay, and prolonged exposure to antimicrobial agents.³¹⁹⁻³³⁰ Furthermore, adverse patient outcomes in this setting are more severe and are associated with a higher mortality.³³¹ Outbreaks associated with various bacterial,

fungus, and viral pathogens due to common-source and person-to-person transmissions are frequent in adult ICUs and pediatric ICUs (PICUs).^{31,332-337}

I.D.1.b. Burn Units. Burn wounds can provide optimal conditions for colonization, infection, and transmission of pathogens; infection acquired by burn patients is a frequent cause of morbidity and mortality.^{319,338,339} The risk of invasive burn wound infection is particularly high in patients with a burn injury involving > 30% of the total body surface area (TBSA).^{340,341} Infections occurring in patients with burn injuries involving < 30% of the TBSA are usually associated with the use of invasive devices. MSSA, MRSA, enterococci (including VRE), gram-negative bacteria, and *Candida* spp are prevalent pathogens in burn infections,^{53,339,342-349} and outbreaks of these organisms have been reported.³⁵⁰⁻³⁵³ Shifts over time in the predominance of pathogens causing infections in burn patients often lead to changes in burn care practices.^{342,354-357} Burn wound infections caused by *Aspergillus* spp or other environmental molds may result from exposure to supplies contaminated during construction³⁵⁸ or to dust generated during construction or other environmental disruption.³⁵⁹

Hydrotherapy equipment is an important environmental reservoir of gram-negative organisms. Its use in burn care is discouraged based on demonstrated associations between the use of contaminated hydrotherapy equipment and infections. Burn wound infections and colonization, as well as bloodstream infections, caused by multidrug-resistant *P. aeruginosa*,³⁶⁰ *Acinetobacter baumannii*,³⁶¹ and MRSA³⁵¹ have been associated with hydrotherapy; thus, excision of burn wounds in operating rooms is the preferred approach.

Advances in burn care (specifically, early excision and grafting of the burn wound, use of topical antimicrobial agents, and institution of early enteral feeding) have led to decreased infectious complications. Other advances have included prophylactic antimicrobial use, selective digestive decontamination, and use of antimicrobial-coated catheters; however, few epidemiologic studies and no efficacy studies have been performed to investigate the relative benefit of these measures.³⁵⁶

There is no consensus on the most effective infection control practices to prevent transmission of infections to and from patients with serious burns (eg, single-bed rooms,³⁵⁷ laminar flow,³⁶² and high-efficiency particulate air [HEPA] filtration,³⁵⁹ or maintaining burn patients in a separate unit with no exposure to patients or equipment from other units³⁶³). There also is controversy regarding the need for and type of barrier precautions in the routine care of burn patients. One retrospective study demonstrated the efficacy and cost-effectiveness of a simplified barrier

isolation protocol for wound colonization, emphasizing handwashing and use of gloves, caps, masks, and impermeable plastic aprons (rather than isolation gowns) for direct patient contact.³⁶⁴ However, to date no studies have determined the most effective combination of infection control precautions for use in burn settings. Prospective studies in this area are needed.

I.D.1.c. Pediatrics. Studies of the epidemiology of HAIs in children have identified unique infection control issues in this population.^{63,64,365-369} Pediatric ICU patients and the lowest birth weight babies in the NICU monitored in the NNIS system have had high rates of central venous catheter-associated bloodstream infections.^{64,319,368-371} In addition, there is a high prevalence of community-acquired infections among hospitalized infants and young children who have not yet become immune either by vaccination or by natural infection. This results in more patients and their sibling visitors with transmissible infections in pediatric health care settings, especially during seasonal epidemics (eg, pertussis;^{36,40,41} respiratory viral infections, including those caused by RSV,²⁴ influenza viruses,³⁷² parainfluenza virus,³⁷³ human metapneumovirus,³⁷⁴ and adenoviruses;³⁷⁵ rubella [measles];³⁴ varicella [chickenpox];³⁷⁶ and rotavirus^{38,377}).

Close physical contact between HCWs and infants and young children (eg, cuddling, feeding, playing, changing soiled diapers, and cleaning copious uncontrolled respiratory secretions) provides abundant opportunities for transmission of infectious material. Such practices and behaviors as congregation of children in play areas where toys and bodily secretions are easily shared and rooming-in of family members with pediatric patients can further increase the risk of transmission. Pathogenic bacteria have been recovered from toys used by hospitalized patients;³⁷⁸ contaminated bath toys were implicated in an outbreak of multidrug-resistant *P. aeruginosa* on a pediatric oncology unit.⁸⁰ In addition, several patient factors increase the likelihood that infection will result from exposure to pathogens in health care settings (eg, immaturity of the neonatal immune system, lack of previous natural infection and resulting immunity, prevalence of patients with congenital or acquired immune deficiencies, congenital anatomic anomalies, and use of life-saving invasive devices in NICUs and PICUs).⁶³ There are theoretical concerns that infection risk will increase in association with innovative practices used in the NICU for the purpose of improving developmental outcomes. Such factors include co-bedding³⁷⁹ and kangaroo care,³⁸⁰ which may increase opportunity for skin-to-skin exposure of multiple gestation infants to each other and to their mothers, respectively; although the risk of infection actually may

be reduced among infants receiving kangaroo care.³⁸¹ Children who attend child care centers^{382,383} and pediatric rehabilitation units³⁸⁴ may increase the overall burden of antimicrobial resistance by contributing to the reservoir of CA-MRSA.³⁸⁵⁻³⁹⁰ Patients in chronic care facilities may have increased rates of colonization with resistant gram-negative bacilli and may be sources of introduction of resistant organisms to acute care settings.⁵⁰

I.D.2. Nonacute Health Care Settings. Health care is provided in various settings outside of hospitals, including long-term care facilities (LTCFs) (eg nursing homes), homes for the developmentally disabled, behavioral health service settings, rehabilitation centers, and hospices.³⁹¹ In addition, health care may be provided in non-health care settings, such as workplaces with occupational health clinics, adult day care centers, assisted-living facilities, homeless shelters, jails and prisons, school clinics, and infirmaries. Each of these settings has unique circumstances and population risks that must be considered when designing and implementing an infection control program. Several of the most common settings and their particular challenges are discussed below. Although this guideline does not address each setting, the principles and strategies provided herein may be adapted and applied as appropriate.

I.D.2.a. Long-Term Care. The designation LTCF applies to a diverse group of residential settings, ranging from institutions for the developmentally disabled to nursing homes for the elderly and pediatric chronic care facilities.³⁹²⁻³⁹⁴ Nursing homes for the elderly predominate numerically and frequently represent long-term care as a group of facilities. Approximately 1.8 million Americans reside in the nation's 16,500 nursing homes.³⁹⁵ Estimates of HAI rates of 1.8 to 13.5 per 1000 resident-care days have been reported, with a range of 3 to 7 per 1000 resident-care days in the more rigorous studies.³⁹⁶⁻⁴⁰⁰ The infrastructure described in the Department of Veterans Affairs' nursing home care units is a promising example for the development of a nationwide HAI surveillance system for LTCFs.⁴⁰¹

LTCFs are different from other health care settings in that elderly patients at increased risk for infection are brought together in one setting and remain in the facility for extended periods; for most residents, it is their home. An atmosphere of community is fostered, and residents share common eating and living areas and participate in various facility-sponsored activities.^{402,403} Because able residents interact freely with each other, controlling infection transmission in this setting can be challenging.⁴⁰⁴ A residents who is colonized or infected with certain microorganisms are in some cases restricted to his or her room. However,

because of the psychosocial risks associated with such restriction, balancing psychosocial needs with infection control needs is important in the LTCF setting.⁴⁰⁵⁻⁴⁰⁸ Documented LTCF outbreaks have been caused by various viruses (eg, influenza virus,^{35,409-411} rhinovirus,⁴¹² adenovirus [conjunctivitis],⁴¹³ norovirus^{274,277,278,280}) and bacteria, including group A streptococcus,¹⁶² *B pertussis*,⁴¹⁴ nonsusceptible *S pneumoniae*,^{197,198} other MDROs, and *C difficile*⁴¹⁵). These pathogens can lead to substantial morbidity and mortality, as well as increased medical costs; prompt detection and implementation of effective control measures are needed.

Risk factors for infection are prevalent among LTCF residents.^{394,416,417} Age-related declines in immunity may affect the response to immunizations for influenza and other infectious agents and increase the susceptibility to tuberculosis. Immobility, incontinence, dysphagia, underlying chronic diseases, poor functional status, and age-related skin changes increase susceptibility to urinary, respiratory, and cutaneous and soft tissue infections, whereas malnutrition can impair wound healing.⁴¹⁸⁻⁴²² Medications (eg, drugs that affect level of consciousness, immune function, gastric acid secretions, and normal flora, including antimicrobial therapy) and invasive devices (eg, urinary catheters and feeding tubes) heighten the susceptibility to infection and colonization in LTCF residents.⁴²³⁻⁴²⁵ Finally, limited functional status and total dependence on HCWs for activities of daily living have been identified as independent risk factors for infection^{400,416,426} and for colonization with MRSA^{427,428} and ESBL-producing *Klebsiella pneumoniae*.⁴²⁹ Several position papers and review articles provide guidance on various aspects of infection control and antimicrobial resistance in LTCFs.^{405-407,430-435} The Centers for Medicare and Medicaid Services has established regulations for the prevention of infection in LTCFs.⁴³⁶

Because residents of LTCFs are hospitalized frequently, they can transfer pathogens between LTCFs and health care facilities in which they receive care.^{8,437-440} This also is true for pediatric long-term care populations. Pediatric chronic care facilities have been associated with the importation of extended-spectrum cephalosporin-resistant, gram-negative bacilli into a PICU.⁵⁰ Children from pediatric rehabilitation units may contribute to the reservoir of community-associated MRSA.^{384,388-390}

I.D.2.b. Ambulatory Care. Over the past decade, health care delivery in the United States has shifted from the acute, inpatient hospital to various ambulatory and community-based settings, including the home. Ambulatory care is provided in hospital-based outpatient clinics, nonhospital-based clinics and physicians' offices, public health clinics, free-standing

dialysis centers, ambulatory surgical centers, urgent care centers, and other setting. In 2000, there were 83 million visits to hospital outpatient clinics and more than 823 million visits to physicians' offices;⁴⁴¹ ambulatory care now accounts for most patient encounters with the health care system.⁴⁴² Adapting transmission prevention guidelines to these settings is challenging, because patients remain in common areas for prolonged periods waiting to be seen by a health care provider or awaiting admission to the hospital, examination or treatment rooms are turned around quickly with limited cleaning, and infectious patients may not be recognized immediately. Furthermore, immunocompromised patients often receive chemotherapy in infusion rooms, where they stay for extended periods along with other types of patients.

Little data exist on the risk of HAIs in ambulatory care settings, with the exception of hemodialysis centers.^{18,443,444} Transmission of infections in outpatient settings has been reviewed in 3 studies.⁴⁴⁵⁻⁴⁴⁷ Goodman and Solomon⁴⁴⁵ summarized 53 clusters of infections associated with the outpatient setting between 1961 and 1990. Overall, 29 clusters were associated with common source transmission from contaminated solutions or equipment, 14 were associated with person-to-person transmission from or involving HCWs, and 10 were associated with airborne or droplet transmission among patients and health care workers. Transmission of bloodborne pathogens (ie, HBV, HCV, and, rarely, HIV) in outbreaks, sometimes involving hundreds of patients, continues to occur in ambulatory settings. These outbreaks often are related to common source exposures, usually a contaminated medical device, multidose vial, or intravenous solution.^{82,448-452} In all cases, transmission has been attributed to failure to adhere to fundamental infection control principles, including safe injection practices and aseptic technique. This subject has been reviewed, and recommended infection control and safe injection practices have been summarized.⁴⁵³

Airborne transmission of *M tuberculosis* and measles in ambulatory settings, most often emergency departments, has been reported.^{34,127,445,447,454-456} Measles virus was transmitted in physicians' offices and other outpatient settings during an era when immunization rates were low and measles outbreaks in the community were occurring regularly.^{34,122,457} Rubella has been transmitted in the outpatient obstetric setting;³³ there are no published reports of varicella transmission in the outpatient setting. In the ophthalmology setting, adenovirus type 8 epidemic keratoconjunctivitis has been transmitted through incompletely disinfected ophthalmology equipment and/or from HCWs to patients, presumably by contaminated hands.^{17,445,447,458-461}

Preventing transmission in outpatient settings necessitates screening for potentially infectious symptomatic and asymptomatic individuals, especially those at possible risk for transmitting airborne infectious agents (eg, *M tuberculosis*, varicella-zoster virus, rubella [measles]), at the start of the initial patient encounter. On identification of a potentially infectious patient, implementation of prevention measures, including prompt separation of potentially infectious patients and implementation of appropriate control measures (eg, respiratory hygiene/cough etiquette and Transmission-Based Precautions) can decrease transmission risks.^{9,12} Transmission of MRSA and VRE in outpatient settings has not been reported, but the association of CA-MRSA in HCWs working in an outpatient HIV clinic with environmental CA-MRSA contamination in that clinic suggests the possibility of transmission in that setting.⁴⁶² Patient-to-patient transmission of *Burkholderia* spp and *P aeruginosa* in outpatient clinics for adults and children with cystic fibrosis has been confirmed.^{463,464}

I.D.2.c. Home Care. Home care in the United States is delivered by more than 20,000 provider agencies, including home health agencies, hospices, durable medical equipment providers, home infusion therapy services, and personal care and support services providers. Home care is provided to patients of all ages with both acute and chronic conditions. The scope of services ranges from assistance with activities of daily living and physical and occupational therapy to the care of wounds, infusion therapy, and chronic ambulatory peritoneal dialysis.

The incidence of infection in home care patients, other than that associated with infusion therapy, has not been well studied.⁴⁶⁵⁻⁴⁷⁰ However, data collection and calculation of infection rates have been done for central venous catheter-associated bloodstream infections in patients receiving home infusion therapy⁴⁶⁹⁻⁴⁷³ and for the risk of blood contact through percutaneous or mucosal exposures, demonstrating that surveillance can be performed in this setting.⁴⁷⁴ Draft definitions for home care-associated infections have been developed.⁴⁷⁵

Transmission risks during home care are presumed to be minimal. The main transmission risks to home care patients are from an infectious home care provider or contaminated equipment; a provider also can be exposed to an infectious patient during home visits. Because home care involves patient care by a limited number of personnel in settings without multiple patients or shared equipment, the potential reservoir of pathogens is reduced. Infections of home care providers that could pose a risk to home care patients include infections transmitted by the airborne or drop-let routes (eg, chickenpox, tuberculosis, influenza),

skin infestations (eg, scabies⁶⁹ and lice), and infections transmitted by direct or indirect contact (eg, impetigo). There are no published data on indirect transmission of MDROs from one home care patient to another, although this is theoretically possible if contaminated equipment is transported from an infected or colonized patient and used on another patient. Of note, investigations of the first case of VISA in home care¹⁸⁶ and the first 2 reported cases of VRSA^{178,180,181,183} found no evidence of transmission of VISA or VRSA to other home care recipients. Home health care also may contribute to antimicrobial resistance; a review of outpatient vancomycin use found that 39% of recipients did not receive prescribed antibiotics according to recommended guidelines.⁴⁷⁶

Although most home care agencies implement policies and procedures aimed at preventing transmission of organisms, the current approach is based on the adaptation of the 1996 *Guideline for Isolation Precautions in Hospitals*,¹ as well as other professional guidance.^{477,478} This issue has proven very challenging to the home care industry, and practice has been inconsistent and frequently not evidence-based. For example, many home health agencies continue to observe “nursing bag technique,” a practice that prescribes the use of barriers between the nursing bag and environmental surfaces in the home.⁴⁷⁹ Although the home environment may not always appear clean, the use of barriers between 2 noncritical surfaces has been questioned.^{480,481} Opportunities exist to conduct research in home care related to infection transmission risks.⁴⁸²

I.D.2.d. Other Sites of Health Care Delivery. Facilities that are not primarily health care settings but in which health care is delivered include clinics in correctional facilities and shelters. Both of these settings can have suboptimal features, such as crowded conditions and poor ventilation. Economically disadvantaged individuals who may have chronic illnesses and health care problems related to alcoholism, injected drug use, poor nutrition, and/or inadequate shelter often receive their primary health care at such sites.⁴⁸³ Infectious diseases of special concern for transmission include tuberculosis, scabies, respiratory infections (eg, *N meningitidis*, *S pneumoniae*), sexually transmitted and bloodborne diseases (eg, HIV, HBV, HCV, syphilis, gonorrhea), hepatitis A virus, diarrheal agents such as norovirus, and foodborne diseases.^{285,484-487} A high index of suspicion for tuberculosis and CA-MRSA in these populations is needed; outbreaks in these settings or among the populations they serve have been reported.⁴⁸⁸⁻⁴⁹⁶

Patient encounters in these types of facilities provide an opportunity to deliver recommended immunizations and screen for *M tuberculosis* infection, along

with diagnosing and treating acute illnesses.⁴⁹⁷ Recommended infection control measures in these nontraditional areas designated for health care delivery are the same as for other ambulatory care settings. Therefore, these settings must be equipped to observe Standard Precautions and, when indicated, Transmission-Based Precautions.

I.E. Transmission Risks Associated With Special Patient Populations

As new treatments emerge for complex diseases, unique infection control challenges associated with special patient populations must be addressed.

I.E.1. Immunocompromised Patients. Patients who have congenital primary immune deficiencies or acquired disease (eg, treatment-induced immune deficiencies) are at increased risk for numerous types of infections while receiving health care; these patients may be located throughout the health care facility. The specific immune system defects determine the types of infections most likely to be acquired (eg, viral infections are associated with T cell defects, and fungal and bacterial infections occur in patients who are neutropenic). As a general group, immunocompromised patients can be cared for in the same environment as other patients; however, it is always advisable to minimize exposure to other patients with transmissible infections, such as influenza and other respiratory viruses.^{498,499} The use of more intense chemotherapy regimens for treatment of childhood leukemia may be associated with prolonged periods of neutropenia and suppression of other components of the immune system, extending the period of infection risk and raising the concern that additional precautions may be indicated for select groups.^{500,501} With the application of newer and more intense immunosuppressive therapies for various medical conditions (eg, rheumatologic disease,^{502, 503} inflammatory bowel disease⁵⁰⁴), immunosuppressed patients are likely to be more widely distributed throughout a health care facility rather than localized to single patient units (eg, hematology-oncology). Guidelines for preventing infections in certain groups of immunocompromised patients have been published previously.^{15,505,506}

Published data provide evidence to support placing patients undergoing allogeneic HSCT in a PE.^{15,157,158} In addition, guidelines have been developed that address the special requirements of these immunocompromised patients, including use of antimicrobial prophylaxis and engineering controls to create a PE for the prevention of infections caused by *Aspergillus* spp and other environmental fungi.^{11,14,15} As more intense chemotherapy regimens associated with prolonged periods of neutropenia or graft-versus-host

disease are implemented, the period of risk and duration of environmental protection may need to be prolonged beyond the traditional 100 days.⁵⁰⁷

I.E.2. Cystic Fibrosis Patients. Patients with cystic fibrosis (CF) require special consideration when developing infection control guidelines. Compared with other patients, CF patients require additional protection to prevent transmission from contaminated respiratory therapy equipment.⁵⁰⁸⁻⁵¹² Such infectious agents as *B cepacia* complex and *P aeruginosa*.^{463,464,513,514} have unique clinical and prognostic significance. In CF patients, *B cepacia* infection has been associated with increased morbidity and mortality,⁵¹⁵⁻⁵¹⁷ whereas delayed acquisition of chronic *P aeruginosa* infection may be associated with an improved long-term clinical outcome.^{518,519}

Person-to-person transmission of *B cepacia* complex has been demonstrated among children⁵¹⁶ and adults⁵²⁰ with CF in health care settings^{463,521} and from various social contacts,⁵²² most notably attendance at camps for patients with CF⁵²³ and among siblings with CF.⁵²⁴ Successful infection control measures used to prevent transmission of respiratory secretions include segregation of CF patients from each other in ambulatory and hospital settings (including use of private rooms with separate showers), environmental decontamination of surfaces and equipment contaminated with respiratory secretions, elimination of group chest physiotherapy sessions, and disbanding of CF camps.^{97,525} The Cystic Fibrosis Foundation has published a consensus document with evidence-based recommendations for infection control practices in CF patients.²⁰

I.F. New Therapies Associated With Potentially Transmissible Infectious Agents

I.F.1. Gene Therapy. Gene therapy has been attempted using various viral vectors, including nonreplicating retroviruses, adenoviruses, adeno-associated viruses, and replication-competent strains of poxviruses. Unexpected adverse events have restricted the prevalence of gene therapy protocols.

The infectious hazards of gene therapy are theoretical at this time but require meticulous surveillance due to the possible occurrence of in vivo recombination and the subsequent emergence of a transmissible genetically altered pathogen. The greatest concern attends the use of replication-competent viruses, especially vaccinia. To date, no reports have described transmission of a vector virus from a gene therapy recipient to another individual, but surveillance is ongoing. Recommendations for monitoring infection control issues throughout the course of gene therapy trials have been published.⁵²⁶⁻⁵²⁸

I.F.2. Infections Transmitted Through Blood, Organs, and Other Tissues. The potential hazard of transmitting infectious pathogens through biologic products is a small but ever-present risk, despite donor screening. Reported infections transmitted by transfusion or transplantation include West Nile virus infection,⁵²⁹ cytomegalovirus infection,⁵³⁰ CJD,²³⁰ hepatitis C,⁵³¹ infections with *Clostridium* spp⁵³² and group A streptococcus,⁵³³ malaria,⁵³⁴ babesiosis,⁵³⁵ Chagas disease,⁵³⁶ lymphocytic choriomeningitis,⁵³⁷ and rabies.^{538,539} Therefore, it is important to consider receipt of biologic products when evaluating patients for potential sources of infection.

I.F.3. Xenotransplantation. Transplantation of non-human cells, tissues, and organs into humans potentially exposes patients to zoonotic pathogens. Transmission of known zoonotic infections (eg, trichinosis from porcine tissue) is of concern. Also of concern is the possibility that transplantation of non-human cells, tissues, or organs may transmit previously unknown zoonotic infections (xenozoonoses) to immunosuppressed human recipients. Potential infections that potentially could accompany transplantation of porcine organs have been described previously.⁵⁴⁰ Guidelines from the US Public Health Service address many infectious diseases and infection control issues that surround the developing field of xenotransplantation;⁵⁴¹ work in this area is ongoing.

PART II: FUNDAMENTAL ELEMENTS NEEDED TO PREVENT TRANSMISSION OF INFECTIOUS AGENTS IN HEALTH CARE SETTINGS

II.A. Health Care System Components That Influence the Effectiveness of Precautions to Prevent Transmission

II.A.1. Administrative Measures. Health care organizations can demonstrate a commitment to preventing transmission of infectious agents by incorporating infection control into the objectives of the organization's patient and occupational safety programs.⁵⁴²⁻⁵⁴⁶ An infrastructure designed to guide, support, and monitor adherence to Standard Precautions and Transmission-Based Precautions^{434,547,548} will facilitate fulfillment of the organization's mission and achievement of the Joint Commission on Accreditation of Health Care Organizations' patient safety goal to decrease HAIs.⁵⁴⁹ Policies and procedures that explain how Standard Precautions and Transmission-Based Precautions are applied, including systems used to identify and communicate information on patients with potentially transmissible infectious agents, are essential to ensure the success of these measures. These policies and procedures may vary according to the characteristics of the organization.

A key administrative measure is the provision of fiscal and human resources for maintaining infection control and occupational health programs that are responsive to emerging needs. Specific components include bedside nurse⁵⁵⁰ and infection prevention and control professional (ICP) staffing levels,⁵⁵¹ inclusion of ICPs in facility construction and design decisions,¹¹ clinical microbiology laboratory support,^{552,553} adequate supplies and equipment including facility ventilation systems,¹¹ adherence monitoring,⁵⁵⁴ assessment and correction of system failures that contribute to transmission,^{555,556} and provision of feedback to HCWs and senior administrators.^{433,547,548,557} The positive influence of institutional leadership has been demonstrated repeatedly in studies of HCWs' adherence to recommended hand hygiene practices.^{176,177,433,547,548,558-563} Health care administrators' involvement in the infection control processes can improve their awareness of the rationale and resource requirements for following recommended infection control practices.

Several administrative factors may affect the transmission of infectious agents in health care settings, including the institutional culture, individual HCW behavior, and the work environment. Each of these areas is suitable for performance improvement monitoring and incorporation into the organization's patient safety goals.^{542,543,545,564}

II.A.1.a. Scope of Work and Staffing Needs for Infection Control Professionals. The effectiveness of infection surveillance and control programs in preventing nosocomial infections in USt hospitals was assessed by the CDC through the Study on the Efficacy of Nosocomial Infection Control (SENIC Project) conducted between 1970 and 1976.⁵⁶⁵ In a representative sample of US general hospitals, those with a trained infection control physician or microbiologist involved in an infection control program and at least 1 infection control nurse per 250 beds were associated with a 32% lower rate of the 4 infections studied (CVC-associated bloodstream infections, ventilator-associated pneumonias, catheter-related urinary tract infections, and surgical site infections).

Since the publication of that landmark study, responsibilities of ICPs have expanded commensurate with the growing complexity of the health care system, the patient populations served, and the increasing numbers of medical procedures and devices used in all types of health care settings. The scope of work of ICPs was first assessed in 1982⁵⁶⁶⁻⁵⁶⁸ by the Certification Board of Infection Control, and has been reassessed every 5 years since that time.^{557,569-571} The findings of these analyses have been used to develop and update the Infection Control Certification Examination, which was first offered in 1983. With each new survey, it becomes

increasingly apparent that the role of the ICP is growing in complexity and scope beyond traditional infection control activities in acute care hospitals. Activities currently assigned to ICPs in response to emerging challenges include (1) surveillance and infection prevention at facilities other than acute care hospitals (eg, ambulatory clinics, day surgery centers, LTCFs, rehabilitation centers, home care); (2) oversight of employee health services related to infection prevention (eg, assessment of risk and administration of recommended treatment after exposure to infectious agents, tuberculosis screening, influenza vaccination, respiratory protection fit testing, and administration of other vaccines as indicated, such as smallpox vaccine in 2003); (3) preparedness planning for annual influenza outbreaks, pandemic influenza, SARS, and bioweapons attacks; (4) adherence monitoring for selected infection control practices; (5) oversight of risk assessment and implementation of prevention measures associated with construction and renovation; (6) prevention of transmission of MDROs; (7) evaluation of new medical products that could be associated with increased infection risk (eg, intravenous infusion materials); (8) communication with the public, facility staff, and state and local health departments concerning infection control-related issues; and (9) participation in local and multicenter research projects.^{433,548,551,557,572,573}

None of the Certification Board of Infection Control job analyses addressed specific staffing requirements for the identified tasks, although the surveys did include information about hours worked; the 2001 survey included the number of ICPs assigned to the responding facilities.⁵⁵⁷ There is agreement in the literature that a ratio of 1 ICP per 250 acute care beds is no longer adequate to meet current infection control needs; a Delphi project that assessed staffing needs of infection control programs in the 21st century concluded that a ratio of 0.8 to 1.0 ICP per 100 occupied acute care beds is an appropriate staffing level.⁵⁵¹ A survey of participants in the NNIS system found an average daily patient census of 115 per ICP.³¹⁵ Results of other studies have been similar: 3 per 500 beds for large acute care hospitals, 1 per 150 to 250 beds in LTCFs, and 1.56 per 250 in small rural hospitals.^{572,574} The foregoing demonstrates that infection control staffing no longer can be based on patient census alone, but rather must be determined by the scope of the program, characteristics of the patient population, complexity of the health care system, tools available to assist personnel to perform essential tasks (eg, electronic tracking and laboratory support for surveillance), and unique or urgent needs of the institution and community.⁵⁵¹ Furthermore, appropriate training is required to optimize the quality of work performed.^{557,571,575}

II.A.1.a.i. Infection Control Nurse Liaison. Designating a bedside nurse on a patient care unit as an infection control liaison or "link nurse" is reported to be an effective adjunct to enhance infection control at the unit level.⁵⁷⁶⁻⁵⁸¹ Such individuals receive training in basic infection control and have frequent communication with ICPs, but maintain their primary role as bedside caregiver on their units. The infection control nurse liaison increases the awareness of infection control at the unit level. He or she is especially effective in implementing new policies or control interventions because of the rapport with individuals on the unit, an understanding of unit-specific challenges, and ability to promote strategies that are most likely to be successful in that unit. This position is an adjunct to, not a replacement for, fully trained ICPs. Furthermore, the infection control liaison nurses should not be counted when considering ICP staffing.

II.A.1.b. Bedside Nurse Staffing. There is increasing evidence that the level of bedside nurse staffing influences the quality of patient care.^{582,583} Adequate nursing staff makes it more likely that infection control practices, including hand hygiene, Standard Precautions, and Transmission-Based Precautions, will be given appropriate attention and applied correctly and consistently.⁵⁵¹ A national multicenter study reported strong and consistent inverse relationships between nurse staffing and 5 adverse outcomes in medical patients, 2 of which were HAIs (urinary tract infections and pneumonia).⁵⁸² The association of nursing staff shortages with increased rates of HAI has been demonstrated in several outbreaks in hospitals and LTCFs, and with increased transmission of hepatitis C virus in dialysis units.^{22,417,550,584-596} In most cases, when staffing was improved as part of a comprehensive control intervention, the outbreak ended or the HAI rate declined. In 2 studies,^{589,595} the composition of the nursing staff ("pool" or "float" vs regular staff nurses) influenced the rate of primary bloodstream infections, with an increased infection rate occurring when the proportion of regular nurses decreased and that of pool nurses increased.

II.A.1.c. Clinical Microbiology Laboratory Support. The critical role of the clinical microbiology laboratory in infection control and health care epidemiology has been well described^{552,553,597-599} and is supported by the Infectious Disease Society of America's policy statement on the consolidation of clinical microbiology laboratories published in 2001.⁵⁵² The clinical microbiology laboratory contributes to preventing transmission of infectious diseases in health care settings by promptly detecting and reporting epidemiologically important organisms, identifying emerging patterns of antimicrobial resistance, and assessing the effectiveness of recommended precautions to limit transmission during outbreaks.⁵⁹⁷ Outbreaks of infections may be

recognized first by laboratorians.¹⁶¹ Health care organizations need to ensure the availability of the recommended scope and quality of laboratory services, a sufficient number of appropriately trained laboratory staff members, and systems to promptly communicate epidemiologically important results to those who will take action (eg, providers of clinical care, infection control staff, health care epidemiologists, and infectious disease consultants).⁶⁰⁰ As concerns about emerging pathogens and bioterrorism grow, the role of the clinical microbiology laboratory assumes ever-greater importance. For health care organizations that outsource microbiology laboratory services (eg, ambulatory care, home care, LTCFs, smaller acute care hospitals), it is important to specify by contract the types of services (eg, periodic institution-specific aggregate susceptibility reports) required to support infection control.

Several key functions of the clinical microbiology laboratory are relevant to this guideline:

- Antimicrobial susceptibility by testing and interpretation in accordance with current guidelines developed by the National Committee for Clinical Laboratory Standards, known as the Clinical and Laboratory Standards Institute since 2005,⁶⁰¹ for the detection of emerging resistance patterns^{602,603} and for the preparation, analysis, and distribution of periodic cumulative antimicrobial susceptibility summary reports.⁶⁰⁴⁻⁶⁰⁶ Although not required, clinical laboratories ideally should have access to rapid genotypic identification of bacteria and their antibiotic resistance genes.⁶⁰⁷
- Performance of surveillance cultures when appropriate (including retention of isolates for analysis), to assess patterns of infection transmission and effectiveness of infection control interventions at the facility or organization. Microbiologists assist in decision making regarding the indications for initiating and discontinuing active surveillance programs and optimizing the use of laboratory resources.
- Molecular typing, onsite or outsourced, to investigate and control health care-associated outbreaks.⁶⁰⁸
- Application of rapid diagnostic tests to support clinical decisions involving patient treatment, room selection, and implementation of control measures, including barrier precautions and use of vaccine or chemoprophylaxis agents (eg, influenza,⁶⁰⁹⁻⁶¹¹ *B pertussis*,⁶¹² RSV,^{613, 614} and enteroviruses⁶¹⁵). The microbiologist provides guidance to limit rapid testing to clinical situations in which rapid results influence patient management decisions, and also provides oversight of point-of-care testing performed by non-laboratory HCWs.⁶¹⁶
- Detection and rapid reporting of epidemiologically important organisms, including those that are reportable to public health agencies.

- Implementation of a quality control program to ensure that testing services are appropriate for the population being served and are stringently evaluated for sensitivity, specificity, applicability, and feasibility.
- Participation in a multidisciplinary team to develop and maintain an effective institutional program for the judicious use of antimicrobial agents.^{617,618}

II.A.2. Institutional Safety Culture and Organizational Characteristics. Safety culture (or safety climate) refers to a work environment in which a shared commitment to safety on the part of management and the workforce is understood and maintained.^{558,619,620}

The authors of the Institute of Medicine's report titled *To Err is Human*⁵⁴² acknowledged that causes of medical error are multifaceted but emphasized the pivotal role of system failures and the benefits of a safety culture. A safety culture is created through (1) the actions that management takes to improve patient and worker safety, (2) worker participation in safety planning, (3) the availability of appropriate PPE, (4) the influence of group norms regarding acceptable safety practices, and (5) the organization's socialization process for new personnel. Safety and patient outcomes can be enhanced by improving or creating organizational characteristics within patient care units, as demonstrated by studies of surgical ICUs.^{621,622} Each of these factors has a direct bearing on adherence to transmission prevention recommendations.²⁵⁶ Measurement of an institution's culture of safety is useful in designing improvements in health care.^{623,624} Several hospital-based studies have linked measures of safety culture with both employee adherence to safe practices and reduced exposures to blood and body fluids.⁶²⁵⁻⁶³¹ One study of hand hygiene practices concluded that improved adherence requires integration of infection control into the organization's safety culture.⁵⁶⁰ Several hospitals that are part of the Veterans Administration health care system have taken specific steps toward improving the safety culture, including error-reporting mechanisms, root cause analyses of identified problems, safety incentives, and employee education.⁶³²⁻⁶³⁴

II.A.3. Adherence of Health Care Workers to Recommended Guidelines. HCWs' adherence to recommended infection control practices decreases the transmission of infectious agents in health care settings.^{116,561,635-639} Several observational studies have shown limited adherence to recommended practices by HCWs.^{558,639-656} Observed adherence to universal precautions ranged from 43 % to 89 %.^{640,641,648,650,651} The degree of adherence often depended on the specific practice that was assessed and, for glove use, the circumstance in which the practice was applied. Observed rates of appropriate glove use has ranged from a low of 15 %⁶⁴⁴ to a high of 82 %.⁶⁴⁹ However, 92 %

and 98% adherence with glove use have been reported during arterial blood gas collection and resuscitation, respectively, procedures in which considerable blood contact may occur.^{642,655} Differences in observed adherence have been reported among occupational groups in the same health care facility⁶⁴⁰ and between experienced and nonexperienced professionals.⁶⁴⁴ In surveys of HCWs, self-reported adherence was generally higher than actual adherence found in observational studies. Furthermore, where an observational component was included with a self-reported survey, self-perceived adherence was often greater than observed adherence.⁶⁵⁶ Among nurses and physicians, increasing years of experience is a negative predictor of adherence.^{644,650} Education to improve adherence is the primary intervention that has been studied. Whereas positive changes in knowledge and attitude have been demonstrated,^{639,657} no or only limited accompanying changes in behavior often have been found.^{641,643} Self-reported adherence is higher in groups that received an educational intervention.^{629,658} In one study, educational interventions that incorporated videotaping and performance feedback were successful in improving adherence during the study period, but the long-term effect of such interventions is not known.⁶⁵³ The use of videotaping also served to identify system problems (eg, communication and access to PPE) that otherwise may not have been recognized.

Interest is growing in the use of engineering controls and facility design concepts for improving adherence. Whereas the introduction of automated sinks was found to have a negative impact on consistent adherence to handwashing in one study,⁶⁵⁹ the use of electronic monitoring and voice prompts to remind HCWs to perform hand hygiene and improving accessibility to hand hygiene products increased adherence and contributed to a decrease in HAIs in another study.⁶⁶⁰ More information is needed regarding ways in which technology might improve adherence.

Improving adherence to infection control practices requires a multifaceted approach that incorporates continuous assessment of both the individual and the work environment.^{558,560} Using several behavioral theories, Kretzer and Larson concluded that a single intervention (eg, a handwashing campaign or putting up new posters about transmission precautions) likely would be ineffective in improving HCWs adherence.⁶⁶¹ Improvement requires the organizational leadership to make prevention an institutional priority and integrate infection control practices into the organization's safety culture.⁵⁶⁰ A recent review of the literature concluded that variations in organizational factors (eg, safety climate, policies and procedures, education and training) and individual factors (eg, knowledge, perceptions of

risk, past experience) were determinants of adherence to infection control guidelines for protection against SARS and other respiratory pathogens.²⁵⁶

II.B. Surveillance for Health Care-Associated Infections

Surveillance is an essential tool for case finding of single patients or clusters of patients who are infected or colonized with epidemiologically important organisms (eg, susceptible bacteria such as *S aureus*, *S pyogenes* [group A streptococcus] or *Enterobacter-Klebsiella* spp; MRSA, VRE, and other MDROs; *C difficile*; RSV; influenza virus) for which transmission-based precautions may be required. Surveillance is defined as the ongoing systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health.⁶⁶² The work of Ignaz Semmelweis delineating the role of person-to-person transmission in puerperal sepsis is the earliest example of the use of surveillance data to reduce transmission of infectious agents.⁶⁶³ Surveillance of both process measures and the infection rates to which they are linked is important in evaluating the effectiveness of infection prevention efforts and identifying indications for change.^{554,664-667}

The Study on the Efficacy of Nosocomial Infection Control (SENIC) found that different combinations of infection control practices resulted in reduced rates of nosocomial surgical site infections, pneumonia, urinary tract infections, and bacteremia in acute care hospitals;⁵⁶⁵ however, surveillance was the only component essential for reducing all 4 types of HAIs. Although a similar study has not been conducted in other health care settings, a role for surveillance and the need for novel strategies in LTCFs^{397,433,668,669} and in home care⁴⁶⁹⁻⁴⁷² have been described. The essential elements of a surveillance system are (1) standardized definitions, (2) identification of patient populations at risk for infection, (3) statistical analysis (eg, risk adjustment, calculation of rates using appropriate denominators, trend analysis using such methods as statistical process control charts), and (4) feedback of results to the primary caregivers.⁶⁷⁰⁻⁶⁷⁵ Data gathered through surveillance of high-risk populations, device use, procedures, and facility locations (eg, ICUs) are useful in detecting transmission trends.⁶⁷⁰⁻⁶⁷² Identification of clusters of infections should be followed by a systematic epidemiologic investigation to determine commonalities in persons, places, and time and to guide implementation of interventions and evaluation of the effectiveness of those interventions.

Targeted surveillance based on the highest-risk areas or patients has been preferred over facility-wide

surveillance for the most effective use of resources.^{672,675} However, for certain epidemiologically important organisms, surveillance may need to be facility-wide. Surveillance methods will continue to evolve as health care delivery systems change^{391,676} and user-friendly electronic tools for electronic tracking and trend analysis become more widely available.^{673,677,678} Individuals with experience in health care epidemiology and infection control should be involved in selecting software packages for data aggregation and analysis, to ensure that the need for efficient and accurate HAI surveillance will be met. Effective surveillance is increasingly important as legislation requiring public reporting of HAI rates is passed and states work to develop effective systems to support such legislation.⁶⁷⁹

II.C. Education of Health Care Workers, Patients, and Families

The education and training of HCWs is a prerequisite for ensuring that policies and procedures for Standard and Transmission-Based Precautions are understood and practiced. Understanding the scientific rationale for the precautions will allow HCWs to apply procedures correctly, as well as to safely modify precautions based on changing requirements, resources, or health care settings.^{14,654,680-687} One study found that the likelihood of HCWs developing SARS was strongly associated with less than 2 hours of infection control training and poor understanding of infection control procedures.⁶⁸⁸ Education regarding the important role of vaccines (eg, influenza, measles, varicella, pertussis, pneumococcal) in protecting HCWs, their patients, and family members can help improve vaccination rates.⁶⁸⁹⁻⁶⁹²

Education on the principles and practices for preventing transmission of infectious agents should begin during training in the health professions and be provided to anyone who has an opportunity for contact with patients or medical equipment (eg, nursing and medical staff; therapists and technicians, including respiratory, physical, occupational, radiology, and cardiology personnel; phlebotomists; housekeeping and maintenance staff; and students). In health care facilities, education and training on Standard and Transmission-Based Precautions are typically provided at the time of orientation and should be repeated as necessary to maintain competency; updated education and training are necessary when policies and procedures are revised or when a special circumstance occurs, such as an outbreak that requires modification of current practice or adoption of new recommendations. Education and training materials and methods appropriate to the HCW's level of responsibility, individual

learning habits, and language needs can improve the learning experience.^{657,693-701}

Education programs for HCWs have been associated with sustained improvement in adherence to best practices and a related decrease in device-associated HAIs in teaching and nonteaching settings^{638,702} and in medical and surgical ICUs (Coopersmith, 2002 #2149; Babcock, 2004 #2126; Berenholtz, 2004 #2289; <http://www.ihl.org/IHI/Programs/Campaign>, #2563). Several studies have shown that in addition to targeted education to improve specific practices, periodic assessment and feedback of the HCW's knowledge and adherence to recommended practices are necessary to achieve the desired changes and identify continuing education needs.^{561,703-707} The effectiveness of this approach for isolation practices has been demonstrated in the control of RSV.^{116,683}

Patients, family members, and visitors can be partners in preventing transmission of infections in health care settings.^{9,42,708-710} Information on Standard Precautions, especially hand hygiene, respiratory hygiene/cough etiquette, vaccination (especially against influenza), and other routine infection prevention strategies, may be incorporated into patient information materials provided on admission to the health care facility. Additional information on Transmission-Based Precautions is best provided when these precautions are initiated. Fact sheets, pamphlets, and other printed material may include information on the rationale for the additional precautions, risks to household members, room assignment for Transmission-Based Precautions purposes, explanation of the use of PPE by HCWs, and directions for use of such equipment by family members and visitors. Such information may be particularly helpful in the home environment, where household members often have the primary responsibility for adherence to recommended infection control practices. HCWs must be available and prepared to explain this material and answer questions as needed.

II.D. Hand Hygiene

Hand hygiene has been frequently cited as the single most important practice to reduce the transmission of infectious agents in health care settings^{558,711,712} and is an essential element of Standard Precautions. The term "hand hygiene" includes both handwashing with either plain or antiseptic-containing soap and water and the use of alcohol-based products (gels, rinses, foams) that do not require water. In the absence of visible soiling of hands, approved alcohol-based products for hand disinfection are preferred over antimicrobial or plain soap and water because of their superior microbicidal activity, reduced drying of the skin, and convenience.⁵⁵⁸ Improved hand hygiene practices

have been associated with a sustained decrease in the incidence of MRSA and VRE infections primarily in ICUs.^{560,561,713-716} The scientific rationale, indications, methods, and products for hand hygiene have been summarized in previous publications.^{558,716}

The effectiveness of hand hygiene can be reduced by the type and length of fingernails.^{558,717,718} Individuals wearing artificial nails have been shown to harbor more pathogenic organisms, especially gram-negative bacilli and yeasts, on the nails and in the subungual area compared with individuals with native nails.^{719,720} In 2002, the CDC/HICPAC recommended (Category IA) that artificial fingernails and extenders not be worn by HCWs who have contact with high-risk patients (eg, those in ICUs and operating rooms), due to the association with outbreaks of gram-negative bacillus and candidal infections as confirmed by molecular typing of isolates.^{30,31,558,721-724} The need to restrict the wearing of artificial fingernails by all HCWs who provide direct patient care and those who have contact with other high-risk groups (eg, oncology and cystic fibrosis patients) has not been studied but has been recommended by some experts.²⁰ Currently, such decisions are at the discretion of an individual facility's infection control program. There is less evidence indicating that jewelry affects the quality of hand hygiene. Although hand contamination with potential pathogens is increased with ring-wearing,^{558,725} no studies have related this practice to HCW-to-patient transmission of pathogens.

II.E. Personal Protective Equipment for Health Care Workers

PPE refers to various barriers and respirators used alone or in combination to protect mucous membranes, airways, skin, and clothing from contact with infectious agents. The choice of PPE is based on the nature of the patient interaction and/or the likely mode(s) of transmission. Specific guidance on the use of PPE is provided in Part III of this guideline. A suggested procedure for donning and removing PPE aimed at preventing skin or clothing contamination is presented in Figure 1. Designated containers for used disposable or reusable PPE should be placed in a location convenient to the site of removal, to facilitate disposal and containment of contaminated materials. Hand hygiene is always the final step after removing and disposing of PPE. The following sections highlight the primary uses of and criteria for selecting this equipment.

II.E.1. Gloves. Gloves are used to prevent contamination of HCW hands when (1) anticipating direct contact with blood or body fluids, mucous membranes, nonintact skin and other potentially infectious material; (2) having direct contact with patients who are colonized or infected with pathogens transmitted by the

contact route (eg, VRE, MRSA, RSV^{558,726,727}); or (3) handling or touching visibly or potentially contaminated patient care equipment and environmental surfaces.^{72,73,558} Gloves can protect both patients and HCWs from exposure to infectious material that may be carried on hands.⁷³ The extent to which gloves will protect HCWs from transmission of bloodborne pathogens (eg, HIV, HBV, HCV) after a needlestick or other puncture that penetrates the glove barrier has not yet been determined. Although gloves may reduce the volume of blood on the external surface of a sharp by 46% to 86%,⁷²⁸ the residual blood in the lumen of a hollow-bore needle would not be affected; therefore, the effect on transmission risk is unknown.

Gloves manufactured for health care purposes are subject to FDA evaluation and clearance.⁷²⁹ Nonsterile disposable medical gloves made of various materials (eg, latex, vinyl, nitrile) are available for routine patient care.⁷³⁰ The selection of glove type for nonsurgical use is based on various factors, including the task to be performed, anticipated contact with chemicals and chemotherapeutic agents, latex sensitivity, sizing, and facility policies for creating a latex-free environment.^{17,731-733} For contact with blood and body fluids during nonsurgical patient care, a single pair of gloves generally provides adequate barrier protection.⁷³³ However, there is considerable variability among gloves; both the quality of the manufacturing process and type of material influence their barrier effectiveness.⁷³⁴ Whereas there is little difference in the barrier properties of unused intact gloves,⁷³⁵ studies have shown repeatedly that vinyl gloves have higher failure rates than latex or nitrile gloves when tested under simulated and actual clinical conditions.^{730,734-737} For this reason, either latex or nitrile gloves are preferable for clinical procedures that require manual dexterity or will involve more than brief patient contact. A facility may need to stock gloves in several sizes. Heavier, reusable utility gloves are indicated for non-patient care activities, such as handling or cleaning contaminated equipment or surfaces.^{11,14,738}

During patient care, transmission of infectious organisms can be reduced by adhering to the principles of working from "clean" to "dirty" and confining or limiting contamination to those surfaces directly needed for patient care. It may be necessary to change gloves during the care of a single patient to prevent cross-contamination of body sites.^{558,739} It also may be necessary to change gloves if the patient interaction also involves touching portable computer keyboards or other mobile equipment transported from room to room. Discarding gloves between patients is necessary to prevent transmission of infectious material. Gloves must not be washed for subsequent reuse, because microorganisms cannot be removed reliably from glove surfaces, and

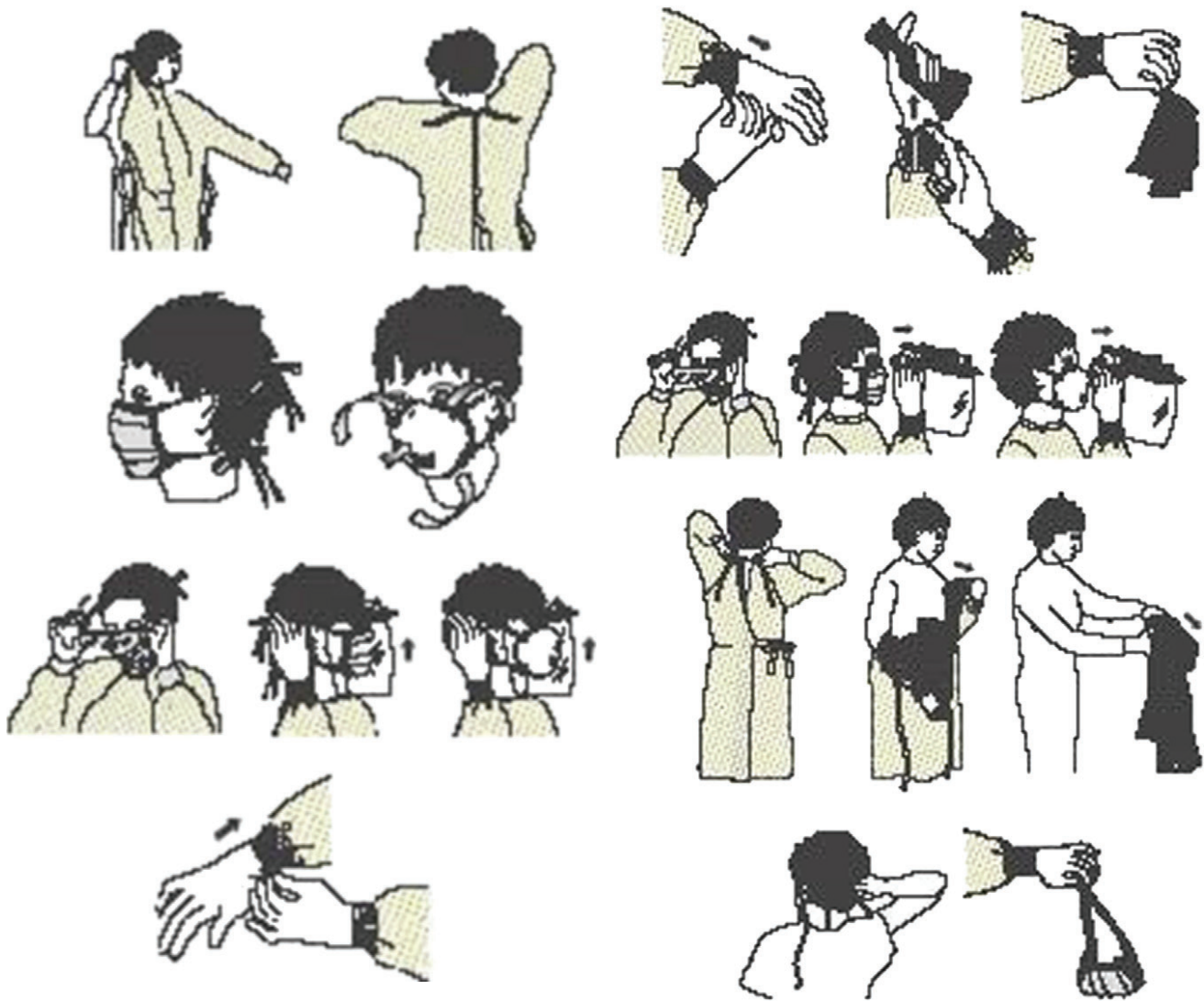


Fig 1. Example of safe donning and removal of PPE.

continued glove integrity cannot be ensured. Furthermore, glove reuse has been associated with transmission of MRSA and gram-negative bacilli.⁷⁴⁰⁻⁷⁴²

When gloves are worn in combination with other PPE, they are put on last. Gloves that fit snugly around the wrist are preferred for use with an isolation gown, because they will cover the gown cuff and provide a more reliable continuous barrier for the arms, wrists, and hands. Proper glove removal will prevent hand contamination (Fig 1). Hand hygiene after glove removal further ensures that the hands will not carry potentially infectious material that might have penetrated through unrecognized tears or that could have contaminated the hands during glove removal.^{558,727,740}

II.E.2. Isolation Gowns. Isolation gowns are used as specified by Standard and Transmission-Based Precautions to protect the HCW's arms and exposed body areas and prevent contamination of clothing with

blood, body fluids, and other potentially infectious material.^{24,88,261,743-745} The need for and the type of isolation gown selected is based on the nature of the patient interaction, including the anticipated degree of contact with infectious material and potential for blood and body fluid penetration of the barrier. The wearing of isolation gowns and other protective apparel is mandated by the Occupational Safety and Health Administration's (OSHA) Bloodborne Pathogens Standard.⁷³⁸ Clinical and laboratory coats or jackets worn over personal clothing for comfort and/or purposes of identity are not considered PPE.

When applying Standard Precautions, an isolation gown is worn only if contact with blood or body fluid is anticipated. However, when Contact Precautions are used (ie, to prevent transmission of an infectious agent that is not interrupted by Standard Precautions alone and is associated with environmental

contamination), donning of both gown and gloves on room entry is indicated, to prevent unintentional contact with contaminated environmental surfaces.^{54,72,73,88} The routine donning of isolation gowns on entry into an ICU or other high-risk area does not prevent or influence potential colonization or infection of patients in those areas, however.^{364,746-749}

Isolation gowns are always worn in combination with gloves, and with other PPE when indicated. Gowns are usually the first piece of PPE to be donned. Full coverage of the arms and body front, from neck to the mid-thigh or below, will ensure protection of clothing and exposed upper body areas. Several gown sizes should be available in a health care facility to ensure appropriate coverage for staff members. Isolation gowns should be removed before leaving the patient care area to prevent possible contamination of the environment outside the patient's room. Isolation gowns should be removed in a manner that prevents contamination of clothing or skin (Fig 1); the outer, "contaminated" side of the gown is turned inward and rolled into a bundle, and then discarded into a designated container for waste or linen to contain contamination.

II.E.3. Face Protection: Masks, Goggles, and Face Shields.

II.E.3.a. Masks. Masks are used for 3 primary purposes in health care settings: (1) placed on HCWs to protect them from contact with infectious material from patients (eg, respiratory secretions and sprays of blood or body fluids), consistent with Standard Precautions and Droplet Precautions; (2) placed on HCWs engaged in procedures requiring sterile technique, to protect patients from exposure to infectious agents carried in the HCW's mouth or nose; and (3) placed on coughing patients to limit potential dissemination of infectious respiratory secretions from the patient to others (ie, respiratory hygiene/cough etiquette). Masks may be used in combination with goggles to protect the mouth, nose, and eyes, or, alternatively, a face shield may be used instead of a mask and goggles to provide more complete protection for the face, as discussed below. Masks should not be confused with particulate respirators used to prevent inhalation of small particles that may contain infectious agents transmitted through the airborne route, as described below.

The mucous membranes of the mouth, nose, and eyes are susceptible portals of entry for infectious agents; other skin surfaces also may be portals if skin integrity is compromised (by, eg, acne, dermatitis).^{66,750-753} Therefore, use of PPE to protect these body sites is an important component of Standard Precautions. The protective effect of masks for exposed HCWs has been demonstrated previously.^{93,113,754,755} Procedures that generate splashes or sprays of blood, body fluids, secretions, or excretions (eg, endotracheal suctioning,

bronchoscopy, invasive vascular procedures) require either a face shield (disposable or reusable) or a mask and goggles.^{93-96,113,115,261,738,756} The wearing of masks, eye protection, and face shields in specified circumstances when blood or body fluid exposure is likely is mandated by OSHA's Bloodborne Pathogens Standard.⁷³⁸ Appropriate PPE should be selected based on the anticipated level of exposure.

Two mask types are available for use in health care settings: surgical masks that are cleared by the FDA and required to have fluid-resistant properties, and procedure or isolation masks.^{757,#2688} To date, no studies comparing mask types to determine whether one mask type provides better protection than another have been published. Because procedure/isolation masks are not regulated by the FDA, they may be more variable in terms of quality and performance than surgical masks. Masks come in various shapes (eg, molded and nonmolded), sizes, filtration efficiency, and method of attachment (eg, ties, elastic, ear loops). Health care facilities may find that different types of masks are needed to meet individual HCW needs.

II.E.3.b. Goggles and Face Shields. Guidance on eye protection for infection control has been published.⁷⁵⁸ The eye protection chosen for specific work situations (eg, goggles or face shield) depends on the circumstances of exposure, other PPE used, and personal vision needs. Personal eyeglasses and contact lenses are not considered adequate eye protection (see <http://www.cdc.gov/niosh/topics/eye/eye-infectious.html>). NIOSH guidelines specify that eye protection must be comfortable, allow for sufficient peripheral vision, and adjustable to ensure a secure fit. A health care facility may need to provide several different types, styles, and sizes of eye protection equipment. Indirectly vented goggles with a manufacturer's antifog coating may provide the most reliable practical eye protection from splashes, sprays, and respiratory droplets from multiple angles. Newer styles of goggles may provide better indirect airflow properties to reduce fogging, as well as better peripheral vision and more size options for fitting goggles to different workers. Many styles of goggles fit adequately over prescription glasses with minimal gaps. Although effective as eye protection, goggles do not provide splash or spray protection to other parts of the face.

The role of goggles in addition to a mask in preventing exposure to infectious agents transmitted through respiratory droplets has been studied only for RSV. Reports published in the mid-1980s demonstrated that eye protection reduced occupational transmission of RSV.^{759,760} Whether this was due to the prevention hand-eye contact or the prevention of respiratory droplet-eye contact has not been determined. However, subsequent studies demonstrated that RSV transmission is effectively prevented by

adherence to Standard Precautions plus Contact Precautions and that routine use of goggles is not necessary for this virus.^{24,116,117,683,761} It is important to remind HCWs that even if Droplet Precautions are not recommended for a specific respiratory tract pathogen, protection for the eyes, nose, and mouth using a mask and goggles or a face shield alone is necessary when a splash or spray of any respiratory secretions or other body fluids is likely to occur, as defined in Standard Precautions.

Disposable or nondisposable face shields may be used as an alternative to goggles.⁷⁵⁸ Compared with goggles, a face shield can provide protection to other facial areas besides the eyes. Face shields extending from the chin to crown provide better face and eye protection from splashes and sprays; face shields that wrap around the sides may reduce splashes around the edge of the shield.

Removal of a face shield, goggles, and mask can be performed safely after gloves have been removed and hand hygiene performed. The ties, earpieces, and/or headband used to secure the equipment to the head are considered “clean” and thus safe to touch with bare hands. The front of a mask, goggles, and face shield are considered contaminated (Fig 1).

II.E.4. Respiratory Protection. The subject of respiratory protection as it applies to preventing transmission of airborne infectious agents, including the need for and frequency of fit testing is under scientific review and was the subject of a 2004 CDC workshop.⁷⁶² Respiratory protection currently requires the use of a respirator with N95 or higher-level filtration to prevent inhalation of infectious particles. Information about respirators and respiratory protection programs is summarized in the *Guideline for Preventing Transmission of Mycobacterium tuberculosis in Health Care Settings*.¹²

Respiratory protection is broadly regulated by OSHA under the general industry standard for respiratory protection (29 CFR 1910.134),⁷⁶³ which requires that US employers in all employment settings implement a program to protect employees from inhalation of toxic materials. OSHA program components include medical clearance to wear a respirator; provision and use of appropriate respirators, including fit-tested NIOSH-certified N95 and higher-level particulate filtering respirators; education on respirator use, and periodic reevaluation of the respiratory protection program. When selecting particulate respirators, models with inherently good fit characteristics (ie, those expected to provide protection factors of $\geq 10\%$ to 95% of wearers) are preferred and theoretically could preclude the need for fit testing.^{764,765} Issues pertaining to respiratory protection remain the subject of ongoing debate. Information on various types of

respirators is available at <http://www.cdc.gov/niosh/nppt/respirators/respsars.html> and in several previously published studies.^{764,766,767} A user-seal check (formerly called a “fit check”) should be performed by the wearer of a respirator each time that the respirator is donned, to minimize air leakage around the face piece.⁷⁶⁸ The optimal frequency of fit testing has not been determined; retesting may be indicated if there is a change in wearer’s facial features, onset of a medical condition that would affect respiratory function in the wearer, or a change in the model or size of the respirator that was initially assigned.¹²

Respiratory protection was first recommended for protection of US HCWs from exposure to *M tuberculosis* in 1989. That recommendation has been maintained in 2 successive revisions of the *Guidelines for Prevention of Transmission of Tuberculosis in Hospitals and Other Health Care Settings*.^{12,126} The incremental benefit from respirator use, in addition to administrative and engineering controls (ie, AIIRs, early recognition of patients likely to have tuberculosis and prompt placement in an AIIR, and maintenance of a patient with suspected tuberculosis in an AIIR until no longer infectious), for preventing transmission of airborne infectious agents (eg, *M tuberculosis*) remains undetermined. Although some studies have demonstrated effective prevention of *M tuberculosis* transmission in hospitals in which surgical masks instead of respirators were used in conjunction with other administrative and engineering controls,^{636,769,770} the CDC currently recommends N95 or higher-level respirators for personnel exposed to patients with suspected or confirmed tuberculosis. Currently, this recommendation also holds for other diseases that could be transmitted through the airborne route, including SARS²⁶¹ and smallpox,^{108,129,771} until inhalational transmission is better defined or health care-specific PPE more suitable for preventing infection is developed. Wearing of respirators is also currently recommended during the performance of aerosol-generating procedures (eg, intubation, bronchoscopy, suctioning) in patients with SARS-CoV infection, avian influenza, and pandemic influenza (see Appendix A).

Although Airborne Precautions are recommended for preventing airborne transmission of measles and varicella-zoster viruses, no data are available on which to base a recommendation for respiratory protection to protect susceptible personnel against these 2 infections. Transmission of varicella-zoster virus has been prevented among pediatric patients using negative-pressure isolation alone.⁷⁷² Whether respiratory protection (ie, wearing a particulate respirator) will enhance protection from these viruses has not yet been studied. Because most HCWs have natural or acquired immunity to these viruses, only immune personnel

generally care for patients with these infections.⁷⁷³⁻⁷⁷⁶ Although there is no evidence suggesting that masks are not adequate to protect HCWs in these settings, for purposes of consistency and simplicity, or because of difficulties in ascertaining immunity, some facilities may require the use of respirators for entry into all AIIRs, regardless of the specific infectious agent present.

Procedures for safe removal of respirators are provided in Figure 1. In some health care settings, particulate respirators used to provide care for patients with *M tuberculosis* are reused by the same HCW. This is an acceptable practice providing that the respirator is not damaged or soiled, the fit is not compromised by a change in shape, and the respirator has not been contaminated with blood or body fluids. No data are available on which to base a recommendation regarding the length of time that a respirator may be safely reused.

II.F. Safe Work Practices to Prevent Health Care Worker Exposure to Bloodborne Pathogens

II.F.1. Prevention of Needlesticks and Other Sharps-Related Injuries. Injuries due to needles and other sharps have been associated with transmission of HBV, HCV, and HIV to HCWs.^{777,778} The prevention of sharps injuries has always been an essential element of Universal Precautions and is now an aspect of Standard Precautions.^{1,779} These include measures to handle needles and other sharp devices in a manner that will prevent injury to the user and to others who may encounter the device during or after a procedure. These measures apply to routine patient care and do not address the prevention of sharps injuries and other blood exposures during surgical and other invasive procedures addressed elsewhere.⁷⁸⁰⁻⁷⁸⁴

Since 1991, when OSHA first issued its Bloodborne Pathogens Standard to protect HCWs from blood exposure, the focus of regulatory and legislative activity has been on implementing a hierarchy of control measures. This has included focusing attention on removing sharps hazards through the development and use of engineering controls. The federal Needlestick Safety and Prevention Act, signed into law in November 2000, authorized OSHA's revision of its Bloodborne Pathogens Standard to more explicitly require the use of safety-engineered sharps devices.⁷⁸⁵ The CDC has provided guidance on sharps injury prevention,^{786,787} including guidelines for the design, implementation and evaluation of a comprehensive sharps injury prevention program.⁷⁸⁸

II.F.2. Prevention of Mucous Membrane Contact. Exposure of mucous membranes of the eyes, nose, and mouth to blood and body fluids has been associated with the transmission of bloodborne viruses and other infectious agents to HCWs.^{66,751,753,778} The

prevention of mucous membrane exposures has always been an element of Universal Precautions and is now an element of Standard Precautions for routine patient care^{1,752} and is subject to OSHA bloodborne pathogen regulations. Safe work practices, in addition to wearing PPE, are designed to protect mucous membranes and nonintact skin from contact with potentially infectious material. These include keeping contaminated gloved and ungloved hands from touching the mouth, nose, eyes, or face and positioning patients to direct sprays and splatter away from the caregiver's face. Careful placement of PPE before patient contact will help avoid the need to make adjustments to PPE and prevent possible face or mucous membrane contamination during use.

In areas where the need for resuscitation is unpredictable, mouthpieces, pocket resuscitation masks with 1-way valves, and other ventilation devices provide an alternative to mouth-to-mouth resuscitation, preventing exposure of the caregiver's nose and mouth to oral and respiratory fluids during the procedure.

II.F.2.a. Precautions During Aerosol-Generating Procedures. The performance of procedures that can generate small-particle aerosols (aerosol-generating procedures), such as bronchoscopy, endotracheal intubation, and open suctioning of the respiratory tract, have been associated with transmission of infectious agents to HCWs, including *M tuberculosis*,⁷⁸⁹ SARS-CoV,^{93,94,98} and *N meningitidis*.⁹⁵ Protection of the eyes, nose, and mouth, in addition to gown and gloves, is recommended during performance of these procedures in accordance with Standard Precautions. The use of a particulate respirator is recommended during aerosol-generating procedures when the aerosol is likely to contain *M tuberculosis*, SARS-CoV, or avian or pandemic influenza viruses.

II.G. Patient Placement

II.G.1. Hospitals and Long-Term Care Facilities. Options for patient placement include single-patient rooms, 2-patient rooms, and multibed wards. Of these, single-patient rooms are preferred when transmission of an infectious agent is of concern. Although some studies have failed to demonstrate the efficacy of single-patient rooms in preventing HAIs,⁷⁹⁰ other published studies, including one commissioned by the AIA and the Facility Guidelines Institute, have documented a beneficial relationship between private rooms and reduced infectious and noninfectious adverse patient outcomes.^{791,792} The AIA notes that private rooms are the trend in hospital planning and design. However, most hospitals and LTCFs have multibed rooms and must consider many competing priorities when determining the appropriate room placement for patients

(eg, reason for admission; patient characteristics, such as age, gender, and mental status; staffing needs; family requests; psychosocial factors; reimbursement concerns). In the absence of obvious infectious diseases that require specified airborne infection isolation rooms (eg, tuberculosis, SARS, chickenpox), the risk of transmission of infectious agents is not always considered when making placement decisions.

When only a limited number of single-patient rooms is available, it is prudent to prioritize room assignments for those patients with conditions that facilitate transmission of infectious material to other patients (eg, draining wounds, stool incontinence, uncontained secretions) and those at increased risk of acquisition and adverse outcomes resulting from HAIs (due to, eg, immunosuppression, open wounds, indwelling catheters, anticipated prolonged length of stay, total dependence on HCWs for activities of daily living).^{15,24,43,429,793,794}

Single-patient rooms are always indicated for patients placed on Airborne Precautions in a PE and are preferred for patients requiring Contact or Droplet Precautions.^{23,24,409,434,795,796} During a suspected or proven outbreak caused by a pathogen whose reservoir is the gastrointestinal tract, the use of single-patient rooms with private bathrooms limits opportunities for transmission, especially when the colonized or infected patient has poor personal hygiene habits or fecal incontinence, or cannot be expected to assist in maintaining procedures that prevent transmission of microorganisms (eg, infants, children, and patients with altered mental status or developmental delay). In the absence of continued transmission, it is not necessary to provide a private bathroom for patients colonized or infected with enteric pathogens as long as personal hygiene practices and Standard Precautions (especially hand hygiene and appropriate environmental cleaning) are maintained. Assignment of a dedicated commode to a patient, and cleaning and disinfecting fixtures and equipment that may have fecal contamination (eg, bathrooms, commodes,⁷⁹⁷ scales used for weighing diapers) and the adjacent surfaces with appropriate agents may be especially important when a single-patient room cannot be assigned, because environmental contamination with intestinal tract pathogens is likely from both continent and incontinent patients.^{54,798} The results of several studies that investigated the benefit of a single-patient room in preventing transmission of *C difficile* were inconclusive.^{167,799-801} Some studies have shown that being in the same room with a colonized or infected patient is not necessarily a risk factor for transmission,^{790,802-804} however, for children, the risk of health care–associated diarrhea is increased with the increased number of patients per room.⁸⁰⁵ These findings demonstrate that patient

factors are important determinants of infection transmission risks. The need for a single-patient room and/or private bathroom for any patient is best determined on a case-by-case basis.

Cohorting is the practice of grouping together patients who are colonized or infected with the same organism to confine their care to a single area and prevent contact with other patients. Cohorts are created based on clinical diagnosis, microbiologic confirmation (when available), epidemiology, and mode of transmission of the infectious agent. Avoiding placing severely immunosuppressed patients in rooms with other patients is generally preferred. Cohorting has been extensively used for managing outbreaks of MDROs, including MRSA,^{22, 806} VRE,^{637,807,808} MDR-ESBL,⁸⁰⁹ *P aeruginosa*,²⁹ MSSA,⁸¹⁰ RSV,^{811,812} adenovirus keratoconjunctivitis,⁸¹³ rotavirus,⁸¹⁴ and SARS.⁸¹⁵ Modeling studies provide additional support for cohorting patients to control outbreaks;⁸¹⁶⁻⁸¹⁸ however, cohorting often is implemented only after routine infection control measures have failed to control an outbreak.

Assigning or cohorting HCWs to care only for patients infected or colonized with a single target pathogen limits further transmission of the target pathogen to uninfected patients,^{739,818} but is difficult to achieve in the face of current staffing shortages in hospitals⁵⁸² and residential health care sites.⁸¹⁹⁻⁸²¹ However, cohorting of HCWs may be beneficial when transmission continues after implementing routine infection control measures and creating patient cohorts.

During periods when RSV, human metapneumovirus,⁸²² parainfluenza, influenza, other respiratory viruses,⁸²³ and rotavirus are circulating in the community, cohorting based on the presenting clinical syndrome is often a priority in facilities that care for infants and young children.⁸²⁴ For example, during the respiratory virus season, infants may be cohorted based solely on the clinical diagnosis of bronchiolitis, due to the logistical difficulties and costs associated with requiring microbiologic confirmation before room placement and the predominance of RSV during most of the season. However, when available, single-patient rooms are always preferred, because a common clinical presentation (eg, bronchiolitis), can be caused by more than 1 infectious agent.^{822,823,825} Furthermore, the inability of infants and children to contain body fluids, and the close physical contact associated with their care, increases the risk of infection transmission for patients and personnel in this setting.^{24,794}

II.G.2. Ambulatory Care Settings. Patients actively infected with or incubating transmissible infectious diseases are frequently seen in ambulatory settings (eg, outpatient clinics, physicians' offices, emergency departments) and potentially expose HCWs and other patients, family members, and visitors.^{21,34,127,135,142,826}

In response to the global outbreak of SARS in 2003 and in preparation for pandemic influenza, HCWs working in outpatient settings are urged to implement source containment measures (eg, asking coughing patients to wear a surgical mask or cover coughing with tissues) to prevent transmission of respiratory infections, beginning at the initial patient encounter,^{9,261,827} as described in Section III.A.1.a. Signs can be posted at the facility's entrance or at the reception or registration desk requesting that the patient or individuals accompanying the patient promptly inform the receptionist of any symptoms of respiratory infection (eg, cough, flu-like illness, increased production of respiratory secretions). The presence of diarrhea, skin rash, or known or suspected exposure to a transmissible disease (eg, measles, pertussis, chickenpox, tuberculosis) also could be added. Prompt placement of a potentially infectious patient in an examination room limits the number of exposed individuals in the common waiting area.

In waiting areas, maintaining a distance between symptomatic and nonsymptomatic patients (eg, > 3 feet), in addition to source control measures, may limit exposures. However, infections transmitted through the airborne route (eg, *M tuberculosis*, measles, chickenpox) require additional precautions.^{12,125,828} Patients suspected of having such an infection can wear a surgical mask for source containment, if tolerated, and should be placed in an examination room (preferably an AIIR) as soon as possible. If this is not possible, then having the patient wear a mask and segregating the patient from other patients in the waiting area will reduce the risk of exposing others. Because the person(s) accompanying the patient also may be infectious, application of the same infection control precautions may be extended to these persons if they are symptomatic.^{21,251,829} Family members accompanying children admitted with suspected *M tuberculosis* have been found to have unsuspected pulmonary tuberculosis with cavitary lesions, even when asymptomatic.^{42,830}

Patients with underlying conditions that increase their susceptibility to infection (eg, immunocompromised status^{43,44} or cystic fibrosis²⁰) require special efforts to protect them from exposure to infected patients in common waiting areas. Informing the receptionist of their infection risk on arrival allows appropriate steps to further protect these patients from infection. In some cystic fibrosis clinics, to avoid exposure to other patients who could be colonized with *B cepacia*, patients have been given beepers on registration so that they may leave the area and receive notification to return when an examination room becomes available.⁸³¹

II.G.3. Home Care. In home care, patient placement concerns focus on protecting others in the home from exposure to an infectious household member. For individuals who are especially vulnerable to adverse

outcomes associated with certain infections, it may be beneficial to either remove them from the home or segregate them within the home. Persons who are not part of the household may need to be prohibited from visiting during the period of infectivity. For example, in a situation where a patient with pulmonary tuberculosis is contagious and being cared for at home, very young children (age under 4 years)⁸³² and immunocompromised persons who have not yet been infected should be removed or excluded from the household. During the SARS outbreak of 2003, segregation of infected persons during the communicable phase of the illness was found to be beneficial in preventing household transmission.^{249,833}

II.H. Transport of Patients

Several principles guide the transport of patients requiring Transmission-Based Precautions. In the inpatient and residential settings, these include the following:

1. Limiting transport of such patients to essential purposes, such as diagnostic and therapeutic procedures that cannot be performed in the patient's room.
2. When transport is necessary, applying appropriate barriers on the patient (eg, mask, gown, wrapping in sheets or use of impervious dressings to cover the affected areas) when infectious skin lesions or drainage are present, consistent with the route and risk of transmission.
3. Notifying HCWs in the receiving area of the patient's impending arrival and of the necessary precautions to prevent transmission.
4. For patients being transported outside the facility, informing the receiving facility and the medivan or emergency vehicle personnel in advance about the type of Transmission-Based Precautions being used.

For tuberculosis, additional precautions may be needed in a small shared air space, such as in an ambulance.¹²

II.I. Environmental Measures

Cleaning and disinfecting noncritical surfaces in patient care areas is an aspect of Standard Precautions. In general, these procedures do not need to be changed for patients on Transmission-Based Precautions. The cleaning and disinfection of all patient care areas is important for frequently touched surfaces, especially those closest to the patient, which are most likely to be contaminated (eg, bedrails, bedside tables, commodes, doorknobs, sinks, surfaces and equipment in close proximity to the patient).^{11,72,73,834} The frequency or intensity of cleaning may need to be changed, based on the patient's level of hygiene and the degree of environmental contamination and for certain infectious agents with reservoirs in the

intestinal tract.⁵⁴ This may be particularly important in LTCFs and pediatric facilities, where patients with stool and urine incontinence are encountered more frequently. In addition, increased frequency of cleaning may be needed in a PE to minimize dust accumulation.¹¹ Special recommendations for cleaning and disinfecting environmental surfaces in dialysis centers have been published previously.¹⁸ In all health care settings, administrative, staffing, and scheduling activities should prioritize the proper cleaning and disinfection of surfaces that could be implicated in transmission. During a suspected or proven outbreak in which an environmental reservoir is suspected, routine cleaning procedures should be reviewed, and the need for additional trained cleaning staff should be assessed. Adherence should be monitored and reinforced to promote consistent and correct cleaning.

US Environmental Protection Agency-registered disinfectants or detergents/disinfectants that best meet the overall needs of the health care facility for routine cleaning and disinfection should be selected.^{11,835} In general, use of the existing facility detergent/disinfectant according to the manufacturer's recommendations for amount, dilution, and contact time is sufficient to remove pathogens from surfaces of rooms where colonized or infected individuals were housed. This includes those pathogens that are resistant to multiple classes of antimicrobial agents (eg, *C difficile*, VRE, MRSA, MDR-GNB^{11,24,88,434,745,795,836}). Most often, environmental reservoirs of pathogens during outbreaks are related to a failure to follow recommended procedures for cleaning and disinfection, rather than to the specific cleaning and disinfectant agents used.⁸³⁷⁻⁸⁴⁰

Certain pathogens (eg, rotavirus, noroviruses, *C difficile*) may be resistant to some routinely used hospital disinfectants.^{274,291,841-846} The role of specific disinfectants in limiting transmission of rotavirus has been demonstrated experimentally.⁸⁴¹ Also, because *C difficile* may display increased levels of spore production when exposed to non-chlorine-based cleaning agents, and because these spores are more resistant than vegetative cells to commonly used surface disinfectants, some investigators have recommended the use of a 1:10 dilution of 5.25% sodium hypochlorite (household bleach) and water for routine environmental disinfection of rooms of patients with *C difficile* when there is continued transmission.^{843,847} One study found an association between the use of a hypochlorite solution and decreased rates of *C difficile* infections.⁸⁴⁶ The need to change disinfectants based on the presence of these organisms can be determined in consultation with the infection control committee.^{11,846,847}

Detailed recommendations for disinfection and sterilization of surfaces and medical equipment that have been in contact with prion-containing tissue or high

risk body fluids, and for cleaning of blood and body substance spills, are available in the *Guidelines for Environmental Infection Control in Health Care Facilities*¹¹ and in the *Guideline for Disinfection and Sterilization*.⁸⁴⁷

II.J. Patient Care Equipment and Instruments/Devices

Medical equipment and instruments/devices must be cleaned and maintained according to the manufacturers' instructions to prevent patient-to-patient transmission of infectious agents.^{86,87,324,848} Cleaning to remove organic material always must precede high-level disinfection and sterilization of critical and semi-critical instruments and devices, because residual proteinaceous material reduces the effectiveness of the disinfection and sterilization processes.^{835,847} Noncritical equipment, such as commodes, intravenous pumps, and ventilators, must be thoroughly cleaned and disinfected before being used on another patient. All such equipment and devices should be handled in a manner that will prevent HCW and environmental contact with potentially infectious material. It is important to include computers and personal digital assistants used in patient care in policies for cleaning and disinfection of noncritical items. The literature on contamination of computers with pathogens has been summarized,⁸⁴⁹ and 2 reports have linked computer contamination to colonization and infections in patients.^{850,851} Although keyboard covers and washable keyboards that can be easily disinfected are available, the infection control benefit of these items and their optimal management have not yet been determined.

In all health care settings, providing patients who are on Transmission-Based Precautions with dedicated noncritical medical equipment (eg, stethoscope, blood pressure cuff, electronic thermometer) has proven beneficial for preventing transmission.^{74,89,739,852,853} When this is not possible, disinfection of this equipment after each use is recommended. Other previously published guidelines should be consulted for detailed guidance in developing specific protocols for cleaning and reprocessing medical equipment and patient care items in both routine and special circumstances.^{11,14,18,20,739,835,847}

In home care, it is preferable to remove visible blood or body fluids from durable medical equipment before it leaves the home. Equipment can be cleaned onsite using a detergent/disinfectant and, when possible, should be placed in a plastic bag for transport to the reprocessing location.^{20,738}

II.K. Textiles and Laundry

Although soiled textiles, including bedding, towels, and patient or resident clothing, may be contaminated

with pathogenic microorganisms, the risk of disease transmission is negligible if these textiles are handled, transported, and laundered in a safe manner.^{11,854,855} Key principles for handling soiled laundry are (1) avoiding shaking the items or handling them in any way that may aerosolize infectious agents, (2) avoiding contact of one's body and personal clothing with the soiled items being handled, and (3) containing soiled items in a laundry bag or designated bin. If a laundry chute is used, it must be maintained to minimize dispersion of aerosols from contaminated items.¹¹ Methods of handling, transporting, and laundering soiled textiles are determined by organizational policy and any applicable regulations;⁷³⁸ guidance is provided in the *Guidelines for Environmental Infection Control in Health Care Facilities*.¹¹ Rather than rigid rules and regulations, hygienic and common sense storage and processing of clean textiles is recommended.^{11,856} When laundering is done outside of a health care facility, the clean items must be packaged or completely covered and placed in an enclosed space during transport to prevent contamination with outside air or construction dust that could contain infectious fungal spores that pose a risk for immunocompromised patients.¹¹

Institutions are required to launder garments used as PPE and uniforms visibly soiled with blood or infective material.⁷³⁸ Little data exist on the safety of home laundering of HCW uniforms, but no increase in infection rates was observed in the one published study,⁸⁵⁷ and no pathogens were recovered from home- or hospital-laundered scrubs in another study.⁸⁵⁸ In the home, textiles and laundry from patients with potentially transmissible infectious pathogens do not require special handling or separate laundering and may be washed with warm water and detergent.^{11,857,858}

II.L. Solid Waste

The management of solid waste emanating from the health care environment is subject to federal and state regulations for medical and nonmedical waste.^{859,860} No additional precautions are needed for nonmedical solid waste removed from rooms of patients on Transmission-Based Precautions. Solid waste may be contained in a single bag of sufficient strength.⁸⁶¹

II.M. Dishware and Eating Utensils

The combination of hot water and detergents used in dishwashers is sufficient to decontaminate dishware and eating utensils. Therefore, no special precautions are needed for dishware (eg, dishes, glasses, cups) or eating utensils. Reusable dishware and utensils may be used for patients requiring Transmission-Based Precautions. In the home and other communal settings, eating utensils and drinking vessels should not be shared,

consistent with principles of good personal hygiene and to help prevent transmission of respiratory viruses, herpes simplex virus, and infectious agents that infect the gastrointestinal tract and are transmitted by the fecal/oral route (eg, hepatitis A virus, noroviruses). If adequate resources for cleaning utensils and dishes are not available, then disposable products may be used.

II.N. Adjunctive Measures

Important adjunctive measures that are not considered primary components of programs to prevent transmission of infectious agents but nonetheless improve the effectiveness of such programs include (1) antimicrobial management programs, (2) postexposure chemoprophylaxis with antiviral or antibacterial agents, (3) vaccines used both for pre-exposure and postexposure prevention, and (4) screening and restricting visitors with signs of transmissible infections. Detailed discussion of judicious use of antimicrobial agents is beyond the scope of this document; however, this topic has been addressed in a previous CDC guideline (<http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf>).

II.N.1. Chemoprophylaxis. Antimicrobial agents and topical antiseptics may be used to prevent infection and potential outbreaks of selected agents. Infections for which postexposure chemoprophylaxis is recommended under defined conditions include *B pertussis*,^{17,862} *N meningitidis*,⁸⁶³ *B anthracis* after environmental exposure to aerosolizable material,⁸⁶⁴ influenza virus,⁶¹⁰ HIV,⁸⁶⁵ and group A streptococcus.¹⁶⁰ Orally administered antimicrobials also may be used under defined circumstances for MRSA decolonization of patients or HCWs.⁸⁶⁶

Another form of chemoprophylaxis involves the use of topical antiseptic agents. For example, triple dye is routinely used on the umbilical cords of term newborns to reduce the risk of colonization, skin infections, and omphalitis caused by *S aureus*, including MRSA, and group A streptococcus.^{867,868} Extension of the use of triple dye to low birth weight infants in a NICU was one component of a program that controlled a long-standing MRSA outbreak.²² Topical antiseptics (eg, mupirocin) also are used for decolonization of HCWs or selected patients colonized with MRSA, as discussed in the MDRO guideline.^{866,869-872}

II.N.2. Immunoprophylaxis. Certain immunizations recommended for susceptible HCWs have decreased the risk of infection and the potential for transmission in health care facilities.^{17,873} The OSHA mandate requiring employers to offer HBV vaccination to HCWs has played a substantial role in the sharp decline in incidence of occupational HBV infection.^{777,874} The routine administration of varicella vaccine to HCWs has

decreased the need to place susceptible HCWs on administrative leave after exposure to patients with varicella.⁷⁷⁴ In addition, reports of health care–associated transmission of rubella in obstetric clinics^{33,875} and measles in acute care settings³⁴ demonstrate the importance of immunization of susceptible HCWs against childhood diseases. Many states have requirements for vaccination of HCWs for measles and rubella in the absence of evidence of immunity. Annual influenza vaccine campaigns targeted at patients and HCWs in LTCFs and acute care settings have been instrumental in preventing or limiting institutional outbreaks; consequently, increasing attention is being directed toward improving influenza vaccination rates in HCWs.^{35,610,689,876-878}

Transmission of *B pertussis* in health care facilities has been associated with large and costly outbreaks that include both HCWs and patients.^{17,36,41,100,682,826,879,880} HCWs in close contact with infants with pertussis are at particularly high risk because of waning immunity and, until 2005, the absence of a vaccine appropriate for adults. But 2 acellular pertussis vaccines were licensed in the United States in 2005, 1 for use in individuals age 11 to 18 years and the other for use in those age 10 to 64 years.⁸⁸¹ Current Advisory Committee on Immunization Practices provisional recommendations include immunization of adolescents and adults, especially those in contact with infants under age 12 months and HCWs with direct patient contact.^{882,883}

Immunization of children and adults will help prevent the introduction of vaccine-preventable diseases into health care settings. The recommended immunization schedule for children is published annually in the January issues of the *Morbidity and Mortality Weekly Report*, with interim updates as needed.^{884,885} An adult immunization schedule also is available for healthy adults and those with special immunization needs due to high-risk medical conditions.⁸⁸⁶

Some vaccines are also used for postexposure prophylaxis of susceptible individuals, including varicella,⁸⁸⁷ influenza,⁶¹⁰ hepatitis B,⁷⁷⁷ and smallpox²²⁵ vaccines.^{17,873} In the future, administration of a newly developed *S aureus* conjugate vaccine (still under investigation) to selected patients may provide a novel method of preventing health care–associated *S aureus* (including MRSA) infections in high-risk groups (eg, hemodialysis patients and candidates for selected surgical procedures).^{888, 889}

Immune globulin preparations also are used for postexposure prophylaxis of certain infectious agents under specified circumstances (eg, varicella-zoster virus, HBV, rabies, measles and hepatitis A virus^{17,832,873}). The RSV monoclonal antibody preparation palivizumab may have contributed to controlling a nosocomial

outbreak of RSV in one NICU, but there is insufficient evidence to support a routine recommendation for its use in this setting.⁸⁹⁰

II.N.3. Management of Visitors.

II.N.3.a. Visitors as Sources of Infection. Visitors have been identified as the source of several types of HAIs (eg, pertussis,^{40,41} *M tuberculosis*,^{42,891} influenza and other respiratory viruses^{24,43,44,372} and SARS^{21,252-254}). Effective methods for visitor screening in health care settings have not yet been studied, however. Visitor screening is especially important during community outbreaks of infectious diseases and for high-risk patient units. Sibling visits are often encouraged in birthing centers, postpartum rooms, pediatric inpatient units, PICUs, and residential settings for children; in hospital settings, a child visitor should visit only his or her own sibling. Screening of visiting siblings and other children before they are allowed into clinical areas is necessary to prevent the introduction of childhood illnesses and common respiratory infections. Screening may be passive, through the use of signs to alert family members and visitors with signs and symptoms of communicable diseases not to enter clinical areas. More active screening may include the completion of a screening tool or questionnaire to elicit information related to recent exposures or current symptoms. This information is reviewed by the facility staff, after which the visitor is either permitted to visit or is excluded.⁸³²

Family and household members visiting pediatric patients with pertussis and tuberculosis may need to be screened for a history of exposure, as well as signs and symptoms of current infection. Potentially infectious visitors are excluded until they receive appropriate medical screening, diagnosis, or treatment. If exclusion is not considered to be in the best interest of the patient or family (ie, primary family members of critically or terminally ill patients), then the symptomatic visitor must wear a mask while in the health care facility and remain in the patient's room, avoiding exposure to others, especially in public waiting areas and the cafeteria.

Visitor screening is used consistently on HSCT units.^{15,43} However, considering the experience during the 2003 SARS outbreaks and the potential for pandemic influenza, developing effective visitor screening systems will be beneficial.⁹ Education concerning respiratory hygiene/cough etiquette is a useful adjunct to visitor screening.

II.N.3.b. Use of Barrier Precautions by Visitors.

The use of gowns, gloves, and masks by visitors in health care settings has not been addressed specifically in the scientific literature. Some studies included the use of gowns and gloves by visitors in the control of MDROs but did not perform a separate analysis to determine whether their use by visitors had a measurable

impact.⁸⁹²⁻⁸⁹⁴ Family members or visitors who are providing care to or otherwise are in very close contact with the patient (eg, feeding, holding) may also have contact with other patients and could contribute to transmission in the absence of effective barrier precautions. Specific recommendations may vary by facility or by unit and should be determined by the specific level of interaction.

PART III: PRECAUTIONS TO PREVENT TRANSMISSION OF INFECTIOUS AGENTS

There are 2 tiers of HICPAC/CDC precautions to prevent transmission of infectious agents, Standard Precautions and Transmission-Based Precautions. Standard Precautions are intended to be applied to the care of all patients in all health care settings, regardless of the suspected or confirmed presence of an infectious agent. Implementation of Standard Precautions constitutes the primary strategy for the prevention of health care–associated transmission of infectious agents among patients and HCWs. Transmission-Based Precautions are for patients who are known or suspected to be infected or colonized with infectious agents, including certain epidemiologically important pathogens, which require additional control measures to effectively prevent transmission. Because the infecting agent often is not known at the time of admission to a health care facility, Transmission-Based Precautions are used empirically, according to the clinical syndrome and the likely etiologic agents at the time, and then modified when the pathogen is identified or a transmissible infectious etiology is ruled out. Examples of this syndromic approach are presented in Table 2. The HICPAC/CDC Guidelines also include recommendations for creating a Protective Environment for allogeneic HSCT patients.

The specific elements of Standard and Transmission-Based Precautions are discussed in Part II of this guideline. In Part III, the circumstances in which Standard Precautions, Transmission-Based Precautions, and a Protective Environment are applied are discussed. Tables 4 and 5 summarize the key elements of these sets of precautions

III.A. Standard Precautions

Standard Precautions combine the major features of Universal Precautions^{779, 895} and Body Substance Isolation⁶³⁹ and are based on the principle that all blood, body fluids, secretions, excretions except sweat, nonintact skin, and mucous membranes may contain transmissible infectious agents. Standard Precautions include a group of infection prevention practices that apply to all patients, regardless of suspected or confirmed infection status, in any setting in which health

care is delivered (Table 4). These include hand hygiene; use of gloves, gown, mask, eye protection, or face shield, depending on the anticipated exposure; and safe injection practices. Also, equipment or items in the patient environment likely to have been contaminated with infectious body fluids must be handled in a manner to prevent transmission of infectious agents (eg, wear gloves for direct contact, contain heavily soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient).

The application of Standard Precautions during patient care is determined by the nature of the HCW–patient interaction and the extent of anticipated blood, body fluid, or pathogen exposure. For some interactions (eg, performing venipuncture), only gloves may be needed; during other interactions (eg, intubation), use of gloves, gown, and face shield or mask and goggles is necessary. Education and training on the principles and rationale for recommended practices are critical elements of Standard Precautions because they facilitate appropriate decision-making and promote adherence when HCWs are faced with new circumstances.^{654,680-685} An example of the importance of the use of Standard Precautions is intubation, especially under emergency circumstances when infectious agents may not be suspected, but later are identified (eg, SARS-CoV, *N meningitidis*). The application of Standard Precautions is described below and summarized in Table 4. Guidance on donning and removing gloves, gowns and other PPE is presented in Figure 1.

Standard Precautions are also intended to protect patients by ensuring that HCWs do not carry infectious agents to patients on their hands or via equipment used during patient care.

III.A.1. New Elements of Standard Precautions. Infection control problems that are identified in the course of outbreak investigations often indicate the need for new recommendations or reinforcement of existing infection control recommendations to protect patients. Because such recommendations are considered a standard of care and may not be included in other guidelines, they are added here to Standard Precautions. Three such areas of practice that have been added are respiratory hygiene/cough etiquette, safe injection practices, and use of masks for insertion of catheters or injection of material into spinal or epidural spaces through lumbar puncture procedures (eg, myelogram, spinal or epidural anesthesia). Although most elements of Standard Precautions evolved from Universal Precautions that were developed for protection of HCWs, these new elements of Standard Precautions focus on protection of patients.

III.A.1.a. Respiratory Hygiene/Cough Etiquette. The transmission of SARS-CoV in emergency departments by patients and their family members during

the widespread SARS outbreaks in 2003 highlighted the need for vigilance and prompt implementation of infection control measures at the first point of encounter within a health care setting (eg, reception and triage areas in emergency departments, outpatient clinics, and physician offices).^{21,254,896} The strategy proposed has been termed respiratory hygiene/cough etiquette^{9,827} and is intended to be incorporated into infection control practices as a new component of Standard Precautions. The strategy is targeted at patients and accompanying family members and friends with undiagnosed transmissible respiratory infections, and applies to any person with signs of illness including cough, congestion, rhinorrhea, or increased production of respiratory secretions when entering a health care facility.^{40,41,43} The term *cough etiquette* is derived from recommended source control measures for *M tuberculosis*.^{12,126}

The elements of respiratory hygiene/cough etiquette include (1) education of health care facility staff, patients, and visitors; (2) posted signs, in language(s) appropriate to the population served, with instructions to patients and accompanying family members or friends; (3) source control measures (eg, covering the mouth/nose with a tissue when coughing and prompt disposal of used tissues, using surgical masks on the coughing person when tolerated and appropriate); (4) hand hygiene after contact with respiratory secretions; and (5) spatial separation, ideally >3 feet, of persons with respiratory infections in common waiting areas when possible. Covering sneezes and coughs and placing masks on coughing patients are proven means of source containment that prevent infected persons from dispersing respiratory secretions into the air.^{107,145,897,898} Masking may be difficult in some settings, (eg, pediatrics), in which case the emphasis by necessity may be on cough etiquette.⁸⁹⁹ Physical proximity of < 3 feet has been associated with an increased risk for transmission of infections through the droplet route (eg, *N meningitidis*¹⁰³ and group A streptococcus¹¹⁴) and thus supports the practice of distancing infected persons from others who are not infected. The effectiveness of good hygiene practices, especially hand hygiene, in preventing transmission of viruses and reducing the incidence of respiratory infections both within and outside⁹⁰⁰⁻⁹⁰² health care settings is summarized in several reviews.^{558,716,903}

These measures should be effective in decreasing the risk of transmission of pathogens contained in large respiratory droplets (eg, influenza virus,²³ adenovirus,¹¹¹ *B pertussis*,⁸²⁶ and *M pneumoniae*¹¹²). Although fever will be present in many respiratory infections, patients with pertussis and mild upper respiratory tract infections are often afebrile. Therefore, the absence of fever does not always exclude a respiratory infection.

Patients who have asthma, allergic rhinitis, or chronic obstructive lung disease also may be coughing and sneezing. Although these patients often are not infectious, cough etiquette measures are prudent.

HCWs are advised to observe Droplet Precautions (ie, wear a mask) and hand hygiene when examining and caring for patients with signs and symptoms of a respiratory infection. HCWs who have a respiratory infection are advised to avoid direct patient contact, especially with high-risk patients. If this is not possible, then a mask should be worn while providing patient care.

III.A.1.b. Safe Injection Practices. The investigation of 4 large outbreaks of HBV and HCV among patients in ambulatory care facilities in the United States identified a need to define and reinforce safe injection practices.⁴⁵² The 4 outbreaks occurred in a private medical practice, a pain clinic, an endoscopy clinic, and a hematology/oncology clinic. The primary breaches in infection control practice that contributed to these outbreaks were reinsertion of used needles into a multiple-dose vial or solution container (eg, saline bag) and use of a single needle/syringe to administer intravenous medication to multiple patients. In 1 of these outbreaks, preparation of medications in the same workspace where used needle/syringes were dismantled also may have been a contributing factor. These and other outbreaks of viral hepatitis could have been prevented by adherence to basic principles of aseptic technique for the preparation and administration of parenteral medications.^{452,453} These include the use of a sterile, single-use, disposable needle and syringe for each injection given and prevention of contamination of injection equipment and medication. Whenever possible, use of single-dose vials is preferred over multiple-dose vials, especially when medications will be administered to multiple patients.

Outbreaks related to unsafe injection practices indicate that some HCWs are unaware of, do not understand, or do not adhere to basic principles of infection control and aseptic technique. A survey of US health care workers who provide medication through injection found that 1% to 3% reused the same needle and/or syringe on multiple patients.⁹⁰⁴ Among the deficiencies identified in recent outbreaks were a lack of oversight of personnel and failure to follow up on reported breaches in infection control practices in ambulatory settings. Therefore, to ensure that all HCWs understand and adhere to recommended practices, principles of infection control and aseptic technique need to be reinforced in training programs and incorporated into institutional policies that are monitored for adherence.⁴⁵³

III.A.1.c. Infection Control Practices for Special Lumbar Puncture Procedures. In 2004, the CDC investigated 8 cases of postmyelography meningitis that

either were reported to the CDC or identified through a survey of the Emerging Infections Network of the Infectious Disease Society of America. Blood and/or cerebrospinal fluid of all 8 cases yielded streptococcal species consistent with oropharyngeal flora and there were changes in the CSF indices and clinical status indicative of bacterial meningitis. Equipment and products used during these procedures (eg, contrast media) were excluded as probable sources of contamination. Procedural details available for 7 cases determined that antiseptic skin preparations and sterile gloves had been used. However, none of the clinicians wore a face mask, giving rise to the speculation that droplet transmission of oropharyngeal flora was the most likely explanation for these infections. Bacterial meningitis after myelography and other spinal procedures (eg, lumbar puncture, spinal and epidural anesthesia, intrathecal chemotherapy) has been reported previously.⁹⁰⁵⁻⁹¹⁴ As a result, the question of whether face masks should be worn to prevent droplet spread of oral flora during spinal procedures (eg, myelography, lumbar puncture, spinal anesthesia) has been debated.^{915, 916} Face masks are effective in limiting the dispersal of oropharyngeal droplets⁹¹⁷ and are recommended for the placement of central venous catheters.⁹¹⁸ In October 2005, HICPAC reviewed the evidence and concluded that there is sufficient experience to warrant the additional protection of a face mask for the individual placing a catheter or injecting material into the spinal or epidural space.

III.B. Transmission-Based Precautions

There are 3 categories of Transmission-Based Precautions: Contact Precautions, Droplet Precautions, and Airborne Precautions. Transmission-Based Precautions are used when the route(s) of transmission is (are) not completely interrupted using Standard Precautions alone. For some diseases that have multiple routes of transmission (eg, SARS), more than 1 Transmission-Based Precautions category may be used. When used either singly or in combination, they are always used in addition to Standard Precautions. See Appendix A for recommended precautions for specific infections. When Transmission-Based Precautions are indicated, efforts must be made to counteract possible adverse effects on patients (ie, anxiety, depression and other mood disturbances,⁹¹⁹⁻⁹²¹ perceptions of stigma,⁹²² reduced contact with clinical staff,⁹²³⁻⁹²⁵ and increases in preventable adverse events⁵⁶⁴) to improve acceptance by the patients and adherence by HCWs.

III.B.1. Contact Precautions. Contact Precautions are intended to prevent transmission of infectious agents, including epidemiologically important microorganisms, which are spread by direct or indirect

contact with the patient or the patient's environment as described in Section I.B.3.a. The specific agents and circumstance for which Contact Precautions are indicated are found in Appendix A. The application of Contact Precautions for patients infected or colonized with MDROs is described in the 2006 HICPAC/CDC MDRO guideline.⁹²⁶ Contact Precautions also apply where the presence of excessive wound drainage, fecal incontinence, or other discharges from the body suggest an increased potential for extensive environmental contamination and risk of transmission. A single-patient room is preferred for patients who require Contact Precautions. When a single-patient room is not available, consultation with infection control personnel is recommended to assess the various risks associated with other patient placement options (eg, cohorting, keeping the patient with an existing roommate). In multipatient rooms, ≥ 3 feet spatial separation between beds is advised to reduce the opportunities for inadvertent sharing of items between the infected/colonized patient and other patients. HCWs caring for patients on Contact Precautions wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient's environment. Donning PPE on room entry and discarding before exiting the patient room is done to contain pathogens, especially those that have been implicated in transmission through environmental contamination (eg, VRE, *C difficile*, noroviruses and other intestinal tract pathogens, RSV).^{54,72,73,78,273,274,739}

III.B.2. Droplet Precautions. Droplet Precautions are intended to prevent transmission of pathogens spread through close respiratory or mucous membrane contact with respiratory secretions as described in Section I.B.3.b. Because these pathogens do not remain infectious over long distances in a health care facility, special air handling and ventilation are not required to prevent droplet transmission. Infectious agents for which Droplet Precautions are indicated are listed in Appendix A and include *B pertussis*, influenza virus, adenovirus, rhinovirus, *N meningitidis*, and group A streptococcus (for the first 24 hours of antimicrobial therapy). A single-patient room is preferred for patients who require Droplet Precautions. When a single-patient room is not available, consultation with infection control personnel is recommended to assess the various risks associated with other patient placement options (eg, cohorting, keeping the patient with an existing roommate). Spatial separation of ≥ 3 feet and drawing the curtain between patient beds is especially important for patients in multibed rooms with infections transmitted by the droplet route. HCWs wear a mask (a respirator is not necessary) for close contact with infectious patient; the mask is generally donned on room entry. Patients on Droplet Precautions who

must be transported outside of the room should wear a mask if tolerated and follow respiratory hygiene/cough etiquette.

III.B.3. Airborne Precautions. Airborne Precautions prevent transmission of infectious agents that remain infectious over long distances when suspended in the air (eg, rubeola virus [measles], varicella virus [chickenpox], *M tuberculosis*, and possibly SARS-CoV), as described in Section I.B.3.c and Appendix A. The preferred placement for patients who require Airborne Precautions is in an AIIR, a single-patient room equipped with special air handling and ventilation capacity that meet the AIA/Facility Guidelines Institute standards for AIIRs (ie, monitored negative pressure relative to the surrounding area; 12 air exchanges per hour for new construction and renovation and 6 air exchanges per hour for existing facilities; air exhausted directly to the outside or recirculated through HEPA filtration before return).^{12,13} Some states require the availability of such rooms in hospitals, emergency departments, and nursing homes that care for patients with *M tuberculosis*. A respiratory protection program that includes education about use of respirators, fit testing, and user seal checks is required in any facility with AIIRs. In settings where Airborne Precautions cannot be implemented due to limited engineering resources (eg, physician offices), masking the patient, placing the patient in a private room (eg, office examination room) with the door closed, and providing N95 or higher-level respirators or masks if respirators are not available for HCWs will reduce the likelihood of airborne transmission until the patient is either transferred to a facility with an AIIR or returned to the home environment, as deemed medically appropriate. HCWs caring for patients on Airborne Precautions wear a mask or respirator, depending on the disease-specific recommendations (see Section II.E.4, Table 2, and Appendix A), that is donned before room entry. Whenever possible, non-immune HCWs should not care for patients with vaccine-preventable airborne diseases (eg, measles, chickenpox, smallpox).

III.C. Syndromic and Empiric Applications of Transmission-Based Precautions

Diagnosis of many infections requires laboratory confirmation. Because laboratory tests, especially those that depend on culture techniques, often require 2 or more days for completion, Transmission-Based Precautions must be implemented while test results are pending, based on the clinical presentation and likely pathogens. Use of appropriate Transmission-Based Precautions at the time a patient develops symptoms or signs of transmissible infection, or arrives at a health care facility for care, reduces transmission

opportunities. Although it is not possible to identify prospectively all patients needing Transmission-Based Precautions, certain clinical syndromes and conditions carry a sufficiently high risk to warrant their use empirically while confirmatory tests are pending (see Table 2). ICPs are encouraged to modify or adapt this table according to local conditions.

III.D. Discontinuation of Transmission-Based Precautions

Transmission-Based Precautions remain in effect for limited periods (ie, while the risk for transmission of the infectious agent persists or for the duration of the illness (see Appendix A). For most infectious diseases, this duration reflects known patterns of persistence and shedding of infectious agents associated with the natural history of the infectious process and its treatment. For some diseases (eg, pharyngeal or cutaneous diphtheria, RSV), Transmission-Based Precautions remain in effect until culture or antigen-detection test results document eradication of the pathogen and, for RSV, symptomatic disease is resolved. For other diseases (eg, *M tuberculosis*), state laws and regulations and health care facility policies may dictate the duration of precautions.¹² In immunocompromised patients, viral shedding can persist for prolonged periods of time (many weeks to months) and transmission to others may occur during that time; therefore, the duration of contact and/or droplet precautions may be prolonged for many weeks.^{499,927-932}

The duration of Contact Precautions for patients who are colonized or infected with MDROs remains undefined. MRSA is the only MDRO for which effective decolonization regimens are available.⁸⁶⁶ However, carriers of MRSA who have negative nasal cultures after a course of systemic or topical therapy may resume shedding MRSA in the weeks after therapy.^{933,934} Although early guidelines for VRE suggested discontinuation of Contact Precautions after 3 stool cultures obtained at weekly intervals proved negative,⁷³⁹ subsequent experiences have indicated that such screening may fail to detect colonization that can persist for > 1 year.^{27,935-937} Likewise, available data indicate that colonization with VRE, MRSA,⁹³⁸ and possibly MDR-GNB can persist for many months, especially in the presence of severe underlying disease, invasive devices, and recurrent courses of antimicrobial agents.

It may be prudent to assume that MDRO carriers are colonized permanently and manage them accordingly. Alternatively, an interval free of hospitalizations, antimicrobial therapy, and invasive devices (eg, 6 or 12 months) before reculturing patients to document clearance of carriage may be used. Determination of the best strategy awaits the results of additional studies. See the

2006 HICPAC/CDC MDRO guideline⁹²⁶ for a discussion of possible criteria to discontinue Contact Precautions for patients colonized or infected with MDROs.

III.E. Application of Transmission-Based Precautions in Ambulatory and Home Care Settings

Although Transmission-Based Precautions generally apply in all health care settings, exceptions exist. For example, in home care, AIIRs are not available. Furthermore, family members already exposed to diseases such as varicella and tuberculosis would not use masks or respiratory protection, but visiting HCWs would need to use such protection. Similarly, management of patients colonized or infected with MDROs may necessitate Contact Precautions in acute care hospitals and in some LTCFs when there is continued transmission, but the risk of transmission in ambulatory care and home care has not been defined. Consistent use of Standard Precautions may suffice in these settings, but more information is needed.

III.F. Protective Environment

A PE is designed for allogeneic HSCT patients to minimize fungal spore counts in the air and reduce the risk of invasive environmental fungal infections (see Table 5 for specifications).^{11,13-15} The need for such controls has been demonstrated in studies of aspergillosis outbreaks associated with construction.^{11,14,15,157,158} As defined by the AIA¹³ and presented in detail in the CDC's 2003 *Guideline for Environmental Infection Control in Health Care Facilities*,^{11,860} air quality for HSCT patients is improved through a combination of environmental controls that include (1) HEPA filtration of incoming air, (2) directed room air flow, (3) positive room air pressure relative to the corridor, (4) well-sealed rooms (including sealed walls, floors, ceilings, windows, electrical outlets) to prevent flow of air from the outside, (5) ventilation to provide ≥ 12 air changes per hour, (6) strategies to minimize dust (eg, scrubbable surfaces rather than upholstery⁹³⁹ and carpet,⁹⁴⁰ and routinely cleaning crevices and sprinkler heads), and (7) prohibiting dried and fresh flowers and potted plants in the rooms of HSCT patients. The latter is based on molecular typing studies that have found indistinguishable strains of *Aspergillus terreus* in patients with hematologic malignancies and in potted plants in the vicinity of the patients.⁹⁴¹⁻⁹⁴³ The desired quality of air may be achieved without incurring the inconvenience or expense of laminar airflow.^{15,157} To prevent inhalation of fungal spores during periods when construction, renovation, or other dust-generating activities that may be ongoing in and around the health care facility, it has been recommended that severely immunocompromised

patients wear a high-efficiency respiratory protection device (eg, an N95 respirator) when they leave the PE.^{11,14,944} The use of masks or respirators by HSCT patients when they are outside of the PE for prevention of environmental fungal infections in the absence of construction has not been evaluated. A PE does not include the use of barrier precautions beyond those indicated for Standard Precautions and Transmission-Based Precautions. No published reports support the benefit of placing patients undergoing solid organ transplantation or other immunocompromised patients in a PE.

PART IV: RECOMMENDATIONS

These recommendations are designed to prevent transmission of infectious agents among patients and HCWs in all settings where health care is delivered. As in other CDC/HICPAC guidelines, each recommendation is categorized on the basis of existing scientific data, theoretical rationale, applicability, and, when possible, economic impact. The CDC/HICPAC system for categorizing recommendations is as follows:

Category IA. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

Category IB. Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

Category IC. Required for implementation, as mandated by federal and/or state regulation or standard.

Category II. Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

No recommendation; unresolved issue. Practices for which insufficient evidence or no consensus regarding efficacy exists.

I. Administrative Responsibilities

Health care organization administrators should ensure the implementation of recommendations specified in this section.

I.A. Incorporate preventing transmission of infectious agents into the objectives of the organization's patient and occupational safety programs.^{542-545,560,629,625,945}

Category IB/IC
I.B. Make preventing transmission of infectious agents a priority for the health care organization. Provide administrative support, including fiscal and human resources for maintaining infection control programs.^{433,547,548,551,558,560-563,565,661,945}

Category IB/IC
I.B.1. Ensure that individuals with training in infection control are employed by or are

available by contract to all health care facilities, so that the infection control program is managed by 1 or more qualified individuals.^{315,551,565,572,575,574,945,946} *Category IB/IC*

- I.B.1.a. Determine the specific infection control full-time equivalents according to the scope of the infection control program, the complexity of the health care facility or system, the characteristics of the patient population, the unique or urgent needs of the facility and community, and proposed staffing levels based on survey results and recommendations from professional organizations.^{315,433,548,551,565,568,572,574,947,948} *Category IB*
- I.B.2. Include prevention of HAIs as a determinant of bedside nurse staffing levels and composition, especially in high-risk units.^{417,550,582,584-589,591-596} *Category IB*
- I.B.3. Delegate authority to infection control personnel or their designees (eg, patient care unit charge nurses) for making infection control decisions concerning patient placement and assignment of Transmission-Based Precautions.^{433,548,856,945} *Category IC*
- I.B.4. Involve infection control personnel in decisions on facility construction and design, determination of AIIR and PE capacity needs, and environmental assessments.^{11-13, 949,950} *Category IB/IC*
 - I.B.4.a. Provide ventilation systems required for a sufficient number of AIIRs (as determined by a risk assessment) and PEs in health care facilities that provide care to patients for whom such rooms are indicated, according to published recommendations.^{11-13,15} *Category IB/IC*
- I.B.5. Involve infection control personnel in the selection and postimplementation evaluation of medical equipment and supplies and changes in practice that could affect the risk of HAI.^{951,952} *Category IC*
- I.B.6. Ensure availability of human and fiscal resources to provide clinical microbiology laboratory support, including a sufficient number of medical technologists trained in microbiology, appropriate to the health care setting, for monitoring transmission of microorganisms, planning and conducting epidemiologic investigations, and detecting emerging pathogens. Identify resources for performing surveillance cultures, rapid diagnostic testing

for viral and other selected pathogens, preparation of antimicrobial susceptibility summary reports, trend analysis, and molecular typing of clustered isolates (performed either onsite or in a reference laboratory) and use these resources according to facility-specific epidemiologic needs, in consultation with clinical microbiologists.^{552,553,597,598,602,604-606,608,609,611,613-616,953} *Category IB*

- I.B.7. Provide human and fiscal resources to meet occupational health needs related to infection control (eg, HCWs immunization, post-exposure evaluation and care, evaluation and management of HCWs with communicable infections).^{12,17,134,689,738,878-880} *Category IB/IC*
- I.B.8. In all areas where health care is delivered, provide supplies and equipment necessary for the consistent observance of Standard Precautions, including hand hygiene products and PPE (eg, gloves, gowns, face and eye protection).^{558,738,945} *Category IB/IC*
- I.B.9. Develop and implement policies and procedures to ensure that reusable patient care equipment is cleaned and reprocessed appropriately before use on another patient.^{11,87,836,954-959} *Category IA/IC*
- I.C. Develop and implement processes to ensure oversight of infection control activities appropriate to the health care setting and assign responsibility for oversight of infection control activities to an individual or group within the health care organization that is knowledgeable about infection control.^{433,548,565} *Category II*
- I.D. Develop and implement systems for early detection and management (eg, use of appropriate infection control measures, including isolation precautions, PPE) of potentially infectious persons at initial points of patient encounter in outpatient settings (eg, triage areas, emergency departments, outpatient clinics, physician offices) and at the time of admission to hospitals and LTCFs.^{9,122,134,253,826} *Category IB*
- I.E. Develop and implement policies and procedures to limit patient visitation by persons with signs or symptoms of a communicable infection. Screen visitors to high-risk patient care areas (eg, oncology units, HSCT units, intensive care units, other severely immunocompromised patients) for possible infection.^{24,41,43,960,961} *Category IB*
- I.F. Identify performance indicators of the effectiveness of organization-specific measures to prevent transmission of infectious agents (Standard Precautions and Transmission-Based Precautions), establish processes to monitor adherence to those

performance measures, and provide feedback to staff members.^{554,665-667,703,704,739,962} *Category IB*

II. Education and Training

II.A. Provide job- or task-specific education and training on preventing transmission of infectious agents associated with health care during orientation to the health care facility; update information periodically during ongoing education programs. Target all HCWs for education and training, including but not limited to medical, nursing, clinical technicians, and laboratory staff; property service (housekeeping), laundry, maintenance and dietary workers; students; contract staff; and volunteers. Document competency initially and repeatedly, as appropriate, for the specific staff positions. Develop a system to ensure that HCWs employed by outside agencies meet these education and training requirements through programs offered by the agencies or by participation in the health care facility's program designed for full-time personnel.^{126,558,560,561,654,680-683,685,687,688,701,892,918,963} *Category IB*

II.A.1. Include in education and training programs, information concerning use of vaccines as an adjunctive infection control measure.^{17,610,689,873} *Category IB*

II.A.2. Enhance education and training by applying principles of adult learning, using reading level and language appropriate material for the target audience, and using online educational tools available to the institution.^{657,693,694,696,697,699,964} *Category IB*

II.B. Provide instructional materials for patients and visitors on recommended hand hygiene and respiratory hygiene/cough etiquette practices and the application of Transmission-Based Precautions.^{9,708,709,961} *Category II*

III. Surveillance

III.A. Monitor the incidence of epidemiologically important organisms and targeted HAIs that have a substantial impact on outcome and for which effective preventive interventions are available. Use information collected through surveillance of high-risk populations, procedures, devices, and highly transmissible infectious agents to detect transmission of infectious agents in the health care facility.^{565,670,671,672,674,686,918,965-968} *Category IA*

III.B. Apply the following epidemiologic principles of infection surveillance.^{662,663,670,672,965,967} *Category IB*

- Use standardized definitions of infection.
- Use laboratory-based data (when available).
- Collect epidemiologically important variables (eg, patient locations and/or clinical service in hospitals and other large multiunit facilities, population-specific risk factors [eg, low birth weight neonates], underlying conditions that predispose to serious adverse outcomes).
- Analyze data to identify trends that may indicate increased rates of transmission.
- Feedback information on trends in the incidence and prevalence of HAIs, probable risk factors, and prevention strategies and their impact to the appropriate health care providers, organization administrators, and as required by local and state health authorities.

III.C. Develop and implement strategies to reduce risks for transmission and evaluate effectiveness.^{565,672, 683,961,968,969} *Category IB*

III.D. When transmission of epidemiologically important organisms continues despite implementation and documented adherence to infection prevention and control strategies, obtain consultation from persons knowledgeable in infection control and health care epidemiology to review the situation and recommend additional measures for control.^{247,566,686} *Category IB*

III.E. Periodically review information on community or regional trends regarding the incidence and prevalence of epidemiologically important organisms (eg, influenza, RSV, pertussis, invasive group A streptococcal disease, MRSA, VRE) (including in other health care facilities) that may affect transmission of organisms within the facility.^{397,686,970-972} *Category II*

IV. Standard Precautions

Assume that every person is potentially infected or colonized with an organism that could be transmitted in the health care setting and apply the following infection control practices during the delivery of health care.

IV.A. Hand Hygiene

IV.A.1. During the delivery of health care, avoid unnecessary touching of surfaces in close proximity to the patient to prevent both contamination of clean hands from environmental surfaces and transmission of pathogens from contaminated hands to surfaces.^{72,73,738,799,973} {CDC, 2001 #970}. *Category IB/IC*

IV.A.2. When hands are visibly dirty, contaminated with proteinaceous material, or visibly soiled with blood or body fluids, wash hands with either a nonantimicrobial soap

and water or an antimicrobial soap and water.⁵⁵⁸ *Category IA*

- IV.A.3. If hands are not visibly soiled, or after removing visible material with nonantimicrobial soap and water, decontaminate hands in the clinical situations described in IV.A.2.a–f. The preferred method of hand decontamination is with an alcohol-based hand rub.^{561,974} Alternatively, hands may be washed with an antimicrobial soap and water. Frequent use of an alcohol-based hand rub immediately after handwashing with nonantimicrobial soap may increase the frequency of dermatitis.⁵⁵⁸ *Category IB*

Perform hand hygiene:

- IV.A.3.a. Before having direct contact with patients.^{663,975} *Category IB*
- IV.A.3.b. After contact with blood, body fluids or excretions, mucous membranes, nonintact skin, or wound dressings.⁶⁶³ *Category IA*
- IV.A.3.c. After contact with a patient's intact skin (eg, when measuring pulse or blood pressure or lifting a patient).^{167,976-978} *Category IB*
- IV.A.3.d. If hands will be moving from a contaminated body site to a clean body site during patient care. *Category II*
- IV.A.3.e. After contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient.^{72,73,88,799,979,980} *Category II*
- IV.A.3.f. After removing gloves.^{727,740,741} *Category IB*
- IV.A.4. Wash hands with nonantimicrobial soap and water or with antimicrobial soap and water if contact with spores (eg, *C difficile* or *B anthracis*) is likely to have occurred. The physical action of washing and rinsing hands under such circumstances is recommended because alcohols, chlorhexidine, iodophors, and other antiseptic agents have poor activity against spores.^{558,954,981} *Category II*
- IV.A.5. Do not wear artificial fingernails or extenders if duties include direct contact with patients at high risk for infection and associated adverse outcomes (eg, those in ICUs or operating rooms).^{30,31,558,721-723} *Category IA*
- IV.A.5.a. Develop an organizational policy on the wearing of nonnatural nails by HCWs who have direct contact with patients outside of the groups specified above.⁹⁸² *Category II*

IV.B. Personal protective equipment (see Fig 1)

IV.B.1. Observe the following principles of use:

- IV.B.1.a. Wear PPE, as described in IV.B.2–4, when the nature of the anticipated patient interaction indicates that contact with blood or body fluids may occur.^{738,779,895} *Category IB/IC*
- IV.B.1.b. Prevent contamination of clothing and skin during the process of removing PPE (see Fig 1). *Category II*
- IV.B.1.c. Before leaving the patient's room or cubicle, remove and discard PPE.^{18,738} *Category IB/IC*

IV.B.2. Gloves

- IV.B.2.a. Wear gloves when it can be reasonably anticipated that contact with blood or other potentially infectious materials, mucous membranes, nonintact skin, or potentially contaminated intact skin (eg, of a patient incontinent of stool or urine) could occur.^{18,727,738,740,779,983} *Category IB/IC*
- IV.B.2.b. Wear gloves with fit and durability appropriate to the task.^{558,730,731,738,984,985} *Category IB*
- IV.B.2.b.i. Wear disposable medical examination gloves for providing direct patient care.
- IV.B.2.b.ii. Wear disposable medical examination gloves or reusable utility gloves for cleaning the environment or medical equipment.
- IV.B.2.c. Remove gloves after contact with a patient and/or the surrounding environment (including medical equipment) using proper technique to prevent hand contamination (see Fig 1). Do not wear the same pair of gloves for the care of more than 1 patient. Do not wash gloves for the purpose of reuse, because this practice has been associated with transmission of pathogens.^{558,727,740-742,986} *Category IB*
- IV.B.2.d. Change gloves during patient care if the hands will move from a contaminated body site (eg, perineal area) to a clean body site (eg, face). *Category II*
- IV.B.3. Gowns
- IV.B.3.a. Wear a gown appropriate to the task to protect skin and prevent soiling

or contamination of clothing during procedures and patient care activities when contact with blood, body fluids, secretions, or excretions is anticipated.^{738,779,894} *Category IB/IC*

IV.B.3.a.i. Wear a gown for direct patient contact if the patient has uncontained secretions or excretions.^{24,88,89,738,743} *Category IB/IC*

IV.B.3.a.ii. Remove gown and perform hand hygiene before leaving the patient's environment.^{24,88,89,738,743} *Category IB/IC*

IV.B.3.b. Do not reuse gowns, even for repeated contacts with the same patient. *Category II*

IV.B.3.c. Routine donning of gowns on entrance into a high-risk unit (eg, ICU, NICU, HSCT unit) is not indicated.^{364,746-749} *Category IB*

IV.B.4. Mouth, nose, and eye protection

IV.B.4.a. Use PPE to protect the mucous membranes of the eyes, nose, and mouth during procedures and patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions. Select masks, goggles, face shields, and combinations of these according to the need anticipated by the task to be performed.^{113,738,779,895} *Category IB/IC*

IV.B.5. During aerosol-generating procedures (eg, bronchoscopy, suctioning of the respiratory tract [if not using in-line suction catheters], endotracheal intubation) in patients who are not suspected of being infected with an agent for which respiratory protection is otherwise recommended (eg, *M tuberculosis*, SARS, or hemorrhagic fever viruses), wear one of the following: a face shield that fully covers the front and sides of the face, a mask with attached shield, or a mask and goggles (in addition to gloves and gown).^{93-96,113,126,134} *Category IB*

IV.C. Respiratory hygiene/cough etiquette

IV.C.1. Educate HCWs on the importance of source control measures to contain respiratory secretions, to prevent droplet and fomite transmission of respiratory pathogens, especially during seasonal outbreaks of viral respiratory tract infections (eg, influenza,

RSV, adenovirus, parainfluenza virus) in communities.^{10,14,24,261,683} *Category IB*

IV.C.2. Implement the following measures to contain respiratory secretions in patients and accompanying individuals who have signs and symptoms of a respiratory infection, beginning at the point of initial encounter in a health care setting (eg, triage, reception and waiting areas in emergency departments, outpatient clinics, and physicians' offices).^{20,24,145,901,987}

IV.C.2.a. Post signs at entrances and in strategic places (eg, elevators, cafeterias) within ambulatory and inpatient settings with instructions to patients and other persons with symptoms of respiratory infection to cover their mouths and noses when coughing or sneezing, use and dispose of tissues, and perform hand hygiene after hands have been in contact with respiratory secretions. *Category II*

IV.C.2.b. Provide tissues and no-touch receptacles (eg, foot pedal-operated lid or open, plastic-lined wastebasket) for disposal of tissues.²⁰ *Category II*

IV.C.2.c. Provide resources and instructions for performing hand hygiene in or near waiting areas in ambulatory and inpatient settings; provide conveniently located dispensers of alcohol-based hand rubs and, where sinks are available, supplies for handwashing.^{558,901} *Category IB*

IV.C.2.d. During periods of increased prevalence of respiratory infections in the community (as indicated by, eg, increased school absenteeism, increased number of patients seeking care for respiratory infection), offer masks to coughing patients and other symptomatic persons (eg, persons who accompany ill patients) on entry into the facility or medical office.^{126,898,899} and encourage them to maintain special separation (ideally, at least 3 feet) from others in common waiting areas.^{20,23,103,111,114,134} *Category IB*

IV.C.2.d.i. Some facilities may find it logistically easier to institute this recommendation year-round as a standard of practice. *Category II*

IV.D. Patient placement

IV.D.1. Include the potential for transmission of infectious agents in patient placement decisions. Place patients who pose a risk for transmission to others (eg, those with uncontained secretions, excretions, or wound drainage; infants with suspected viral respiratory or gastrointestinal infections) in a single-patient room when available.^{24,409,429,434,792,795,796,805,988} *Category IB*

IV.D.2. Determine patient placement based on the following factors:

- Route(s) of transmission of the known or suspected infectious agent
- Risk factors for transmission in the infected patient
- Risk factors for adverse outcomes resulting from an HAI in other patients in the area or room being considered for patient placement
- Availability of single-patient rooms
- Patient options for room sharing (eg, co-horting patients with the same infection)

Category II

IV.E. Patient care equipment and instruments/devices⁹⁵⁴

IV.E.1. Establish policies and procedures for containing, transporting, and handling patient care equipment and instruments/devices that may be contaminated with blood or body fluids.^{18,738,973} *Category IB/IC*

IV.E.2. Remove organic material from critical and semicritical instrument/devices, using recommended cleaning agents before high-level disinfection and sterilization to enable effective disinfection and sterilization processes.^{835,989,990} *Category IA*

IV.E.3. Wear PPE (eg, gloves, gown), according to the level of anticipated contamination, when handling patient care equipment and instruments/devices that is visibly soiled or may have been in contact with blood or body fluids.^{18,738,973} *Category IB/IC*

IV.F. Care of the environment¹¹

IV.F.1. Establish policies and procedures for routine and targeted cleaning of environmental surfaces as indicated by the level of patient contact and degree of soiling.¹¹ *Category II*

IV.F.2. Clean and disinfect surfaces likely to be contaminated with pathogens, including those in close proximity to the patient (eg, bed rails, over bed tables) and frequently touched surfaces in the patient care environment (eg, door knobs, surfaces in and surrounding toilets in patient rooms) on a

more frequent schedule compared with that for other surfaces (eg, horizontal surfaces in waiting rooms).^{11,72,73,739,745,799,833,991-993} *Category IB*

IV.F.3. Use EPA-registered disinfectants that have microbiocidal (ie, killing) activity against the pathogens most likely to contaminate the patient care environment. Use in accordance with manufacturer's instructions.^{841-843,954,994} *Category IB/IC*

IV.F.3.a. Review the efficacy of disinfectants in use when evidence of continuing transmission of an infectious agent (eg, rotavirus, *C difficile*, norovirus) may indicate resistance to the product and a change to a more effective disinfectant as indicated.^{274,841,846} *Category II*

IV.F.4. In facilities that provide health care to pediatric patients or that have waiting areas with children's toys (eg, obstetric/gynecology offices and clinics), establish policies and procedures for cleaning and disinfecting toys at regular intervals.^{80,378} *Category IB*

Consider the following principles when developing this policy and procedures: *Category II*

- Select play toys that can be easily cleaned and disinfected.
- Do not permit use of stuffed furry toys if they will be shared.
- Clean and disinfect large stationary toys (eg, climbing equipment) at least weekly and whenever visibly soiled.
- If toys are likely to be mouthed, rinse with water after disinfection; alternatively, wash in a dishwasher.
- When a toy requires cleaning and disinfection, do so immediately or store in a designated labeled container separate from toys that are clean and ready for use.

IV.F.5. Include multiuse electronic equipment in policies and procedures for preventing contamination and for cleaning and disinfection, especially those items that are used by patients, those used during delivery of patient care, and mobile devices that are moved in and out of patient rooms frequently (eg, daily).^{849,850,851,995} *Category IB*

IV.F.5.a. No recommendation for use of removable protective covers or washable keyboards. *Unresolved issue*

IV.G. Textiles and laundry

IV.G.1. Handle used textiles and fabrics with minimum agitation to avoid contamination of

air, surfaces, and persons.^{738,996,997} *Category IB/IC*

IV.G.2. If laundry chutes are used, ensure that they are properly designed, maintained, and used in a manner to minimize dispersion of aerosols from contaminated laundry.^{11,13,998,999} *Category IB/IC*

IV.H. Safe injection practices

The following recommendations apply to the use of needles, cannulas that replace needles, and, where applicable, intravenous delivery systems:⁴⁵³

IV.H.1. Use aseptic technique to avoid contamination of sterile injection equipment^{1000,1001} *Category IA*

IV.H.2. Do not administer medications from a syringe to multiple patients, even if the needle or cannula on the syringe is changed. Needles, cannulae, and syringes are sterile, single-use items; they should not be reused for another patient or to access a medication or solution that might be used for a subsequent patient.^{452,918,1002,1003} *Category IA*

IV.H.3. Use fluid infusion and administration sets (ie, intravenous bags, tubing and connectors) for one patient only and dispose of appropriately after use. Consider a syringe or needle/cannula to be contaminated once it has been used to enter or connect to a patient's intravenous infusion bag or administration set.⁴⁵² *Category IB*

IV.H.4. Use single-dose vials for parenteral medications whenever possible.⁴⁵² *Category IA*

IV.H.5. Do not administer medications from single-dose vials or ampules to multiple patients or combine leftover contents for later use.^{368,452,1003} *Category IA*

IV.H.6. If multidose vials must be used, both the needle or cannula and syringe used to access the multidose vial must be sterile.^{452,1000} *Category IA*

IV.H.7. Do not keep multidose vials in the immediate patient treatment area. Store in accordance with the manufacturer's recommendations; discard if sterility is compromised or questionable.^{452,1001} *Category IA*

IV.H.8. Do not use bags or bottles of intravenous solution as a common source of supply for multiple patients.^{452,1004} *Category IB*

IV.I. Infection control practices for special lumbar puncture procedures

Wear a surgical mask when placing a catheter or injecting material into the spinal canal or subdural space (ie, during myelograms, lumbar puncture and spinal or epidural anesthesia).^{904-912,916,1005} *Category IB*

IV.J. Worker safety

Adhere to federal and state requirements for protection of HCWs from exposure to bloodborne pathogens.⁷³⁸ *Category IC*

V. Transmission-Based Precautions

V.A. General principles

V.A.1. In addition to Standard Precautions, use Transmission-Based Precautions for patients with documented or suspected infection or colonization with highly transmissible or epidemiologically important pathogens for which additional precautions are needed to prevent transmission (see Appendix A).^{24,93,126,141,305,805,1006} *Category IA*

V.A.2. Extend the duration of Transmission-Based Precautions, (eg, Droplet, Contact) for immunosuppressed patients with viral infections due to prolonged shedding of viral agents that may be transmitted to others.^{927,930-932,1007-1009} *Category IA*

V.B. Contact Precautions

V.B.1. Use Contact Precautions as recommended in Appendix A for patients with known or suspected infections or evidence of syndromes that represent an increased risk for contact transmission. For specific recommendations for use of Contact Precautions for colonization or infection with MDROs, consult the MDRO guideline, available at <http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf>.⁸⁶⁹

V.B.2. Patient placement

V.B.2.a. In acute care hospitals, place patients who require Contact Precautions in a single-patient room when available.^{24,686,792,795,796,805,836,892,1010,1011} *Category IB*

V.B.2.b. When single-patient rooms are in short supply, apply the following principles for making decisions on patient placement:

- Prioritize patients with conditions that may facilitate transmission (eg, uncontained drainage, stool incontinence) for single-patient room placement. *Category II*
- Place patients who are infected or colonized with the same pathogen and are suitable roommates together in the same room (cohort).^{29,637,807,810-812,814,817,818} *Category IB*

- If it becomes necessary to place a patient requiring Contact Precautions in a room with a patient who is not infected or colonized with the same infectious agent:
 - Avoid placing patients on Contact Precautions in the same room with patients who have conditions that may increase the risk of adverse outcome from infection or that may facilitate transmission (eg, those who are immunocompromised, have open wounds, or have anticipated prolonged lengths of stay). *Category II*
 - Ensure that patients are physically separated (ie, >3 feet apart) from each other. Draw the privacy curtain between beds to minimize opportunities for direct contact. *Category II*
 - Change protective attire and perform hand hygiene between contact with patients in the same room, regardless of whether or not either of the patients is on Contact Precautions.^{727,740,741,986,1012,1013} *Category IB*
- V.B.2.c. In long-term care and other residential settings, make decisions regarding patient placement on a case-by-case basis, balancing infection risks to other patients in the room, the presence of risk factors that increase the likelihood of transmission, and the potential adverse psychological impact on the infected or colonized patient.^{919,920} *Category II*
- V.B.2.d. In ambulatory settings, place patients who require Contact Precautions in an examination room or cubicle as soon as possible.²⁰ *Category II*
- V.B.3. Use of PPE
 - V.B.3.a. Gloves

Wear gloves whenever touching the patient's intact skin^{24,89,134,558,745,836} or surfaces and articles in close proximity to the patient (eg, medical equipment, bed rails).^{72,73,88,836} Don gloves on entry into the room or cubicle. *Category IB*
 - V.B.3.b. Gowns
 - V.B.3.b.i. Wear a gown whenever it is anticipated that clothing will come in direct contact with the patient or potentially contaminated environmental surfaces or equipment in close proximity to the patient. Don a gown on entry into the room or cubicle. Remove the gown and observe hand hygiene before leaving the patient care environment.^{24,88,134,744,836} *Category IB*
 - V.B.3.b.ii. After gown removal, ensure that clothing and skin do not contact potentially contaminated environmental surfaces that could result in possible transfer of microorganism to other patients or environmental surfaces.^{72,73} *Category II*
- V.B.4. Patient transport
 - V.B.4.a. In acute care hospitals and long-term care and other residential settings, limit transport and movement of patients outside of the room to medically necessary purposes. *Category II*
 - V.B.4.b. When transport or movement in any health care setting is necessary, ensure that infected or colonized areas of the patient's body are contained and covered. *Category II*
 - V.B.4.c. Remove and dispose of contaminated PPE and perform hand hygiene before transporting patients on Contact Precautions. *Category II*
 - V.B.4.d. Don clean PPE to handle the patient at the transport destination. *Category II*
- V.B.5. Patient care equipment and instruments/devices
 - V.B.5.a. Handle patient care equipment and instruments/devices according to Standard Precautions.^{738,835} *Category IB/IC*
 - V.B.5.b. In acute care hospitals and long-term care and other residential settings, use disposable noncritical patient care equipment (eg, blood pressure cuffs) or implement patient-dedicated use of such equipment. If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient.^{24,88,795,835,836,853,1014} *Category IB*
 - V.B.5.c. In-home care settings
 - V.B.5.c.i. Limit the amount of nondisposable patient care equipment

brought into the home of a patient on Contact Precautions. Whenever possible, leave patient care equipment in the home until discharge from home care services. *Category II*

V.B.5.c.ii. If noncritical patient care equipment (eg, stethoscope) cannot remain in the home, clean and disinfect items before taking them from the home using a low- to intermediate-level disinfectant. Alternatively, place contaminated reusable items in a plastic bag for transport and subsequent cleaning and disinfection. *Category II*

V.B.5.d. In ambulatory settings, place contaminated reusable noncritical patient care equipment in a plastic bag for transport to a soiled utility area for reprocessing. *Category II*

V.B.6. Environmental measures

Ensure that rooms of patients on Contact Precautions are prioritized for frequent cleaning and disinfection (eg, at least daily) with a focus on frequently touched surfaces (eg, bed rails, overbed table, bedside commode, lavatory surfaces in patient bathrooms, doorknobs) and equipment in the immediate vicinity of the patient.^{11,24,88,745,836}

Category IB

V.B.7. Discontinue Contact Precautions after signs and symptoms of the infection have resolved or according to pathogen-specific recommendations in Appendix A. *Category IB*

V.C. Droplet Precautions

V.C.1. Use Droplet Precautions as recommended in Appendix A for patients known or suspected infection with pathogens transmitted by respiratory droplets (ie, droplets $> 5 \mu$) generated by a patient who is coughing, sneezing, or talking.^{14,23} Steinberg, 1969 #1708,^{41,95,103,111,112,754,755,987,1015} *Category IB*

V.C.2. Patient placement

V.C.2.a. In acute care hospitals, place patients who require Droplet Precautions in a single-patient room when available *Category II*

When single-patient rooms are in short supply, apply the following principles when making decisions on patient placement:

- Prioritize patients who have excessive cough and sputum production for single-patient room placement. *Category II*
- Place patients who are infected the same pathogen and are suitable roommates together in the same room (cohort).^{813,815} *Category IB*
- If it becomes necessary to place patients who require Droplet Precautions in a room with a patient who does not have the same infection:
 - Avoid placing patients on Droplet Precautions in the same room with patients who have conditions that may increase the risk of adverse outcome from infection or that may facilitate transmission (eg, those who are immunocompromised or have anticipated prolonged lengths of stay). *Category II*
 - Ensure that patients are physically separated (ie, >3 feet apart) from each other. Draw the privacy curtain between beds to minimize opportunities for close contact.^{103,104,409} *Category IB*
 - Change protective attire and perform hand hygiene between contact with patients in the same room, regardless of whether or not either patient is on Droplet Precautions.^{740-741,986,1012,1013} *Category IB*

V.C.2.b. In long-term care and other residential settings, make decisions regarding patient placement on a case-by-case basis after considering infection risks to other patients in the room and available alternatives.⁴⁰⁹ *Category II*

V.C.2.c. In ambulatory settings, place patients who require Droplet Precautions in an examination room or cubicle as soon as possible. Instruct patients to follow recommendations for respiratory hygiene/cough etiquette.^{9,446,447,827} *Category II*

V.C.3. Use of PPE

V.C.3.a. Don a mask on entry into the patient's room or cubicle.^{14,23,41,103,111,113,115,826} *Category IB*

V.C.3.b. No recommendation for routinely wearing eye protection (eg, goggle or face shield) in addition to a mask, for close contact with patients

who require Droplet Precautions.
Unresolved issue

- V.C.3.c. For patients with suspected or proven SARS, avian influenza or pandemic influenza, refer to the following websites for the most current recommendations: <http://www.cdc.gov/ncidod/sars/>; <http://www.cdc.gov/flu/avian/>; and <http://www.pandemicflu.gov/>.^{134,1016,1017}

V.C.4. Patient transport

- V.C.4.a. In acute care hospitals and long-term care and other residential settings, limit transport and movement of patients outside of the room to medically necessary purposes. *Category II*
- V.C.4.b. If transport or movement in any health care setting is necessary, instruct the patient to wear a mask and follow respiratory hygiene/cough etiquette (see <http://www.cdc.gov/flu/professionals/infectioncontrol/resphygiene.htm>). *Category IB*
- V.C.4.c. No mask is required for persons transporting patients on Droplet Precautions. *Category II*
- V.C.4.d. Discontinue Droplet Precautions after signs and symptoms have resolved or according to pathogen-specific recommendations in Appendix A. *Category IB*

V.D. Airborne Precautions

- V.D.1. Use Airborne Precautions as recommended in Appendix A for patients known or suspected to be infected with infectious agents transmitted person to person by the airborne route (eg, *M tuberculosis*,¹² measles,^{34,122,1018} chickenpox,^{123,772,1019} disseminated herpes zoster¹⁰²⁰). *Category IA/IC*
- V.D.2. Patient placement
- V.D.2.a. In acute care hospitals and long-term care settings, place patients who require Airborne Precautions in an AIIR that has been constructed in accordance with current guidelines.¹¹⁻¹³ *Category IA/IC*
- V.D.2.a.i. Provide at least 6 (in an existing facility) or 12 (in new construction/renovation) air changes per hour.
- V.D.2.a.ii. Direct exhaust of air to the outside. If it is not possible to

exhaust air from an AIIR directly to the outside, the air may be returned to the air-handling system or adjacent spaces if all air is directed through HEPA filters.

- V.D.2.a.iii. Whenever an AIIR is in use for a patient on Airborne Precautions, monitor air pressure daily with visual indicators (eg, smoke tubes, flutter strips), regardless of the presence or absence of differential pressure-sensing devices (eg, manometers).^{11,12,1021,1022}

- V.D.2.a.iv. Keep the AIIR door closed when not required for entry and exit.

- V.D.2.b. When an AIIR is not available, transfer the patient to a facility that has an available AIIR.¹² *Category II*

- V.D.2.c. In the event of an outbreak or exposure involving large numbers of patients who require Airborne Precautions:

- Consult an ICP before patient placement to determine the safety of an alternative room that does not meet engineering requirements for an AIIR.
- Place patients who are presumed to have the same infection (based on clinical presentation and diagnosis when known) together (cohort) in areas of the facility away from other patients, especially patients at increased risk for infection (eg, immunocompromised patients).
- Use temporary portable solutions (eg, exhaust fan) to create a negative-pressure environment in the converted area of the facility. Discharge air directly to the outside, away from people and air intakes, or direct all of the air through HEPA filters before it is introduced to other air spaces.¹² *Category II*

- V.D.2.d. In ambulatory settings:

- V.D.2.d.i. Develop systems (eg, triage, signage) to identify patients with known or suspected infections who require Airborne Precautions on entry into ambulatory settings.^{9,12,34,127,134} *Category IA*

- V.D.2.d.ii. Place the patient in an AIIR as soon as possible. If an AIIR is

not available, place a surgical mask on the patient and place the patient in an examination room. Once the patient leaves, the room should remain vacant for the appropriate time (generally 1 hour) to allow for a full exchange of air.^{11,12,122}

Category IB/IC

- V.D.2.d.iii. Instruct a patient with a known or suspected airborne infection to wear a surgical mask and observe respiratory hygiene/cough etiquette. Once in an AIIR, the mask may be removed; the mask should remain on if the patient is not in an AIIR.^{12,107,145,898} *Category IB/IC*

V.D.3. Personnel restrictions

Restrict susceptible HCWs from entering the rooms of patients known or suspected to have measles (rubeola), varicella (chickenpox), disseminated zoster, or smallpox if other immune HCWs are available.^{17,774} *Category IB*

V.D.4. Use of PPE

- V.D.4.a. Wear a fit-tested NIOSH-approved N95 or higher-level respirator for respiratory protection when entering the room or home of a patient when the following diseases are suspected or confirmed:

- Infectious pulmonary or laryngeal tuberculosis, or when infectious tuberculosis skin lesions are present and procedures that would aerosolize viable organisms (eg, irrigation, incision and drainage, whirlpool treatments) are performed.^{12,1023,1024} *Category IB*
- Smallpox (vaccinated and unvaccinated). Respiratory protection is recommended for all HCWs, including those with a documented "take" after smallpox vaccination due to the risk of a genetically engineered virus against which the vaccine may not provide protection, or of exposure to a very large viral load (from, eg, high-risk aerosol-generating procedures, immunocompromised patients, hemorrhagic or flat smallpox).^{108,129} *Category II*

- V.D.4.b. No recommendation is made regarding the use of PPE by HCWs who are presumed to be immune

to measles (rubeola) or varicella-zoster based on history of disease, vaccine, or serologic testing when caring for an individual with known or suspected measles, chickenpox, or disseminated zoster due to difficulties in establishing definite immunity.^{1025,1026} *Unresolved issue*

- V.D.4.c. No recommendation is made regarding the type of PPE (ie, surgical mask or respiratory protection with a N95 or higher-level respirator) to be worn by susceptible HCWs who must have contact with patients with known or suspected measles, chickenpox, or disseminated herpes zoster. *Unresolved issue*

V.D.5. Patient transport

- V.D.5.a. In acute care hospitals and long-term care and other residential settings, limit transport and movement of patients outside of the room to medically necessary purposes. *Category II*

- V.D.5.b. If transport or movement outside an AIIR is necessary, instruct the patient to wear a surgical mask, if possible, and to observe respiratory hygiene/cough etiquette.¹² *Category II*

- V.D.5.c. For a patient with skin lesions associated with varicella or smallpox or draining skin lesions caused by *M tuberculosis*, cover the affected areas to prevent aerosolization or contact with the infectious agent in skin lesions.^{108,1023,1024,1027-1029} *Category IB*

- V.D.5.d. An HCW transporting a patient on Airborne Precautions does not need to wear a mask or respirator during transport if the patient is wearing a mask and infectious skin lesions are covered. *Category II*

V.D.6. Exposure management

Immunize or provide the appropriate immune globulin to susceptible persons as soon as possible after unprotected contact (ie, exposure) to a patient with measles, varicella, or smallpox: *Category IA*

- Administer measles vaccine to exposed susceptible persons within 72 hours after the exposure or administer immune globulin within 6 days of the exposure event for high-risk persons in whom vaccine is contraindicated.^{17,1030-1033}

- Administer varicella vaccine to exposed susceptible persons within 120 hours after the exposure or administer varicella immune globulin (VZIG or an alternative product), when available, within 96 hours for high-risk persons in whom vaccine is contraindicated (eg, immunocompromised patients, pregnant women, newborns whose mother's varicella onset was < 5 days before or within 48 hours after delivery).^{887,1033-1035}
- Administer smallpox vaccine to exposed susceptible persons within 4 days after exposure.^{108,1036-1038}

V.D.7. Discontinue Airborne Precautions according to pathogen-specific recommendations in Appendix A. *Category IB*

V.D.8. Consult the *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health Care Settings, 2005*¹² and the *Guideline for Environmental Infection Control in Health Care Facilities*¹¹ for additional guidance on environment strategies for preventing transmission of tuberculosis in health care settings. The environmental recommendations in these guidelines may be applied to patients with other infections that necessitate Airborne Precautions.

VI. Protective Environment (see Table 4)

VI.A. Place allogeneic HSCT patients in a PE as described in the *Guideline to Prevent Opportunistic Infections in HSCT Patients*,¹⁵ *Guideline for Environmental Infection Control in Health Care Facilities*,¹¹ and *Guidelines for Preventing Health Care-Associated Pneumonia, 2003*¹⁴ to reduce exposure to environmental fungi (eg, *Aspergillus* spp).^{157,158} *Category IB*

VI.B. No recommendation for placing patients with other medical conditions associated with increased risk for environmental fungal infections (eg, aspergillosis) in a PE.¹¹ *Unresolved issue*

VI.C. For patients who require a PE, implement the following (see Table 5).^{11,15}

VI.C.1. Environmental controls

VI.C.1.a. Filtered incoming air using central or point-of-use HEPA filters capable of removing 99.97% of particles $\geq 0.3 \mu\text{m}$ in diameter.¹⁵ *Category IB*

VI.C.1.b. Directed room airflow with the air supply on one side of the room that moves air across the patient bed and out through an exhaust on the opposite side of the room.¹⁵ *Category IB*

VI.C.1.c. Positive air pressure in room relative to the corridor (pressure differential of $\geq 12.5 \text{ Pa}^{0.01\text{-in water gauge}}$).¹³ *Category IB*

VI.C.1.c.i. Monitor air pressure daily with visual indicators (eg, smoke tubes, flutter strips).^{11,1022} *Category IA*

VI.C.1.d. Well-sealed rooms that prevent infiltration of outside air.¹³ *Category IB*

VI.C.1.e. At least 12 air changes per hour.¹³ *Category IB*

VI.C.2. Lower dust levels by using smooth, nonporous surfaces and finishes that can be scrubbed, rather than textured material (eg, upholstery). Wet dust horizontal surfaces whenever dust detected and routinely clean crevices and sprinkler heads where dust may accumulate.^{939,940} *Category II*

VI.C.3. Avoid carpeting in hallways and patient rooms in areas.⁹⁴⁰ *Category IB*

VI.C.4. Prohibit dried and fresh flowers and potted plants.⁹⁴⁰⁻⁹⁴² *Category II*

VI.D. Minimize the time that patients who require a PE are outside their rooms for diagnostic procedures and other activities.^{11,158,944} *Category IB*

VI.E. During periods of construction, to prevent inhalation of respirable particles that could contain infectious spores, provide respiratory protection (eg, N95 respirator) to patients who are medically fit to tolerate a respirator when they are required to leave the PE.^{158,944} *Category II*

VI.E.1.a. No recommendation for fit testing of patients who are using respirators. *Unresolved issue*

VI.E.1.b. No recommendation for use of particulate respirators when leaving the PE in the absence of construction. *Unresolved issue*

VI.F. Use of Standard and Transmission-Based Precautions in a PE

VI.F.1. Use Standard Precautions as recommended for all patient interactions. *Category IA*

VI.F.2. Implement Droplet and Contact Precautions as recommended for diseases listed in Appendix A. Transmission-Based precautions for viral infections may need to be prolonged because of the patient's immunocompromised state and prolonged shedding of viruses.^{927,929,931,1008,1009} *Category IB*

VI.F.3. Barrier precautions, (eg, masks, gowns, gloves) are not required for HCWs in the absence of suspected or confirmed infection

in the patient or if they are not indicated according to Standard Precautions.¹⁵ *Category II*

VI.F.4. Implement Airborne Precautions for patients who require a PE and who also have an airborne infectious disease (eg, pulmonary or laryngeal tuberculosis, acute varicella-zoster). *Category IA*

VI.F.4.a. Ensure that the PE is designed to maintain positive pressure.¹⁵ *Category IB*

VI.F.4.b. Use an anteroom to further support the appropriate air balance relative to the corridor and the PE; provide independent exhaust of contaminated air to the outside or place a HEPA filter in the exhaust duct if the return air must be recirculated.^{13,1039} *Category IB*

VI.F.4.c. If an anteroom is not available, place the patient in an AIIR and use portable, industrial-grade HEPA filters in the room to enhance filtration of spores.¹⁰⁴⁰ *Category II*

GLOSSARY

Airborne infection isolation room (AIIR). Formerly known as a negative-pressure isolation room, an AIIR is a single-occupancy patient care room used to isolate persons with a suspected or confirmed airborne infectious disease. Environmental factors are controlled in AIIRs to minimize the transmission of infectious agents that are usually transmitted from person to person by droplet nuclei associated with coughing or aerosolization of contaminated fluids. AIIRs should provide negative pressure in the room (so that air flows under the door gap into the room), an air flow rate of 6 to 12 air changes per hour (ACH) (6 ACH for existing structures, 12 ACH for new construction or renovation), and direct exhaust of air from the room to the outside of the building or recirculation of air through a high-efficiency particulate air filter before returning to circulation. (MMWR 2003; 52 [RR-10]; MMWR 1994; 43 [RR-13].)

American Institute of Architects (AIA). A professional organization that has developed standards for building ventilation, the *2001 Guidelines for Design and Construction of Hospital and Health Care Facilities*, the development of which was supported by the AIA, Academy of Architecture for Health, and Facilities Guideline Institute, with assistance from the US Department of Health and Human Services and the National Institutes of Health, is the primary source of guidance for

creating airborne infection isolation rooms and protective environments (<http://www.aia.org/aah>).

Ambulatory care setting. A facility that provides health care to patients who do not remain overnight; examples include hospital-based outpatient clinics, non-hospital-based clinics and physician offices, urgent care centers, surgicenters, free-standing dialysis centers, public health clinics, imaging centers, ambulatory behavioral health and substance abuse clinics, physical therapy and rehabilitation centers, and dental practices.

Bioaerosol. An airborne dispersion of particles containing whole or parts of biological entities, including bacteria, viruses, dust mites, fungal hyphae, and fungal spores. Such aerosols usually consist of a mixture of monodispersed and aggregate cells, spores, or viruses carried by other materials, such as respiratory secretions and/or inert particles. Infectious bioaerosols (ie, those containing biological agents capable of causing an infectious disease) can be generated from human sources (eg, expulsion from the respiratory tract during coughing, sneezing, talking, singing, suctioning, or wound irrigation), wet environmental sources (eg, high-volume air conditioning and cooling tower water with *Legionella*) or dry sources (eg, construction dust with spores produced by *Aspergillus* spp). Bioaerosols include large respiratory droplets and small droplet nuclei (Cole EC. AJIC 1998;26: 453-64).

Caregiver. Any person who is not an employee of an organization, is not paid, and provides or assists in providing health care to a patient (eg, family member, friend) and acquire technical training as needed based on the tasks that must be performed.

Cohorting. In the context of this guideline, this term applies to the practice of grouping patients infected or colonized with the same infectious agent together to confine their care to one area and prevent contact with susceptible patients (cohorting patients). During outbreaks, health care personnel may be assigned to a cohort of patients to further limit opportunities for transmission (cohorting staff).

Colonization. Proliferation of microorganisms on or within body sites without detectable host immune response, cellular damage, or clinical expression. The presence of a microorganism within a host may occur with varying durations but may become a source of potential transmission. In many instances, colonization and carriage are synonymous.

Droplet nuclei. Microscopic particles < 5 µm in size that are the residue of evaporated droplets and are produced when a person coughs, sneezes, shouts, or sings. These particles can remain suspended in the air for prolonged periods and can be carried on normal air currents in a room or beyond, to adjacent spaces or areas receiving exhaust air.

Engineering controls. Removal or isolation of a workplace hazard through technology. An airborne infection isolation room, a protective environment, engineered sharps injury prevention device, and a sharps container are examples of engineering controls.

Epidemiologically important pathogen. An infectious agent that has one or more of the following characteristics: (1) readily transmissible, (2) a proclivity toward causing outbreaks, (3) possible association with a severe outcome, and (4) difficult to treat. Examples include *Acinetobacter* spp, *Aspergillus* spp, *Burkholderia cepacia*, *Clostridium difficile*, *Klebsiella* or *Enterobacter* spp, extended-spectrum beta-lactamase-producing gram-negative bacilli, methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa*, vancomycin-resistant enterococci, vancomycin-resistant *Staphylococcus aureus*, influenza virus, respiratory syncytial virus, rotavirus, severe acute respiratory syndrome coronavirus, noroviruses, and the hemorrhagic fever viruses.

Hand hygiene. A general term that applies to any one of the following: (1) handwashing with plain (non-antimicrobial) soap and water, (2) antiseptic handwashing (soap containing antiseptic agents and water), (3) antiseptic handrub (waterless antiseptic product, most often alcohol-based, rubbed on all surfaces of hands), or (4) surgical hand antisepsis (antiseptic handwash or antiseptic handrub performed preoperatively by surgical personnel to eliminate transient hand flora and reduce resident hand flora).⁵⁵⁸

Health care–associated infection (HAI). An infection that develops in a patient who is cared for in any setting where health care is delivered (eg, acute care hospital, chronic care facility, ambulatory clinic, dialysis center, surgicenter, home) and is related to receiving health care (ie, was not incubating or present at the time health care was provided). In ambulatory and home settings, HAI refers to any infection that is associated with a medical or surgical intervention. Because the geographic location of infection acquisition is often uncertain, the preferred term is considered to be health care–associated rather than health care–acquired.

Healthcare epidemiologist. A person whose primary training is medical (MD, DO) and/or masters- or doctorate-level epidemiology who has received advanced training in health care epidemiology. Typically these professionals direct or provide consultation to an infection control program in a hospital, long-term care facility, or health care delivery system (also see Infection control professional).

Health care personnel, health care worker (HCW). Any paid or unpaid person who works in a health care setting (eg, any person who has professional or technical training in a health care–related field and provides patient care in a health care setting or any

person who provides services that support the delivery of health care such as dietary, housekeeping, engineering, maintenance personnel).

Hematopoietic stem cell transplantation (HSCT). Any transplantation of blood- or bone marrow–derived hematopoietic stem cells, regardless of donor type (eg, allogeneic or autologous) or cell source (eg, bone marrow, peripheral blood, or placental/umbilical cord blood), associated with periods of severe immunosuppression that vary with the source of the cells, the intensity of chemotherapy required, and the presence of graft versus host disease (MMWR 2000; 49: RR-10).

High-efficiency particulate air (HEPA) filter. An air filter that removes >99.97% of particles > 0.3 μm (the most penetrating particle size) at a specified flow rate of air. HEPA filters may be integrated into the central air handling systems, installed at the point of use above the ceiling of a room, or used as portable units (MMWR 2003; 52: RR-10).

Home care. A wide range of medical, nursing, rehabilitation, hospice, and social services delivered to patients in their place of residence (eg, private residence, senior living center, assisted living facility). Home health care services include care provided by home health aides and skilled nurses, respiratory therapists, dietitians, physicians, chaplains, and volunteers; provision of durable medical equipment; home infusion therapy; and physical, speech, and occupational therapy.

Immunocompromised patient. A patient whose immune mechanisms are deficient because of a congenital or acquired immunologic disorder (eg, human immunodeficiency virus infection, congenital immune deficiency syndromes), chronic diseases such as diabetes mellitus, cancer, emphysema, or cardiac failure, intensive care unit care, malnutrition, and immunosuppressive therapy of another disease process [eg, radiation, cytotoxic chemotherapy, anti-graft rejection medication, corticosteroids, monoclonal antibodies directed against a specific component of the immune system]). The type of infections for which an immunocompromised patient has increased susceptibility is determined by the severity of immunosuppression and the specific component(s) of the immune system that is affected. Patients undergoing allogeneic hematopoietic stem cell transplantation and those with chronic graft versus host disease are considered the most vulnerable to health care–associated infections. Immunocompromised states also make it more difficult to diagnose certain infections (eg, tuberculosis) and are associated with more severe clinical disease states than persons with the same infection and a normal immune system.

Infection. The transmission of microorganisms into a host after evading or overcoming defense

mechanisms, resulting in the organism's proliferation and invasion within host tissue(s). Host responses to infection may include clinical symptoms or may be subclinical, with manifestations of disease mediated by direct organisms pathogenesis and/or a function of cell-mediated or antibody responses that result in the destruction of host tissues.

Infection control and prevention professional (ICP). A person whose primary training is in either nursing, medical technology, microbiology, or epidemiology and who has acquired specialized training in infection control. Responsibilities may include collection, analysis, and feedback of infection data and trends to health care providers; consultation on infection risk assessment, prevention, and control strategies; performance of education and training activities; implementation of evidence-based infection control practices or those mandated by regulatory and licensing agencies; application of epidemiologic principles to improve patient outcomes; participation in planning renovation and construction projects (eg, to ensure appropriate containment of construction dust); evaluation of new products or procedures on patient outcomes; oversight of employee health services related to infection prevention; implementation of preparedness plans; communication within the health care setting, with local and state health departments, and with the community at large concerning infection control issues; and participation in research. Certification in infection control is available through the Certification Board of Infection Control and Epidemiology.

Infection control and prevention program. A multidisciplinary program that includes a group of activities to ensure that recommended practices for the prevention of health care-associated infections are implemented and followed by health care workers, making the health care setting safe from infection for patients and health care personnel. The Joint Commission on Accreditation of Healthcare Organizations requires the following 5 components of an infection control program for accreditation: (1) *surveillance*: monitoring patients and health care personnel for acquisition of infection and/or colonization; (2) *investigation*: identification and analysis of infection problems or undesirable trends; (3) *prevention*: implementation of measures to prevent transmission of infectious agents and to reduce risks for device- and procedure-related infections; (4) *control*: evaluation and management of outbreaks; and (5) *reporting*: provision of information to external agencies as required by state and federal laws and regulations (see <http://www.jcaho.org>). The infection control program staff has the ultimate authority to determine infection control policies for a health care organization with the approval of the organization's governing body.

Long-term care facility (LTCF). A residential or outpatient facility designed to meet the biopsychosocial needs of persons with sustained self-care deficits. These include skilled nursing facilities, chronic disease hospitals, nursing homes, foster and group homes, institutions for the developmentally disabled, residential care facilities, assisted living facilities, retirement homes, adult day health care facilities, rehabilitation centers, and long-term psychiatric hospitals.

Mask. A term that applies collectively to items used to cover the nose and mouth and includes both procedure masks and surgical masks (see <http://www.fda.gov/cdrh/ode/guidance/094.html#4>).

Multidrug-resistant organism (MDRO). In general, a bacterium (excluding *Mycobacterium tuberculosis*) that is resistant to 1 or more classes of antimicrobial agents and usually is resistant to all but 1 or 2 commercially available antimicrobial agents (eg, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, extended-spectrum beta-lactamase-producing or intrinsically resistant gram-negative bacilli).¹⁷⁶

Nosocomial infection. Derived from 2 Greek words, "nosos" (disease) and "komeion" (to take care of), refers to any infection that develops during or as a result of an admission to an acute care facility (hospital) and was not incubating at the time of admission.

Personal protective equipment (PPE). A variety of barriers used alone or in combination to protect mucous membranes, skin, and clothing from contact with infectious agents. PPE includes gloves, masks, respirators, goggles, face shields, and gowns.

Procedure mask. A covering for the nose and mouth that is intended for use in general patient care situations. These masks generally attach to the face with ear loops rather than ties or elastic. Unlike surgical masks, procedure masks are not regulated by the Food and Drug Administration.

Protective environment. A specialized patient care area, usually in a hospital, with a positive air flow relative to the corridor (ie, air flows from the room to the outside adjacent space). The combination of high-efficiency particulate air filtration, high numbers (>12) of air changes per hour, and minimal leakage of air into the room creates an environment that can safely accommodate patients with a severely compromised immune system (eg, those who have received allogeneic hemopoietic stem cell transplantation) and decrease the risk of exposure to spores produced by environmental fungi. Other components include use of scrubbable surfaces instead of materials such as upholstery or carpeting, cleaning to prevent dust accumulation, and prohibition of fresh flowers or potted plants.

Quasi-experimental study. A study undertaken to evaluate interventions but do not use randomization

as part of the study design. These studies are also referred to as nonrandomized, pre-/postintervention study designs. These studies aim to demonstrate causality between an intervention and an outcome but cannot achieve the level of confidence concerning an attributable benefit obtained through a randomized controlled trial. In hospitals and public health settings, randomized control trials often cannot be implemented due to ethical, practical, and urgency reasons; therefore, quasi-experimental design studies are commonly used. However, even if an intervention appears to be effective statistically, the question can be raised as to the possibility of alternative explanations for the result. Such a study design is used when it is not logistically feasible or ethically possible to conduct a randomized controlled trial, (eg, during outbreaks). Within the classification of quasi-experimental study designs, there is a hierarchy of design features that may contribute to validity of results (Harris et al. *CID* 2004;38: 1586).

Residential care setting. A facility in which people live, minimal medical care is delivered, and the psychosocial needs of the residents are provided for.

Respirator. A personal protective device worn by health care personnel over the nose and mouth to protect them from acquiring airborne infectious diseases due to inhalation of infectious airborne particles < 5 μm in size. These include infectious droplet nuclei from patients with *Mycobacterium tuberculosis*, variola virus [smallpox], or severe acute respiratory syndrome and dust particles that contain infectious particles, such as spores of environmental fungi (eg, *Aspergillus* spp). The Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health (NIOSH) certifies respirators used in health care settings (see <http://www.cdc.gov/niosh/topics/respirators/>). The N95 disposable particulate, air-purifying respirator is the type used most commonly by health care personnel. Other respirators used include N-99 and N-100 particulate respirators, powered air-purifying respirators with high-efficiency filters, and nonpowered full-facepiece elastomeric negative pressure respirators. A listing of NIOSH-approved respirators can be found at <http://www.cdc.gov/niosh/npptl/respirators/disparticlist.html>. Respirators must be used in conjunction with a complete respiratory protection program, as required by the Occupational Safety and Health Administration, which includes fit testing, training, proper selection of respirators, medical clearance, and respirator maintenance.

Respiratory hygiene/cough etiquette. A combination of measures designed to minimize the transmission of respiratory pathogens through droplet or airborne routes in health care settings. The components of respiratory hygiene/cough etiquette are (1)

covering the mouth and nose during coughing and sneezing, (2) using tissues to contain respiratory secretions with prompt disposal into a no-touch receptacle, (3) offering a surgical mask to persons who are coughing to decrease contamination of the surrounding environment, and (4) turning the head away from others and maintaining spatial separation (ideally >3 feet) when coughing. These measures are targeted to all patients with symptoms of respiratory infection and their accompanying family members or friends beginning at the point of initial encounter with a health care setting (eg, reception/triage in emergency departments, ambulatory clinics, health care provider offices).¹²⁶ (Srinivasin A *ICHE* 2004; 25: 1020; <http://www.cdc.gov/flu/professionals/infectioncontrol/resphygiene.htm>).

Safety culture. Shared perceptions of workers and management regarding the level of safety in the work environment. A hospital safety climate includes the following organizational components: (1) senior management support for safety programs, (2) absence of workplace barriers to safe work practices, (3) cleanliness and orderliness of the worksite, (4) minimal conflict and good communication among staff members, (5) frequent safety-related feedback/training by supervisors, and (6) availability of PPE and engineering controls.⁶¹⁸

Source control. The process of containing an infectious agent either at the portal of exit from the body or within a confined space. The term is applied most frequently to containment of infectious agents transmitted by the respiratory route but could apply to other routes of transmission, (eg, a draining wound, vesicular or bullous skin lesions). Respiratory hygiene/cough etiquette that encourages individuals to "cover your cough" and/or wear a mask is a source control measure. The use of enclosing devices for local exhaust ventilation (eg, booths for sputum induction or administration of aerosolized medication) is another example of source control.

Standard precautions. A group of infection prevention practices that apply to all patients, regardless of suspected or confirmed diagnosis or presumed infection status. Standard precautions represents a combination and expansion of universal precautions⁷⁷⁸ and body substance isolation.¹¹⁰⁹ Standard precautions are based on the principle that all blood, body fluids, secretions, excretions except sweat, nonintact skin, and mucous membranes may contain transmissible infectious agents. Standard precautions include hand hygiene and, depending on the anticipated exposure, use of gloves, gown, mask, eye protection, or face shield. In addition, equipment or items in the patient environment likely to have been contaminated with infectious fluids must be handled in a manner to prevent transmission of infectious agents (eg, wear gloves for

handling, contain heavily soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient).

Surgical mask. A device worn over the mouth and nose by operating room personnel during surgical procedures to protect both surgical patients and operating room personnel from transfer of microorganisms and body fluids. Surgical masks also are used to protect health care personnel from contact with large infectious droplets ($> 5 \mu\text{m}$ in size). According to draft guidance issued by the Food and Drug Administration on May 15, 2003, surgical masks are evaluated using standardized testing procedures for fluid resistance, bacterial filtration efficiency, differential pressure (air exchange), and flammability to mitigate the risks to health associated with the use of surgical masks. These specifications apply to any masks that are labeled surgical, laser, isolation, or dental or medical procedure (<http://www.fda.gov/cdrh/ode/guidance/094.html#4>). Surgical masks do not protect against inhalation of small particles or droplet nuclei and should not be confused with particulate respirators that are recommended for protection against selected airborne infectious agents (eg, *Mycobacterium tuberculosis*).

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References

- Garner JS. Guideline for isolation precautions in hospitals. The Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1996;17:53-80.
- Harris AD, Bradham DD, Baumgarten M, Zuckerman IH, Fink JC, Perencevich EN. The use and interpretation of quasi-experimental studies in infectious diseases. *Clin Infect Dis* 2004;38:1586-91.
- Morton V, Torgerson DJ. Effect of regression to the mean on decision making in health care. *BMJ* 2003;326:1083-4.
- Pocock SJ, Elbourne DR. Randomized trials or observational tribulations? *N Engl J Med* 2000;342:1907-9.
- Ioannidis JP, Haidich AB, Pappa M, et al. Comparison of evidence of treatment effects in randomized and nonrandomized studies. *JAMA* 2001;286:821-30.
- Bent S, Shojania KG, Saint S. The use of systematic reviews and meta-analyses in infection control and hospital epidemiology. *Am J Infect Control* 2004;32:246-54.
- Harris AD, Lautenbach E, Perencevich E. A systematic review of quasi-experimental study designs in the fields of infection control and antibiotic resistance. *Clin Infect Dis* 2005;41:77-82.
- Evans R, Lloyd JF, Abouzelof RH, Taylor CW, Anderson VR, Samore MH. System-wide surveillance for clinical encounters by patients previously identified with MRSA and VRE. *Medinfo* 2004;2004:212-6.
- Srinivasan A, McDonald LC, Jernigan D, et al. Foundations of the severe acute respiratory syndrome preparedness and response plan for healthcare facilities. *Infect Control Hosp Epidemiol* 2004;25:1020-5.
- www.cdc.gov/flu/avian/professional/infect-control.htm.
- Centers for Disease Control and Prevention. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep* 2003;52:1-42.
- Centers for Disease Control and Prevention. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. *MMWR Recomm Rep* 2005;54:1-141.
- American Institute of Architects. Guidelines for design and construction of hospital and health care facilities. Washington, DC: American Institute of Architects Press; 2006.
- Centers for Disease Control and Prevention. Guidelines for preventing health care-associated pneumonia, 2003. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. *MMWR Recomm Rep* 2004;53:1-40.
- Centers for Disease Control and Prevention. Guidelines for preventing opportunistic infections among hematopoietic stem cell transplant recipients. Recommendations of CDC, the Infectious Disease Society of America, and the American Society of Blood and Marrow Transplantation. *MMWR Recomm Rep* 2000;49:1-125.
- Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force, Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America. *MMWR Recomm Rep* 2002; 51:1-45.
- Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control in healthcare personnel, 1998. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1998;19:407-63.
- Centers for Disease Control and Prevention. Recommendations for preventing transmission of infections among chronic hemodialysis patients. *MMWR Recomm Rep* 2001;50:1-43.
- Kohn WG, Collins AS, Cleveland JL, Harte JA, Eklund KJ, Malvitz DM. Guidelines for infection control in dental health-care settings, 2003. *MMWR Recomm Rep* 2003;52:1-61.
- Saiman L, Siegel J. Infection control recommendations for patients with cystic fibrosis: microbiology, important pathogens, and infection control practices to prevent patient-to-patient transmission. *Infect Control Hosp Epidemiol* 2003;24(5 Suppl):S6-S52.
- Varia M, Wilson S, Sarwal S, et al. Investigation of a nosocomial outbreak of severe acute respiratory syndrome (SARS) in Toronto, Canada. *CMAJ* 2003;169:285-92.
- Haley RW, Cushion NB, Tenover FC, et al. Eradication of endemic methicillin-resistant *Staphylococcus aureus* infections from a neonatal intensive care unit. *J Infect Dis* 1995;171:614-24.
- Bridges CB, Kuehnert MJ, Hall CB. Transmission of influenza: implications for control in health care settings. *Clin Infect Dis* 2003;37: 1094-101.
- Hall CB. Nosocomial respiratory syncytial virus infections: the "cold war" has not ended. *Clin Infect Dis* 2000;31:590-6.
- Campbell JR, Zaccaria E, Mason EO Jr, Baker CJ. Epidemiological analysis defining concurrent outbreaks of *Serratia marcescens* and methicillin-resistant *Staphylococcus aureus* in a neonatal intensive-care unit. *Infect Control Hosp Epidemiol* 1998;19:924-8.
- Pena C, Pujol M, Ardanuy C, et al. Epidemiology and successful control of a large outbreak due to *Klebsiella pneumoniae* producing extended-spectrum beta-lactamases. *Antimicrob Agents Chemother* 1998;42:53-8.
- Bonten MJ, Slaughter S, Ambergen AW, et al. The role of "colonization pressure" in the spread of vancomycin-resistant enterococci: an important infection control variable. *Arch Intern Med* 1998; 158:1127-32.
- Jenseni M, Ringertz SH, Berild D, Bell H, Espinoza R, Grinde B. Prolonged nosocomial outbreak of hepatitis A arising from an alcoholic with pneumonia. *Scand J Infect Dis* 1998;30:119-23.
- Zawacki A, O'Rourke E, Potter-Bynoe G, Maccone A, Harbarth S, Goldmann D. An outbreak of *Pseudomonas aeruginosa* pneumonia

- and bloodstream infection associated with intermittent otitis externa in a healthcare worker. *Infect Control Hosp Epidemiol* 2004;25:1083-9.
30. Foca M, Jakob K, Whittier S, et al. Endemic *Pseudomonas aeruginosa* infection in a neonatal intensive care unit. *N Engl J Med* 2000;343:695-700.
 31. Gupta A, Della-Latta P, Todd B, et al. Outbreak of extended-spectrum beta-lactamase-producing *Klebsiella pneumoniae* in a neonatal intensive care unit linked to artificial nails. *Infect Control Hosp Epidemiol* 2004;25:210-5.
 32. Boyce JM, Opal SM, Potter-Bynoe G, Medeiros AA. Spread of methicillin-resistant *Staphylococcus aureus* in a hospital after exposure to a health care worker with chronic sinusitis. *Clin Infect Dis* 1993;17:496-504.
 33. Fliegel PE, Weinstein WM. Rubella outbreak in a prenatal clinic: management and prevention. *Am J Infect Control* 1982;10:29-33.
 34. Atkinson WL, Markowitz LE, Adams NC, Seastrom GR. Transmission of measles in medical settings, United States, 1985-1989. *Am J Med* 1991;91:320S-4S.
 35. Carman WF, Elder AG, Wallace LA, et al. Effects of influenza vaccination of health-care workers on mortality of elderly people in long-term care: a randomised controlled trial. *Lancet* 2000;355:93-7.
 36. Centers for Disease Control and Prevention. Outbreaks of pertussis associated with hospitals: Kentucky, Pennsylvania, and Oregon, 2003. *MMWR Morb Mortal Wkly Rep* 2005;54:67-71.
 37. Mermel LA, McKay M, Dempsey J, Parenteau S. *Pseudomonas* surgical-site infections linked to a healthcare worker with onychomycosis. *Infect Control Hosp Epidemiol* 2003;24:749-52.
 38. Barnes GL, Callaghan SL, Kirkwood CD, Bogdanovic-Sakran N, Johnston LJ, Bishop RF. Excretion of serotype G1 rotavirus strains by asymptomatic staff: a possible source of nosocomial infection. *J Pediatr* 2003;142:722-5.
 39. Wang JT, Chang SC, Ko WJ, et al. A hospital-acquired outbreak of methicillin-resistant *Staphylococcus aureus* infection initiated by a surgeon carrier. *J Hosp Infect* 2001;47:104-9.
 40. Valenti WM, Pincus PH, Messner MK. Nosocomial pertussis: possible spread by a hospital visitor. *Am J Dis Child* 1980;134:520-1.
 41. Christie CD, Glover AM, Willke MJ, Marx ML, Reising SF, Hutchinson NM. Containment of pertussis in the regional pediatric hospital during the greater Cincinnati epidemic of 1993. *Infect Control Hosp Epidemiol* 1995;16:556-63.
 42. Munoz FM, Ong LT, Seavy D, Medina D, Correa A, Starke JR. Tuberculosis among adult visitors of children with suspected tuberculosis and employees at a children's hospital. *Infect Control Hosp Epidemiol* 2002;23:568-72.
 43. Garcia R, Raad I, Abi-Said D, et al. Nosocomial respiratory syncytial virus infections: prevention and control in bone marrow transplant patients. *Infect Control Hosp Epidemiol* 1997;18:412-6.
 44. Whimbey E, Champlin RE, Couch RB, et al. Community respiratory virus infections among hospitalized adult bone marrow transplant recipients. *Clin Infect Dis* 1996;22:778-82.
 45. Saiman L, O'Keefe M, Graham PL, et al. Hospital transmission of community-acquired methicillin-resistant *Staphylococcus aureus* among postpartum women. *Clin Infect Dis* 2003;37:1313-9.
 46. Bonten MJ, Slaughter S, Hayden MK, Nathan C, van Voorhis J, Weinstein RA. External sources of vancomycin-resistant enterococci for intensive care units. *Crit Care Med* 1998;26:2001-4.
 47. Flynn DM, Weinstein RA, Nathan C, Gaston MA, Kabins SA. Patients' endogenous flora as the source of "nosocomial" *Enterobacter* in cardiac surgery. *J Infect Dis* 1987;156:363-8.
 48. Olson B, Weinstein RA, Nathan C, Chamberlin W, Kabins SA. Epidemiology of endemic *Pseudomonas aeruginosa*: why infection control efforts have failed. *J Infect Dis* 1984;150:808-16.
 49. Perl TM, Cullen JJ, Wenzel RP, et al. Intranasal mupirocin to prevent postoperative *Staphylococcus aureus* infections. *N Engl J Med* 2002;346:1871-7.
 50. Toltzis P, Hoyer C, et al. Factors that predict preexisting colonization with antibiotic-resistant Gram-negative bacilli in patients admitted to a pediatric intensive care unit. *Pediatrics* 1999;103(4 Pt 1):719-23.
 51. Sarginson RE, Taylor N, Reilly N, Baines PB, Van Saene HK. Infection in prolonged pediatric critical illness: a prospective four-year study based on knowledge of the carrier state. *Crit Care Med* 2004;32:839-47.
 52. Silvestri L, Monti Bragadin C, Milanese M, et al. Are most ICU infections really nosocomial? A prospective observational cohort study in mechanically ventilated patients. *J Hosp Infect* 1999;42:125-33.
 53. Heggors JP, Phillips LG, Boertman JA, et al. The epidemiology of methicillin-resistant *Staphylococcus aureus* in a burn center. *J Burn Care Rehabil* 1988;9:610-2.
 54. Donskey CJ. The role of the intestinal tract as a reservoir and source for transmission of nosocomial pathogens. *Clin Infect Dis* 2004;39:219-26.
 55. Osterholm MT, Hedberg CW, Moore KA. The epidemiology of infectious diseases. In: G.L. M, Jr DRG, J.E. B, editors. Principles and practice of infectious diseases. 5th ed. Philadelphia: Churchill Livingstone; 2000. p 161-3.
 56. Thomsen RW, Hundborg HH, Lervang HH, Johnsen SP, Schonheyder HC, Sorensen HT. Risk of community-acquired pneumococcal bacteremia in patients with diabetes: a population-based case-control study. *Diabetes Care* 2004;27:1143-7.
 57. Carton JA, Maradona JA, Nuno FJ, Fernandez-Alvarez R, Perez-Gonzalez F, Asensi V. Diabetes mellitus and bacteraemia: a comparative study between diabetic and non-diabetic patients. *Eur J Med* 1992;1:281-7.
 58. Hirschtick RE, Glassroth J, Jordan MC, et al. Bacterial pneumonia in persons infected with the human immunodeficiency virus. Pulmonary Complications of HIV Infection Study Group. *N Engl J Med* 1995;333:845-51.
 59. Rosenberg AL, Senoff MG, Atiyeh L, Wagner R, Bojanowski L, Zimmerman JE. The importance of bacterial sepsis in intensive care unit patients with acquired immunodeficiency syndrome: implications for future care in the age of increasing antiretroviral resistance. *Crit Care Med* 2001;29:548-56.
 60. Malone JL, Ijaz K, Lambert L, et al. Investigation of healthcare-associated transmission of *Mycobacterium tuberculosis* among patients with malignancies at three hospitals and at a residential facility. *Cancer* 2004;101:2713-21.
 61. Fishman JA, Rubin RH. Infection in organ transplant recipients. *N Engl J Med* 1998;338:1741-51.
 62. Safdar N, Kluger DM, Maki DG. A review of risk factors for catheter-related bloodstream infection caused by percutaneously inserted, noncuffed central venous catheters: implications for preventive strategies. *Medicine (Baltimore)* 2002;81:466-79.
 63. Jarvis WR, Robles B. Nosocomial infections in pediatric patients. *Adv Pediatr Infect Dis* 1996;12:243-59.
 64. Yogaraj JS, Elward AM, Fraser VJ. Rate, risk factors, and outcomes of nosocomial primary bloodstream infection in pediatric intensive care unit patients. *Pediatrics* 2002;110:481-5.
 65. Donlan RM. Biofilms: microbial life on surfaces. *Emerg Infect Dis* 2002;8:881-90.
 66. Rosen HR. Acquisition of hepatitis C by a conjunctival splash. *Am J Infect Control* 1997;25:242-7.
 67. Beltrami EM, Kozak A, Williams IT, et al. Transmission of HIV and hepatitis C virus from a nursing home patient to a health care worker. *Am J Infect Control* 2003;31:168-75.
 68. Obasanjo OO, Wu P, Conlon M, et al. An outbreak of scabies in a teaching hospital: lessons learned. *Infect Control Hosp Epidemiol* 2001;22:13-8.
 69. Andersen BM, Haugen H, Rasch M, Heldal Haugen A, Tageson A. Outbreak of scabies in Norwegian nursing homes and home care patients: control and prevention. *J Hosp Infect* 2000;45:160-4.

70. Avitzur Y, Amir J. Herpetic whitlow infection in a general pediatrician: an occupational hazard. *Infection* 2002;30:234-6.
71. Adams G, Stover BH, Keenlyside RA, et al. Nosocomial herpetic infections in a pediatric intensive care unit. *Am J Epidemiol* 1981;113:126-32.
72. Bhalla A, Pultz NJ, Gries DM, et al. Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. *Infect Control Hosp Epidemiol* 2004;25:164-7.
73. Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant enterococci via health care worker hands. *Arch Intern Med* 2005;165:302-7.
74. Brooks SE, Veal RO, Kramer M, Dore L, Schupf N, Adachi M. Reduction in the incidence of *Clostridium difficile*-associated diarrhea in an acute care hospital and a skilled nursing facility following replacement of electronic thermometers with single-use disposables. *Infect Control Hosp Epidemiol* 1992;13:98-103.
75. Centers for Disease Control and Prevention. Nosocomial hepatitis B virus infection associated with reusable fingerstick blood sampling devices, Ohio and New York City, 1996. *MMWR Morb Mortal Wkly Rep* 1997;46:217-21.
76. Desenclos JC, Bourdiol-Razes M, Rolin B, et al. Hepatitis C in a ward for cystic fibrosis and diabetic patients: possible transmission by spring-loaded finger-stick devices for self-monitoring of capillary blood glucose. *Infect Control Hosp Epidemiol* 2001;22:701-7.
77. Centers for Disease Control and Prevention. Transmission of hepatitis B virus among persons undergoing blood glucose monitoring in long-term care facilities, Mississippi, North Carolina, and Los Angeles County, California, 2003-2004. *MMWR Morb Mortal Wkly Rep* 2005;54:220-3.
78. Hall CB, Douglas RG Jr. Modes of transmission of respiratory syncytial virus. *J Pediatr* 1981;99:100-3.
79. Hall CB, Douglas RG Jr, Geiman JM. Possible transmission by fomites of respiratory syncytial virus. *J Infect Dis* 1980;141:98-102.
80. Buttery JP, Alabaster SJ, Heine RG, et al. Multiresistant *Pseudomonas aeruginosa* outbreak in a pediatric oncology ward related to bath toys. *Pediatr Infect Dis J* 1998;17:509-13.
81. Agerton T, Valway S, Gore B, et al. Transmission of a highly drug-resistant strain (strain W1) of *Mycobacterium tuberculosis*: community outbreak and nosocomial transmission via a contaminated bronchoscope. *JAMA* 1997;278:1073-7.
82. Bronowicki JP, Venard V, Botte C, et al. Patient-to-patient transmission of hepatitis C virus during colonoscopy. *N Engl J Med* 1997;337:237-40.
83. Michele TM, Cronin WA, Graham NM, et al. Transmission of *Mycobacterium tuberculosis* by a fiberoptic bronchoscope: identification by DNA fingerprinting. *JAMA* 1997;278:1093-5.
84. Schelenz S, French G. An outbreak of multidrug-resistant *Pseudomonas aeruginosa* infection associated with contamination of bronchoscopes and an endoscope washer-disinfector. *J Hosp Infect* 2000;46:23-30.
85. Weber DJ, Rutala WA. Lessons from outbreaks associated with bronchoscopy. *Infect Control Hosp Epidemiol* 2001;22:403-8.
86. Kirschke DL, Jones TF, Craig AS, et al. *Pseudomonas aeruginosa* and *Serratia marcescens* contamination associated with a manufacturing defect in bronchoscopes. *N Engl J Med* 2003;348:214-20.
87. Srinivasan A, Wolfenden LL, Song X, et al. An outbreak of *Pseudomonas aeruginosa* infections associated with flexible bronchoscopes. *N Engl J Med* 2003;348:221-7.
88. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: possible infection control implications. *Infect Control Hosp Epidemiol* 1997;18:622-7.
89. Zachary KC, Bayne PS, Morrison VJ, Ford DS, Silver LC, Hooper DC. Contamination of gowns, gloves, and stethoscopes with vancomycin-resistant enterococci. *Infect Control Hosp Epidemiol* 2001;22:560-4.
90. Perry C, Marshall R, Jones E. Bacterial contamination of uniforms. *J Hosp Infect* 2001;48:238-41.
91. Papineni RS, Rosenthal FS. The size distribution of droplets in the exhaled breath of healthy human subjects. *J Aerosol Med* 1997;10:105-16.
92. Wells WF. On airborne infection. Study II: droplets and droplet nuclei. *Am J Hygiene* 1934;20:611-8.
93. Loeb M, McGeer A, Henry B, et al. SARS among critical care nurses, Toronto. *Emerg Infect Dis* 2004;10:251-5.
94. Fowler RA, Guest CB, Lapinsky SE, et al. Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation. *Am J Respir Crit Care Med* 2004;169:1198-202.
95. Gehanno JF, Kohen-Couderc L, Lemeland JF, Leroy J. Nosocomial meningococemia in a physician. *Infect Control Hosp Epidemiol* 1999;20:564-5.
96. Scales D, et al. Illness in intensive-care staff after brief exposure to severe acute respiratory syndrome. *Emerg Infect Dis* 2003;9:1205-10.
97. Ensor E, Humphreys H, Peckham D, Webster C, Knox AJ. Is *Burkholderia (Pseudomonas) cepacia* disseminated from cystic fibrosis patients during physiotherapy? *J Hosp Infect* 1996;32:9-15.
98. Christian MD, Loutfy M, McDonald LC, et al. Possible SARS coronavirus transmission during cardiopulmonary resuscitation. *Emerg Infect Dis* 2004;10:287-93.
99. Valenzuela TD, Hooton TM, Kaplan EL, Schlievert P. Transmission of "toxic strep" syndrome from an infected child to a firefighter during CPR. *Ann Emerg Med* 1991;20:90-2.
100. Bassinet L, Matrat M, Njamkepo E, Aberrane S, Housset B, Guiso N. Nosocomial pertussis outbreak among adult patients and health-care workers. *Infect Control Hosp Epidemiol* 2004;25:995-7.
101. Wong TW, Lee CK, Tam W, et al. Cluster of SARS among medical students exposed to single patient, Hong Kong. *Emerg Infect Dis* 2004;10:269-76.
102. Pachucki CT, Pappas SA, Fuller GF, Krause SL, Lentino JR, Schaaff DM. Influenza A among hospital personnel and patients: implications for recognition, prevention, and control. *Arch Intern Med* 1989;149:77-80.
103. Feigin RD, Baker CJ, Herwaldt LA, Lampe RM, Mason EO, Whitney SE. Epidemic meningococcal disease in an elementary school classroom. *N Engl J Med* 1982;307:1255-7.
104. Dick EC, Jennings LC, Mink KA, Wartgow CD, Inhorn SL. Aerosol transmission of rhinovirus colds. *J Infect Dis* 1987;156:442-8.
105. Duguid JP. The size and duration of air-carriage of respiratory droplets and droplet nuclei. *J Hyg (Lond)* 1946;44:471-9.
106. Hall CB, Douglas RG Jr, Schnabel KC, Geiman JM. Infectivity of respiratory syncytial virus by various routes of inoculation. *Infect Immun* 1981;33:779-83.
107. Downie AV, Meiklejohn M, St Vincent L, Rao AR, Sundara Babu BV, Kempe CH. The recovery of smallpox virus from patients and their environment in a smallpox hospital. *Bull World Health Organ* 1965;33:615-22.
108. Fenner F, Henderson DA, Arita I, Jezek Z, Ladnyi ID. The epidemiology of smallpox. In: Smallpox and its eradication. Geneva, Switzerland: World Health Organization; 1988.
109. Cole EC, Cook CE. Characterization of infectious aerosols in health care facilities: an aid to effective engineering controls and preventive strategies. *Am J Infect Control* 1998;26:453-64.
110. Christie C, Mazon D, Hierholzer W Jr, Patterson JE. Molecular heterogeneity of *Acinetobacter baumannii* isolates during seasonal increase in prevalence. *Infect Control Hosp Epidemiol* 1995;16:590-4.
111. Musher DM. How contagious are common respiratory tract infections? *N Engl J Med* 2003;348:1256-66.
112. Steinberg P, White RJ, Fuld SL, Gutekunst RR, Chanock RM, Senterfit LB. Ecology of *Mycoplasma pneumoniae* infections in marine recruits at Parris Island, South Carolina. *Am J Epidemiol* 1969;89:62-73.

113. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet* 2003; 361:1519-20.
114. Hamburger M, Robertson OH. Expulsion of group A haemolytic streptococci in droplets and droplet nuclei by sneezing, coughing and talking. *Am J Med* 1948;4:690.
115. Centers for Disease Control and Prevention. Nosocomial meningococemia. *MMWR Morb Mortal Wkly Rep* 1978;27:358.
116. LeClair JM, Freeman J, Sullivan BF, Crowley CM, Goldmann DA. Prevention of nosocomial respiratory syncytial virus infections through compliance with glove and gown isolation precautions. *N Engl J Med* 1987;317:329-34.
117. Madge P, Paton JY, McColl JH, Mackie PL. Prospective controlled study of four infection-control procedures to prevent nosocomial infection with respiratory syncytial virus. *Lancet* 1992;340:1079-83.
118. Bassetti S, Bischoff WE, Walter M, et al. Dispersal of *Staphylococcus aureus* into the air associated with a rhinovirus infection. *Infect Control Hosp Epidemiol* 2005;26:196-203.
119. Eichenwald HF, Kotsevalov O, Fasso LA. The "cloud baby": an example of bacterial-viral interaction. *Am J Dis Child* 1960;100:161-73.
120. Sheretz RJ, Reagan DR, Hampton KD, et al. A cloud adult: the *Staphylococcus aureus*-virus interaction revisited. *Ann Intern Med* 1996;124:539-47.
121. Coronado VG, Beck-Sague CM, Hutton MD, et al. Transmission of multidrug-resistant *Mycobacterium tuberculosis* among persons with human immunodeficiency virus infection in an urban hospital: epidemiologic and restriction fragment length polymorphism analysis. *J Infect Dis* 1993;168:1052-5.
122. Bloch AB, Orenstein WA, Ewing WM, et al. Measles outbreak in a pediatric practice: airborne transmission in an office setting. *Pediatrics* 1985;75:676-83.
123. LeClair JM, Zaia JA, Levin MJ, Congdon RG, Goldmann DA. Airborne transmission of chickenpox in a hospital. *N Engl J Med* 1980;302:450-3.
124. Riley RL, Mills CC, Nyka W, et al. Aerial dissemination of pulmonary tuberculosis: a two-year study of contagion in a tuberculosis ward. *Am J Hygiene* 1959;70:185-96.
125. Beck-Sague C, Dooley SW, Hutton MD, et al. Hospital outbreak of multidrug-resistant *Mycobacterium tuberculosis* infections: factors in transmission to staff and HIV-infected patients. *JAMA* 1992;268:1280-6.
126. Centers for Disease Control and Prevention. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care facilities, 1994. *MMWR Recomm Rep* 1994;43:1-132.
127. Haley CE, McDonald RC, Rossi L, Jones WD Jr, Haley RW, Luby JP. Tuberculosis epidemic among hospital personnel. *Infect Control Hosp Epidemiol* 1989;10:204-10.
128. Wehrle PF, Posch J, Richter KH, Henderson DA. An airborne outbreak of smallpox in a German hospital and its significance with respect to other recent outbreaks in Europe. *Bull World Health Organ* 1970;43:669-79.
129. Gelfand HM, Posch J. The recent outbreak of smallpox in Meschede, West Germany. *Am J Epidemiol* 1971;93:234-7.
130. Moser MR, Bender TR, Margolis HS, Noble GR, Kendal AP, Ritter DG. An outbreak of influenza aboard a commercial airliner. *Am J Epidemiol* 1979;110:1-6.
131. Alford RH, Kasel JA, Gerone PJ, Knight V. Human influenza resulting from aerosol inhalation. *Proc Soc Exp Biol Med* 1966;122:800-4.
132. Chadwick PR, McCann R. Transmission of a small round structured virus by vomiting during a hospital outbreak of gastroenteritis. *J Hosp Infect* 1994;26:251-9.
133. Prince DS, Astry C, Vonderfecht S, Jakab G, Shen FM, Yolken RH. Aerosol transmission of experimental rotavirus infection. *Pediatr Infect Dis* 1986;5:218-22.
134. Centers for Disease Control and Prevention. Available from www.cdc.gov/ncidod/sars. Accessed.
135. Peiris JS, Yuen KY, Osterhaus AD, Stohr K. The severe acute respiratory syndrome. *N Engl J Med* 2003;349:2431-41.
136. Olsen SJ, Chang HL, Cheung TY, et al. Transmission of the severe acute respiratory syndrome on aircraft. *N Engl J Med* 2003;349:2416-22.
137. Wilder-Smith A, Leong HN, Villacian JS. In-flight transmission of severe acute respiratory syndrome (SARS): a case report. *J Travel Med* 2003;10:299-300.
138. Booth TF, Kournikakis B, Bastien N, et al. Detection of airborne severe acute respiratory syndrome (SARS) coronavirus and environmental contamination in SARS outbreak units. *J Infect Dis* 2005; 191:1472-7.
139. Yu IT, Li Y, Wong TW, et al. Evidence of airborne transmission of the severe acute respiratory syndrome virus. *N Engl J Med* 2004; 350:1731-9.
140. Centers for Disease Control and Prevention. Update: outbreak of severe acute respiratory syndrome worldwide. *MMWR Morb Mortal Wkly Rep* 2003;52:241-8.
141. Centers for Disease Control and Prevention. Cluster of severe acute respiratory syndrome cases among protected health-care workers, Toronto, Canada, April 2003. *MMWR Morb Mortal Wkly Rep* 2003;52:433-6.
142. Sawyer LA, Murphy JJ, Kaplan JE, et al. 25- to 30-nm virus particles associated with a hospital outbreak of acute gastroenteritis with evidence for airborne transmission. *Am J Epidemiol* 1988;127:1261-71.
143. Marks PJ, Vipond IB, Carlisle D, Deakin D, Fey RE, Caul EO. Evidence for airborne transmission of Norwalk-like virus (NLV) in a hotel restaurant. *Epidemiol Infect* 2000;124:481-7.
144. Salgado CD, Farr BM, Hall KK, Hayden FG. Influenza in the acute hospital setting. *Lancet Infect Dis* 2002;2:145-55.
145. Riley RL. Airborne infection. *Am J Med* 1974;57:466-75.
146. McLean R. General discussion. *Am Rev Respir Dis* 1961;83:36-8.
147. Cheesbrough JS, Green J, Gallimore CI, Wright PA, Brown DW. Widespread environmental contamination with Norwalk-like viruses (NLV) detected in a prolonged hotel outbreak of gastroenteritis. *Epidemiol Infect* 2000;125:93-8.
148. Marks PJ, Vipond IB, Regan FM, Wedgwood K, Fey RE, Caul EO. A school outbreak of Norwalk-like virus: evidence for airborne transmission. *Epidemiol Infect* 2003;131:727-36.
149. Roy CJ, Milton DK. Airborne transmission of communicable infection: the elusive pathway. *N Engl J Med* 2004;350:1710-2.
150. Dull PM, Wilson KE, Kournikakis B, et al. *Bacillus anthracis* aerosolization associated with a contaminated mail-sorting machine. *Emerg Infect Dis* 2002;8:1044-7.
151. Weis CP, Intrepido AJ, Miller AK, et al. Secondary aerosolization of viable *Bacillus anthracis* spores in a contaminated US Senate Office. *JAMA* 2002;288:2853-8.
152. Patterson JE, Zidouh A, Minitier P, Andriole VT, Patterson TF. Hospital epidemiologic surveillance for invasive aspergillosis: patient demographics and the utility of antigen detection. *Infect Control Hosp Epidemiol* 1997;18:104-8.
153. Arnou PM, Andersen RL, Mainous PD, Smith EJ. Pulmonary aspergillosis during hospital renovation. *Am Rev Respir Dis* 1978;118:49-53.
154. Pegues DA, Lasker BA, McNeil MM, Hamm PM, Lundal JL, Kubak BM. Cluster of cases of invasive aspergillosis in a transplant intensive care unit: evidence of person-to-person airborne transmission. *Clin Infect Dis* 2002;34:412-6.
155. Buffington J, Reporter R, Lasker BA, et al. Investigation of an epidemic of invasive aspergillosis: utility of molecular typing with the use of random amplified polymorphic DNA probes. *Pediatr Infect Dis J* 1994;13:386-93.
156. Krasinski K, Holzman RS, Hanna B, Greco MA, Graff M, Bhogal M. Nosocomial fungal infection during hospital renovation. *Infect Control* 1985;6:278-82.

157. Humphreys H. Positive-pressure isolation and the prevention of invasive aspergillosis: what is the evidence? *J Hosp Infect* 2004;56:93-100.
158. Thio CL, Smith D, Merz WG, et al. Refinements of environmental assessment during an outbreak investigation of invasive aspergillosis in a leukemia and bone marrow transplant unit. *Infect Control Hosp Epidemiol* 2000;21:18-23.
159. Anaissie EJ, Stratton SL, Dignani MC, et al. Pathogenic *Aspergillus* species recovered from a hospital water system: a 3-year prospective study. *Clin Infect Dis* 2002;34:780-9.
160. Centers for Disease Control and Prevention. Prevention of invasive group A streptococcal disease among household contacts of case patients and among postpartum and postsurgical patients: recommendations from the Centers for Disease Control and Prevention. *Clin Infect Dis* 2002;35:950-9.
161. Gruteke P, van Belkum A, Schouls LM, et al. Outbreak of group A streptococci in a burn center: use of pheno- and genotypic procedures for strain tracking. *J Clin Microbiol* 1996;34:114-8.
162. Greene CM, Van Beneden CA, Javadi M, et al. Cluster of deaths from group A streptococcus in a long-term care facility, Georgia, 2001. *Am J Infect Control* 2005;33:108-13.
163. Sabria M, Campins M. Legionnaires' disease: update on epidemiology and management options. *Am J Respir Med* 2003;2:235-43.
164. Bille J, Marchetti O, Calandra T. Changing face of health care-associated fungal infections. *Curr Opin Infect Dis* 2005;18:314-9.
165. Hall IC, O'Toole E. Intestinal flora in newborn infants with a description of a new pathogenic anaerobe, *Bacillus difficilis*. *Am J Dis Child* 1935;49:390-402.
166. George WL, Sutter VL, Finegold SM. Antimicrobial agent-induced diarrhea: a bacterial disease. *J Infect Dis* 1977;136:822-8.
167. McFarland LV, Mulligan ME, Kwok RY, Stamm WE. Nosocomial acquisition of *Clostridium difficile* infection. *N Engl J Med* 1989;320:204-10.
168. Pepin J, Valiquette L, Alary ME, et al. *Clostridium difficile*-associated diarrhea in a region of Quebec from 1991 to 2003: a changing pattern of disease severity. *CMAJ* 2004;171:466-72.
169. Agency HP. Outbreak of *Clostridium difficile* infection in a hospital in southeast England. *Commun Dis Rep CDR Wkly* 2005;31:.
170. Koopmans M, Wilbrink B, Conyn M, et al. Transmission of H7N7 avian influenza A virus to human beings during a large outbreak in commercial poultry farms in the Netherlands. *Lancet* 2004;363:587-93.
171. McDonald LC, Killgore GE, Thompson A, et al. An epidemic, toxin gene-variant strain of *Clostridium difficile*. *N Engl J Med* 2005;353:2433-41.
172. Loo VG, Poirier L, Miller MA, et al. A predominantly clonal multi-institutional outbreak of *Clostridium difficile*-associated diarrhea with high morbidity and mortality. *N Engl J Med* 2005;353:2442-9.
173. Warny M, Pepin J, Fang A, et al. Toxin production by an emerging strain of *Clostridium difficile* associated with outbreaks of severe disease in North America and Europe. *Lancet* 2005;366:1079-84.
174. Layton BAML, Gerding DN, Liedtke LA, Strausbaugh LJ. Perceived increases in the incidence and severity of *Clostridium difficile* disease: an emerging threat that continues to unfold. Presented at the 15th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America, Los Angeles, CA, 2005.
175. Sohn S, Climo M, Diekema D, et al. Varying rates of *Clostridium difficile*-associated diarrhea at prevention epicenter hospitals. *Infect Control Hosp Epidemiol* 2005;26:676-9.
176. Harrison PF, Lederberg J, editors. Institute of Medicine. Antimicrobial resistance: issues and options. Washington, DC: National Academy Press; 1998. p. 8-74.
177. Shlaes DM, Gerding DN, John JF Jr, et al. Society for Healthcare Epidemiology of America and Infectious Diseases Society of America Joint Committee on the Prevention of Antimicrobial Resistance guidelines for the prevention of antimicrobial resistance in hospitals. *Infect Control Hosp Epidemiol* 1997;18:275-91.
178. Whitener CJ, Park SY, Browne FA, et al. Vancomycin-resistant *Staphylococcus aureus* in the absence of vancomycin exposure. *Clin Infect Dis* 2004;38:1049-55.
179. Centers for Disease Control and Prevention. *Staphylococcus aureus* with reduced susceptibility to vancomycin, United States. *MMWR Morb Mortal Wkly Rep* 1997;46:765-6.
180. Centers for Disease Control and Prevention. *Staphylococcus aureus* resistant to vancomycin, United States, 2002. *MMWR Morb Mortal Wkly Rep* 2002;51:565-7.
181. Centers for Disease Control and Prevention. Public health dispatch: vancomycin-resistant *Staphylococcus aureus*, Pennsylvania, 2002. *MMWR Morb Mortal Wkly Rep* 2002;51:902.
182. Centers for Disease Control and Prevention. Vancomycin-resistant *Staphylococcus aureus*, New York, 2004. *MMWR Morb Mortal Wkly Rep* 2004;53:322-3.
183. Chang S, Sievert DM, Hageman JC, et al. Infection with vancomycin-resistant *Staphylococcus aureus* containing the *vanA* resistance gene. *N Engl J Med* 2003;348:1342-7.
184. Fridkin SK, Hageman J, McDougal LK, et al. Epidemiological and microbiological characterization of infections caused by *Staphylococcus aureus* with reduced susceptibility to vancomycin, United States, 1997-2001. *Clin Infect Dis* 2003;36:429-39.
185. Gold HS, Moellering RC Jr. Antimicrobial drug resistance. *N Engl J Med* 1996;335:1445-53.
186. Hageman JC, Pegues DA, Jepson C, et al. Vancomycin-intermediate *Staphylococcus aureus* in a home health care patient. *Emerg Infect Dis* 2001;7:1023-5.
187. Harwell JI, Brown RB. The drug-resistant pneumococcus: clinical relevance, therapy, and prevention. *Chest* 2000;117:530-41.
188. Jones RN. Resistance patterns among nosocomial pathogens: trends over the past few years. *Chest* 2001;119(2 Suppl):397S-404S.
189. Murray BE. Vancomycin-resistant enterococcal infections. *N Engl J Med* 2000;342:710-21.
190. Neuhauser MM, Weinstein RA, Rydman R, Danziger LH, Karam G, Quinn JP. Antibiotic resistance among Gram-negative bacilli in US intensive care units: implications for fluoroquinolone use. *JAMA* 2003;289:885-8.
191. Pitout JD, Sanders CC, Sanders WE Jr. Antimicrobial resistance with focus on beta-lactam resistance in Gram-negative bacilli. *Am J Med* 1997;103:51-9.
192. Rotun SS, McMath V, Schoonmaker DJ, et al. *Staphylococcus aureus* with reduced susceptibility to vancomycin isolated from a patient with fatal bacteremia. *Emerg Infect Dis* 1999;5:147-9.
193. Smith TL, Pearson ML, Wilcox KR, et al. Emergence of vancomycin resistance in *Staphylococcus aureus*. Glycopeptide-Intermediate *Staphylococcus aureus* Working Group. *N Engl J Med* 1999;340:493-501.
194. Srinivasan A, Dick JD, Perl TM. Vancomycin resistance in staphylococci. *Clin Microbiol Rev* 2002;15:430-8.
195. Hyle EP, Lipworth AD, Zaoutis TE, et al. Risk factors for increasing multidrug resistance among extended-spectrum β -lactamase-producing *Escheria coli* and *Klebsiella* species. *Clin Infect Dis* 2005;40:1317-24.
196. Gleich S, Morad Y, Echague R, et al. *Streptococcus pneumoniae* serotype 4 outbreak in a home for the aged: report and review of recent outbreaks. *Infect Control Hosp Epidemiol* 2000;21:711.
197. Fry AM, Udeagu CC, Soriano-Gabarro M, et al. Persistence of fluoroquinolone-resistant, multidrug-resistant *Streptococcus pneumoniae* in a long-term-care facility: efforts to reduce intrafacility transmission. *Infect Control Hosp Epidemiol* 2005;26:239-47.
198. Carter RJ, Sorenson G, Heffernan R, et al. Failure to control an outbreak of multidrug-resistant *Streptococcus pneumoniae* in a long-term-care facility: emergence and ongoing transmission of a fluoroquinolone-resistant strain. *Infect Control Hosp Epidemiol* 2005;26:248-55.
199. Blok HE, Troelstra A, Kamp-Hopmans TE, et al. Role of healthcare workers in outbreaks of methicillin-resistant *Staphylococcus aureus*: a

- 10-year evaluation from a Dutch university hospital. *Infect Control Hosp Epidemiol* 2003;24:679-85.
200. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and enterococcus. *Infect Control Hosp Epidemiol* 2003;24:362-86.
 201. Tammelin A, Klotz F, Hambraeus A, Stahle E, Ransjo U. Nasal and hand carriage of *Staphylococcus aureus* in staff at a Department for Thoracic and Cardiovascular Surgery: endogenous or exogenous source? *Infect Control Hosp Epidemiol* 2003;24:686-9.
 202. Centers for Disease Control and Prevention. Biological and chemical terrorism: strategic plan for preparedness and response. Recommendations of the CDC Strategic Planning Workgroup. *MMWR Recomm Rep* 2000;49:1-14.
 203. Inglesby TV, O'Toole T, Henderson DA, et al. Anthrax as a biological weapon, 2002: updated recommendations for management. *JAMA* 2002;287:2236-52.
 204. Henderson DA, Inglesby TV, Bartlett JG, et al. Smallpox as a biological weapon: medical and public health management. Working Group on Civilian Biodefense. *JAMA* 1999;281:2127-37.
 205. www.bt.cdc.gov/agent/smallpox/.
 206. www.who.int/csr/disease/smallpox/en/.
 207. Kool JL. Risk of person-to-person transmission of pneumonic plague. *Clin Infect Dis* 2005;40:1166-72.
 208. Inglesby TV, Dennis DT, Henderson DA, et al. Plague as a biological weapon: medical and public health management. Working Group on Civilian Biodefense. *JAMA* 2000;283:2281-90.
 209. Arnon SS, Schechter R, Inglesby TV, et al. Botulinum toxin as a biological weapon: medical and public health management. *JAMA* 2001;285:1059-70.
 210. Dennis DT, Inglesby TV, Henderson DA, et al. Tularemia as a biological weapon: medical and public health management. *JAMA* 2001;285:2763-73.
 211. Centers for Disease Control and Prevention. Notice to readers update: management of patients with suspected viral hemorrhagic fever, United States. *MMWR Recomm Rep* 1995;44:475-9.
 212. Borio L, Inglesby T, Peters CJ, et al. Hemorrhagic fever viruses as biological weapons: medical and public health management. *JAMA* 2002;287:2391-405.
 213. Neff JM, Lane JM, Fulginiti VA, Henderson DA. Contact vaccinia: transmission of vaccinia from smallpox vaccination. *JAMA* 2002;288:1901-5.
 214. Sepkowitz KA. How contagious is vaccinia? *N Engl J Med* 2003;348:439-46.
 215. Lane JM, Fulginiti VA. Transmission of vaccinia virus and rationale for measures for prevention. *Clin Infect Dis* 2003;37:281-4.
 216. Centers for Disease Control and Prevention. Smallpox vaccination and adverse reactions: guidance for clinicians. *MMWR Morb Mortal Wkly Rep* 2003;52:1-28.
 217. Fulginiti VA, Papier A, Lane JM, Neff JM, Henderson DA. Smallpox vaccination: a review. Part II: adverse events. *Clin Infect Dis* 2003;37:251-71.
 218. www.smallpox.mil/event/SPSafetySum.asp.
 219. Centers for Disease Control and Prevention. Update: adverse events following civilian smallpox vaccination, United States, 2003. *MMWR Morb Mortal Wkly Rep* 2003;52:419-20.
 220. Centers for Disease Control and Prevention. Secondary and tertiary transfer of vaccinia virus among US military personnel, United States and worldwide, 2002-2004. *MMWR Morb Mortal Wkly Rep* 2004;53:103-5.
 221. Talbot TR, Ziel E, Doersam JK, LaFleur B, Tollefson S, Edwards KM. Risk of vaccinia transfer to the hands of vaccinated persons after smallpox immunization. *Clin Infect Dis* 2004;38:536-41.
 222. Hepburn MJ, Dooley DP, Murray CK, et al. Frequency of vaccinia virus isolation on semipermeable versus nonocclusive dressings covering smallpox vaccination sites in hospital personnel. *Am J Infect Control* 2004;32:126-30.
 223. Waibel KH, Ager EP, Topolski RL, Walsh DS. Randomized trial comparing vaccinia on the external surfaces of 3 conventional bandages applied to smallpox vaccination sites in primary vaccinees. *Clin Infect Dis* 2004;39:1004-7.
 224. Tenorio AR, Peebles M, Patri M, et al. Quantitative vaccinia cultures and evolution of vaccinia-specific CD8⁺ cytotoxic T-lymphocyte (CTL) responses in revaccinees [abstract 823]. Presented at the Infectious Diseases Society of America 41st annual meeting, San Diego, CA, October 2003.
 225. Wharton M, Strikas RA, Harpaz R, et al. Recommendations for using smallpox vaccine in a pre-event vaccination program: supplemental recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep* 2003;52:1-16.
 226. Centers for Disease Control and Prevention. Surveillance for Creutzfeldt-Jakob disease, United States. *MMWR Morb Mortal Wkly Rep* 1996;45:665-8.
 227. Johnson RT, Gibbs CJ Jr. Creutzfeldt-Jakob disease and related transmissible spongiform encephalopathies. *N Engl J Med* 1998;339:1994-2004.
 228. Brown P, Gajdusek DC, Gibbs CJ Jr, Asher DM. Potential epidemic of Creutzfeldt-Jakob disease from human growth hormone therapy. *N Engl J Med* 1985;313:728-31.
 229. Frasier SD, Foley TP Jr. Clinical review 58: Creutzfeldt-Jakob disease in recipients of pituitary hormones. *J Clin Endocrinol Metab* 1994;78:1277-9.
 230. Centers for Disease Control and Prevention. Update: Creutzfeldt-Jakob disease associated with cadaveric dura mater grafts, Japan, 1979-2003. *MMWR Morb Mortal Wkly Rep* 2003;52(48):1179-81.
 231. Lang CJ, Heckmann JG, Neundorfer B. Creutzfeldt-Jakob disease via dural and corneal transplants. *J Neurol Sci* 1998;160:128-39.
 232. el Hachimi KH, Chaunu MP, Cervenakova L, Brown P, Foncin JF. Putative neurosurgical transmission of Creutzfeldt-Jakob disease with analysis of donor and recipient: agent strains. *C R Acad Sci Ser III* 1997;320:319-28.
 233. Will RG, Matthews WB. Evidence for case-to-case transmission of Creutzfeldt-Jakob disease. *J Neurol Neurosurg Psychiatry* 1982;45:235-8.
 234. Bernoulli C, Siegfried J, Baumgartner G, et al. Danger of accidental person-to-person transmission of Creutzfeldt-Jakob disease by surgery. *Lancet* 1977;1:478-9.
 235. Rutala WA, Weber DJ. Creutzfeldt-Jakob disease: recommendations for disinfection and sterilization. *Clin Infect Dis* 2001;32:1348-56.
 236. Belay ED, Maddox RA, Williams ES, Miller MW, Gambetti P, Schonberger LB. Chronic wasting disease and potential transmission to humans. *Emerg Infect Dis* 2004;10:977-84.
 237. Collinge J, Sidle KC, Meads J, Ironside J, Hill AF. Molecular analysis of prion strain variation and the aetiology of "new variant" CJD. *Nature* 1996;383:685-90.
 238. Belay ED, Schonberger LB. The public health impact of prion diseases. *Annu Rev Public Health* 2005;26:191-212.
 239. Belay ED, Schonberger LB. Variant Creutzfeldt-Jakob disease and bovine spongiform encephalopathy. *Clin Lab Med* 2002;22:849-62.
 240. Hill AF, Butterworth RJ, Joiner S, et al. Investigation of variant Creutzfeldt-Jakob disease and other human prion diseases with tonsil biopsy samples. *Lancet* 1999;353:183-9.
 241. Evatt B. Creutzfeldt-Jakob disease and haemophilia: assessment of risk. *Haemophilia* 2000;6(Suppl 1):94-9.
 242. Chamberland ME. Emerging infectious agents: do they pose a risk to the safety of transfused blood and blood products? *Clin Infect Dis* 2002;34:797-805.
 243. Available from. Accessed.

244. Llewelyn CA, Hewitt PE, Knight RS, et al. Possible transmission of variant Creutzfeldt-Jakob disease by blood transfusion. *Lancet* 2004;363:417-21.
245. Peden AH, Head MW, Ritchie DL, Bell JE, Ironside JW. Preclinical vCJD after blood transfusion in a PRNP codon 129 heterozygous patient. *Lancet* 2004;364:527-9.
246. Brown P. Guidelines for high-risk autopsy cases: special precautions for Creutzfeldt-Jakob disease. In: Hutchins G, editor. *Autopsy performance and reporting*. Northfield (IL): College of American Pathologists; 1990. p. 68-74.
247. Drosten C, Gunther S, Preiser W, et al. Identification of a novel coronavirus in patients with severe acute respiratory syndrome. *N Engl J Med* 2003;348:1967-76.
248. Ksiazek TG, Erdman D, Goldsmith CS, et al. A novel coronavirus associated with severe acute respiratory syndrome. *N Engl J Med* 2003;348:1953-66.
249. Chan WM, Kwan YW, Wan HS, Leung CW, Chiu MC. Epidemiologic linkage and public health implication of a cluster of severe acute respiratory syndrome in an extended family. *Pediatr Infect Dis J* 2004;23:1156-9.
250. Leung CW, Kwan YW, Ko PW, et al. Severe acute respiratory syndrome among children. *Pediatrics* 2004;113:e535-43.
251. Bitnun A, Allen U, Heurter H, et al. Children hospitalized with severe acute respiratory syndrome-related illness in Toronto. *Pediatrics* 2003;112:e261.
252. Chow KY, Lee CE, Ling ML, Heng DM, Yap SG. Outbreak of severe acute respiratory syndrome in a tertiary hospital in Singapore, linked to an index patient with atypical presentation: epidemiological study. *BMJ* 2004;328:195.
253. Shen Z, Ning F, Zhou VV, et al. Super-spreading SARS events, Beijing, 2003. *Emerg Infect Dis* 2004;10:256-60.
254. Chen Y-C, Huang L-M, Chan C-C, Su C-P, Chang S-C, Chang Y-Y, et al. SARS in hospital emergency room. *Emerg Infect Dis* 2004;10:782-8.
255. Gamage B, Moore D, Copes R, Yassi A, Bryce E. Protecting health care workers from SARS and other respiratory pathogens: a review of the infection control literature. *Am J Infect Control* 2005;33:114-21.
256. Moore D, Gamage B, Bryce E, Copes R, Yassi A. Protecting health care workers from SARS and other respiratory pathogens: organizational and individual factors that affect adherence to infection control guidelines. *Am J Infect Control* 2005;33:88-96.
257. Dowell SF, Simmerman JM, Erdman DD, et al. Severe acute respiratory syndrome coronavirus on hospital surfaces. *Clin Infect Dis* 2004;39:652-7.
258. Public Health Guidance for Community-Level Preparedness and Response to Severe Acute Respiratory Syndrome (SARS). 2004. Available from <http://www.cdc.gov/ncidod/sars/guidance//occupational.htm>.
259. Le DH, Bloom SA, Nguyen QH, et al. Lack of SARS transmission among public hospital workers. Vietnam. *Emerg Infect Dis* 2004;10:265-8.
260. Lim PL, Kurup A, Gopalakrishna G, et al. Laboratory-acquired severe acute respiratory syndrome. *N Engl J Med* 2004;350:1740-5.
261. Centers for Disease Control and Prevention. 2003. Available from www.cdc.gov/ncidod/sars.
262. Reed KD, Melski JW, Graham MB, et al. The detection of monkeypox in humans in the Western Hemisphere. *N Engl J Med* 2004;350:342-50.
263. Anderson MG, Frenkel LD, Homann S, Guffey J. A case of severe monkeypox virus disease in an American child: emerging infections and changing professional values. *Pediatr Infect Dis J* 2003;22:1093-6.
264. Jezek Z, Fenner F. Human monkey pox. In: Melnick JL, editor. *Vol. 17. Monographs in virology*. Basel, Switzerland: S Karger; 1988. p. 81-102.
265. Marennikova SS, Jezek Z, Szczeniowski M, Mbudi PM, Vernet M. Contagiousness of monkey pox for humans: results of an investigation of 2 outbreaks of the infection in Zaire. *Zh Mikrobiol Epidemiol Immunobiol* 1985;38-43.
266. Jezek Z, Arita I, Mutombo M, Dunn C, Nakano JH, Szczeniowski M. Four generations of probable person-to-person transmission of human monkeypox. *Am J Epidemiol* 1986;123:1004-12.
267. Learned LA, Reynolds MG, Wassa DW, et al. Extended interhuman transmission of monkeypox in a hospital community in the Republic of the Congo, 2003. *Am J Trop Med Hyg* 2005;73:428-34.
268. Fleischauer AT, Kile JC, Davidson M, et al. Evaluation of human-to-human transmission of monkeypox from infected patients to health care workers. *Clin Infect Dis* 2005;40:689-94.
269. Likos AM, Sammons SA, Olson VA, et al. A tale of two clades: monkeypox viruses. *J Gen Virol* 2005;86(Pt 10):2661-72.
270. Fine PE, Jezek Z, Grab B, Dixon H. The transmission potential of monkeypox virus in human populations. *Int J Epidemiol* 1988;17:643-50.
271. Jezek Z, Grab B, Paluku KM, Szczeniowski MV. Human monkeypox: disease pattern, incidence and attack rates in a rural area of north-east Zaire. *Trop Geogr Med* 1988;40:73-83.
272. Centers for Disease Control. Norwalk-like viruses: public health consequences and outbreak management. *MMWR Recomm Rep* 2001;50:1-18.
273. Evans MR, Meldrum R, Lane W, et al. An outbreak of viral gastroenteritis following environmental contamination at a concert hall. *Epidemiol Infect* 2002;129:355-60.
274. Wu HM, Fornek M, Kellogg JS, et al. A norovirus outbreak at a long-term-care facility: the role of environmental surface contamination. *Infect Control Hosp Epidemiol* 2005;26:802-10.
275. Duizer E, Schwab KJ, Neill FH, Atmar RL, Koopmans MP, Estes MK. Laboratory efforts to cultivate noroviruses. *J Gen Virol* 2004;85(Pt 1):79-87.
276. Zingg W, Colombo C, Jucker T, Bossart W, Ruef C. Impact of an outbreak of norovirus infection on hospital resources. *Infect Control Hosp Epidemiol* 2005;26:263-7.
277. Calderon-Margalit R, Sheffer R, Halperin T, Orr N, Cohen D, Shohat T. A large-scale gastroenteritis outbreak associated with norovirus in nursing homes. *Epidemiol Infect* 2005;133:35-40.
278. Marx A, Shay DK, Noel JS, et al. An outbreak of acute gastroenteritis in a geriatric long-term-care facility: combined application of epidemiological and molecular diagnostic methods. *Infect Control Hosp Epidemiol* 1999;20:306-11.
279. Gellert GA, Waterman SH, Ewert D, et al. An outbreak of acute gastroenteritis caused by a small round structured virus in a geriatric convalescent facility. *Infect Control Hosp Epidemiol* 1990;11:459-64.
280. Cooper E, Blamey S. A norovirus gastroenteritis epidemic in a long-term-care facility. *Infect Control Hosp Epidemiol* 2005;26:256.
281. Navarro G, Sala RM, Segura F, et al. An outbreak of norovirus infection in a long-term-care facility. *Infect Control Hosp Epidemiol* 2005;26:259.
282. Green KY, Belliot G, Taylor JL, et al. A predominant role for Norwalk-like viruses as agents of epidemic gastroenteritis in Maryland nursing homes for the elderly. *J Infect Dis* 2002;185:133-46.
283. Widdowson MA, Cramer EH, Hadley L, et al. Outbreaks of acute gastroenteritis on cruise ships and on land: identification of a predominant circulating strain of norovirus, United States, 2002. *J Infect Dis* 2004;190:27-36.
284. Centers for Disease Control and Prevention. Outbreaks of gastroenteritis associated with noroviruses on cruise ships, United States, 2002. *MMWR Morb Mortal Wkly Rep* 2002;51:1112-5.
285. Centers for Disease Control and Prevention. Norovirus outbreak among evacuees from hurricane Katrina, Houston, Texas, September 2005. *MMWR Morb Mortal Wkly Rep* 2005;54:1016-8.

286. Mattner F, Mattner L, Borck HU, Gastmeier P. Evaluation of the impact of the source (patient versus staff) on nosocomial norovirus outbreak severity. *Infect Control Hosp Epidemiol* 2005;26:268-72.
287. Isakbaeva ET, Bulens SN, Beard RS, et al. Norovirus and child care: challenges in outbreak control. *Pediatr Infect Dis J* 2005;24:561-3.
288. Kapikian AZ, Estes MK, Chanock RM. Norwalk group of viruses. In: Fields BN, Knipe DM, Howley PM, editors. *Fields virology*. 3rd ed. Philadelphia: Lippincott-Raven; 1996. p. 783-810.
289. Duizer E, Bijkerk P, Rockx B, De Groot A, Twisk F, Koopmans M. Inactivation of caliciviruses. *Appl Environ Microbiol* 2004;70:4538-43.
290. Doultree JC, Druce JD, Birch CJ, Bowden DS, Marshall JA. Inactivation of feline calicivirus, a Norwalk virus surrogate. *J Hosp Infect* 1999;41:51-7.
291. Barker J, Vipond IB, Bloomfield SF. Effects of cleaning and disinfection in reducing the spread of norovirus contamination via environmental surfaces. *J Hosp Infect* 2004;58:42-9.
292. Gulati BR, Allwood PB, Hedberg CW, Goyal SM. Efficacy of commonly used disinfectants for the inactivation of calicivirus on strawberry, lettuce, and a food-contact surface. *J Food Prot* 2001;64:1430-4.
293. Gehrke C, Steinmann J, Goroncy-Bernes P. Inactivation of feline calicivirus, a surrogate of norovirus (formerly Norwalk-like viruses), by different types of alcohol in vitro and in vivo. *J Hosp Infect* 2004;56:49-55.
294. Hutson AM, Atmar RL, Graham DY, Estes MK. Norwalk virus infection and disease is associated with ABO histo-blood group type. *J Infect Dis* 2002;185:1335-7.
295. National Center for Infectious Diseases, Division of Viral and Rickettsial Diseases. Available from. Accessed.
296. LeDuc JW. Epidemiology of hemorrhagic fever viruses. *Rev Infect Dis* 1989;11(Suppl 4):S730-5.
297. Roels TH, Bloom AS, Buffington J, et al. Ebola hemorrhagic fever, Kikwit, Democratic Republic of the Congo, 1995: risk factors for patients without a reported exposure. *J Infect Dis* 1999;179(Suppl 1):S92-7.
298. Suleiman MN, Muscat-Baron JM, Harries JR, et al. Congo/Crimean haemorrhagic fever in Dubai: an outbreak at the Rashid Hospital. *Lancet* 1980;21:939-41.
299. Monath TP, Mertens PE, Patton R, et al. A hospital epidemic of Lassa fever in Zoror, Liberia, March-April 1972. *Am J Trop Med Hyg* 1973;22:773-9.
300. Dowell SF, Mukunu R, Ksiazek TG, Khan AS, Rollin PE, Peters CJ. Transmission of Ebola hemorrhagic fever: a study of risk factors in family members, Kikwit, Democratic Republic of the Congo, 1995. *J Infect Dis* 1999;179(Suppl 1):S87-91.
301. Peters CJ. Marburg and Ebola: arming ourselves against the deadly filoviruses. *N Engl J Med* 2005;352:2571-3.
302. Ebola haemorrhagic fever in Zaire, 1976. *Bull World Health Organ* 1978;56:271-93.
303. Emond RT, Evans B, Bowen ET, Lloyd G. A case of Ebola virus infection. *Br Med J* 1977;2:541-4.
304. Zaki SR, Shieh WJ, Greer PW, et al. A novel immunohistochemical assay for the detection of Ebola virus in skin: implications for diagnosis, spread, and surveillance of Ebola hemorrhagic fever. *Commission de Lutte contre les Epidemies a Kikwit. J Infect Dis* 1999;179(Suppl 1):S36-47.
305. Khan AS, Tshioko FK, Heymann DL, et al. The reemergence of Ebola hemorrhagic fever, Democratic Republic of the Congo, 1995. *Commission de Lutte contre les Epidemies a Kikwit. J Infect Dis* 1999;179(Suppl 1):S76-86.
306. Muyembe-Tamfum JJ, Kipasa M, Kiyungu C, Colebunders R. Ebola outbreak in Kikwit, Democratic Republic of the Congo: discovery and control measures. *J Infect Dis* 1999;179(Suppl 1):S259-62.
307. Haas WH, Breuer T, Pfaff G, et al. Imported Lassa fever in Germany: surveillance and management of contact persons. *Clin Infect Dis* 2003;36:1254-8.
308. Simpson DI. Marburg agent disease in monkeys. *Trans R Soc Trop Med Hyg* 1969;63:303-9.
309. Jaax NK, Davis KJ, Geisbert TJ, et al. Lethal experimental infection of rhesus monkeys with Ebola-Zaire (Mayinga) virus by the oral and conjunctival route of exposure. *Arch Pathol Lab Med* 1996;120:140-55.
310. Stephenson EH, Larson EW, Dominik JW. Effect of environmental factors on aerosol-induced Lassa virus infection. *J Med Virol* 1984;14:295-303.
311. Johnson E, Jaax N, White J, Jahrling P. Lethal experimental infections of rhesus monkeys by aerosolized Ebola virus. *Int J Exp Pathol* 1995;76:227-36.
312. Jaax N, Jahrling P, Geisbert T, et al. Transmission of Ebola virus (Zaire strain) to uninfected control monkeys in a biocontainment laboratory. *Lancet* 1995;346:1669-71.
313. www.bt.cdc.gov/agent/vhfl/.
314. Nguyen GT, Proctor SE, Sinkowitz-Cochran RL, Garrett DO, Jarvis WR. Status of infection surveillance and control programs in the United States, 1992-1996. *Association for Professionals in Infection Control and Epidemiology. Am J Infect Control* 2000;28:392-400.
315. Richards C, Emori TG, Edwards J, Fridkin S, Tolson J, Gaynes R. Characteristics of hospitals and infection control professionals participating in the National Nosocomial Infections Surveillance System 1999. *Am J Infect Control* 2001;29:400-3.
316. Wenzel RP, Thompson RL, Landry SM, et al. Hospital-acquired infections in intensive care unit patients: an overview with emphasis on epidemics. *Infect Control* 1983;4:371-5.
317. Wenzel RP, Gennings C. Bloodstream infections due to *Candida* species in the intensive care unit: identifying especially high-risk patients to determine prevention strategies. *Clin Infect Dis* 2005;41(Suppl 6):S389-93.
318. San Miguel LG, Cobo J, Otheo E, Sanchez-Sousa A, Abaira V, Moreno S. Secular trends of candidemia in a large tertiary-care hospital from 1988 to 2000: emergence of *Candida parapsilosis*. *Infect Control Hosp Epidemiol* 2005;26:548-52.
319. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004;32:470-85.
320. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in medical intensive care units in the United States. *National Nosocomial Infections Surveillance System. Crit Care Med* 1999;27:887-92.
321. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in combined medical-surgical intensive care units in the United States. *Infect Control Hosp Epidemiol* 2000;21:510-5.
322. Hugonnet S, Eggimann P, Borst F, Maricot P, Chevrolet JC, Pittet D. Impact of ventilator-associated pneumonia on resource utilization and patient outcome. *Infect Control Hosp Epidemiol* 2004;25:1090-6.
323. O'Neill JM, Schutze GE, Heulitt MJ, Simpson PM, Taylor BJ. Nosocomial infections during extracorporeal membrane oxygenation. *Intensive Care Med* 2001;27:1247-53.
324. Villegas MV, Hartstein AI. *Acinetobacter* outbreaks, 1977-2000. *Infect Control Hosp Epidemiol* 2003;24:284-95.
325. Gordon SM, Schmitt SK, Jacobs M, et al. Nosocomial bloodstream infections in patients with implantable left ventricular assist devices. *Ann Thorac Surg* 2001;72:725-30.
326. Giamarellou H. Nosocomial cardiac infections. *J Hosp Infect* 2002;50:91-105.
327. Fridkin SK. Increasing prevalence of antimicrobial resistance in intensive care units. *Crit Care Med* 2001;29(4 Suppl):N64-8.
328. Kollef MH, Fraser VJ. Antibiotic resistance in the intensive care unit. *Ann Intern Med* 2001;134:298-314.
329. Fridkin SK, Edwards JR, Courval JM, et al. The effect of vancomycin and third-generation cephalosporins on prevalence of vancomycin-

- resistant enterococci in 126 US adult intensive care units. *Ann Intern Med* 2001;135:175-83.
330. Crnich CJ, Safdar N, Maki DG. The role of the intensive care unit environment in the pathogenesis and prevention of ventilator-associated pneumonia. *Respir Care* 2005;50:813-38.
331. Knaus WA, Wagner DP, Zimmerman JE, Draper EA. Variations in mortality and length of stay in intensive care units. *Ann Intern Med* 1993;118:753-61.
332. Villarino ME, Stevens LE, Schable B, et al. Risk factors for epidemic *Xanthomonas maltophilia* infection/colonization in intensive care unit patients. *Infect Control Hosp Epidemiol* 1992;13:201-6.
333. Sanchez V, Vazquez JA, Barth-Jones D, Dembry L, Sobel JD, Zervos MJ. Nosocomial acquisition of *Candida parapsilosis*: an epidemiologic study. *Am J Med* 1993;94:577-82.
334. Husni RN, Goldstein LS, Arroliga AC, et al. Risk factors for an outbreak of multidrug-resistant *Acinetobacter* nosocomial pneumonia among intubated patients. *Chest* 1999;115:1378-82.
335. McDonald LC, Walker M, Carson L, et al. Outbreak of *Acinetobacter* spp bloodstream infections in a nursery associated with contaminated aerosols and air conditioners. *Pediatr Infect Dis J* 1998;17:716-22.
336. Trick WE, Kioski CM, Howard KM, et al. Outbreak of *Pseudomonas aeruginosa* ventriculitis among patients in a neurosurgical intensive care unit. *Infect Control Hosp Epidemiol* 2000;21:204-8.
337. Guidry GG, Black-Payne CA, Payne DK, Jamison RM, George RB, Bocchini JA Jr. Respiratory syncytial virus infection among intubated adults in a university medical intensive care unit. *Chest* 1991;100:1377-84.
338. Wurtz R, Karajovic M, Dacumos E, Jovanovic B, Hanumadass M. Nosocomial infections in a burn intensive care unit. *Burns* 1995;21:181-4.
339. Rodgers GL, Mortensen J, Fisher MC, Lo A, Cresswell A, Long SS. Predictors of infectious complications after burn injuries in children. *Pediatr Infect Dis J* 2000;19:990-5.
340. Pruitt BA Jr, McManus AT, Kim SH, Goodwin CW. Burn wound infections: current status. *World J Surg* 1998;22:135-45.
341. Weber J, editor. Epidemiology of infections and strategies for control in burn care and therapy. St. Louis: Mosby; 1998.
342. Heggors JP, McCoy L, Reisner B, Smith M, Edgar P, Ramirez RJ. Alternate antimicrobial therapy for vancomycin-resistant enterococci burn wound infections. *J Burn Care Rehabil* 1998;19:399-403.
343. Sheridan RL, Weber J, Benjamin J, Pasternack MS, Tompkins RG. Control of methicillin-resistant *Staphylococcus aureus* in a pediatric burn unit. *Am J Infect Control* 1994;22:340-5.
344. Matsumura H, Yoshizawa N, Narumi A, Harunari N, Sugamata A, Watanabe K. Effective control of methicillin-resistant *Staphylococcus aureus* in a burn unit. *Burns* 1996;22:283-6.
345. McGregor JC. Profile of the first four years of the Regional Burn Unit based at St. John's Hospital, West Lothian (1992-1996). *J R Coll Surg Edinb* 1998;43:45-8.
346. Desai MH, Rutan RL, Heggors JP, Herndon DN. *Candida* infection with and without nystatin prophylaxis: an 11-year experience with patients with burn injury. *Arch Surg* 1992;127:159-62.
347. Ekenna O, Sherertz RJ, Bingham H. Natural history of bloodstream infections in a burn patient population: the importance of candidemia. *Am J Infect Control* 1993;21:189-95.
348. Bowser-Wallace BH, Graves DB, Caldwell FT. An epidemiological profile and trend analysis of wound flora in burned children: 7 years' experience. *Burns Incl Therm Inj* 1984;11:16-25.
349. Tredget EE, Shankowsky HA, Rennie R, Burrell RE, Logsetty S. *Pseudomonas* infections in the thermally injured patient. *Burns* 2004;30:3-26.
350. Edgar P, Mlcak R, Desai M, Linares HA, Phillips LG, Heggors JP. Containment of a multiresistant *Serratia marcescens* outbreak. *Burns* 1997;23:15-8.
351. Embil JM, McLeod JA, Al-Barrak AM, et al. An outbreak of methicillin-resistant *Staphylococcus aureus* on a burn unit: potential role of contaminated hydrotherapy equipment. *Burns* 2001;27:681-8.
352. Meier PA, Carter CD, Wallace SE, Hollis RJ, Pfaller MA, Herwaldt LA. A prolonged outbreak of methicillin-resistant *Staphylococcus aureus* in the burn unit of a tertiary medical center. *Infect Control Hosp Epidemiol* 1996;17:798-802.
353. Snyder LL, Wiebelhaus P, Boon SE, Morin RA, Goering R. Methicillin-resistant *Staphylococcus aureus* eradication in a burn center. *J Burn Care Rehabil* 1993;14(2 Pt 1):164-8.
354. May AK, Melton SM, McGwin G, Cross JM, Moser SA, Rue LW. Reduction of vancomycin-resistant enterococcal infections by limitation of broad-spectrum cephalosporin use in a trauma and burn intensive care unit. *Shock* 2000;14:259-64.
355. Sheridan RL, Weber JM, Budkevich LG, Tompkins RG. Candidemia in the pediatric patient with burns. *J Burn Care Rehabil* 1995;16:440-3.
356. Mayhall CG. The epidemiology of burn wound infections: then and now. *Clin Infect Dis* 2003;37:543-50.
357. McManus AT, Mason AD Jr, McManus WF, Pruitt BA Jr. A decade of reduced Gram-negative infections and mortality associated with improved isolation of burned patients. *Arch Surg* 1994;129:1306-9.
358. Bryce EA, Walker M, Scharf S, et al. An outbreak of cutaneous aspergillosis in a tertiary care hospital. *Infect Control Hosp Epidemiol* 1996;17:170-2.
359. Levenson C, Wohlford P, Djou J, Evans S, Zawacki B. Preventing postoperative burn wound aspergillosis. *J Burn Care Rehabil* 1991;12:132-5.
360. Tredget EE, Shankowsky HA, Joffe AM, et al. Epidemiology of infections with *Pseudomonas aeruginosa* in burn patients: the role of hydrotherapy. *Clin Infect Dis* 1992;15:941-9.
361. Wisplinghoff H, Perbix W, Seifert H. Risk factors for nosocomial bloodstream infections due to *Acinetobacter baumannii*: a case-control study of adult burn patients. *Clin Infect Dis* 1999;28:59-66.
362. Weber JM, Sheridan RL, Schulz JT, Tompkins RG, Ryan CM. Effectiveness of bacteria-controlled nursing units in preventing cross-colonization with resistant bacteria in severely burned children. *Infect Control Hosp Epidemiol* 2002;23:549-51.
363. Bayat A, Shaaban H, Dodgson A, Dunn KW. Implications for burn unit design following outbreak of multi-resistant *Acinetobacter* infection in an ICU and burn unit. *Burns* 2003;29:303-6.
364. Lee JJ, Marvin JA, Heimbach DM, Grube BJ, Engrav LH. Infection control in a burn center. *J Burn Care Rehabil* 1990;11:575-80.
365. Raymond J, Aujard Y. Nosocomial infections in pediatric patients: a European, multicenter prospective study. European Study Group. *Infect Control Hosp Epidemiol* 2000;21:260-3.
366. Campins M, Vaque J, Rossello J, et al. Nosocomial infections in pediatric patients: a prevalence study in Spanish hospitals. EPINE Working Group. *Am J Infect Control* 1993;21:58-63.
367. Allen U, Ford-Jones EL. Nosocomial infections in the pediatric patient: an update. *Am J Infect Control* 1990;18:176-93.
368. Grohskopf LA, Sinkowitz-Cochran RL, Garrett DO, et al. A national point-prevalence survey of pediatric intensive care unit-acquired infections in the United States. *J Pediatr* 2002;140:432-8.
369. Sohn AH, Garrett DO, Sinkowitz-Cochran RL, et al. Prevalence of nosocomial infections in neonatal intensive care unit patients: results from the first national point-prevalence survey. *J Pediatr* 2001;139:821-7.
370. Gaynes RP, Edwards JR, Jarvis WR, Culver DH, Tolson JS, Martone WJ. Nosocomial infections among neonates in high-risk nurseries in the United States. National Nosocomial Infections Surveillance System. *Pediatrics* 1996;98(3 Pt 1):357-61.
371. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in pediatric intensive care units in the United States. National

- Nosocomial Infections Surveillance System. *Pediatrics* 1999;103:e39.
372. Maltezos HC, Drancourt M. Nosocomial influenza in children. *J Hosp Infect* 2003;55:83-91.
 373. Moisiuk SE, Robson D, Klass L, et al. Outbreak of parainfluenza virus type 3 in an intermediate care neonatal nursery. *Pediatr Infect Dis J* 1998;17:49-53.
 374. Mullins JA, Erdman DD, Weinberg GA, et al. Human metapneumovirus infection among children hospitalized with acute respiratory illness. *Emerg Infect Dis* 2004;10:700-5.
 375. Hatherill M, Levin M, Lawrenson J, Hsiao NY, Reynolds L, Argent A. Evolution of an adenovirus outbreak in a multidisciplinary children's hospital. *J Paediatr Child Health* 2004;40:449-54.
 376. Langley JM, Hanakowski M. Variation in risk for nosocomial chickenpox after inadvertent exposure. *J Hosp Infect* 2000;44:224-6.
 377. Ratner AJ, Neu N, Jakob K, et al. Nosocomial rotavirus in a pediatric hospital. *Infect Control Hosp Epidemiol* 2001;22:299-301.
 378. Avila-Aguero ML, German G, Paris MM, Herrera JF. Toys in a pediatric hospital: are they a bacterial source? *Am J Infect Control* 2004;32:287-90.
 379. Nyqvist KH, Lutes LM. Co-bedding twins: a developmentally supportive care strategy. *J Obstet Gynecol Neonatal Nurs* 1998;27:450-6.
 380. Feldman R, Eidelman AI, Sirota L, Weller A. Comparison of skin-to-skin (kangaroo) and traditional care: parenting outcomes and pre-term infant development. *Pediatrics* 2002;110(1 Pt 1):16-26.
 381. Conde-Agudelo A, Diaz-Rossello JL, Belizan JM. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. *Cochrane Database Syst Rev* 2003; CD002771.
 382. Adcock PM, Pastor P, Medley F, Patterson JE, Murphy TV. Methicillin-resistant *Staphylococcus aureus* in two child care centers. *J Infect Dis* 1998;178:577-80.
 383. Shahin R, Johnson IL, Jamieson F, McGeer A, Tolkin J, Ford-Jones EL. Methicillin-resistant *Staphylococcus aureus* carriage in a child care center following a case of disease. Toronto Child Care Center Study Group. *Arch Pediatr Adolesc Med* 1999;153:864-8.
 384. Stover BH, Duff A, Adams G, Buck G, Hancock G, Rabalais G. Emergence and control of methicillin-resistant *Staphylococcus aureus* in a children's hospital and pediatric long-term care facility. *Am J Infect Control* 1992;20:248-55.
 385. Herold BC, Immergluck LC, Maranan MC, et al. Community-acquired methicillin-resistant *Staphylococcus aureus* in children with no identified predisposing risk. *JAMA* 1998;279:593-8.
 386. Centers for Disease Control and Prevention. Four pediatric deaths from community-acquired methicillin-resistant *Staphylococcus aureus*, Minnesota and North Dakota, 1997-1999. *MMWR Morb Mortal Wkly Rep* 1999;48:707-10.
 387. Abi-Hanna P, Frank AL, Quinn JP, et al. Clonal features of community-acquired methicillin-resistant *Staphylococcus aureus* in children. *Clin Infect Dis* 2000;30:630-1.
 388. Fergie JE, Purcell K. Community-acquired methicillin-resistant *Staphylococcus aureus* infections in south Texas children. *Pediatr Infect Dis J* 2001;20:860-3.
 389. Sattler CA, Mason EO Jr, Kaplan SL. Prospective comparison of risk factors and demographic and clinical characteristics of community-acquired, methicillin-resistant versus methicillin-susceptible *Staphylococcus aureus* infection in children. *Pediatr Infect Dis J* 2002;21:910-7.
 390. Kaplan SL, Hulten KG, Gonzalez BE, et al. Three-year surveillance of community-acquired *Staphylococcus aureus* infections in children. *Clin Infect Dis* 2005;40:1785-91.
 391. Jarvis WR. Infection control and changing health-care delivery systems. *Emerg Infect Dis* 2001;7:170-3.
 392. Garibaldi RA. Residential care and the elderly: the burden of infection. *J Hosp Infect* 1999;43(Suppl):S9-S18.
 393. Hsu K, Harris JA. Control of infections in nonacute care pediatric settings. *Semin Pediatr Infect Dis* 2001;12:92-9.
 394. Strausbaugh LJ, Joseph CL. The burden of infection in long-term care. *Infect Control Hosp Epidemiol* 2000;21:674-9.
 395. Centers for Medicare and Medicaid Services. Healthcare industry market update. Available from http://www.cms.hhs.gov/reports/hcimu/hcimu_05202003pdf, May 2003.
 396. Lee YL, Thrupp LD, Friis RH, Fine M, Maleki P, Cesario TC. Nosocomial infection and antibiotic utilization in geriatric patients: a pilot prospective surveillance program in skilled nursing facilities. *Gerontology* 1992;38:223-32.
 397. Stevenson KB. Regional data set of infection rates for long-term care facilities: description of a valuable benchmarking tool. *Am J Infect Control* 1999;27:20-6.
 398. Jackson MM, Fierer J, Barrett-Connor E, et al. Intensive surveillance for infections in a three-year study of nursing home patients. *Am J Epidemiol* 1992;135:685-96.
 399. Darnowski SB, Gordon M, Simor AE. Two years of infection surveillance in a geriatric long-term care facility. *Am J Infect Control* 1991;19:185-90.
 400. Hoffman N, Jenkins R, Putney K. Nosocomial infection rates during a one-year period in a nursing home care unit of a Veterans Administration hospital. *Am J Infect Control* 1990;18:55-63.
 401. Tsan L, Hojlo C, Kearns MA, et al. Infection surveillance and control programs in the Department of Veterans Affairs nursing home care units: a preliminary assessment. *Am J Infect Control* 2006;34:80-3.
 402. Kane RA, Caplan AL, Urv-Wong EK, Freeman IC, Aroskar MA, Finch M. Everyday matters in the lives of nursing home residents: wish for and perception of choice and control. *J Am Geriatr Soc* 1997;45:1086-93.
 403. Libow LS, Starer P. Care of the nursing home patient. *N Engl J Med* 1989;321:93-6.
 404. Perls TT, Herget M. Higher respiratory infection rates on an Alzheimer's special care unit and successful intervention. *J Am Geriatr Soc* 1995;43:1341-4.
 405. Bradley SF. Issues in the management of resistant bacteria in long-term-care facilities. *Infect Control Hosp Epidemiol* 1999;20:362-6.
 406. Crossley K. Vancomycin-resistant enterococci in long-term-care facilities. *Infect Control Hosp Epidemiol* 1998;19:521-5.
 407. Strausbaugh LJ, Crossley KB, Nurse BA, Thrupp LD. Antimicrobial resistance in long-term-care facilities. *Infect Control Hosp Epidemiol* 1996;17:129-40.
 408. Richards CL. Infections in Long-Term-Care Facilities: Screen or Clean? *Infect Control Hosp Epidemiol* 2005;26:800-1.
 409. Drinka PJ, Krause P, Nest L, Goodman BM, Gravenstein S. Risk of acquiring influenza A in a nursing home from a culture-positive roommate. *Infect Control Hosp Epidemiol* 2003;24:872-4.
 410. Falsey AR, Treanor JJ, Betts RF, Walsh EE. Viral respiratory infections in the institutionalized elderly: clinical and epidemiologic findings. *J Am Geriatr Soc* 1992;40:115-9.
 411. Ellis SE, Coffey CS, Mitchel EF Jr, Dittus RS, Griffin MR. Influenza and respiratory syncytial virus-associated morbidity and mortality in the nursing home population. *J Am Geriatr Soc* 2003;51:761-7.
 412. Louie JK, Yagi S, Nelson FA, et al. Rhinovirus outbreak in a long-term care facility for elderly persons associated with unusually high mortality. *Clin Infect Dis* 2005;41:262-5.
 413. Piednoir E, Bureau-Chalot F, Merle C, Gotzamanis A, Wuibout J, Bajole O. Direct costs associated with a nosocomial outbreak of adenoviral conjunctivitis infection in a long-term care institution. *Am J Infect Control* 2002;30:407-10.
 414. Addiss DG, Davis JP, Meade BD, et al. A pertussis outbreak in a Wisconsin nursing home. *J Infect Dis* 1991;164:704-10.
 415. Gaynes R, Rimland D, Killum E, et al. Outbreak of *Clostridium difficile* infection in a long-term care facility: association with gatifloxacin use. *Clin Infect Dis* 2004;38:640-5.

416. High KP, Bradley S, Loeb M, Palmer R, Quagliarello V, Yoshikawa T. A new paradigm for clinical investigation of infectious syndromes in older adults: assessment of functional status as a risk factor and outcome measure. *Clin Infect Dis* 2005;40:114-22.
417. Loeb MB, Craven S, McGeer AJ, et al. Risk factors for resistance to antimicrobial agents among nursing home residents. *Am J Epidemiol* 2003;157:40-7.
418. Vergis EN, Brennen C, Wagener M, Muder RR. Pneumonia in long-term care: a prospective case-control study of risk factors and impact on survival. *Arch Intern Med* 2001;161:2378-81.
419. Loeb M, McGeer A, McArthur M, Walter S, Simor AE. Risk factors for pneumonia and other lower respiratory tract infections in elderly residents of long-term care facilities. *Arch Intern Med* 1999;159:2058-64.
420. Brandeis GH, Ooi WL, Hossain M, Morris JN, Lipsitz LA. A longitudinal study of risk factors associated with the formation of pressure ulcers in nursing homes. *J Am Geriatr Soc* 1994;42:388-93.
421. Allard JP, Aghdassi E, McArthur M, et al. Nutrition risk factors for survival in the elderly living in Canadian long-term care facilities. *J Am Geriatr Soc* 2004;52:59-65.
422. Pick N, McDonald A, Bennett N, et al. Pulmonary aspiration in a long-term care setting: clinical and laboratory observations and an analysis of risk factors. *J Am Geriatr Soc* 1996;44:763-8.
423. Nicolle LE. The chronic indwelling catheter and urinary infection in long-term care facility residents. *Infect Control Hosp Epidemiol* 2001;22:316-21.
424. Pien EC, Hume KE, Pien FD. Gastrostomy tube infections in a community hospital. *Am J Infect Control* 1996;24:353-8.
425. Gomes GF, Pisani JC, Macedo ED, Campos AC. The nasogastric feeding tube as a risk factor for aspiration and aspiration pneumonia. *Curr Opin Clin Nutr Metab Care* 2003;6:327-33.
426. Bula CJ, Ghilardi G, Wietlisbach V, Petignat C, Francioli P. Infections and functional impairment in nursing home residents: a reciprocal relationship. *J Am Geriatr Soc* 2004;52:700-6.
427. Bradley SF, Terpenning MS, Ramsey MA, et al. Methicillin-resistant *Staphylococcus aureus*: colonization and infection in a long-term care facility. *Ann Intern Med* 1991;115:417-22.
428. Washio M, Nishisaka S, Kishikawa K, et al. Incidence of methicillin-resistant *Staphylococcus aureus* (MRSA) isolation in a skilled nursing home: a third report on the risk factors for the occurrence of MRSA infection in the elderly. *J Epidemiol* 1996;6:69-73.
429. Trick WE, Weinstein RA, DeMarais PL, et al. Colonization of skilled-care facility residents with antimicrobial-resistant pathogens. *J Am Geriatr Soc* 2001;49:270-6.
430. Nicolle LE, Garibaldi RA. Infection control in long-term care facilities. *Infect Control Hosp Epidemiol* 1995;16:348-53.
431. Crossley K. Long-term care facilities as sources of antibiotic-resistant nosocomial pathogens. *Curr Opin Infect Dis* 2001;14:455-9.
432. Smith PV, Rusnak PG. Infection prevention and control in the long-term-care facility. SHEA Long-Term-Care Committee and APIC Guidelines Committee. *Infect Control Hosp Epidemiol* 1997;18:831-49.
433. Friedman C, Barnette M, Buck AS, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in out-of-hospital settings: a consensus panel report. Association for Professionals in Infection Control and Epidemiology and Society for Healthcare Epidemiology of America. *Infect Control Hosp Epidemiol* 1999;20:695-705.
434. Nicolle LE. Infection control in long-term care facilities. *Clin Infect Dis* 2000;31:752-6.
435. Bradley SF. Methicillin-resistant *Staphylococcus aureus*: long-term care concerns. *Am J Med* 1999;106:2S-10S.
436. www.cms.hhs.gov/manuals/Downloads/som107ap_pp_guidelines_ltcf.
437. Mylotte JM, Goodnough S, Tayara A. Antibiotic-resistant organisms among long-term care facility residents on admission to an inpatient geriatrics unit: retrospective and prospective surveillance. *Am J Infect Control* 2001;29:139-44.
438. Strausbaugh LJ, Jacobson C, Yost T. Methicillin-resistant *Staphylococcus aureus* in a nursing home and affiliated hospital: a four-year perspective. *Infect Control Hosp Epidemiol* 1993;14:331-6.
439. Wiener J, Quinn JP, Bradford PA, et al. Multiple antibiotic-resistant *Klebsiella* and *Escherichia coli* in nursing homes. *JAMA* 1999;281:517-23.
440. Pop-Vicas AE, D'Agata EM. The rising influx of multidrug-resistant Gram-negative bacilli in tertiary care hospitals. *Clin Infect Dis* 2005;40:1792-8.
441. Ly N, McCaig LF. National Hospital Ambulatory Medical Care Survey: 2000 outpatient department summary. *Adv Data* 2002;1-27.
442. Cherry DK, Woodwell DA. National Ambulatory Medical Care Survey: 2000 summary. *Adv Data* 2002;1-32.
443. Finelli L, Miller JT, Tokars JL, Alter MJ, Arduino MJ. National surveillance of dialysis-associated diseases in the United States. *Semin Dial* 2002;2005(18):52-61.
444. D'Agata EM. Antimicrobial-resistant, Gram-positive bacteria among patients undergoing chronic hemodialysis. *Clin Infect Dis* 2002;35:1212-8.
445. Goodman RA, Solomon SL. Transmission of infectious diseases in outpatient health care settings. *JAMA* 1991;265:2377-81.
446. Nafziger DA, Lundstrom T, Chandra S, Massanari RM. Infection control in ambulatory care. *Infect Dis Clin North Am* 1997;11:279-96.
447. Herwaldt LA, Smith SD, Carter CD. Infection control in the outpatient setting. *Infect Control Hosp Epidemiol* 1998;19:41-74.
448. Hlady WG, Hopkins RS, Ogilby TE, Allen ST. Patient-to-patient transmission of hepatitis B in a dermatology practice. *Am J Public Health* 1993;83:1689-93.
449. Birnie GG, Quigley EM, Clements GB, Follet EA, Watkinson G. Endoscopic transmission of hepatitis B virus. *Gut* 1983;24:171-4.
450. Chant K, Lowe D, Rubin G, et al. Patient-to-patient transmission of HIV in private surgical consulting rooms. *Lancet* 1993;342:1548-9.
451. Chant K, Kociuba K, Munro R, et al. Investigation of possible patient-to-patient transmission of hepatitis C in a hospital. *NSW Public Health Bull* 1994;5:47-51.
452. Centers for Disease Control and Prevention. Transmission of hepatitis B and C viruses in outpatient settings, New York, Oklahoma, and Nebraska, 2000-2002. *MMWR Morb Mortal Wkly Rep* 2003;52:901-6.
453. Williams IT, Perz JF, Bell BP. Viral hepatitis transmission in ambulatory health care settings. *Clin Infect Dis* 2004;38:1592-8.
454. Couldwell DL, Dore GJ, Harkness JL, et al. Nosocomial outbreak of tuberculosis in an outpatient HIV treatment room. *AIDS* 1996;10:521-5.
455. Centers for Disease Control and Prevention. *Mycobacterium tuberculosis* transmission in a health clinic, Florida. *MMWR Morb Mortal Wkly Rep* 1989;38:256-8.
456. Calder RA, Duclos P, Wilder MH, Pryor VL, Scheel WJ. *Mycobacterium tuberculosis* transmission in a health clinic. *Bull Int Union Tuberc Lung Dis* 1991;66:103-6.
457. Istre GR, McKee PA, West GR, et al. Measles spread in medical settings: an important focus of disease transmission? *Pediatrics* 1987;79:356-8.
458. Dawson C, Darrell R. Infections due to adenovirus type 8 in the United States. I: an outbreak of epidemic keratoconjunctivitis originating in a physician's office. *N Engl J Med* 1963;268:1031-4.
459. Montessori V, Scharf S, Holland S, Werker DH, Roberts FJ, Bryce E. Epidemic keratoconjunctivitis outbreak at a tertiary referral eye care clinic. *Am J Infect Control* 1998;26:399-405.
460. Jernigan JA, Lowry BS, Hayden FG, et al. Adenovirus type 8 epidemic keratoconjunctivitis in an eye clinic: risk factors and control. *J Infect Dis* 1993;167:1307-13.

461. Buehler JW, Finton RJ, Goodman RA, et al. Epidemic keratoconjunctivitis: report of an outbreak in an ophthalmology practice and recommendations for prevention. *Infect Control* 1984;5:390-4.
462. Johnston CP, Cooper L, Ruby W, Teeter T, et al. Community-associated methicillin resistant *Staphylococcus aureus* skin infections among outpatient healthcare workers and its isolation in the clinic environment [abstract 132]. Presented at the 15th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America (SHEA), Los Angeles, CA, April 10, 2005.
463. Biddick R, Spilker T, Martin A, LiPuma JJ. Evidence of transmission of *Burkholderia cepacia*, *Burkholderia multivorans*, and *Burkholderia dolosa* among persons with cystic fibrosis. *FEMS Microbiol Lett* 2003;228:57-62.
464. Griffiths AL, Jansen K, Carlin JB, et al. Effects of segregation on an epidemic *Pseudomonas aeruginosa* strain in a cystic fibrosis clinic. *Am J Respir Crit Care Med* 2005;171:1020-5.
465. Danzig LE, Short LJ, Collins K, et al. Bloodstream infections associated with a needleless intravenous infusion system in patients receiving home infusion therapy. *JAMA* 1995;273:1862-4.
466. Kellerman S, Shay DK, Howard J, et al. Bloodstream infections in home infusion patients: the influence of race and needleless intravascular access devices. *J Pediatr* 1996;129:711-7.
467. Do AN, Ray BJ, Banerjee SN, et al. Bloodstream infection associated with needleless device use and the importance of infection-control practices in the home health care setting. *J Infect Dis* 1999;179:442-8.
468. Tokars JL, Cookson ST, McArthur MA, Boyer CL, McGeer AJ, Jarvis WR. Prospective evaluation of risk factors for bloodstream infection in patients receiving home infusion therapy. *Ann Intern Med* 1999;131:340-7.
469. Manangan LP, Pearson ML, Tokars JL, Miller E, Jarvis WR. Feasibility of national surveillance of health care-associated infections in home-care settings. *Emerg Infect Dis* 2002;8:233-6.
470. Shah SS, Manning ML, Leahy E, Magnusson M, Rheingold SR, Bell LM. Central venous catheter-associated bloodstream infections in pediatric oncology home care. *Infect Control Hosp Epidemiol* 2002;23:99-101.
471. Gorski LA. Central venous access device outcomes in a home care agency: a 7-year study. *J Infus Nurs* 2004;27:104-11.
472. Rosenheimer L, Embry FC, Sanford J, Silver SR. Infection surveillance in home care: device-related incidence rates. *Am J Infect Control* 1998;26:359-63.
473. White MC, Ragland KE. Surveillance of intravenous catheter-related infections among home care clients. *Am J Infect Control* 1994;22:231-5.
474. Beltrami EM, McArthur MA, McGeer A, et al. The nature and frequency of blood contacts among home healthcare workers. *Infect Control Hosp Epidemiol* 2000;21:765-70.
475. Embry FC, Chinnes LF. Draft definitions for surveillance of infections in home health care. *Am J Infect Control* 2000;28:449-53.
476. Fraser TG, Stosor V, Wang Q, Allen A, Zembower TR. Vancomycin and home health care. *Emerg Infect Dis* 2005;11:1558-64.
477. Carrico RM, Niner S. Multidrug-resistant organisms—VRE and MRSA: practical home care tips. *Home Healthcare Nurse* 2002;20:23-8.
478. Friedman MM, Rhinehart E. Improving infection control in home care: from ritual to science-based practice. *Home Healthcare Nurse* 2000;18:99-105.
479. Friedman MM, Rhinehart E. Putting infection control principles into practice in home care. *Nurs Clin North Am* 1999;34:463-82.
480. Davis PL, Madigan EA. Evidence-based practice and the home care nurse's bag. *Home Healthcare Nurse* 1999;17:295-9.
481. Sitzman KL, Pett MA, Boswick DS. An exploratory study of nurse bag use by home visiting nurses. *Home Healthcare Nurse* 2002;20:237-43.
482. Anderson MA, Madigan EA, Helms LB. Nursing research in home health care: endangered species? *Home Care Provid* 2001;6:200-4.
483. White MC. Identifying infectious diseases in prisons: surveillance, protection, and intervention. *West J Med* 1999;170:177.
484. Puisis M. Update on public health in correctional facilities. *West J Med* 1998;169:374.
485. Levy MH, Lerwitworapong J. Issues facing TB control (3.1). Tuberculosis in prisons. *Scott Med J* 2000;45(5 Suppl):30-3.
486. Parece MS, Herrera GA, Voigt RF, Middlekauff SL, Irwin KL. STD testing policies and practices in US city and county jails. *Sex Transm Dis* 1999;26:431-7.
487. Cieslak PR, Curtis MB, Coulombier DM, Hathcock AL, Bean NH, Tauxe RV. Preventable disease in correctional facilities: desmoteretic foodborne outbreaks in the United States, 1974–1991. *Arch Intern Med* 1996;156:1883-8.
488. Centers for Disease Control and Prevention. Public health dispatch: tuberculosis outbreak in a homeless population, Portland, Maine, 2002–2003. *MMWR Morb Mortal Wkly Rep* 2003;52:1184.
489. Centers for Disease Control and Prevention. Public health dispatch: tuberculosis outbreak among homeless persons, King County, Washington, 2002–2003. *MMWR Morb Mortal Wkly Rep* 2003;52:1209-10.
490. Centers for Disease Control and Prevention. Tuberculosis transmission in a homeless shelter population, New York, 2000–2003. *MMWR Morb Mortal Wkly Rep* 2005;54:149-52.
491. Baillargeon J, Kelley MF, Leach CT, Baillargeon G, Pollock BH. Methicillin-resistant *Staphylococcus aureus* infection in the Texas prison system. *Clin Infect Dis* 2004;38:e92-5.
492. Young DM, Harris HW, Charlebois ED, et al. An epidemic of methicillin-resistant *Staphylococcus aureus* soft tissue infections among medically underserved patients. *Arch Surg* 2004;139:947-53.
493. Pan ES, Diep BA, Carleton HA, et al. Increasing prevalence of methicillin-resistant *Staphylococcus aureus* infection in California jails. *Clin Infect Dis* 2003;37:1384-8.
494. Centers for Disease Control and Prevention. Drug-susceptible tuberculosis outbreak in a state correctional facility housing HIV-infected inmates, South Carolina, 1999–2000. *MMWR Morb Mortal Wkly Rep* 2000;49:1041-4.
495. Centers for Disease Control and Prevention. Methicillin-resistant *Staphylococcus aureus* skin or soft tissue infections in a state prison, Mississippi, 2000. *MMWR Morb Mortal Wkly Rep* 2001;50:919-22.
496. Mohle-Boetani JC, Miguelino V, Dewsnup DH, et al. Tuberculosis outbreak in a housing unit for human immunodeficiency virus-infected patients in a correctional facility: transmission risk factors and effective outbreak control. *Clin Infect Dis* 2002;34:668-76.
497. Centers for Disease Control and Prevention. Prevention and control of tuberculosis in correctional facilities: recommendations of the Advisory Council for the Elimination of Tuberculosis. *MMWR Recomm Rep* 1996;45:1-37.
498. Whimbey E, Englund JA, Couch RB. Community respiratory virus infections in immunocompromised patients with cancer. *Am J Med* 1997;102:10-8.
499. Zamboni M, Bull T, Sadler CJ, Goldman JM, Ward KN. Molecular epidemiology of two consecutive outbreaks of parainfluenza 3 in a bone marrow transplant unit. *J Clin Microbiol* 1998;36:2289-93.
500. Gamis AS, Howells WB, DeSwarte-Wallace J, Feusner JH, Buckley JD, Woods WG. Alpha-hemolytic streptococcal infection during intensive treatment for acute myeloid leukemia: a report from the Children's Cancer Group Study CCG-2891. *J Clin Oncol* 2000;18:1845-55.
501. Ek T, Mellander L, Andersson B, Abrahamsson J. Immune reconstitution after childhood acute lymphoblastic leukemia is most severely affected in the high-risk group. *Pediatr Blood Cancer* 2005;44:461-8.
502. Pascual V, Allantaz F, Arce E, Punaro M, Banchereau J. Role of interleukin-1 (IL-1) in the pathogenesis of systemic onset juvenile idiopathic arthritis and clinical response to IL-1 blockade. *J Exp Med* 2005;201:1479-86.

503. Marchesoni A, Puttini PS, Gorla R, et al. Cyclosporine in addition to infliximab and methotrexate in refractory rheumatoid arthritis. *Clin Exp Rheumatol* 2005;23:916-7.
504. Isaacs KL, Lewis JD, Sandborn WJ, Sands BE, Targan SR. State of the art: IBD therapy and clinical trials in IBD. *Inflamm Bowel Dis* 2005; 11(Suppl 1):S3-S12.
505. Centers for Disease Control and Prevention. Guidelines for preventing opportunistic infections among HIV-infected persons. *MMWR Recomm Rep* 2002;51:1-52.
506. Kusne S, Krystofak S. Infection control issues after solid organ transplantation. In: Bowden RA, Ljungman P, Paya CV, editors. *Transplant infections*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2003.
507. Anderson D, DeFor T, Burns L, et al. A comparison of related donor peripheral blood and bone marrow transplants: importance of late-onset chronic graft-versus-host disease and infections. *Biol Blood Marrow Transplant* 2003;9:52-9.
508. Pitchford KC, Corey M, Highsmith AK, et al. *Pseudomonas* species contamination of cystic fibrosis patients' home inhalation equipment. *J Pediatr* 1987;111:212-6.
509. Hamill RJ, Houston ED, Georgiou PR, et al. An outbreak of *Burkholderia* (formerly *Pseudomonas*) *cepacia* respiratory tract colonization and infection associated with nebulized albuterol therapy. *Ann Intern Med* 1995;122:762-6.
510. Hutchinson GR, Parker S, Pryor JA, et al. Home-use nebulizers: a potential primary source of *Burkholderia cepacia* and other colistin-resistant, Gram-negative bacteria in patients with cystic fibrosis. *J Clin Microbiol* 1996;34:584-7.
511. Jakobsson BM, Onnered AB, Hjelte L, Nystrom B. Low bacterial contamination of nebulizers in home treatment of cystic fibrosis patients. *J Hosp Infect* 1997;36:201-7.
512. Rosenfeld M, Joy P, Nguyen CD, Krzewinski J, Burns JL. Cleaning home nebulizers used by patients with cystic fibrosis: is rinsing with tap water enough? *J Hosp Infect* 2001;49:229-30.
513. Govan JR. Infection control in cystic fibrosis: methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa* and the *Burkholderia cepacia* complex. *J R Soc Med* 2000;93(Suppl 38):40-5.
514. Frederiksen B, Koch C, Hoiby N. Changing epidemiology of *Pseudomonas aeruginosa* infection in Danish cystic fibrosis patients (1974-1995). *Pediatr Pulmonol* 1999;28:159-66.
515. Isles A, Maclusky I, Corey M, et al. *Pseudomonas cepacia* infection in cystic fibrosis: an emerging problem. *J Pediatr* 1984;104:206-10.
516. LiPuma JJ. *Burkholderia cepacia*: Management issues and new insights. *Clin Chest Med* 1998;19:473-86.
517. Tablan OC, Chorba TL, Schidlow DV, et al. *Pseudomonas cepacia* colonization in patients with cystic fibrosis: risk factors and clinical outcome. *J Pediatr* 1985;107:382-7.
518. Hudson VL, Wielinski CL, Regelman WE. Prognostic implications of initial oropharyngeal bacterial flora in patients with cystic fibrosis diagnosed before the age of two years. *J Pediatr* 1993;122:854-60.
519. Farrell PM, Li Z, Kosorok MR, et al. Bronchopulmonary disease in children with cystic fibrosis after early or delayed diagnosis. *Am J Respir Crit Care Med* 2003;168:1100-8.
520. Smith DL, Gumery LB, Smith EG, Stableforth DE, Kaufmann ME, Pitt TL. Epidemic of *Pseudomonas cepacia* in an adult cystic fibrosis unit: evidence of person-to-person transmission. *J Clin Microbiol* 1993;31:3017-22.
521. Pegues DA, Schidlow DV, Tablan OC, Carson LA, Clark NC, Jarvis WR. Possible nosocomial transmission of *Pseudomonas cepacia* in patients with cystic fibrosis. *Arch Pediatr Adolesc Med* 1994;148:805-12.
522. Govan JR, Brown PH, Maddison J, et al. Evidence for transmission of *Pseudomonas cepacia* by social contact in cystic fibrosis. *Lancet* 1993; 342:15-9.
523. Pegues DA, Carson LA, Tablan OC, et al. Acquisition of *Pseudomonas cepacia* at summer camps for patients with cystic fibrosis. Summer Camp Study Group. *J Pediatr* 1994;124(5 Pt 1):694-702.
524. Tablan OC, Martone WJ, Doershuk CF, et al. Colonization of the respiratory tract with *Pseudomonas cepacia* in cystic fibrosis. risk factors and outcomes. *Chest* 1987;91:527-32.
525. Thomassen MJ, Demko CA, Doershuk CF, Stern RC, Klinger JD. *Pseudomonas cepacia*: decrease in colonization in patients with cystic fibrosis. *Am Rev Respir Dis* 1986;134:669-71.
526. Weber DJ, Rutala WA. Gene therapy: a new challenge for infection control. *Infect Control Hosp Epidemiol* 1999;20:530-2.
527. Evans ME, Lesnaw JA. Infection control for gene therapy: a busy physician's primer. *Clin Infect Dis* 2002;35:597-605.
528. Strausbaugh LJ. Gene therapy and infection control: more light on the way. *Infect Control Hosp Epidemiol* 2000;21:630-2.
529. Centers for Disease Control and Prevention. West Nile virus infections in organ transplant recipients, New York and Pennsylvania, August-September, 2005. *MMWR Morb Mortal Wkly Rep* 2005; 54:1021-3.
530. Lawson CA. Cytomegalovirus after kidney transplantation: a case review. *Prog Transplant* 2005;15:157-60.
531. Tugwell BD, Patel PR, Williams IT, et al. Transmission of hepatitis C virus to several organ and tissue recipients from an antibody-negative donor. *Ann Intern Med* 2005;143:648-54.
532. Kainer MA, Linden JV, Whaley DN, et al. *Clostridium* infections associated with musculoskeletal tissue allografts. *N Engl J Med* 2004;350: 2564-71.
533. Centers for Disease Control and Prevention. Invasive *Streptococcus pyogenes* after allograft implantation, Colorado, 2003. *MMWR Morb Mortal Wkly Rep* 2003;52:1174-6.
534. Mungai M, Tegtmeier G, Chamberland M, Parise M. Transfusion-transmitted malaria in the United States from 1963 through 1999. *N Engl J Med* 2001;344:1973-8.
535. Lux JZ, Weiss D, Linden JV, et al. Transfusion-associated babesiosis after heart transplant. *Emerg Infect Dis* 2003;9:116-9.
536. Centers for Disease Control and Prevention. Chagas disease after organ transplantation, United States, 2001. *MMWR Morb Mortal Wkly Rep* 2002;51:210-2.
537. Centers for Disease Control and Prevention. Lymphocytic choriomeningitis virus infection in organ transplant recipients, Massachusetts and Rhode Island, 2005. *MMWR Morb Mortal Wkly Rep* 2005;54:537-9.
538. Srinivasan A, Burton EC, Kuehnert MJ, et al. Transmission of rabies virus from an organ donor to four transplant recipients. *N Engl J Med* 2005;352:1103-11.
539. Gottesdiener KM. Transplanted infections: donor-to-host transmission with the allograft. *Ann Intern Med* 1989;110:1001-16.
540. Borie DC, Cramer DV, Phan-Thanh L, et al. Microbiological hazards related to xenotransplantation of porcine organs into man. *Infect Control Hosp Epidemiol* 1998;19:355-65.
541. Centers for Disease Control and Prevention. US Public Health Service guideline on infectious disease issues in xenotransplantation. *MMWR Recomm Rep* 2001;50:1-46.
542. Institute of Medicine. To err is human: building a safer health system. Washington DC: National Academy Press; 1999.
543. Gerberding JL. Hospital-onset infections: a patient safety issue. *Ann Intern Med* 2002;137:665-70.
544. Leape LL, Berwick DM, Bates DW. What practices will most improve safety? Evidence-based medicine meets patient safety. *JAMA* 2002;288:501-7.
545. Burke JR. Patient safety. Infection control: a problem for patient safety. *N Engl J Med* 2003;348:651-6.
546. Shulman L, Ost D. Managing infection in the critical care unit: how can infection control make the ICU safe? *Crit Care Clin* 2005;21: 111-28.
547. Goldmann DA, Weinstein RA, Wenzel RP, et al. Strategies to prevent and control the emergence and spread of antimicrobial-resistant microorganisms in hospitals: a challenge to hospital leadership. *JAMA* 1996;275:234-40.

548. Scheckler WE, Brimhall D, Buck AS, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: a consensus panel report. Society for Healthcare Epidemiology of America. Infect Control Hosp Epidemiol 1998;19:114-24.
549. www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals/.
550. Jackson M, Chiarello LA, Gaynes RP, Gerberding JL. Nurse staffing and health care-associated infections: proceedings from a working group meeting. Am J Infect Control 2002;30:199-206.
551. O'Boyle C, Jackson M, Henly SJ. Staffing requirements for infection control programs in US health care facilities: Delphi project. Am J Infect Control 2002;30:321-33.
552. Peterson LR, Hamilton JD, Baron EJ, et al. Role of clinical microbiology laboratories in the management and control of infectious diseases and the delivery of health care. Clin Infect Dis 2001;32:605-11.
553. McGowan JE Jr, Tenover FC. Confronting bacterial resistance in healthcare settings: a crucial role for microbiologists. Nat Rev Microbiol 2004;2:251-8.
554. Available from. Accessed.
555. Curtis JR, Cook DJ, Wall RJ, et al. Intensive care unit quality improvement: a "how-to" guide for the interdisciplinary team. Crit Care Med 2006;34:211-8.
556. Pronovost PJ, Nolan T, Zeger S, Miller M, Rubin H. How can clinicians measure safety and quality in acute care? Lancet 2004;363:1061-7.
557. Goldrick BA, Dingle DA, Gilmore GK, Curchoe RM, Plackner CL, Fabrey LJ. Practice analysis for infection control and epidemiology in the new millennium. Am J Infect Control 2002;30:437-48.
558. Centers for Disease Control and Prevention. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. MMWR Recomm Rep 2002;51:1-44.
559. Bonomo RA, Rice LB. Emerging issues in antibiotic resistant infections in long-term care facilities. J Gerontol A Biol Sci Med Sci 1999;54:B260-7.
560. Larson EL, Early E, Cloonan P, Sugrue S, Parides M. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. Behav Med 2000;26:14-22.
561. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. Lancet 2000;356:1307-12.
562. Murthy R. Implementation of strategies to control antimicrobial resistance. Chest 2001;119(2 Suppl):405S-11S.
563. Rondeau KV, Wagar TH. Organizational learning and continuous quality improvement: examining the impact on nursing home performance. Health Care Manage Forum 2002;15:17-23.
564. Stelfox HT, Bates DW, Redelmeier DA. Safety of patients isolated for infection control. JAMA 2003;290:1899-905.
565. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121:182-205.
566. McArthur BJ, Pugliese G, Weinstein S, et al. A national task analysis of infection control practitioners, 1982. Part One: methodology and demography. Am J Infect Control 1984;12:88-95.
567. Shannon R, McArthur BJ, Weinstein S, et al. A national task analysis of infection control practitioners, 1982. Part Two: tasks, knowledge, and abilities for practice. Am J Infect Control 1984;12:187-96.
568. Pugliese G, McArthur BJ, Weinstein S, et al. A national task analysis of infection control practitioners, 1982. Part Three: the relationship between hospital size and tasks performed. Am J Infect Control 1984;12:221-7.
569. Larson E, Eisenberg R, Soule BM. Validating the certification process for infection control practice. Am J Infect Control 1988;16:198-205.
570. Bjerke NB, Fabrey LJ, Johnson CB, et al. Job analysis 1992: infection control practitioner. Am J Infect Control 1993;21:51-7.
571. Turner JG, Kolenc KM, Docken L. Job analysis 1996: infection control professional. Certification Board in Infection Control and Epidemiology Inc, 1996 Job Analysis Committee. Am J Infect Control 1999;27:145-57.
572. Health Canada, Nosocomial and Occupational Infections Section. Development of a resource model for infection prevention and control programs in acute, long-term, and home care settings: conference proceedings of the Infection Prevention and Control Alliance. Am J Infect Cont 2004;32:2-6.
573. Lee TH, Meyer GS, Brennan TA. A middle ground on public accountability. N Engl J Med 2004;350:2409-12.
574. Stevenson KB, Murphy CL, Samore MH, et al. Assessing the status of infection control programs in small rural hospitals in the western United States. Am J Infect Control 2004;32:255-61.
575. Simonds DN, Horan TC, Kelley R, Jarvis WR. Detecting pediatric nosocomial infections: how do infection control and quality assurance personnel compare? Am J Infect Control 1997;25:202-8.
576. Dawson SJ. The role of the infection control link nurse. J Hosp Infect 2003;54:251-7.
577. Wright J, Stover BH, Wilkerson S, Bratcher D. Expanding the infection control team: development of the infection control liaison position for the neonatal intensive care unit. Am J Infect Control 2002;30:174-8.
578. Teare EL, Peacock A. The development of an infection control link-nurse programme in a district general hospital. J Hosp Infect 1996;34:267-78.
579. Ching TY, Seto WH. Evaluating the efficacy of the infection control liaison nurse in the hospital. J Adv Nurs 1990;15:1128-31.
580. Amundsen J, Drennan DP. An infection control nurse-advisor program. Am J Infect Control 1983;11:20-3.
581. Ross KA. A program for infection surveillance utilizing an infection control liaison nurse. Am J Infect Control 1982;10:24-8.
582. Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med 2002;346:1715-22.
583. Dimick JB, Swoboda SM, Pronovost PJ, Lipsett PA. Effect of nurse-to-patient ratio in the intensive care unit on pulmonary complications and resource use after hepatectomy. Am J Crit Care 2001;10:376-82.
584. Mayhall CG, Lamb VA, Gayle WE Jr, Haynes BW Jr. *Enterobacter cloacae* septicemia in a burn center: epidemiology and control of an outbreak. J Infect Dis 1979;139:166-71.
585. Goldmann DA, Durbin WA Jr, Freeman J. Nosocomial infections in a neonatal intensive care unit. J Infect Dis 1981;144:449-59.
586. Arnoff P, Allyn PA, Nichols EM, Hill DL, Pezzlo M, Bartlett RH. Control of methicillin-resistant *Staphylococcus aureus* in a burn unit: role of nurse staffing. J Trauma 1982;22:954-9.
587. Haley RW, Bregman DA. The role of understaffing and overcrowding in recurrent outbreaks of staphylococcal infection in a neonatal special-care unit. J Infect Dis 1982;145:875-85.
588. Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. Infect Control Hosp Epidemiol 1996;17:150-8.
589. Robert J, Fridkin SK, Blumberg HM, et al. The influence of the composition of the nursing staff on primary bloodstream infection rates in a surgical intensive care unit. Infect Control Hosp Epidemiol 2000;21:12-7.
590. Li J, Birkhead GS, Strogatz DS, Coles FB. Impact of institution size, staffing patterns, and infection control practices on communicable disease outbreaks in New York State nursing homes. Am J Epidemiol 1996;143:1042-9.
591. Archibald LK, Manning ML, Bell LM, Banerjee S, Jarvis WR. Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric cardiac intensive care unit. Pediatr Infect Dis J 1997;16:1045-8.

592. Harbarth S, Sudre P, Dharan S, Cadenas M, Pittet D. Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding, and poor hygiene practices. *Infect Control Hosp Epidemiol* 1999;20:598-603.
593. Vicca AF. Nursing staff workload as a determinant of methicillin-resistant *Staphylococcus aureus* spread in an adult intensive therapy unit. *J Hosp Infect* 1999;43:109-13.
594. Stegenga J, Bell E, Matlow A. The role of nurse understaffing in nosocomial viral gastrointestinal infections on a general pediatrics ward. *Infect Control Hosp Epidemiol* 2002;23:133-6.
595. Alonso-Echanove J, Edwards JR, Richards MJ, et al. Effect of nurse staffing and antimicrobial-impregnated central venous catheters on the risk for bloodstream infections in intensive care units. *Infect Control Hosp Epidemiol* 2003;24:916-25.
596. Petrosillo N, Gilli P, Serraino D, et al. Prevalence of infected patients and understaffing have a role in hepatitis C virus transmission in dialysis. *Am J Kidney Dis* 2001;37:1004-10.
597. Pfaller MA, Herwaldt LA. The clinical microbiology laboratory and infection control: emerging pathogens, antimicrobial resistance, and new technology. *Clin Infect Dis* 1997;25:858-70.
598. Simor AE. The role of the laboratory in infection prevention and control programs in long-term-care facilities for the elderly. *Infect Control Hosp Epidemiol* 2001;22:459-63.
599. Weinstein RA, Mallison GF. The role of the microbiology laboratory in surveillance and control of nosocomial infections. *Am J Clin Pathol* 1978;69:130-6.
600. Kolmos HJ. Interaction between the microbiology laboratory and clinician: what the microbiologist can provide. *J Hosp Infect* 1999;43(Suppl):S285-91.
601. Clinical and Laboratory Standards Institute. www.clsi.org/.
602. Ginocchio CC. Role of NCCLS in antimicrobial susceptibility testing and monitoring. *Am J Health Syst Pharm* 2002;59(8 Suppl. 3):S7-S11.
603. National Committee for Clinical Laboratory Standards. Performance standards for antimicrobial susceptibility testing: twelfth informational supplement. Document M100-S12. Wayne (PA): National Committee for Clinical Laboratory Standards; 2002.
604. National Committee for Clinical Laboratory Standards. Analysis and presentation of cumulative antimicrobial susceptibility test data: approved guideline. Document M39-A. Wayne (PA): National Committee for Clinical Laboratory Standards; 2002.
605. Halstead DC, Gomez N, McCarter YS. Reality of developing a community-wide antibiogram. *J Clin Microbiol* 2004;42:1-6.
606. Ernst EJ, Diekema DJ, BootsMiller BJ, et al. Are United States hospitals following national guidelines for the analysis and presentation of cumulative antimicrobial susceptibility data? *Diagn Microbiol Infect Dis* 2004;49:141-5.
607. Bergeron MG, Ouellette M. Preventing antibiotic resistance through rapid genotypic identification of bacteria and of their antibiotic resistance genes in the clinical microbiology laboratory. *J Clin Microbiol* 1998;36:2169-72.
608. Hacek DM, Suriano T, Noskin GA, Kruszynski J, Reisberg B, Peterson LR. Medical and economic benefit of a comprehensive infection control program that includes routine determination of microbial clonality. *Am J Clin Pathol* 1999;111:647-54.
609. Rodriguez WJ, Schwartz RH, Thorne MM. Evaluation of diagnostic tests for influenza in a pediatric practice. *Pediatr Infect Dis J* 2002;21:193-6.
610. Centers for Disease Control and Prevention. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2005;54:1-40.
611. Uyeki TM. Influenza diagnosis and treatment in children: a review of studies on clinically useful tests and antiviral treatment for influenza. *Pediatr Infect Dis J* 2003;22:164-77.
612. Chan EL, Antonishyn N, McDonald R, et al. The use of TaqMan PCR assay for detection of *Bordetella pertussis* infection from clinical specimens. *Arch Pathol Lab Med* 2002;126:173-6.
613. Barenfanger J, Drake C, Kacich G. Clinical and financial benefits of rapid bacterial identification and antimicrobial susceptibility testing. *J Clin Microbiol* 1999;37:1415-8.
614. Barenfanger J, Drake C, Leon N, Mueller T, Trout T. Clinical and financial benefits of rapid detection of respiratory viruses: an outcomes study. *J Clin Microbiol* 2000;38:2824-8.
615. Ramers C, Billman G, Hartin M, Ho S, Sawyer MH. Impact of a diagnostic cerebrospinal fluid enterovirus polymerase chain reaction test on patient management. *JAMA* 2000;283:2680-5.
616. Mackie PL, Joannidis PA, Beattie J. Evaluation of an acute point-of-care system screening for respiratory syncytial virus infection. *J Hosp Infect* 2001;48:66-71.
617. Guillemot D, Courvalin P. Better control of antibiotic resistance. *Clin Infect Dis* 2001;33:542-7.
618. Paterson DL. The role of antimicrobial management programs in optimizing antibiotic prescribing within hospitals. *Clin Infect Dis* 2006;42(Suppl 2):S90-5.
619. Lundstrom T, Pugliese G, Bartley J, Cox J, Guither C. Organizational and environmental factors that affect worker health and safety and patient outcomes. *Am J Infect Control* 2002;30:93-106.
620. www.patientsafety.com/vision.html.
621. Pronovost PJ, Jenckes MW, Dorman T, et al. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA* 1999;281:1310-7.
622. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremsizov TT, Young TL. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. *JAMA* 2002;288:2151-62.
623. Pronovost PJ, Weast B, Holzmueller CG, et al. Evaluation of the culture of safety: survey of clinicians and managers in an academic medical center. *Qual Saf Health Care* 2003;12:405-10.
624. Nieva VF, Sorra J. Safety culture assessment: a tool for improving patient safety in healthcare organizations. *Qual Saf Health Care* 2003;12(Suppl 2):ii17-23.
625. Clarke SP, Rockett JL, Sloane DM, Aiken LH. Organizational climate, staffing, and safety equipment as predictors of needlestick injuries and near-misses in hospital nurses. *Am J Infect Control* 2002;30:207-16.
626. Rivers DL, Aday LA, Frankowski RF, Felknor S, White D, Nichols B. Predictors of nurses' acceptance of an intravenous catheter safety device. *Nurs Res* 2003;52:249-55.
627. Gershon RR, Karkashian CD, Grosch JW, et al. Hospital safety climate and its relationship with safe work practices and workplace exposure incidents. *Am J Infect Control* 2000;28:211-21.
628. Gershon RR, Vlahov D, Felknor SA, et al. Compliance with universal precautions among health care workers at three regional hospitals. *Am J Infect Control* 1995;23:225-36.
629. Michalsen A, Delclos GL, Felknor SA, et al. Compliance with universal precautions among physicians. *J Occup Environ Med* 1997;39:130-7.
630. Vaughn TE, McCoy KD, Beekmann SE, Woolson RE, Torner JC, Doebbeling BN. Factors promoting consistent adherence to safe needle precautions among hospital workers. *Infect Control Hosp Epidemiol* 2004;25:548-55.
631. Grosch JW, Gershon RR, Murphy LR, DeJoy DM. Safety climate dimensions associated with occupational exposure to blood-borne pathogens in nurses. *Am J Ind Med (Suppl 1)*:122-4.
632. Piotrowski MM, Hinshaw DB. The safety checklist program: creating a culture of safety in intensive care units. *Jt Comm J Qual Improv* 2002;28:306-15.
633. Weeks VWB, Bagian JP. Developing a culture of safety in the Veterans Health Administration. *Eff Clin Pract* 2000;3:270-6.
634. Bagian JP, Gosbee JW. Developing a culture of patient safety at the VA. *Ambul Outreach* 2000;25-9.
635. Tokars JL, McKinley GF, Otten J, et al. Use and efficacy of tuberculosis infection control practices at hospitals with previous outbreaks of multidrug-resistant tuberculosis. *Infect Control Hosp Epidemiol* 2001;22:449-55.

636. Maloney SA, Pearson ML, Gordon MT, Del Castillo R, Boyle JF, Jarvis WR. Efficacy of control measures in preventing nosocomial transmission of multidrug-resistant tuberculosis to patients and health care workers. *Ann Intern Med* 1995;122:90-5.
637. Montecalvo MA, Jarvis WR, Uman J, et al. Infection-control measures reduce transmission of vancomycin-resistant enterococci in an endemic setting. *Ann Intern Med* 1999;131:269-72.
638. Sherertz RJ, Ely EW, Westbrook DM, et al. Education of physicians-in-training can decrease the risk for vascular catheter infection. *Ann Intern Med* 2000;132:641-8.
639. Lynch P, Cummings MJ, Roberts PL, Herriott MJ, Yates B, Stamm WE. Implementing and evaluating a system of generic infection precautions: body substance isolation. *Am J Infect Control* 1990;18:1-12.
640. Kelen GD, DiGiovanna TA, Celentano DD, et al. Adherence to universal (barrier) precautions during interventions on critically ill and injured emergency department patients. *J Acquir Immune Defic Syndr* 1990;3:987-94.
641. Courington KR, Patterson SL, Howard RJ. Universal precautions are not universally followed. *Arch Surg* 1991;126:93-6.
642. Kaczmarek RG, Moore RM Jr, McCrohan J, et al. Glove use by health care workers: results of a tristate investigation. *Am J Infect Control* 1991;19:228-32.
643. Freeman SW, Chambers CV. Compliance with universal precautions in a medical practice with a high rate of HIV infection. *J Am Board Fam Pract* 1992;5:313-8.
644. Friedland LR, Joffe M, Wiley JF 2nd, Schapire A, Moore DF. Effect of educational program on compliance with glove use in a pediatric emergency department. *Am J Dis Child* 1992;146:1355-8.
645. Henry K, Campbell S, Maki M. A comparison of observed and self-reported compliance with universal precautions among emergency department personnel at a Minnesota public teaching hospital: implications for assessing infection control programs. *Ann Emerg Med* 1992;21:940-6.
646. Henry K, Campbell S, Collier P, Williams CO. Compliance with universal precautions and needle handling and disposal practices among emergency department staff at two community hospitals. *Am J Infect Control* 1994;22:129-37.
647. Eustis TC, Wright SW, Wrenn KD, Fowlie EJ, Slovis CM. Compliance with recommendations for universal precautions among pre-hospital providers. *Ann Emerg Med* 1995;25:512-5.
648. DiGiacomo JC, Hoff WS, Rotondo MF, et al. Barrier precautions in trauma resuscitation: real-time analysis utilizing videotape review. *Am J Emerg Med* 1997;15:34-9.
649. Thompson BL, Dwyer DM, Ussery XT, Denman S, Vacek P, Schwartz B. Handwashing and glove use in a long-term-care facility. *Infect Control Hosp Epidemiol* 1997;18:97-103.
650. Helfgott AW, Taylor-Burton J, Garcini FJ, Eriksen NL, Grimes R. Compliance with universal precautions: knowledge and behavior of residents and students in a department of obstetrics and gynecology. *Infect Dis Obstet Gynecol* 1998;6:123-8.
651. Moore S, Goodwin H, Grossberg R, Toltzis P. Compliance with universal precautions among pediatric residents. *Arch Pediatr Adolesc Med* 1998;152:554-7.
652. Akduman D, Kim LE, Parks RL, et al. Use of personal protective equipment and operating room behaviors in four surgical subspecialties: personal protective equipment and behaviors in surgery. *Infect Control Hosp Epidemiol* 1999;20:110-4.
653. Brooks AJ, Phipson M, Potgieter A, Koertzen H, Boffard KD. Education of the trauma team: video evaluation of the compliance with universal barrier precautions in resuscitation. *Eur J Surg* 1999;165:1125-8.
654. Kidd F, Heitkemper P, Kressel AB. A comprehensive educational approach to improving patient isolation practice. *Clin Perform Qual Health Care* 1999;7:74-6.
655. Madan AK, Rentz DE, Wahle MJ, Flint LM. Noncompliance of health care workers with universal precautions during trauma resuscitations. *South Med J* 2001;94:277-80.
656. Madan AK, Raafat A, Hunt JP, Rentz D, Wahle MJ, Flint LM. Barrier precautions in trauma: is knowledge enough? *J Trauma* 2002;52:540-3.
657. Jeffe DB, Mutha S, Kim LE, Evanoff BA, Fraser VJ. Evaluation of a preclinical, educational and skills-training program to improve students' use of blood and body fluid precautions: one-year follow-up. *Prev Med* 1999;29:365-73.
658. Williams CO, Campbell S, Henry K, Collier P. Variables influencing worker compliance with universal precautions in the emergency department. *Am J Infect Control* 1994;22:138-48.
659. Larson E, McGeer A, Quraishi ZA, et al. Effect of an automated sink on handwashing practices and attitudes in high-risk units. *Infect Control Hosp Epidemiol* 1991;12:422-8.
660. Swoboda SM, Earsing K, Strauss K, Lane S, Lipsett PA. Electronic monitoring and voice prompts improve hand hygiene and decrease nosocomial infections in an intermediate care unit. *Crit Care Med* 2004;32:358-63.
661. Kretzer EK, Larson EL. Behavioral interventions to improve infection control practices. *Am J Infect Control* 1998;26:245-53.
662. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems: recommendations from the Guidelines Working Group. *MMWR Recomm Rep* 2001;50:1-35.
663. Semmelweis IP. Die aetiologie, der begriff und die prophylaxis des kindbettfiebers. Pest, Wein, und Leipzig: CA Harleben's Verlags-Expedition; 1861.
664. Bratzler DW, Houck PM. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. *Clin Infect Dis* 2004;38:1706-15.
665. Bloom BT, Craddock A, Delmore PM, et al. Reducing acquired infections in the NICU: observing and implementing meaningful differences in process between high and low acquired infection rate centers. *J Perinatol* 2003;23:489-92.
666. Braun BI, Kritchevsky SB, Wong ES, et al. Preventing central venous catheter-associated primary bloodstream infections: characteristics of practices among hospitals participating in the Evaluation of Processes and Indicators in Infection Control (EPIC) study. *Infect Control Hosp Epidemiol* 2003;24:926-35.
667. Baker OG. Process surveillance: an epidemiologic challenge for all health care organizations. *Am J Infect Cont* 1997;25:96-101.
668. Loeb M, McGeer A, McArthur M, Peeling RW, Petric M, Simor AE. Surveillance for outbreaks of respiratory tract infections in nursing homes. *CMAJ* 2000;162:1133-7.
669. Nicolle LE. Preventing infections in non-hospital settings: long-term care. *Emerg Infect Dis* 2001;7:205-7.
670. Pottinger JM, Herwaldt LA, Perl TM. Basics of surveillance: an overview. *Infect Control Hosp Epidemiol* 1997;18:513-27.
671. Lee TB, Baker OG, Lee JT, Scheckler WE, Steele L, Laxton CE. Recommended practices for surveillance. Association for Professionals in Infection Control and Epidemiology Inc, Surveillance Initiative Working Group. *Am J Infect Control* 1998;26:277-88.
672. Haley RW. The scientific basis for using surveillance and risk factor data to reduce nosocomial infection rates. *J Hosp Infect* 1995;30(Suppl):3-14.
673. Benneyan JC, Lloyd RC, Plsek PE. Statistical process control as a tool for research and healthcare improvement. *Qual Saf Health Care* 2003;12:458-64.
674. Lemmen SW, Zolldann D, Gastmeier P, Lutticken R. Implementing and evaluating a rotating surveillance system and infection control guidelines in 4 intensive care units. *Am J Infect Control* 2001;29:89-93.
675. Gaynes R, Richards C, Edwards J, et al. Feeding back surveillance data to prevent hospital-acquired infections. *Emerg Infect Dis* 2001;7:295-8.
676. Tokars JL, Richards C, Andrus M, et al. The changing face of surveillance for health care-associated infections. *Clin Infect Dis* 2004;39:1347-52.

677. Sands KE, Yokoe DS, Hooper DC, et al. Detection of postoperative surgical-site infections: comparison of health plan-based surveillance with hospital-based programs. *Infect Control Hosp Epidemiol* 2003;24:741-3.
678. Jodra VM, Rodela AR, Martinez EM, Fresnena NL. Standardized infection ratios for three general surgery procedures: a comparison between Spanish hospitals and US centers participating in the National Nosocomial Infections Surveillance System. *Infect Control Hosp Epidemiol* 2003;24:744-8.
679. McKibben L, Horan T, Tokars JI, et al. Guidance on public reporting of healthcare-associated infections: recommendations of the Healthcare Infection Control Practices Advisory Committee. *Am J Infect Control* 2005;33:217-26.
680. Gould D, Chamberlain A. The use of a ward-based educational teaching package to enhance nurses' compliance with infection control procedures. *J Clin Nurs* 1997;6:55-67.
681. Calabro K, Weltge A, Parnell S, Kouzekanani K, Ramirez E. Intervention for medical students: effective infection control. *Am J Infect Control* 1998;26:431-6.
682. Haiduvon DJ, Hench CP, Simpkins SM, Stevens DA. Standardized management of patients and employees exposed to pertussis. *Infect Control Hosp Epidemiol* 1998;19:861-4.
683. Macartney KK, Gorelick MH, Manning ML, Hodinka RL, Bell LM. Nosocomial respiratory syncytial virus infections: the cost-effectiveness and cost benefit of infection control. *Pediatrics* 2000;106:520-6.
684. Beekmann SE, Vaughn TE, McCoy KD, et al. Hospital bloodborne pathogens programs: program characteristics and blood and body fluid exposure rates. *Infect Control Hosp Epidemiol* 2001;22:73-82.
685. Sokas RK, Simmens S, Scott J. A training program in universal precautions for second-year medical students. *Acad Med* 1993;68:374-6.
686. Ostrowsky BE, Trick WE, Sohn AH, et al. Control of vancomycin-resistant enterococcus in health care facilities in a region. *N Engl J Med* 2001;344:1427-33.
687. Bonten MJ, Kollef MH, Hall JB. Risk factors for ventilator-associated pneumonia: from epidemiology to patient management. *Clin Infect Dis* 2004;38:1141-9.
688. Lau JT, Fung KS, Wong TW, et al. SARS transmission among hospital workers in Hong Kong. *Emerg Infect Dis* 2004;10:280-6.
689. Talbot TR, Bradley SE, Cosgrove SE, Ruef C, Siegel JD, Weber DJ. Influenza vaccination of healthcare workers and vaccine allocation for healthcare workers during vaccine shortages. *Infect Control Hosp Epidemiol* 2005;26:882-90.
690. Harbarth S, Siegrist CA, Schira JC, Wunderli W, Pittet D. Influenza immunization: improving compliance of healthcare workers. *Infect Control Hosp Epidemiol* 1998;19:337-42.
691. Bryant KA, Stover B, Cain L, Levine GL, Siegel J, Jarvis WR. Improving influenza immunization rates among healthcare workers caring for high-risk pediatric patients. *Infect Control Hosp Epidemiol* 2004;25:912-7.
692. Martinello RA, Jones L, Topal JE. Correlation between healthcare workers' knowledge of influenza vaccine and vaccine receipt. *Infect Control Hosp Epidemiol* 2003;24:845-7.
693. Goldrick B, Gruendemann B, Larson E. Learning styles and teaching/learning strategy preferences: implications for educating nurses in critical care, the operating room, and infection control. *Heart Lung* 1993;22:176-82.
694. Davis D, O'Brien MA, Freemantle N, Wolf FM, Mazmanian P, Taylor-Vaisey A. Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? *JAMA* 1999;282:867-74.
695. Carr H, Hinson P. Education and training. In *APIC Infection Control and Epidemiology*. 2nd edition Washington, DC: Association for Professionals in Infection Control and Epidemiology; 2005. p 11-1.
696. Caffarella RS. Planning programs for adult learners: a practical guide for educators, trainers, and staff developers. 2nd ed. San Francisco: Jossey-Bass; 2001.
697. Sargeant J, Curran V, Jarvis-Selinger S, et al. Interactive on-line continuing medical education: physicians' perceptions and experiences. *J Contin Educ Health Prof* 2004;24:227-36.
698. Van Harrison R. Systems-based framework for continuing medical education and improvements in translating new knowledge into physicians' practices. *J Contin Educ Health Prof* 2004;24(Suppl 1):S50-62.
699. Cole TB, Glass RM. Learning associated with participation in journal-based continuing medical education. *J Contin Educ Health Prof* 2004;24:205-12.
700. Diekema DJ, Albanese MA, Schuldt SS, Doebbeling BN. Blood and body fluid exposures during clinical training: relation to knowledge of universal precautions. *J Gen Intern Med* 1996;11:109-11.
701. Diekema DJ, Schuldt SS, Albanese MA, Doebbeling BN. Universal precautions training of preclinical students: impact on knowledge, attitudes, and compliance. *Prev Med* 1995;24:580-5.
702. Warren DK, Zack JE, Cox MJ, Cohen MM, Fraser VJ. An educational intervention to prevent catheter-associated bloodstream infections in a nonteaching, community medical center. *Crit Care Med* 2003;31:1959-63.
703. Dubbert PM, Dolce J, Richter W, Miller M, Chapman SW. Increasing ICU staff handwashing: effects of education and group feedback. *Infect Control Hosp Epidemiol* 1990;11:191-3.
704. Avila-Aguero ML, Umana MA, Jimenez AL, Faingezicht I, Paris MM. Handwashing practices in a tertiary-care, pediatric hospital and the effect on an educational program. *Clin Perform Qual Health Care* 1998;6:70-2.
705. Lai KK, Fontecchio SA, Kelley AL, Melvin ZS. Knowledge of the transmission of tuberculosis and infection control measures for tuberculosis among healthcare workers. *Infect Control Hosp Epidemiol* 1996;17:168-70.
706. Koenig S, Chu J. Senior medical students' knowledge of universal precautions. *Acad Med* 1993;68:372-4.
707. Babcock HM, Zack JE, Garrison T, et al. An educational intervention to reduce ventilator-associated pneumonia in an integrated health system: a comparison of effects. *Chest* 2004;125:2224-31.
708. McGuckin M, Taylor A, Martin V, Porten L, Salcido R. Evaluation of a patient education model for increasing hand hygiene compliance in an inpatient rehabilitation unit. *Am J Infect Control* 2004;32:235-8.
709. Cirone N. Patient-education handbook. *Nursing* 1997;27:44-5.
710. Chase TM. Learning styles and teaching strategies: enhancing the patient education experience. *SCI Nursing* 2001;18:138-41.
711. Jarvis WR. Handwashing: the Semmelweis lesson forgotten? *Lancet* 1994;344:1311-2.
712. Daniels IR, Rees BI. Handwashing: simple, but effective. *Ann R Coll Surg Engl* 1999;81:117-8.
713. Webster J, Faoagali JL, Cartwright D. Elimination of methicillin-resistant *Staphylococcus aureus* from a neonatal intensive care unit after hand washing with triclosan. *J Paediatr Child Health* 1994;30:59-64.
714. Zafar AB, Butler RC, Reese DJ, Gaydos LA, Mennonna PA. Use of 0.3% triclosan (Bacti-Stat) to eradicate an outbreak of methicillin-resistant *Staphylococcus aureus* in a neonatal nursery. *Am J Infect Control* 1995;23:200-8.
715. Malik RK, Montecalvo MA, Reale MR, et al. Epidemiology and control of vancomycin-resistant enterococci in a regional neonatal intensive care unit. *Pediatr Infect Dis J* 1999;18:352-6.
716. Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. *Lancet Infect Dis* 2001;9:20.
717. Lin CM, Wu FM, Kim HK, Doyle MP, Michael BS, Williams LK. A comparison of hand-washing techniques to remove *Escherichia coli*

- and caliciviruses under natural or artificial fingernails. *J Food Prot* 2003;66:2296-301.
718. Edel E, Houston S, Kennedy V, LaRocco M. Impact of a 5-minute scrub on the microbial flora found on artificial, polished, or natural fingernails of operating room personnel. *Nurs Res* 1998;47:54-9.
 719. Pottinger J, Burns S, Manske C. Bacterial carriage by artificial versus natural nails. *Am J Infect Control* 1989;17:340-4.
 720. Hedderwick SA, McNeil SA, Lyons MJ, Kauffman CA. Pathogenic organisms associated with artificial fingernails worn by healthcare workers. *Infect Control Hosp Epidemiol* 2000;21:505-9.
 721. Passaro DJ, Waring L, Armstrong R, et al. Postoperative *Serratia marcescens* wound infections traced to an out-of-hospital source. *J Infect Dis* 1997;175:992-5.
 722. Moolenaar RL, Crutcher JM, San Joaquin VH, et al. A prolonged outbreak of *Pseudomonas aeruginosa* in a neonatal intensive care unit: did staff fingernails play a role in disease transmission? *Infect Control Hosp Epidemiol* 2000;21:80-5.
 723. Parry MF, Grant B, Yukna M, et al. *Candida* osteomyelitis and diskitis after spinal surgery: an outbreak that implicates artificial nail use. *Clin Infect Dis* 2001;32:352-7.
 724. Boszczowski I, Nicoletti C, Puccini DM, et al. Outbreak of extended spectrum beta-lactamase-producing *Klebsiella pneumoniae* infection in a neonatal intensive care unit related to onychomycosis in a health care worker. *Pediatr Infect Dis J* 2005;24:648-50.
 725. Trick WE, Vernon MO, Hayes RA, et al. Impact of ring wearing on hand contamination and comparison of hand hygiene agents in a hospital. *Clin Infect Dis* 2003;36:1383-90.
 726. Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. *Arch Intern Med* 1999;159:821-6.
 727. Tenorio AR, Badri SM, Sahgal NB, et al. Effectiveness of gloves in the prevention of hand carriage of vancomycin-resistant enterococcus species by health care workers after patient care. *Clin Infect Dis* 2001;32:826-9.
 728. Mast ST, Woolwine JD, Gerberding JL. Efficacy of gloves in reducing blood volumes transferred during simulated needlestick injury. *J Infect Dis* 1993;168:1589-92.
 729. Medical Glove Guidance Manual. Available from. Accessed.
 730. Korniewicz DM, El-Masri M, Broyles JM, Martin CD, O'Connell KP. Performance of latex and nonlatex medical examination gloves during simulated use. *Am J Infect Control* 2002;30:133-8.
 731. Korniewicz DM, McLeskey SW. Latex allergy and gloving standards. *Semin Perioper Nurs* 1998;7:216-21.
 732. Ranta PM, Ownby DR. A review of natural-rubber latex allergy in health care workers. *Clin Infect Dis* 2004;38:252-6.
 733. Korniewicz DM, Kirwin M, Cresci K, et al. Barrier protection with examination gloves: double versus single. *Am J Infect Control* 1994;22:12-5.
 734. Korniewicz DM, Kirwin M, Cresci K, Larson E. Leakage of latex and vinyl exam gloves in high- and low-risk clinical settings. *Am Ind Hyg Assoc J* 1993;54:22-6.
 735. Rego A, Roley L. In-use barrier integrity of gloves: latex and nitrile superior to vinyl. *Am J Infect Control* 1999;27:405-10.
 736. Kotilainen HR, Brinker JP, Avato JL, Gantz NM. Latex and vinyl examination gloves. Quality control procedures and implications for health care workers. *Arch Intern Med* 1989;149:2749-53.
 737. Korniewicz DM, Laughon BE, Butz A, Larson E. Integrity of vinyl and latex procedure gloves. *Nurs Res* 1989;38:144-6.
 738. Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens: final rule. 29 CFR Part 1910:1030. *Federal Register* 1991;56:64003-182 Revised 2001 CFR 66 2001:5317-25.
 739. Centers for Disease Control and Prevention. Recommendations for preventing the spread of vancomycin resistance: recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep* 1995;44:1-13.
 740. Olsen RJ, Lynch P, Coyle MB, Cummings J, Bokete T, Stamm WE. Examination gloves as barriers to hand contamination in clinical practice. *JAMA* 1993;270:350-3.
 741. Doebbeling BN, Pfaller MA, Houston AK, Wenzel RP. Removal of nosocomial pathogens from the contaminated glove: implications for glove reuse and handwashing. *Ann Intern Med* 1988;109:394-8.
 742. Maki DG, McCormick RD, Zilz MA, et al. A MRSA outbreak in an SICU during universal precautions: new epidemiology for nosocomial MRSA [abstract 473]. Presented at the 30th Annual Meeting of the Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC), Chicago, IL, October 21-24, 1990.
 743. Boyce JM, Jackson MM, Pugliese G, et al. Methicillin-resistant *Staphylococcus aureus* (MRSA): a briefing for acute care hospitals and nursing facilities. The AHA Technical Panel on Infections Within Hospitals. *Infect Control Hosp Epidemiol* 1994;15(2):105-15.
 744. Boyce JM, Mermel LA, Zervos MJ, et al. Controlling vancomycin-resistant enterococci. *Infect Control Hosp Epidemiol* 1995;16:634-7.
 745. Gerding DN, Johnson S, Peterson LR, Mulligan ME, Silva J Jr. *Clostridium difficile*-associated diarrhea and colitis. *Infect Control Hosp Epidemiol* 1995;16:459-77.
 746. Cloney DL, Donowitz LG. Overgrown use for infection control in nurseries and neonatal intensive care units. *Am J Dis Child* 1986;140:680-3.
 747. Pelke S, Ching D, Easa D, Melish ME. Gowning does not affect colonization or infection rates in a neonatal intensive care unit. *Arch Pediatr Adolesc Med* 1994;148:1016-20.
 748. Slaughter S, Hayden MK, Nathan C, et al. A comparison of the effect of universal use of gloves and gowns with that of glove use alone on acquisition of vancomycin-resistant enterococci in a medical intensive care unit. *Ann Intern Med* 1996;125:448-56.
 749. Duquette-Petersen L, Francis ME, Dohnalek L, Skinner R, Dudas P. The role of protective clothing in infection prevention in patients undergoing autologous bone marrow transplantation. *Oncol Nurs Forum* 1999;26:1319-24.
 750. Sartori M, La Terra G, Aglietta M, Manzin A, Navino C, Verzetti G. Transmission of hepatitis C via blood splash into conjunctiva. *Scand J Infect Dis* 1993;25:270-1.
 751. Hosoglu S, Celen MK, Akalin S, Geyik MF, Soyoral Y, Kara IH. Transmission of hepatitis C by blood splash into conjunctiva in a nurse. *Am J Infect Control* 2003;31:502-4.
 752. Centers for Disease Control and Prevention. Update: human immunodeficiency virus infections in health care workers exposed to blood of infected patients. *MMWR Morb Mortal Wkly Rep* 1987;36:285-9.
 753. Keijman J, Tjhie J, Olde Damink S, Alink M. Unusual nosocomial transmission of *Mycobacterium tuberculosis*. *Eur J Clin Microbiol Infect Dis* 2001;20:808-9.
 754. Weaver GH. Value of the face mask and other measures. *JAMA* 1918;70:76.
 755. Weaver GH. Droplet infection and its prevention by the face mask. *J Infect Dis* 1919;24:218-30.
 756. Davidson IR, Crisp AJ, Hinwood DC, Whitaker SC, Gregson RH. Eye splashes during invasive vascular procedures. *Br J Radiol* 1995;68:39-41.
 757. Guidance for industry and FDA staff: surgical masks. Premarket notification [510(k)] submissions; guidance for industry and FDA. <http://www.fda.gov/cdrh/ode/guidance/094.html>.
 758. National Institute for Occupational Health and Safety. Eye protection for infection control. <http://www.cdc.gov/niosh/topics/eye/eye-infectious.html>.
 759. Gala CL, Hall CB, Schnabel KC, et al. The use of eye-nose goggles to control nosocomial respiratory syncytial virus infection. *JAMA* 1986;256:2706-8.
 760. Agah R, Cherry JD, Garakian AJ, Chapin M. Respiratory syncytial virus (RSV) infection rate in personnel caring for children with RSV infections: routine isolation procedure versus routine procedure supplemented by use of masks and goggles. *Am J Dis Child* 1987;141:695-7.

761. Thorburn K, Kerr S, Taylor N, van Saene HK. RSV outbreak in a paediatric intensive care unit. *J Hosp Infect* 2004;57:194-201.
762. <http://a257.g.akamaitech.net/7/257/2422/06jun20041800/edocket.access.gpo.gov/2004/04-25183.htm>.
763. Occupational Safety and Health Administration. Respiratory protection. www.osha.gov/dcspl/ote/trng-materials/respirators/respirators.html.
764. Campbell DL, Coffey CC, Lenhart SW. Respiratory protection as a function of respirator fitting characteristics and fit-test accuracy. *Am Ind Hyg Assoc J* 2001;62:36-44.
765. Lee K, Slavcev A, Nicas M. Respiratory protection against *Mycobacterium tuberculosis*: quantitative fit test outcomes for five type N95 filtering-facepiece respirators. *J Occup Environ Hyg* 2004;1:22-8.
766. Coffey CC, Campbell DL, Zhuang Z. Simulated workplace performance of N95 respirators. *Am Ind Hyg Assoc J* 1999;60:618-24.
767. Coffey CC, Lawrence RB, Zhuang Z, Campbell DL, Jensen PA, Myers WR. Comparison of five methods for fit-testing N95 filtering-facepiece respirators. *Appl Occup Environ Hyg* 2002;17:723-30.
768. National Personal Protective Technology Laboratory. Available from www.cdc.gov/niosh/npptl/. Accessed.
769. McGowan JE Jr. Nosocomial tuberculosis: new progress in control and prevention. *Clin Infect Dis* 1995;21:489-505.
770. Jarvis WR. Nosocomial transmission of multidrug-resistant *Mycobacterium tuberculosis*. *Am J Infect Control* 1995;23:146-51.
771. Centers for Disease Control and Prevention. Emergency preparedness and response. Available from www.btcd.gov 2003. Accessed.
772. Anderson JD, Bonner M, Scheifele DW, Schneider BC. Lack of nosocomial spread of varicella in a pediatric hospital with negative-pressure ventilated patient rooms. *Infect Control* 1985;6:120-1.
773. Brunell PA, Wood D. Varicella serological status of healthcare workers as a guide to whom to test or immunize. *Infect Control Hosp Epidemiol* 1999;20:355-7.
774. Saiman L, LaRossa P, Steinberg SP, et al. Persistence of immunity to varicella-zoster virus after vaccination of healthcare workers. *Infect Control Hosp Epidemiol* 2001;22:279-83.
775. Willy ME, Koziol DE, Fleisher T, et al. Measles immunity in a population of healthcare workers. *Infect Control Hosp Epidemiol* 1994;15:12-7.
776. Wright LJ, Carlquist JF. Measles immunity in employees of a multi-hospital healthcare provider. *Infect Control Hosp Epidemiol* 1994;15:8-11.
777. Centers for Disease Control and Prevention. Updated US Public Health Service Guidelines for the management of occupational exposures to HBV, HCV, and HIV. *MMWR Recomm Rep* 2001;50:1-52.
778. Do AN, Ciesielski CA, Metler RP, Hammett TA, Li J, Fleming PL. Occupationally acquired human immunodeficiency virus (HIV) infection: national case surveillance data during 20 years of the HIV epidemic in the United States. *Infect Control Hosp Epidemiol* 2003;24:86-96.
779. Centers for Disease Control and Prevention. Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other bloodborne pathogens in health-care settings. *MMWR Morb Mortal Wkly Rep* 1988;37:377-88.
780. Davis MS. Occupational hazards of operating: opportunities for improvement. *Infect Control Hosp Epidemiol* 1996;17:691-3.
781. Gerberding JL. Procedure-specific infection control for preventing intraoperative blood exposures. *Am J Infect Control* 1993;21:364-7.
782. Fry DE, Telford GL, Fecteau DL, Sperling RS, Meyer AA. Prevention of blood exposure: body and facial protection. *Surg Clin North Am* 1995;75:1141-57.
783. Hansen ME. Bloodborne pathogens and procedure safety in interventional radiology. *Semin Ultrasound CT MR* 1998;19:209-14.
784. Holodnick CL, Barkauskas V. Reducing percutaneous injuries in the OR by educational methods. *AORN J* 2000;72:461-76.
785. www.osha.gov/SLTC/bloodbornepathogens/index.html.
786. www.cdc.gov/niosh/2000-108.html.
787. National Institute for Occupational Health and Safety. Safer medical device implementation in health care facilities. <http://www.cdc.gov/niosh/topics/bbp/safer/>.
788. Centers for Disease Control and Prevention. Available from www.cdc.gov/sharpssafety/resources.html.
789. Catanzaro A. Nosocomial tuberculosis. *Am Rev Respir Dis* 1982;125:559-62.
790. Cepeda JA, Whitehouse T, Cooper B, et al. Isolation of patients in single rooms or cohorts to reduce spread of MRSA in intensive-care units: prospective two-centre study. *Lancet* 2005;365:295-304.
791. Mulin B, Rouget C, Clement C, et al. Association of private isolation rooms with ventilator-associated *Acinetobacter baumannii* pneumonia in a surgical intensive-care unit. *Infect Control Hosp Epidemiol* 1997;18:499-503.
792. www.aia.org/aah_gd_hospcons.
793. Raad I, Abbas J, Whimbey E. Infection control of nosocomial respiratory viral disease in the immunocompromised host. *Am J Med* 1997;102:48-52.
794. Isaacs D, Dickson H, O'Callaghan C, Sheaves R, Winter A, Moxon ER. Handwashing and cohorting in prevention of hospital acquired infections with respiratory syncytial virus. *Arch Dis Child* 1991;66:227-31.
795. Chang VT, Nelson K. The role of physical proximity in nosocomial diarrhea. *Clin Infect Dis* 2000;31:717-22.
796. Byers KE, Anglim AM, Anneski CJ, et al. A hospital epidemic of vancomycin-resistant *Enterococcus*: risk factors and control. *Infect Control Hosp Epidemiol* 2001;22:140-7.
797. Dassut B. The implementation of a commode cleaning and identification system. *Nurs Times* 2004;100:47.
798. Mayer RA, Geha RC, Helfand MS, Hoyen CK, Salata RA, Donskey CJ. Role of fecal incontinence in contamination of the environment with vancomycin-resistant enterococci. *Am J Infect Control* 2003;31:221-5.
799. Samore MH, Venkataraman L, DeGirolami PC, Arbeit RD, Karchmer AV. Clinical and molecular epidemiology of sporadic and clustered cases of nosocomial *Clostridium difficile* diarrhea. *Am J Med* 1996;100:32-40.
800. Clabots CR, Johnson S, Olson MM, Peterson LR, Gerding DN. Acquisition of *Clostridium difficile* by hospitalized patients: evidence for colonized new admissions as a source of infection. *J Infect Dis* 1992;166:561-7.
801. Samore MH. Epidemiology of nosocomial *Clostridium difficile* diarrhoea. *J Hosp Infect* 1999;43(Suppl):S183-90.
802. Tokars JL, Satake S, Rimland D, et al. The prevalence of colonization with vancomycin-resistant *Enterococcus* at a Veterans' Affairs institution. *Infect Control Hosp Epidemiol* 1999;20:171-5.
803. Cone R, Mohan K, Thoulless M, Corey L. Nosocomial transmission of rotavirus infection. *Pediatr Infect Dis J* 1988;7:103-9.
804. Bruce BB, Blass MA, Blumberg HM, Lennox JL, del Rio C, Hirschburg CR Jr. Risk of *Cryptosporidium parvum* transmission between hospital roommates. *Clin Infect Dis* 2000;31:947-50.
805. Ford-Jones EL, Mindorff CM, Gold R, Petric M. The incidence of viral-associated diarrhea after admission to a pediatric hospital. *Am J Epidemiol* 1990;131:711-8.
806. Murray-Leisure KA, Geib S, Graceley D, et al. Control of epidemic methicillin-resistant *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 1990;11:343-50.
807. Jochimsen EM, Fish L, Manning K, et al. Control of vancomycin-resistant enterococci at a community hospital: efficacy of patient and staff cohorting. *Infect Control Hosp Epidemiol* 1999;20:106-9.
808. Sample ML, Gravel D, Oxley C, Toye B, Garber G, Ramotar K. An outbreak of vancomycin-resistant enterococci in a hematology-oncology unit: control by patient cohorting and terminal cleaning of the environment. *Infect Control Hosp Epidemiol* 2002;23:468-70.
809. Podnos YD, Cinat ME, Wilson SE, Cooke J, Gornick W, Thrupp LD. Eradication of multidrug-resistant *Acinetobacter* from an intensive care unit. *Surg Infect (Larchmt)* 2001;2:297-301.

810. Graham PL 3rd, Morel AS, Zhou J, et al. Epidemiology of methicillin-susceptible *Staphylococcus aureus* in the neonatal intensive care unit. *Infect Control Hosp Epidemiol* 2002;23:677-82.
811. Doherty JA, Brookfield DS, Gray J, McEwan RA. Cohorting of infants with respiratory syncytial virus. *J Hosp Infect* 1998;38:203-6.
812. Hall CB, Geiman JM, Douglas RG Jr, Meagher MP. Control of nosocomial respiratory syncytial viral infections. *Pediatrics* 1978;62:728-32.
813. Buffington J, Chapman LE, Stobierski MG, et al. Epidemic keratoconjunctivitis in a chronic care facility: risk factors and measures for control. *J Am Geriatr Soc* 1993;41:1177-81.
814. Grehn M, Kunz J, Sigg P, Slongo R, Zbinden R. Nosocomial rotavirus infections in neonates: means of prevention and control. *J Perinat Med* 1990;18:369-74.
815. Tan YM, Chow PK, Tan BH, et al. Management of inpatients exposed to an outbreak of severe acute respiratory syndrome (SARS). *J Hosp Infect* 2004;58:210-5.
816. Talon D, Vichard P, Muller A, Bertin M, Jeunet L, Bertrand X. Modelling the usefulness of a dedicated cohort facility to prevent the dissemination of MRSA. *J Hosp Infect* 2003;54:57-62.
817. Hotchkiss JR, Strike DG, Simonson DA, Broccard AF, Crooke PS. An agent-based and spatially explicit model of pathogen dissemination in the intensive care unit. *Crit Care Med* 2005;33:168-76.
818. Austin DJ, Bonten MJ, Weinstein RA, Slaughter S, Anderson RM. Vancomycin-resistant enterococci in intensive-care hospital settings: transmission dynamics, persistence, and the impact of infection control programs. *Proc Natl Acad Sci U S A* 1999;96:6908-13.
819. Kovner CT, Harrington C. Counting nurses: data show many nursing homes to be short-staffed. *Am J Nurs* 2000;100:53-4.
820. Mueller C. Staffing problems in long-term care: let's do something about it!. *J Gerontol Nurs* 2003;29:3-4.
821. Stats & facts: nursing staff shortages in long-term care facilities. *Manag Care Interface* 2000;13:46-7.
822. Mejias A, Chavez-Bueno S, Ramilo O. Human metapneumovirus: a not-so-new virus. *Pediatr Infect Dis J* 2004;23:1-7.
823. Iwane MK, Edwards KM, Szilagyi PG, et al. Population-based surveillance for hospitalizations associated with respiratory syncytial virus, influenza virus, and parainfluenza viruses among young children. *Pediatrics* 2004;113:1758-64.
824. Ong GM, Wyatt DE, O'Neill HJ, McCaughey C, Coyle PV. A comparison of nested polymerase chain reaction and immunofluorescence for the diagnosis of respiratory infections in children with bronchiolitis, and the implications for a cohorting strategy. *J Hosp Infect* 2001;49:122-8.
825. von Linstow ML, Larsen HH, Eugen-Olsen J, et al. Human metapneumovirus and respiratory syncytial virus in hospitalized Danish children with acute respiratory tract infection. *Scand J Infect Dis* 2004;36:578-84.
826. Gehanno JF, Pestel-Caron M, Nouvellon M, Caillard JF. Nosocomial pertussis in healthcare workers from a pediatric emergency unit in France. *Infect Control Hosp Epidemiol* 1999;20:549-52.
827. www.cdc.gov/flu/professionals/infectioncontrol/resphygiene.htm.
828. Edlin BR, Tokars JL, Grieco MH, et al. An outbreak of multidrug-resistant tuberculosis among hospitalized patients with the acquired immunodeficiency syndrome. *N Engl J Med* 1992;326:1514-21.
829. Centers for Disease Control and Prevention. Update: severe acute respiratory syndrome, Toronto, Canada, 2003. *MMWR Morb Mortal Wkly Rep* 2003;52:547-50.
830. Starke JR. Transmission of *Mycobacterium tuberculosis* to and from children and adolescents. *Semin Pediatr Infect Dis* 2001;12:115-23.
831. Saiman L, Macdonald N, Burns JL, Hoiby N, Speert DP, Weber D. Infection control in cystic fibrosis: practical recommendations for the hospital, clinic, and social settings. *Am J Infect Control* 2000;28:381-5.
832. American Academy of Pediatrics. Red Book 2003 Report of the Committee on Infectious Diseases. 24th ed. Elk Grove Village (IL): American Academy of Pediatrics; 2003.
833. Lau JT, Lau M, Kim JH, Tsui HY, Tsang T, Wong TW. Probable secondary infections in households of SARS patients in Hong Kong. *Emerg Infect Dis* 2004;10:235-43.
834. Hota B. Contamination, disinfection, and cross-colonization: are hospital surfaces reservoirs for nosocomial infection? *Clin Infect Dis* 2004;39:1182-9.
835. Rutala WA, Weber DJ. Disinfection and sterilization in health care facilities: what clinicians need to know. *Clin Infect Dis* 2004;39:702-9.
836. Boyce JM, Opal SM, Chow JW, et al. Outbreak of multidrug-resistant *Enterococcus faecium* with transferable vanB class vancomycin resistance. *J Clin Microbiol* 1994;32:1148-53.
837. Engelhart S, Krizek L, Glasmacher A, Fischnaller E, Marklein G, Exner M. *Pseudomonas aeruginosa* outbreak in a haematology-oncology unit associated with contaminated surface cleaning equipment. *J Hosp Infect* 2002;52:93-8.
838. Denton M, Wilcox MH, Parnell P, et al. Role of environmental cleaning in controlling an outbreak of *Acinetobacter baumannii* on a neurosurgical intensive care unit. *J Hosp Infect* 2004;56:106-10.
839. Hollyoak V, Allison D, Summers J. *Pseudomonas aeruginosa* wound infection associated with a nursing home's whirlpool bath. *Commun Dis Rep CDR Rev* 1995;5:R100-2.
840. Malik RE, Cooper RA, Griffith CJ. Use of audit tools to evaluate the efficacy of cleaning systems in hospitals. *Am J Infect Control* 2003;31:181-7.
841. Ansari SA, Springthorpe VS, Sattar SA. Survival and vehicular spread of human rotaviruses: possible relation to seasonality of outbreaks. *Rev Infect Dis* 1991;13:448-61.
842. Kaatz GW, Gitlin SD, Schaberg DR, et al. Acquisition of *Clostridium difficile* from the hospital environment. *Am J Epidemiol* 1988;127:1289-94.
843. Mayfield JL, Leet T, Miller J, Mundy LM. Environmental control to reduce transmission of *Clostridium difficile*. *Clin Infect Dis* 2000;31:995-1000.
844. Dennehy PH. Transmission of rotavirus and other enteric pathogens in the home. *Pediatr Infect Dis J* 2000;19(10 Suppl):S103-5.
845. Dennehy P. Rotavirus infections in infection control reference service. In: Abrutyn E, Goldmann D, Scheckler W, editors. . Philadelphia: Saunders; 2001. p. 821-3.
846. Wilcox MH, Fawley WN, Wigglesworth N, Parnell P, Verity P, Freeman J. Comparison of the effect of detergent versus hypochlorite cleaning on environmental contamination and incidence of *Clostridium difficile* infection. *J Hosp Infect* 2003;54:109-14.
847. Rutala WA, Weber DJ. Healthcare Infection Control Practices Advisory Committee Committee (HICPAC). Guideline for disinfection and sterilization in health care facilities. 2007. in press.
848. Bernards AT, Harinck HJ, Dijkshoorn L, van der Reijden TJ, van den Broek PJ. Persistent *Acinetobacter baumannii*? Look inside your medical equipment. *Infect Control Hosp Epidemiol* 2004;25:1002-4.
849. Neely AN, Weber JM, Daviau P, et al. Computer equipment used in patient care within a multihospital system: recommendations for cleaning and disinfection. *Am J Infect Control* 2005;33:233-7.
850. Neely AN, Maley MP, Warden GD. Computer keyboards as reservoirs for *Acinetobacter baumannii* in a burn hospital. *Clin Infect Dis* 1999;29:1358-60.
851. Bures S, Fishbain JT, Uyehara CF, Parker JM, Berg BW. Computer keyboards and faucet handles as reservoirs of nosocomial pathogens in the intensive care unit. *Am J Infect Control* 2000;28:465-71.
852. Brooks S, Khan A, Stoica D, et al. Reduction in vancomycin-resistant *Enterococcus* and *Clostridium difficile* infections following change to tympanic thermometers. *Infect Control Hosp Epidemiol* 1998;19:333-6.

853. Jernigan JA, Siegelman-Igra Y, Guerrant RC, Farr BM. A randomized crossover study of disposable thermometers for prevention of *Clostridium difficile* and other nosocomial infections. *Infect Control Hosp Epidemiol* 1998;19:494-9.
854. Weinstein SA, Gantz NM, Pelletier C, Hibert D. Bacterial surface contamination of patients' linen: isolation precautions versus standard care. *Am J Infect Control* 1989;17:264-7.
855. Pugliese G. Isolating and double-bagging laundry: is it really necessary? *Health Facil Manag* 1989;2:16-21.
856. Available from. Accessed .
857. Kiehl E, Wallace R, Warren C. Tracking perinatal infection: is it safe to launder your scrubs at home? *MCN Am J Matern Child Nurs* 1997;22:195-7.
858. Jurkovich P. Home- versus hospital-laundered scrubs: a pilot study. *MCN Am J Matern Child Nurs* 2004;29:106-10.
859. US Environmental Protection Agency. Medical waste. Available from www.epa.gov/epaoswer/other/medical/.
860. www.cdc.gov/ncidod/dhqp/gl_environinfection.html.
861. Maki DG, Alvarado C, Hassemer C. Double-bagging of items from isolation rooms is unnecessary as an infection control measure: a comparative study of surface contamination with single- and double-bagging. *Infect Control* 1986;7:535-7.
862. Centers for Disease Control and Prevention. Recommended antimicrobial agents for the treatment and postexposure prophylaxis of pertussis: 2005 CDC guidelines. *MMWR Recomm Rep* 2005;54:1-16.
863. Centers for Disease Control and Prevention. Prevention and control of meningococcal disease: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2000;49:1-10.
864. Centers for Disease Control and Prevention. Notice to readers: additional options for preventive treatment for persons exposed to inhalational anthrax. *MMWR Morb Mortal Wkly Rep* 2001;50:1142-51.
865. Centers for Disease Control and Prevention. Updated US Public Health Service guidelines for the management of occupational exposures to HIV and recommendations for postexposure prophylaxis. *MMWR Recomm Rep* 2005;54:1-17.
866. Boyce JM. MRSA patients: proven methods to treat colonization and infection. *J Hosp Infect* 2001;48(Suppl A):S9-S14.
867. Barrett FF, Mason EO Jr, Fleming D. Brief clinical and laboratory observations. *J Pediatr* 1979;94:796-800.
868. American Academy of Pediatrics and American Academy of Obstetricians and Gynecologists. Guidelines for perinatal care. 4th ed. Elk Grove Village (IL): American Academy of Pediatrics; 2002.
869. Centers for Disease Control and Prevention. Management of multidrug-resistant organisms in health care settings, 2006. Available from. Accessed.
870. Kallen AJ, Wilson CT, Larson RJ. Perioperative intranasal mupirocin for the prevention of surgical-site infections: systematic review of the literature and meta-analysis. *Infect Control Hosp Epidemiol* 2005;26:916-22.
871. Carrier M, Marchand R, Auger P, et al. Methicillin-resistant *Staphylococcus aureus* infection in a cardiac surgical unit. *J Thorac Cardiovasc Surg* 2002;123:40-4.
872. Tacconelli E, Carmeli Y, Aizer A, Ferreira G, Foreman MG, D'Agata EM. Mupirocin prophylaxis to prevent *Staphylococcus aureus* infection in patients undergoing dialysis: a meta-analysis. *Clin Infect Dis* 2003;37:1629-38.
873. Centers for Disease Control and Prevention. Immunization of health-care workers: recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep* 1997;46:1-42.
874. Mahoney FJ, Stewart K, Hu H, Coleman P, Alter MJ. Progress toward the elimination of hepatitis B virus transmission among health care workers in the United States. *Arch Intern Med* 1997;157:2601-5.
875. Gladstone JL, Millian SJ. Rubella exposure in an obstetric clinic. *Obstet Gynecol* 1981;57:182-6.
876. Wilde JA, McMillan JA, Serwint J, Butta J, O'Riordan MA, Steinhoff MC. Effectiveness of influenza vaccine in health care professionals: a randomized trial. *JAMA* 1999;281:908-13.
877. Potter J, Stott DJ, Roberts MA, et al. Influenza vaccination of health care workers in long-term care hospitals reduces the mortality of elderly patients. *J Infect Dis* 1997;175:1-6.
878. Pearson ML, Bridges CB, Harper SA. Influenza vaccination of health-care personnel: recommendations of the Healthcare Infection Control Practices Advisory Committee (HICPAC) and the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2006;55:1-16.
879. Wright SV, Decker MD, Edwards KM. Incidence of pertussis infection in healthcare workers. *Infect Control Hosp Epidemiol* 1999;20:120-3.
880. Calugar A, Ortega-Sanchez IR, Tiwari T, Oakes L, Jahre JA, Murphy TV. Nosocomial pertussis: costs of an outbreak and benefits of vaccinating health care workers. *Clin Infect Dis* 2006;42:981-8.
881. www.fda.gov.
882. Campins-Marti M, Cheng HK, Forsyth K, et al. Recommendations are needed for adolescent and adult pertussis immunisation: rationale and strategies for consideration. *Vaccine* 2001;20:641-6.
883. www.cdc.gov/nip/recs/provisional_rec/default.htm.
884. Centers for Disease Control and Prevention. Recommended childhood and adolescent immunization schedule, United States, 2006. *MMWR Morb Mortal Wkly Rep* 2006;54:Q1-4.
885. Centers for Disease Control and Prevention. Recommended childhood and adolescent immunization schedule, United States, 2006. *Pediatrics* 2006;117:239-40.
886. Centers for Disease Control and Prevention. Recommended adult immunization schedule, United States, October 2005–September 2006. *MMWR Morb Mortal Wkly Rep* 2005;54:Q1-4.
887. Centers for Disease Control and Prevention. Prevention of varicella: updated recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 1999;48:1-5.
888. McKenney D, Pouliot KL, Wang Y, et al. Broadly protective vaccine for *Staphylococcus aureus* based on an in vivo-expressed antigen. *Science* 1999;284:1523-7.
889. Shinefield H, Black S, Fattom A, et al. Use of a *Staphylococcus aureus* conjugate vaccine in patients receiving hemodialysis. *N Engl J Med* 2002;346:491-6.
890. Abadeso C, Almeida HI, Virella D, Carreiro MH, Machado MC. Use of palivizumab to control an outbreak of syncytial respiratory virus in a neonatal intensive care unit. *J Hosp Infect* 2004;58:38-41.
891. George RH, Gully PR, Gill ON, Innes JA, Bakhshi SS, Connolly M. An outbreak of tuberculosis in a children's hospital. *J Hosp Infect* 1986;8:129-42.
892. Simor AE, Lee M, Vearncombe M, et al. An outbreak due to multi-resistant *Acinetobacter baumannii* in a burn unit: risk factors for acquisition and management. *Infect Control Hosp Epidemiol* 2002;23:261-7.
893. Puzniak LA, Leet T, Mayfield J, Kollef M, Mundy LM. To gown or not to gown: the effect on acquisition of vancomycin-resistant enterococci. *Clin Infect Dis* 2002;35:18-25.
894. Hanna H, Umphrey J, Tarrand J, Mendoza M, Raad I. Management of an outbreak of vancomycin-resistant enterococci in the medical intensive care unit of a cancer center. *Infect Control Hosp Epidemiol* 2001;22:217-9.
895. Centers for Disease Control and Prevention. Recommendations for preventing transmission of infection with human T-lymphotropic virus type III/lymphadenopathy-associated virus in the workplace. *MMWR Morb Mortal Wkly Rep* 1985;34:681-95.

896. Centers for Disease Control and Prevention. Severe acute respiratory syndrome, Taiwan, 2003. MMWR Morb Mortal Wkly Rep 2003;52:461-6.
897. Capps JA. Measures for the prevention and control of respiratory infections in military camps. JAMA 1918;71:448-51.
898. Thomas C. Efficiency of surgical masks in use in hospital wards: report to the Control of Infection Subcommittee. Guys Hosp Rep 1961;110:157-67.
899. Beck M, Antle BJ, Berlin D, et al. Wearing masks in a pediatric hospital: developing practical guidelines. Can J Public Health 2004;95:256-7.
900. Ryan MA, Christian RS, Wohlrahe J. Handwashing and respiratory illness among young adults in military training. Am J Prev Med 2001;21:79-83.
901. Roberts L, Smith W, Jorm L, Patel M, Douglas RM, McGilchrist C. Effect of infection control measures on the frequency of upper respiratory infection in child care: a randomized, controlled trial. Pediatrics 2000;105(4 Pt 1):738-42.
902. White C, Kolble R, Carlson R, et al. The effect of hand hygiene on illness rate among students in university residence halls. Am J Infect Control 2003;31:364-70.
903. Aiello AE, Larson EL. What is the evidence for a causal link between hygiene and infections? Lancet Infect Dis 2002;2:103-10.
904. American Association of Nurse Anesthetists. Reuse of needles and syringes by healthcare providers put patients at risk. Available from www.aana.com/news.aspx?ucNavMenu_TSMMenuTargetID=171&ucNavMenu_TSMMenuTargetType=4&ucNavMenu_TSMMenuID=6&id=1613. Accessed November 10, 2007.
905. Watanakunakorn C, Stahl C. *Streptococcus salivarius* meningitis following myelography. Infect Control Hosp Epidemiol 1992;13:454.
906. Gelfand MS, Abolnik IZ. Streptococcal meningitis complicating diagnostic myelography: three cases and review. Clin Infect Dis 1995;20:582-7.
907. Schlesinger JJ, Salit IE, McCormack G. Streptococcal meningitis after myelography. Arch Neurol 1982;39:576-7.
908. Yaniv LG, Potasman I. Iatrogenic meningitis: an increasing role for resistant viridans streptococci? Case report and review of the last 20 years. Scand J Infect Dis 2000;32:693-6.
909. Schlegel L, Merlet C, Laroche JM, Fremaux A, Geslin P. Iatrogenic meningitis due to *Abiotrophia defectiva* after myelography. Clin Infect Dis 1999;28:155-6.
910. Schneeberger PM, Janssen M, Voss A. Alpha-hemolytic streptococci: a major pathogen of iatrogenic meningitis following lumbar puncture. Case reports and a review of the literature. Infection 1996;24:29-33.
911. Veringa E, van Belkum A, Schellekens H. Iatrogenic meningitis by *Streptococcus salivarius* following lumbar puncture. J Hosp Infect 1995;29:316-8.
912. Couzigou C, Vuong TK, Botherel AH, Aggoune M, Astagneau P. Iatrogenic *Streptococcus salivarius* meningitis after spinal anaesthesia: need for strict application of standard precautions. J Hosp Infect 2003;53:313-4.
913. Torres E, Alba D, Frank A, Diez-Tejedor E. Iatrogenic meningitis due to *Streptococcus salivarius* following a spinal tap. Clin Infect Dis 1993;17:525-6.
914. Trautmann M, Lepper PM, Schmitz FJ. Three cases of bacterial meningitis after spinal and epidural anesthesia. Eur J Clin Microbiol Infect Dis 2002;21:43-5.
915. Baer ET. Iatrogenic meningitis: the case for face masks. Clin Infect Dis 2000;31:519-21.
916. Black SR, Weinstein RA. The case for face masks: zorro or zero? Clin Infect Dis 2000;31:522-3.
917. Phillips BJ, Fergusson S, Armstrong P, Anderson FM, Wildsmith JA. Surgical face masks are effective in reducing bacterial contamination caused by dispersal from the upper airway. Br J Anaesth 1992;69:407-8.
918. Centers for Disease Control and Prevention. Guidelines for the prevention of intravascular catheter-related infections. MMWR Recomm Rep 2002;51:1-26.
919. Catalano G, Houston SH, Catalano MC, et al. Anxiety and depression in hospitalized patients in resistant organism isolation. South Med J 2003;96:141-5.
920. Tarzi S, Kennedy P, Stone S, Evans M. Methicillin-resistant *Staphylococcus aureus*: psychological impact of hospitalization and isolation in an older adult population. J Hosp Infect 2001;49:250-4.
921. Kelly-Rossini L, Perlman DC, Mason DJ. The experience of respiratory isolation for HIV-infected persons with tuberculosis. J Assoc Nurses AIDS Care 1996;7:29-36.
922. Knowles HE. The experience of infectious patients in isolation. Nurs Times 1993;89:53-6.
923. Evans HL, Shaffer MM, Hughes MG, et al. Contact isolation in surgical patients: a barrier to care? Surgery 2003;134:180-8.
924. Kirkland KB, Weinstein JM. Adverse effects of contact isolation. Lancet 1999;354:1177-8.
925. Saint S, Higgins LA, Nallamothu BK, Chenoweth C. Do physicians examine patients in contact isolation less frequently? A brief report. Am J Infect Control 2003;31:354-6.
926. Management of multidrug-resistant organisms in healthcare settings, 2006. Available from www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf.
927. Hall CB, Powell KR, MacDonald NE, et al. Respiratory syncytial viral infection in children with compromised immune function. N Engl J Med 1986;315:77-81.
928. Lui SL, Luk WK, Cheung CY, Chan TM, Lai KN, Peiris JS. Nosocomial outbreak of parvovirus B19 infection in a renal transplant unit. Transplantation 2001;71:59-64.
929. Weinstock DM, Gubareva LV, Zuccotti G. Prolonged shedding of multidrug-resistant influenza A virus in an immunocompromised patient. N Engl J Med 2003;348:867-8.
930. van Tol MJ, Claas EC, Heemskerk B, et al. Adenovirus infection in children after allogeneic stem cell transplantation: diagnosis, treatment and immunity. Bone Marrow Transplant 2005;35(Suppl 1):S73-6.
931. Wood DJ, David TJ, Chrystie IL, Totterdell B. Chronic enteric virus infection in two T-cell-immunodeficient children. J Med Virol 1988;24:435-44.
932. Mori I, Matsumoto K, Sugimoto K, et al. Prolonged shedding of rotavirus in a geriatric inpatient. J Med Virol 2002;67:613-5.
933. Cederna JE, Terpenning MS, Ensberg M, Bradley SF, Kauffman CA. *Staphylococcus aureus* nasal colonization in a nursing home: eradication with mupirocin. Infect Control Hosp Epidemiol 1990;11:13-6.
934. Kauffman CA, Terpenning MS, He X, et al. Attempts to eradicate methicillin-resistant *Staphylococcus aureus* from a long-term-care facility with the use of mupirocin ointment. Am J Med 1993;94:371-8.
935. Montecalvo MA, de Lencastre H, Carraher M, et al. Natural history of colonization with vancomycin-resistant *Enterococcus faecium*. Infect Control Hosp Epidemiol 1995;16:680-5.
936. D'Agata EM, et al. High rate of false-negative results of the rectal swab culture method in detection of gastrointestinal colonization with vancomycin-resistant enterococci. Clin Infect Dis 2002;34:167-72.
937. Donskey CJ, Hoen CK, Das SM, Helfand MS, Hecker MT. Recurrence of vancomycin-resistant *Enterococcus* stool colonization during antibiotic therapy. Infect Control Hosp Epidemiol 2002;23:436-40.
938. Scanvic A, Denic L, Gaillon S, Giry P, Andreumont A, Lucet JC. Duration of colonization by methicillin-resistant *Staphylococcus aureus* after hospital discharge and risk factors for prolonged carriage. Clin Infect Dis 2001;32:1393-8.
939. Noskin GA, Bednarz P, Suriano T, Reiner S, Peterson LR. Persistent contamination of fabric-covered furniture by vancomycin-resistant enterococci: implications for upholstery selection in hospitals. Am J Infect Control 2000;28:311-3.
940. Gerson SL, Parker P, Jacobs MR, Creger R, Lazarus HM. Aspergillosis due to carpet contamination. Infect Control Hosp Epidemiol 1994;15(4 Pt 1):221-3.
941. Taplin D, Mertz PM. Flower vases in hospitals as reservoirs of pathogens. Lancet 1973;2:1279-81.

942. Walsh TJ, Dixon DM. Nosocomial aspergillosis: environmental microbiology, hospital epidemiology, diagnosis and treatment. *Eur J Epidemiol* 1989;5:131-42.
943. Lass-Flörl C, Rath P, Niederwieser D, et al. *Aspergillus terreus* infections in haematological malignancies: molecular epidemiology suggests association with in-hospital plants. *J Hosp Infect* 2000;46:31-5.
944. Raad I, Hanna H, Osting C, et al. Masking of neutropenic patients on transport from hospital rooms is associated with a decrease in nosocomial aspergillosis during construction. *Infect Control Hosp Epidemiol* 2002;23:41-3.
945. www.cms.hhs.gov/CLIA.
946. Emori TG, Haley RW, Stanley RC. The infection control nurse in US hospitals, 1976-1977: characteristics of the position and its occupant. *Am J Epidemiol* 1980;111:592-607.
947. Richet HM, Benbachir M, Brown DE, et al. Are there regional variations in the diagnosis, surveillance, and control of methicillin-resistant *Staphylococcus aureus*? *Infect Control Hosp Epidemiol* 2003;24:334-41.
948. Anderson DJ, Kirkland KB, McDonald JR, et al. Results of a survey of work duties of 56 infection control professionals (ICPs): are new guidelines needed for the staffing of infection control (IC) programs? [abstract 146]. Presented at the 16th annual meeting of the Society for Healthcare Epidemiology of America, Chicago, IL, 2006.
949. Harvey MA. Critical care unit bedside design and furnishing: impact on nosocomial infections. *Infect Control Hosp Epidemiol* 1998;19:597-601.
950. Srinivasan A, Beck C, Buckley T, et al. The ability of hospital ventilation systems to filter *Aspergillus* and other fungi following a building implosion. *Infect Control Hosp Epidemiol* 2002;23:520-4.
951. Maragakis LL, Bradley KL, Song X, et al. Increased catheter-related bloodstream infection rates after the introduction of a new mechanical valve intravenous access port. *Infect Control Hosp Epidemiol* 2006;27:67-70.
952. Joint Commission on Accreditation of Healthcare Organizations. Comprehensive accreditation manual for hospitals: the official handbook. Oakbrook Terrace (IL): Joint Commission on Accreditation of Healthcare Organizations; 2007.
953. Peterson LR, Noskin GA. New technology for detecting multidrug-resistant pathogens in the clinical microbiology laboratory. *Emerg Infect Dis* 2001;7:306-11.
954. Diekema DJ, Doebbeling BN. Employee health and infection control. *Infect Control Hosp Epidemiol* 1995;16:292-301.
955. Weems JJ Jr. Nosocomial outbreak of *Pseudomonas cepacia* associated with contamination of reusable electronic ventilator temperature probes. *Infect Control Hosp Epidemiol* 1993;14:583-6.
956. Berthelot P, Grattard F, Mahul P, et al. Ventilator temperature sensors: an unusual source of *Pseudomonas cepacia* in nosocomial infection. *J Hosp Infect* 1993;25:33-43.
957. Centers for Disease Control and Prevention. Bronchoscopy-related infections and pseudoinfections, New York, 1996 and 1998. *MMWR Morb Mortal Wkly Rep* 1999;48:557-60.
958. Heeg P, Roth K, Reichl R, Cogdill CP, Bond WW. Decontaminated single-use devices: an oxymoron that may be placing patients at risk for cross-contamination. *Infect Control Hosp Epidemiol* 2001;22:542-9.
959. www.fda.gov/cdrh/reprocessing/.
960. Centers for Disease Control and Prevention. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2003;52:1-36.
961. Weinstock DM, Eagan J, Malak SA, et al. Control of influenza A on a bone marrow transplant unit. *Infect Control Hosp Epidemiol* 2000;21:730-2.
962. Cromer AL, Hutsell SO, Latham SC, et al. Impact of implementing a method of feedback and accountability related to contact precautions compliance. *Am J Infect Control* 2004;32:451-5.
963. Eveillard M, Eb F, Tramier B, et al. Evaluation of the contribution of isolation precautions in prevention and control of multi-resistant bacteria in a teaching hospital. *J Hosp Infect* 2001;47:116-24.
964. Pfeiffer J, Gilmore G. The text as an orientation tool. In: Pfeiffer J, editor. *APIC Text of Infection Control and Epidemiology*. Washington, DC: Association for Professionals in Infection Control and Epidemiology; 2000 7/1-8.
965. Gaynes RP, Emori TG. Surveillance for nosocomial infections. In: Abrutyn E, Goldmann DA, Scheckler WE, editors. *Saunders Infection Control Reference*. Philadelphia, PA: Saunders; 2001. p. 40-4.
966. Centers for Disease Control and Prevention. Monitoring hospital-acquired infections to promote patient safety, United States, 1990-1999. *MMWR Morb Mortal Wkly Rep* 2000;49:149-53.
967. Curran ET, Benneyan JC, Hood J. Controlling methicillin-resistant *Staphylococcus aureus*: a feedback approach using annotated statistical process control charts. *Infect Control Hosp Epidemiol* 2002;23:13-8.
968. Lanotte P, Cantagrel S, Mereghetti L, et al. Spread of *Stenotrophomonas maltophilia* colonization in a pediatric intensive care unit detected by monitoring tracheal bacterial carriage and molecular typing. *Clin Microbiol Infect* 2003;9:1142-7.
969. Coopersmith CM, Zack JE, Ward MR, et al. The impact of bedside behavior on catheter-related bacteremia in the intensive care unit. *Arch Surg* 2004;139:131-6.
970. O'Brien KL, Beall B, Barrett NL, et al. Epidemiology of invasive group A streptococcus disease in the United States, 1995-1999. *Clin Infect Dis* 2002;35:268-76.
971. Nicolle LE, Dyck B, Thompson G, et al. Regional dissemination and control of epidemic methicillin-resistant *Staphylococcus aureus*. Manitoba Chapter of CHICA-Canada. *Infect Control Hosp Epidemiol* 1999;20(3):202-5.
972. Seybold U, Kourbatova EV, Johnson JG, et al. Emergence of community-associated methicillin-resistant *Staphylococcus aureus* USA300 genotype as a major cause of health care-associated blood stream infections. *Clin Infect Dis* 2006;42:647-56.
973. Bond WW, Favero MS, Petersen NJ, Gravelle CR, Ebert JW, Maynard JE. Survival of hepatitis B virus after drying and storage for one week. *Lancet* 1981;1:550-1.
974. Ehrenkranz NJ, Alfonso BC. Failure of bland soap handwash to prevent hand transfer of patient bacteria to urethral catheters. *Infect Control Hosp Epidemiol* 1991;12:654-62.
975. Winnefeld M, Richard MA, Drancourt M, Grob JJ. Skin tolerance and effectiveness of two hand decontamination procedures in everyday hospital use. *Br J Dermatol* 2000;143:546-50.
976. Widmer AF. Replace hand washing with use of a waterless alcohol hand rub? *Clin Infect Dis* 2000;31:136-43.
977. Mortimer EA Jr, Lipsitz PJ, Wolinsky E, Gonzaga AJ, Rammelkamp CH Jr. Transmission of staphylococci between newborns: importance of the hands to personnel. *Am J Dis Child* 1962;104:289-95.
978. Casewell M, Phillips I. Hands as route of transmission for *Klebsiella* species. *Br Med J* 1977;2:1315-7.
979. Ojajarvi J. Effectiveness of hand washing and disinfection methods in removing transient bacteria after patient nursing. *J Hyg (Lond)* 1980;85:193-203.
980. Otter J, Havill N, Adams N, Joyce J. Extensive environmental contamination associated with patients with loose stools and MRSA colonization of the gastrointestinal tract [abstract 159]. Presented at the 16th annual scientific meeting of the Society for Healthcare Epidemiology of America, Chicago, IL, 2006.
981. Weber DJ, Sickbert-Bennett E, Gergen MF, Rutala WA. Efficacy of selected hand hygiene agents used to remove *Bacillus atrophaeus* (a surrogate of *Bacillus anthracis*) from contaminated hands. *JAMA* 2003;289:1274-7.
982. Saiman L, Lerner A, Saal L, et al. Banning artificial nails from health care settings. *Am J Infect Control* 2002;30:252-4.
983. Johnson S, Gerding DN, Olson MM, et al. Prospective, controlled study of vinyl glove use to interrupt *Clostridium difficile* nosocomial transmission. *Am J Med* 1990;88:137-40.
984. Neal JG, Jackson EM, Suber F, Edlich RF. Latex glove penetration by pathogens: a review of the literature. *J Long Term Eff Med Implants* 1998;8:233-40.

985. Broyles JM, O'Connell KP, Korniewicz DM. PCR-based method for detecting viral penetration of medical exam gloves. *J Clin Microbiol* 2002;40:2725-8.
986. Patterson JE, Vecchio J, Pantelick EL, et al. Association of contaminated gloves with transmission of *Acinetobacter calcoaceticus* var. anitratus in an intensive care unit. *Am J Med* 1991;91:479-83.
987. Goldmann DA. Epidemiology and prevention of pediatric viral respiratory infections in health-care institutions. *Emerg Infect Dis* 2001;7:249-53.
988. Gaggero A, Avendano LF, Fernandez J, Spencer E. Nosocomial transmission of rotavirus from patients admitted with diarrhea. *J Clin Microbiol* 1992;30:3294-7.
989. Merritt K, Hitchins VM, Brown SA. Safety and cleaning of medical materials and devices. *J Biomed Mater Res* 2000;53:131-6.
990. Kampf G, Bloss R, Martiny H. Surface fixation of dried blood by glutaraldehyde and peracetic acid. *J Hosp Infect* 2004;57:139-43.
991. Weber DJ, Rutala WA. Role of environmental contamination in the transmission of vancomycin-resistant enterococci. *Infect Control Hosp Epidemiol* 1997;18:306-9.
992. Byers KE, Durbin LJ, Simonton BM, Anglim AM, Adal KA, Farr BM. Disinfection of hospital rooms contaminated with vancomycin-resistant *Enterococcus faecium*. *Infect Control Hosp Epidemiol* 1998;19:261-4.
993. Martinez JA, Ruthazer R, Hansjosten K, Barefoot L, Snyderman DR. Role of environmental contamination as a risk factor for acquisition of vancomycin-resistant enterococci in patients treated in a medical intensive care unit. *Arch Intern Med* 2003;163:1905-12.
994. US Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticidal Act 7 USC 136 et seq.
995. Devine J, Cooke RP, Wright EP. Is methicillin-resistant *Staphylococcus aureus* (MRSA) contamination of ward-based computer terminals a surrogate marker for nosocomial MRSA transmission and handwashing compliance? *J Hosp Infect* 2001;48:72-5.
996. Sattar SA, Springthorpe S, Mani S, et al. Transfer of bacteria from fabrics to hands and other fabrics: development and application of a quantitative method using *Staphylococcus aureus* as a model. *J Appl Microbiol* 2001;90:962-70.
997. Shiomi T, Miyamoto H, Makishima K, et al. Evaluation of bedmaking-related airborne and surface methicillin-resistant *Staphylococcus aureus* contamination. *J Hosp Infect* 2002;50:30-5.
998. Whyte W, Baird G, Annand R. Bacterial contamination on the surface of hospital linen chutes. *J Hyg (Lond)* 1969;67:427-35.
999. Michaelsen GS. Designing linen chutes to reduce spread of infectious organisms. *Hospitals* 1965;39:116-9.
1000. Plott RT, Wagner RF Jr, Tying SK. Iatrogenic contamination of multidose vials in simulated use: a reassessment of current patient injection technique. *Arch Dermatol* 1990;126:1441-4.
1001. Samandari T, Malakmadze N, Balter S, et al. A large outbreak of hepatitis B virus infections associated with frequent injections at a physician's office. *Infect Control Hosp Epidemiol* 2005;26:745-50.
1002. Comstock RD, Mallonee S, Fox JL, et al. A large nosocomial outbreak of hepatitis C and hepatitis B among patients receiving pain remediation treatments. *Infect Control Hosp Epidemiol* 2004;25:576-83.
1003. Germain JM, Carbonne A, Thiers V, et al. Patient-to-patient transmission of hepatitis C virus through the use of multidose vials during general anesthesia. *Infect Control Hosp Epidemiol* 2005;26:789-92.
1004. Macedo de Oliveira A, White KL, Leschinsky DP, et al. An outbreak of hepatitis C virus infections among outpatients at a hematology/oncology clinic. *Ann Intern Med* 2005;142:898-902.
1005. Hsu J, Jensen B, Arduino M, et al. Streptococcal meningitis following myelogram procedures. *Infect Control Hosp Epidemiol* 2007;28:614-7.
1006. Srinivasan A, Song X, Ross T, Merz W, Brower R, Perl TM. A prospective study to determine whether cover gowns in addition to gloves decrease nosocomial transmission of vancomycin-resistant enterococci in an intensive care unit. *Infect Control Hosp Epidemiol* 2002;23:424-8.
1007. Nichols WG, Corey L, Gooley T, Davis C, Boeckh M. Parainfluenza virus infections after hematopoietic stem cell transplantation: risk factors, response to antiviral therapy, and effect on transplant outcome. *Blood* 2001;98:573-8.
1008. Elizaga J, Olavarria E, Apperley J, Goldman J, Ward K. Parainfluenza virus 3 infection after stem cell transplant: relevance to outcome of rapid diagnosis and ribavirin treatment. *Clin Infect Dis* 2001;32:413-8.
1009. Oishi I, Kimura T, Murakami T, et al. Serial observations of chronic rotavirus infection in an immunodeficient child. *Microbiol Immunol* 1991;35:953-61.
1010. Fierobe L, Lucet JC, Decre D, et al. An outbreak of imipenem-resistant *Acinetobacter baumannii* in critically ill surgical patients. *Infect Control Hosp Epidemiol* 2001;22:35-40.
1011. Montesinos I, Salido E, Delgado T, Lecuona M, Sierra A. Epidemiology of methicillin-resistant *Staphylococcus aureus* at a university hospital in the Canary Islands. *Infect Control Hosp Epidemiol* 2003;24:667-72.
1012. Poutanen SM, Vearncombe M, McGeer AJ, Gardam M, Large G, Simor AE. Nosocomial acquisition of methicillin-resistant *Staphylococcus aureus* during an outbreak of severe acute respiratory syndrome. *Infect Control Hosp Epidemiol* 2005;26:134-7.
1013. Yap FH, Gomersall CD, Fung KS, et al. Increase in methicillin-resistant *Staphylococcus aureus* acquisition rate and change in pathogen pattern associated with an outbreak of severe acute respiratory syndrome. *Clin Infect Dis* 2004;39:511-6.
1014. Layton MC, Perez M, Heald P, Patterson JE. An outbreak of mupirocin-resistant *Staphylococcus aureus* on a dermatology ward associated with an environmental reservoir. *Infect Control Hosp Epidemiol* 1993;14:369-75.
1015. Gilmore A, Stuart J, Andrews N. Risk of secondary meningococcal disease in health-care workers. *Lancet* 2000;356:1654-5.
1016. www.cdc.gov/flu/avian/index.htm.
1017. www.hhs.gov/pandemicflu/plan/pdf/S04.pdf.
1018. Ehresmann KR, Hedberg CW, Grimm MB, Norton CA, MacDonald KL, Osterholm MT. An outbreak of measles at an international sporting event with airborne transmission in a domed stadium. *J Infect Dis* 1995;171:679-83.
1019. Gustafson TL, Lavelle GB, Brawner ER Jr, Hutcheson RH Jr, Wright PF, Schaffner W. An outbreak of airborne nosocomial varicella. *Pediatrics* 1982;70:550-6.
1020. Hyams PJ, Stuewe MC, Heitzer V. Herpes zoster causing varicella (chickenpox) in hospital employees: cost of a casual attitude. *Am J Infect Control* 1984;12:2-5.
1021. Pavelchak N, DePersis RP, London M, et al. Identification of factors that disrupt negative air pressurization of respiratory isolation rooms. *Infect Control Hosp Epidemiol* 2000;21:191-5.
1022. Rice N, Streifel A, Vesley D. An evaluation of hospital special ventilation room pressures. *Infect Control Hosp Epidemiol* 2001;22:19-23.
1023. Hutton MD, Stead WW, Cauthen GM, Bloch AB, Ewing WM. Nosocomial transmission of tuberculosis associated with a draining abscess. *J Infect Dis* 1990;161:286-95.
1024. Frampton MV. An outbreak of tuberculosis among hospital personnel caring for a patient with a skin ulcer. *Ann Intern Med* 1992;117:312-3.
1025. Ammari LK, Bell LM, Hodinka RL. Secondary measles vaccine failure in healthcare workers exposed to infected patients. *Infect Control Hosp Epidemiol* 1993;14:81-6.
1026. Behrman A, Schmid DS, Crivaro A, Watson B. A cluster of primary varicella cases among healthcare workers with false-positive varicella zoster virus titers. *Infect Control Hosp Epidemiol* 2003;24:202-6.
1027. Josephson A, Gombert ME. Airborne transmission of nosocomial varicella from localized zoster. *J Infect Dis* 1988;158:238-41.
1028. Brodtkin RH. Zoster-causing varicella: current dangers of contagion without isolation. *Arch Dermatol* 1963;88:322-4.
1029. Suzuki K, Yoshikawa T, Tomitaka A, Matsunaga K, Asano Y. Detection of aerosolized varicella-zoster virus DNA in patients with localized herpes zoster. *J Infect Dis* 2004;189:1009-12.

1030. Ruuskanen O, Salmi TT, Halonen P. Measles vaccination after exposure to natural measles. *J Pediatr* 1978;93:43-6.
1031. Berkovich S, Starr S. Use of live measles virus vaccine to abort an expected outbreak of measles within a closed population. *N Engl J Med* 1963;269:75-7.
1032. Centers for Disease Control and Prevention. Measles, mumps, and rubella vaccine use and strategies for elimination of measles, rubella, and congenital rubella syndrome and control of mumps: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 1998;47:1-57.
1033. Centers for Disease Control and Prevention. General recommendations on immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2006;55:1-48.
1034. Watson B, Seward J, Yang A, et al. Postexposure effectiveness of varicella vaccine. *Pediatrics* 2000;105(1 Pt 1):84-8.
1035. Salzman MB, Garcia C. Postexposure varicella vaccination in siblings of children with active varicella. *Pediatr Infect Dis J* 1998;17:256-7.
1036. Centers for Disease Control and Prevention. Vaccinia (smallpox) vaccine: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2001. *MMWR Recomm Rep* 2001;50:1-25.
1037. Fulginiti VA, Papier A, Lane JM, Neff JM, Henderson DA. Smallpox vaccination: a review. Part I: background, vaccination technique, normal vaccination and revaccination, and expected normal reactions. *Clin Infect Dis* 2003;37:241-50.
1038. Dixon CW. Smallpox in Tripolitania, 1946: an epidemiological and clinical study of 500 cases, including trials of penicillin treatment. *J Hyg (Lond)* 1948;46:351-77.
1039. Murray WA, Streifel AJ, O'Dea TJ, Rhame FS. Ventilation for protection of immune-compromised patients. *ASHRAE Trans* 1988;94:1185.
1040. Rutala WA, Jones SM, Worthington JM, Reist PC, Weber DJ. Efficacy of portable filtration units in reducing aerosolized particles in the size range of *Mycobacterium tuberculosis*. *Infect Control Hosp Epidemiol* 1995;16:391-8.
1041. Mandell GL, Bennett JE, Dolin R, editors. Mandell, Douglas and Bennett's principles and practice of infectious diseases. 5th ed. Philadelphia: Churchill Livingstone; 2000.
1042. Heymann DL, editor. Control of communicable diseases manual. 18th ed. Washington, DC: American Public Health Association; 2005.
1043. Vreden SG, Visser LG, Verweij JJ, et al. Outbreak of amebiasis in a family in the Netherlands. *Clin Infect Dis* 2000;31:1101-4.
1044. Thacker SB, Kimball AM, Wolfe M, Choi K, Gilmore L. Parasitic disease control in a residential facility for the mentally retarded: failure of selected isolation procedures. *Am J Public Health* 1981;71:303-5.
1045. Sampathkumar P. West Nile virus: epidemiology, clinical presentation, diagnosis, and prevention. *Mayo Clin Proc* 2003;78:1137-43.
1046. Ruben B, Band JD, Wong P, Colville J. Person-to-person transmission of *Brucella melitensis*. *Lancet* 1991;337:14-5.
1047. Vandercam B, Zech F, de Cooman S, Bughin C, Gigi J, Wauters G. Isolation of *Brucella melitensis* from human sperm. *Eur J Clin Microbiol Infect Dis* 1990;9:303-4.
1048. Robichaud S, Libman M, Behr M, Rubin E. Prevention of laboratory-acquired brucellosis. *Clin Infect Dis* 2004;38:e119-22.
1049. Troy CJ, Peeling RV, Ellis AG, et al. *Chlamydia pneumoniae* as a new source of infectious outbreaks in nursing homes. *JAMA* 1997;277:1214-8.
1050. Ekman MR, Grayston JT, Visakorpi R, Kleemola M, Kuo CC, Saikku P. An epidemic of infections due to *Chlamydia pneumoniae* in military conscripts. *Clin Infect Dis* 1993;17:420-5.
1051. Eickhoff TC. An outbreak of surgical wound infections due to *Clostridium perfringens*. *Surg Gynecol Obstet* 1962;114:102-8.
1052. Kohn GJ, Linne SR, Smith CM, Hoeprich PD. Acquisition of coccidioidomycosis at necropsy by inhalation of coccidioid endospores. *Diagn Microbiol Infect Dis* 1992;15:527-30.
1053. Wright PW, Pappagianis D, Wilson M, et al. Donor-related coccidioidomycosis in organ transplant recipients. *Clin Infect Dis* 2003;37:1265-9.
1054. Maitreyi RS, Dar L, Muthukumar A, et al. Acute hemorrhagic conjunctivitis due to enterovirus 70 in India. *Emerg Infect Dis* 1999;5:267-9.
1055. Centers for Disease Control and Prevention. Acute hemorrhagic conjunctivitis outbreak caused by Coxsackievirus A24, Puerto Rico, 2003. *MMWR Morb Mortal Wkly Rep* 2004;53:632-4.
1056. Faden H, Wynn RJ, Campagna L, Ryan RM. Outbreak of adenovirus type 30 in a neonatal intensive care unit. *J Pediatr* 2005;146:523-7.
1057. Chaberny IE, Schnitzler P, Geiss HK, Wendt C. An outbreak of epidemic keratoconjunctivitis in a pediatric unit due to adenovirus type 8. *Infect Control Hosp Epidemiol* 2003;24:514-9.
1058. Warren D, Nelson KE, Farrar JA, et al. A large outbreak of epidemic keratoconjunctivitis: problems in controlling nosocomial spread. *J Infect Dis* 1989;160:938-43.
1059. www.cdc.gov/ncidod/dvrd/cjd/qa_cjd_infection_control.htm.
1060. Wang CY, Wu HD, Hsueh PR. Nosocomial transmission of cryptococcosis. *N Engl J Med* 2005;352:1271-2.
1061. Beyt BE Jr, Waltman SR. Cryptococcal endophthalmitis after corneal transplantation. *N Engl J Med* 1978;298:825-6.
1062. Widdowson MA, Glass R, Monroe S, et al. Probable transmission of norovirus on an airplane. *JAMA* 2005;293:1859-60.
1063. Centers for Disease Control and Prevention. Prevention of hepatitis A through active or passive immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 1999;48:1-37.
1064. Rosenblum LS, Villarino ME, Nainan OV, et al. Hepatitis A outbreak in a neonatal intensive care unit: risk factors for transmission and evidence of prolonged viral excretion among preterm infants. *J Infect Dis* 1991;164:476-82.
1065. Carl M, Kantor RJ, Webster HM, Fields HA, Maynard JE. Excretion of hepatitis A virus in the stools of hospitalized hepatitis patients. *J Med Virol* 1982;9:125-9.
1066. Robson SC, Adams S, Brink N, Woodruff B, Bradley D. Hospital outbreak of hepatitis E. *Lancet* 1992;339:1424-5.
1067. Arvin A, Whitley R. Herpes simplex virus infections. In: Remington JS, Klein JO, editors. Infectious diseases of the fetus and newborn infant. 5th ed. Philadelphia: Saunders; 2001.
1068. Enright AM, Prober CG. Neonatal herpes infection: diagnosis, treatment and prevention. *Semin Neonatol* 2002;7:283-91.
1069. Esper F, Boucher D, Weibel C, Martinello RA, Kahn JS. Human metapneumovirus infection in the United States: clinical manifestations associated with a newly emerging respiratory infection in children. *Pediatrics* 2003;111(6 Pt 1):1407-10.
1070. Colodner R, Sakran W, Miron D, Teitler N, Khavalevsky E, Kopelowitz J. *Listeria monocytogenes* cross-contamination in a nursery. *Am J Infect Control* 2003;31:322-4.
1071. Farber JM, Peterkin PI, Carter AO, Varughese PV, Ashton FE, Ewan EP. Neonatal listeriosis due to cross-infection confirmed by isoenzyme typing and DNA fingerprinting. *J Infect Dis* 1991;163:927-8.
1072. Schuchat A, Lizano C, Broome CV, Swaminathan B, Kim C, Winn K. Outbreak of neonatal listeriosis associated with mineral oil. *Pediatr Infect Dis J* 1991;10:183-9.
1073. Pejaver RK, Watson AH, Mucklow ES. Neonatal cross-infection with *Listeria monocytogenes*. *J Infect* 1993;26:301-3.
1074. Jain SK, Persaud D, Perl TM, et al. Nosocomial malaria and saline flush. *Emerg Infect Dis* 2005;11:1097-9.
1075. Abulrahi HA, Bohlega EA, Fontaine RE, al-Seghayer SM, al-Ruwais AA. *Plasmodium falciparum* malaria transmitted in hospital through heparin locks. *Lancet* 1997;349:23-5.
1076. Al-Saigul AM, Fontaine RE, Haddad Q. Nosocomial malaria from contamination of a multidose heparin container with blood. *Infect Control Hosp Epidemiol* 2000;21:329-30.

1077. Piro S, Samud M, Badi S, Al Ssabi L. Hospital-acquired malaria transmitted by contaminated gloves. *J Hosp Infect* 2001;47:156-8.
1078. Book LS, Overall JC Jr, Herbst JJ, Britt MR, Epstein B, Jung AL. Clustering of necrotizing enterocolitis: interruption by infection-control measures. *N Engl J Med* 1977;297:984-6.
1079. Rotbart HA, Levin MJ. How contagious is necrotizing enterocolitis? *Pediatr Infect Dis* 1983;2:406-13.
1080. Rotbart HA, Levin MJ, Yolken RH, Manchester DK, Jantzen J. An outbreak of rotavirus-associated neonatal necrotizing enterocolitis. *J Pediatr* 1983;103:454-9.
1081. Gerber AR, Hopkins RS, Lauer BA, Curry-Kane AG, Rotbart HA. Increased risk of illness among nursery staff caring for neonates with necrotizing enterocolitis. *Pediatr Infect Dis* 1985;4:246-9.
1082. Sanchez MP, Erdman DD, Torok TJ, Freeman CJ, Matyas BT. Outbreak of adenovirus 35 pneumonia among adult residents and staff of a chronic care psychiatric facility. *J Infect Dis* 1997;176:760-3.
1083. Singh-Naz N, Brown M, Ganesananthan M. Nosocomial adenovirus infection: molecular epidemiology of an outbreak. *Pediatr Infect Dis J* 1993;12:922-5.
1084. Uemura T, Kawashita T, Ostuka Y, Tanaka Y, Kusubae R, Yoshinaga M. A recent outbreak of adenovirus type 7 infection in a chronic inpatient facility for the severely handicapped. *Infect Control Hosp Epidemiol* 2000;21:559-60.
1085. Nuorti JP, Butler JC, Crutcher JM, et al. An outbreak of multidrug-resistant pneumococcal pneumonia and bacteremia among unvaccinated nursing home residents. *N Engl J Med* 1998;338:1861-8.
1086. Houff SA, Burton RC, Wilson RW, et al. Human-to-human transmission of rabies virus by corneal transplant. *N Engl J Med* 1979;300:603-4.
1087. Centers for Disease Control and Prevention. Human rabies prevention, United States, 1999: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 1999;48:1-21.
1088. Hayden FG. Rhinovirus and the lower respiratory tract. *Rev Med Virol* 2004;14:17-31.
1089. Valenti WM, Clarke TA, Hall CB, Menegus MA, Shapiro DL. Concurrent outbreaks of rhinovirus and respiratory syncytial virus in an intensive care nursery: epidemiology and associated risk factors. *J Pediatr* 1982;100:722-6.
1090. Chidekel AS, Rosen CL, Bazy AR. Rhinovirus infection associated with serious lower respiratory illness in patients with bronchopulmonary dysplasia. *Pediatr Infect Dis J* 1997;16:43-7.
1091. Drusin LM, Ross BG, Rhodes KH, Krauss AN, Scott RA. Nosocomial ringworm in a neonatal intensive care unit: a nurse and her cat. *Infect Control Hosp Epidemiol* 2000;21:605-7.
1092. Lewis SM, Lewis BG. Nosocomial transmission of *Trichophyton tonsurans* tinea corporis in a rehabilitation hospital. *Infect Control Hosp Epidemiol* 1997;18:322-5.
1093. Saiman L, Jakob K, Holmes KW, et al. Molecular epidemiology of staphylococcal scalded skin syndrome in premature infants. *Pediatr Infect Dis J* 1998;17:329-34.
1094. Ramage L, Green K, Pyskir D, Simor AE. An outbreak of fatal nosocomial infections due to group A streptococcus on a medical ward. *Infect Control Hosp Epidemiol* 1996;17:429-31.
1095. Kakis A, Gibbs L, Eguia J, et al. An outbreak of group A streptococcal infection among health care workers. *Clin Infect Dis* 2002;35:1353-9.
1096. Schwartz B, Elliott JA, Butler JC, et al. Clusters of invasive group A streptococcal infections in family, hospital, and nursing home settings. *Clin Infect Dis* 1992;15:277-84.
1097. National Communicable Disease Center. Isolation techniques for use in hospitals. Washington, DC: US Government Printing Office; 1970.
1098. Centers for Disease Control and Prevention. Isolation techniques for use in hospitals. 2nd ed. Washington, DC: US Government Printing Office; 1975.
1099. Garner JS, Simmons BP. CDC guideline for isolation precautions in hospitals. Atlanta (GA): US Department of Health and Human Services, Public Health Service, Centers for Disease Control; 1983.
1100. Lynch P, Jackson MM, Cummings MJ, Stamm WE. Rethinking the role of isolation practices in the prevention of nosocomial infections. *Ann Intern Med* 1987;107:243-6.

APPENDIX A: TYPE AND DURATION OF PRECAUTIONS RECOMMENDED FOR SELECTED INFECTIONS AND CONDITIONS

Preamble

The mode(s) and risk of transmission for each specific disease agent listed in this appendix were reviewed. Principle sources consulted for the development of disease-specific recommendations for the appendix included infectious disease manuals and textbooks.^{831,1039,1040} The published literature was searched for evidence of person-to-person transmission in health care and non-health care settings with a focus on reported outbreaks that would assist in developing recommendations for all settings where health care is delivered. The following criteria were used to assign transmission-based precautions categories:

- A transmission-based precautions category was assigned if there was strong evidence for person-to-person transmission via droplet, contact, or airborne routes in health care or non-health care settings and/or if patient factors (eg, diapered infants, diarrhea, draining wounds) increased the risk of transmission.
- Transmission-based precautions category assignments reflect the predominant mode(s) of transmission.
- If there was no evidence for person-to-person transmission by droplet, contact or airborne routes, then Standard Precautions were assigned.
- If there was a low risk for person-to-person transmission and no evidence of health care-associated transmission, then Standard Precautions were assigned.
- Standard precautions were assigned for bloodborne pathogens (eg, HBV, HCV, HIV) in accordance with CDC recommendations for universal precautions issued in 1988.⁷⁷⁸ Subsequent experience has confirmed the efficacy of Standard Precautions to prevent exposure to infected blood and body fluid.^{776,777,863}

Additional information relevant to use of precautions was added in the comments column to assist the caregiver in decision-making. Citations were added as needed to support a change in or provide additional evidence for recommendations for a specific disease and for new infectious agents (eg, SARS-CoV, avian influenza) that have been added to Appendix A. The reader may refer to more detailed discussion concerning modes of transmission and emerging pathogens in the background text and for MDRO control in the MDRO Guideline.

Appendix A. Continued.

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Abscess			
Draining, major	C	DI	No dressing or containment of drainage; until drainage stops or can be contained by dressing.
Draining, minor or limited	S		Dressing to cover and contain drainage.
AIDS/HIV	S		Postexposure chemoprophylaxis for some blood exposures. ⁸⁶⁵
Actinomycosis	S		Not transmitted from person to person.
Adenovirus infection (see agent-specific guidance under gastroenteritis, conjunctivitis, pneumonia)			
Amebiasis	S		Person-to-person transmission is rare. Transmission in settings for the mentally challenged and in a family group has been reported. ¹⁰⁴¹ Use care when handling diapered infants and mentally challenged persons. ¹⁰⁴²
Anthrax	S		Infected patients do not generally pose a transmission risk.
Cutaneous	S		Transmission through nonintact skin contact with draining lesions possible; thus, use Contact Precautions if a large amount of uncontained drainage is present. Handwashing with soap and water is preferable to the use of waterless alcohol-based antiseptics, because alcohol does not have sporicidal activity. ⁹⁷⁹
Pulmonary	S		Not transmitted from person to person.
Environmental: aerosolizable spore-containing powder or other substance		DE	Until decontamination of environment complete. ²⁰³ Wear respirator (N95 mask or PAPR), protective clothing; decontaminate persons with powder on them (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5135a3.htm). Hand hygiene: Handwashing for 30 to 60 seconds with soap and water or 2% chlorhexidine gluconate after spore contact. (Alcohol handrubs are inactive against spores.) ⁹⁷⁹ Postexposure prophylaxis after environmental exposure: 60 days of antimicrobials (either doxycycline, ciprofloxacin, or levofloxacin) and postexposure vaccine under IND.
Antibiotic-associated colitis (see <i>Clostridium difficile</i>)			
Arthropod-borne viral encephalitis (eastern, western, Venezuelan equine encephalomyelitis; St Louis, California encephalitis; west Nile virus) and viral fevers (dengue, yellow fever, Colorado tick fever)	S		Not transmitted from person to person except rarely by transfusion, and for West Nile virus by organ transplant, breastmilk or transplacentally. ^{528,1043} Install screens in windows and doors in endemic areas. Use DEET-containing mosquito repellants and clothing to cover extremities.
Ascariasis	S		Not transmitted from person to person.
Aspergillosis	S		Institute Contact Precautions and Airborne Precautions if massive soft tissue infection with copious drainage and repeated irrigations required. ¹⁵⁴
Avian influenza (see influenza, avian below)			
Babesiosis	S		Not transmitted from person to person except rarely by transfusion.
Blastomycosis, North American, cutaneous or pulmonary	S		Not transmitted from person to person.
Botulism	S		Not transmitted from person to person.
Bronchiolitis (see respiratory infections in infants and young children)	C	DI	Use mask according to Standard Precautions.
Brucellosis (undulant, Malta, Mediterranean fever)	S		Not transmitted from person to person except rarely through banked spermatozoa and sexual contact. ^{1044,1045} Provide antimicrobial prophylaxis following laboratory exposure. ¹⁰⁴⁶
Campylobacter gastroenteritis (see gastroenteritis)			
Candidiasis, all forms, including mucocutaneous	S		
Cat-scratch fever (benign inoculation lymphoreticulosis)	S		Not transmitted from person to person.

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Cellulitis	S		
Chancroid (soft chancre) (<i>Haemophilus ducreyi</i>)	S		Transmitted sexually from person to person.
Chickenpox (see varicella)			
<i>Chlamydia trachomatis</i>			
Conjunctivitis	S		
Genital (lymphogranuloma venereum)	S		
Pneumonia (infants ≤ 3 mos. of age)	S		
<i>Chlamydia pneumoniae</i>	S		Outbreaks in institutionalized populations are rarely reported. ^{1047,1048}
Cholera (see gastroenteritis)			
Closed-cavity infection			
Open drain in place; limited or minor drainage	S		Contact Precautions if copious uncontained drainage is present.
No drain or closed drainage system in place	S		
<i>Clostridium</i> spp			
<i>C. botulinum</i>	S		Not transmitted from person to person.
<i>C. difficile</i> (see gastroenteritis, <i>C. difficile</i>)	C	DI	
<i>C. perfringens</i>			
Food poisoning	S		Not transmitted from person to person.
Gas gangrene	S		Transmission from person to person is rare; 1 outbreak in a surgical setting has been reported. ¹⁰⁵³ Use Contact Precautions if wound drainage is extensive.
Coccidioidomycosis (valley fever)			
Draining lesions	S		Not transmitted from person to person except under extraordinary circumstances, because the infectious arthroconidial form of <i>Coccidioides immitis</i> is not produced in humans. ¹⁰⁵⁰
Pneumonia	S		Not transmitted from person to person except under extraordinary circumstances (eg, inhalation of aerosolized tissue phase endospores during necropsy, transplantation of infected lung), because the infectious arthroconidial form of <i>C immitis</i> is not produced in humans. ^{1050, 1051}
Colorado tick fever	S		Not transmitted from person to person.
Congenital rubella	C	Until age 1 year	Standard Precautions if nasopharyngeal and urine cultures are repeatedly negative after age 3 months.
Conjunctivitis			
Acute bacterial	S		
Chlamydial	S		
Gonococcal	S		
Acute viral (acute hemorrhagic)	C	DI	Adenovirus most common; enterovirus 70, ¹⁰⁵² Coxsackie virus A24 ¹⁰⁵⁴ also associated with community outbreaks. Highly contagious; outbreaks in eye clinics, pediatric and neonatal settings, institutional settings reported. Eye clinics should follow Standard Precautions when handling patients with conjunctivitis. Routine use of infection control measures in the handling of instruments and equipment will prevent the occurrence of outbreaks in this and other settings. ^{458,459,812,1054-1056}
Corona virus associated with SARS (SARS-CoV) (see severe acute respiratory syndrome)			
Coxsackie virus disease (see enteroviral infection)			
Creutzfeldt-Jakob disease (CJD, vCJD)	S		Use disposable instruments or special sterilization/disinfection for surfaces and objects contaminated with neural tissue if CJD or vCJD has not been ruled out; no special burial procedures. ¹⁰⁵⁷
Croup (see respiratory infections in infants and young children)			

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Crimean-Congo Fever (see viral hemorrhagic fever)	S		
Cryptococcosis	S		Not transmitted from person to person, except rarely through tissue and corneal transplantation. ^{1058,1059}
Cryptosporidiosis (see gastroenteritis)			
Cysticercosis	S		Not transmitted from person to person.
Cytomegalovirus infection, including in neonates and immunosuppressed patients	S		No additional precautions for pregnant HCWs.
Decubitus ulcer (see Pressure ulcer)			
Dengue fever	S		Not transmitted from person to person.
Diarrhea, acute-infective etiology suspected (see gastroenteritis)			
Diphtheria			
Cutaneous	C	CN	Until 2 cultures obtained 24 hours apart are negative.
Pharyngeal	D	CN	Until 2 cultures obtained 24 hours apart are negative.
Ebola virus (see viral hemorrhagic fevers)			
Echinococcosis (hydatidosis)	S		Not transmitted from person to person.
Echovirus (see enteroviral infection)			
Encephalitis or encephalomyelitis (see specific etiologic agents)			
Endometritis	S		
(endomyometritis)			
Enterobiasis (pinworm disease, oxyuriasis)	S		
<i>Enterococcus</i> spp (see multidrug-resistant organisms if epidemiologically significant or vancomycin-resistant)			
Enterocolitis, <i>Clostridium difficile</i> (see <i>C difficile</i> , gastroenteritis)			
Enteroviral infections (ie, group A and B Coxsackie viruses and Echo viruses) (excludes polio virus)	S		Use Contact Precautions for diapered or incontinent children for duration of illness and to control institutional outbreaks.
Epiglottitis, due to <i>Haemophilus influenzae</i> type b	D	U 24 hours	(See specific disease agents for epiglottitis due to other etiologies.)
Epstein-Barr virus infection, including infectious mononucleosis	S		
Erythema infectiosum (also see parvovirus B19)			
<i>Escherichia coli</i> gastroenteritis (see gastroenteritis)			
Food poisoning			
Botulism	S		Not transmitted from person to person.
<i>Clostridium perfringens</i> or <i>C welchii</i>	S		Not transmitted from person to person.
Staphylococcal	S		Not transmitted from person to person.
Furunculosis, staphylococcal	S		Contact if drainage not controlled. Follow institutional policies if MRSA.
Infants and young children	C	DI	
Gangrene (gas gangrene)	S		Not transmitted from person to person.

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Gastroenteritis	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks for gastroenteritis caused by all of the agents listed below.
Adenovirus	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Campylobacter</i> spp	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
Cholera (<i>Vibrio cholerae</i>)	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Clostridium difficile</i>	C	DI	Discontinue antibiotics if appropriate. Do not share electronic thermometers; ^{851,852} ensure consistent environmental cleaning and disinfection. Hypochlorite solutions may be required for cleaning if transmission continues. ⁸⁴⁵ Handwashing with soap and water is preferred because of the absence of sporicidal activity of alcohol in waterless antiseptic handrubs. ⁹⁷⁹
<i>Cryptosporidium</i> spp	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Escherichia coli</i> Enteropathogenic O157:H7 and other shiga toxin–producing strains	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
Other species	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Giardia lamblia</i>	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
Noroviruses	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks. Persons who clean areas heavily contaminated with feces or vomitus may benefit from wearing masks, because virus can be aerosolized from these body substances; ^{142,147,148} ensure consistent environmental cleaning and disinfection with focus on restrooms even when apparently unsoiled. ^{272,1060} Hypochlorite solutions may be required when there is continued transmission. ²⁸⁹⁻²⁹¹ Alcohol is less active, but there is no evidence that alcohol antiseptic handrubs are not effective for hand decontamination. ²⁹³ Cohorting of affected patients to separate air spaces and toilet facilities may help interrupt transmission during outbreaks.
Rotavirus	C	DI	Ensure consistent environmental cleaning and disinfection and frequent removal of soiled diapers. Prolonged shedding may occur in both immunocompetent and immunocompromised children and the elderly. ^{930, 931}
Salmonella species (including <i>S typhi</i>)	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
Shigella species (bacillary dysentery)	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Vibrio parahaemolyticus</i>	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
Viral (if not covered elsewhere)	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
<i>Yersinia enterocolitica</i>	S		Use Contact Precautions for diapered or incontinent persons for the duration of illness or to control institutional outbreaks.
German measles (see rubella; see congenital rubella)			
Giardiasis (see gastroenteritis)			
Gonococcal ophthalmia neonatorum (gonorrheal ophthalmia, acute conjunctivitis of newborn)	S		
Gonorrhea	S		
Granuloma inguinale (donovanosis, granuloma venereum)	S		
Guillain-Barré syndrome	S		Not an infectious condition.

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
<i>Haemophilus influenzae</i> (see disease-specific recommendations)			
Hand, foot, and mouth disease (see enteroviral infection)			
Hansen's disease (see leprosy)			
Hantavirus pulmonary syndrome	S		Not transmitted from person to person.
<i>Helicobacter pylori</i>	S		
Hepatitis, viral			
Type A	S		Provide hepatitis A vaccine postexposure as recommended. ¹⁰⁶¹
Diapered or incontinent patients	C		Maintain Contact Precautions for the duration of hospitalization in infants and children under age 3 years, for 2 weeks after onset of symptoms in children age 3 to 14 years, and for 1 week after onset of symptoms in those over age 14 year. ^{831,1062,1063}
Type B-HBsAg positive; acute or chronic	S		See specific recommendations for care of patients in hemodialysis centers. ⁷⁷⁶
Type C and other unspecified non-A, non-B	S		See specific recommendations for care of patients in hemodialysis centers. ⁷⁷⁶
Type D (seen only with hepatitis B)	S		
Type E	S		Use Contact Precautions for diapered or incontinent individuals for the duration of illness. ¹⁰⁶⁴
Type G	S		
Herpangina (see enteroviral infection)			
Hookworm	S		
Herpes simplex (<i>Herpesvirus hominis</i>)			
Encephalitis	S		
Mucocutaneous, disseminated or primary, severe	C	Until lesions dry and crusted	
Mucocutaneous, recurrent (skin, oral, genital)	S		
Neonatal	C	Until lesions dry and crusted	Also for asymptomatic, exposed infants delivered vaginally or by C-section and if mother has active infection and membranes have been ruptured for more than 4 to 6 hours until infant surface cultures obtained at 24 to 36 hours of age negative after 48 hours of incubation. ^{1065, 1066}
Herpes zoster (varicella-zoster) (shingles)			
Disseminated disease in any patient	A,C	DI	Susceptible HCWs should not enter room if immune caregivers are available; no recommendation for protection of immune HCWs; no recommendation for type of protection (ie surgical mask or respirator) for susceptible HCWs.
Localized disease in immunocompromised patient until disseminated infection ruled out			
Localized in patient with intact immune system with lesions that can be contained/covered	S	DI	Susceptible HCWs should not provide direct patient care when other immune caregivers are available.
Histoplasmosis	S		Not transmitted from person to person.
Human immunodeficiency virus (HIV)	S		Postexposure chemoprophylaxis for some blood exposures. ⁸⁶⁴
Human metapneumovirus	C	DI	HAI reported, ¹⁰⁶⁷ but the route of transmission is not established. ⁸²¹ Assumed to be contact transmission as for RSV since the viruses are closely related and have similar clinical manifestations and epidemiology. Wear masks according to Standard Precautions.
Impetigo	C	U 24 hours	
Infectious mononucleosis	S		

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Influenza			
Human (seasonal influenza)	D	5 days except DI in immuno- compromised persons	Single patient room when available or cohort; avoid placement with high-risk patients; mask patient when transported out of room; chemoprophylaxis/vaccine to control/prevent outbreaks. ⁶⁰⁹ Use of gown and gloves according to Standard Precautions may be especially important in pediatric settings. Duration of precautions for immunocompromised patients cannot be defined; prolonged duration of viral shedding (ie for several weeks) has been observed; implications for transmission are unknown. ⁹²⁸
Avian (eg, H5N1, H7, H9 strains)			See http://www.cdc.gov/flu/avian/professional/infect-control.htm for current avian influenza guidance.
Pandemic influenza (also a human influenza virus)	D	5 days from onset of symptoms	See http://www.pandemicflu.gov for current pandemic influenza guidance.
Kawasaki syndrome	S		Not an infectious condition.
Lassa fever (see viral hemorrhagic fevers)			
Legionnaires' disease	S		Not transmitted from person to person.
Leprosy	S		
Leptospirosis	S		Not transmitted from person to person; see
Lice			http://www.cdc.gov/ncidod/dpd/parasites/lice/default.htm .
Head (pediculosis)	C	U 4 hours	
Body	S		Transmitted person to person through infested clothing. Wear gown and gloves when removing clothing; bag and wash clothes according to CDC guidance.
Pubic	S		Transmitted person to person through sexual contact.
Listeriosis (<i>Listeria monocytogenes</i>)	S		Person-to-person transmission rare; cross-transmission in neonatal settings reported. ^{1068,1069,1070, 1071}
Lyme disease	S		Not transmitted from person to person.
Lymphocytic choriomeningitis	S		Not transmitted from person to person.
Lymphogranuloma venereum	S		
Malaria	S		Not transmitted from person to person except rarely through transfusion and due to failure to follow Standard Precautions during patient care. ¹⁰⁷²⁻¹⁰⁷⁵ Install screens in windows and doors in endemic areas. Use DEET-containing mosquito repellants and clothing to cover extremities.
Marburg virus disease (see viral hemorrhagic fevers)			
Measles (rubeola)	A	4 days after onset of rash; DI in immune compromised	Susceptible HCWs should not enter room if immune care providers are available; no recommendation for face protection for immune HCW; no recommendation for type of face protection for susceptible HCWs (ie, mask or respirator). ^{1023,1025} For exposed susceptible HCWs, postexposure vaccine within 72 hours or immune globulin within 6 days when available. ^{17,1028,1030} Place exposed susceptible patients on Airborne Precautions and exclude susceptible HCWs from duty from day 5 after first exposure to day 21 after last exposure, regardless of postexposure vaccine. ¹⁷
Melioidosis, all forms	S		Not transmitted from person to person.
Meningitis			
Aseptic (nonbacterial or viral; also see enteroviral infections)	S		Contact for infants and young children.
Bacterial, gram-negative enteric, in neonates	S		
Fungal	S		
<i>Haemophilus influenzae</i> , type b known or suspected	D	U 24 hours	
<i>Listeria monocytogenes</i> (See listeriosis)	S		
<i>Neisseria meningitidis</i> (meningococcal) known or suspected	D	U 24 hours	See meningococcal disease below.
<i>Streptococcus pneumoniae</i>	S		

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
<i>Mycobacterium tuberculosis</i>	S		Concurrent, active pulmonary disease or draining cutaneous lesions may necessitate addition of Contact and/or Airborne Precautions. For children, airborne precautions until active tuberculosis ruled out in visiting family members (see tuberculosis below). ⁴²
Other diagnosed bacterial	S		
Meningococcal disease: sepsis, pneumonia, meningitis	D	U 24 hours	Postexposure chemoprophylaxis for household contacts, HCWs exposed to respiratory secretions; postexposure vaccine only to control outbreaks. ^{15,17}
<i>Molluscum contagiosum</i>	S		
Monkeypox	A,C	A-Until monkeypox confirmed and smallpox excluded C-Until lesions crusted	See http://www.cdc.gov/ncidod/monkeypox for most current recommendations. Transmission in hospital settings unlikely. ²⁶⁷ Preexposure and postexposure smallpox vaccine recommended for exposed HCWs.
Mucormycosis	S		
Multidrug-resistant organisms (MDROs), infection or colonization (eg, MRSA, VRE, VISA/VRSA, ESBLs, resistant <i>S. pneumoniae</i>)	S/C		MDROs judged by the infection control program, based on local, state, regional, or national recommendations, to be of clinical and epidemiologic significance. Contact Precautions recommended in settings with evidence of ongoing transmission, acute care settings with increased risk for transmission or wounds that cannot be contained by dressings. See recommendations for management options in <i>Management of Multidrug-Resistant Organisms In Health care Settings, 2006</i> . ⁸⁶⁸ Contact state health department for guidance regarding new or emerging MDROs.
Mumps (infectious parotitis)	D	U 9 days	After onset of swelling; susceptible HCWs should not provide care if immune caregivers are available. (Note: Recent assessment of outbreaks in healthy 18- to 24-year-olds has indicated that salivary viral shedding occurred early in the course of illness and that 5 days of isolation after onset of parotitis may be appropriate in community settings; however, the implications for health care personnel and high-risk patient populations remain to be clarified.) Not transmitted person-to-person.
Mycobacteria, nontuberculosis (atypical)			
Pulmonary	S		
Wound	S		
Mycoplasma pneumonia	D	DI	
Necrotizing enterocolitis	S		Contact Precautions when cases clustered temporally. ¹⁰⁷⁶⁻¹⁰⁷⁹
Nocardiosis, draining lesions, or other presentations	S		Not transmitted person-to-person.
Norovirus (see gastroenteritis)			
Norwalk agent gastroenteritis (see gastroenteritis)			
Orf	S		
Parainfluenza virus infection, respiratory in infants and young children	C	DI	Viral shedding may be prolonged in immunosuppressed patients. ^{1005,1006} Reliability of antigen testing to determine when to remove patients with prolonged hospitalizations from Contact Precautions uncertain.
Parvovirus B19 (Erythema infectiosum)	D		Maintain precautions for duration of hospitalization when chronic disease occurs in immunocompromised patients. For patients with transient aplastic crisis or red cell crisis, maintain precautions for 7 days. Duration of precautions for immunosuppressed patients with persistently positive PCR not defined, but transmission has occurred. ⁹²⁷
Pediculosis (lice)	C	U 24 hours after treatment	
Pertussis (whooping cough)	D	U 5 days	Single patient room preferred. Cohorting an option. Postexposure chemoprophylaxis for household contacts and HCWs with prolonged exposure to respiratory secretions. ⁸⁶¹ Recommendations for Tdap vaccine in adults under development.
Pinworm infection (Enterobiasis)	S		
Plague (<i>Yersinia pestis</i>)			
Bubonic	S		
Pneumonic	D	U 48 hours	Antimicrobial prophylaxis for exposed HCW. ²⁰⁷
Pneumonia			

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Adenovirus	D, C	DI	Outbreaks in pediatric and institutional settings reported. ^{375,1080-1082} In immunocompromised hosts, extend duration of Droplet and Contact Precautions due to prolonged shedding of virus. ⁹²⁹
Bacterial not listed elsewhere (including gram-negative bacterial)	S		
<i>B cepacia</i> in patients with CF, including respiratory tract colonization	C	Unknown	Avoid exposure to other persons with CF; private room preferred. Criteria for D/C precautions not established. See the Cystic Fibrosis Foundation guidelines. ²⁰
<i>B cepacia</i> in patients without CF (see multidrug-resistant organisms)			
Chlamydia	S		
Fungal	S		
<i>Haemophilus influenzae</i> , type b			
Adults	S		
Infants and children	D	U 24 hours	
<i>Legionella spp</i>	S		
Meningococcal	D	U 24 hours	See meningococcal disease above.
Multidrug-resistant bacterial (see multidrug-resistant organisms)			
<i>Mycoplasma</i> (primary atypical pneumonia)	D	DI	
Pneumococcal pneumonia	S		Use Droplet Precautions if evidence of transmission within a patient care unit or facility. ^{196-198,1083}
<i>Pneumocystis jiroveci</i> (<i>Pneumocystis carinii</i>)	S		Avoid placement in the same room with an immunocompromised patient.
<i>Staphylococcus aureus</i>	S		For MRSA, see MDROs.
Streptococcus, group A			
Adults	D	U 24 hours	See streptococcal disease (group A streptococcus) below.
Infants and young children	D	U 24 hours	Contact precautions if skin lesions present.
Varicella-zoster (see varicella-zoster)			Contact Precautions if skin lesions present.
Viral			
Adults	S		
Infants and young children (see respiratory infectious disease, acute, or specific viral agent)			
Poliomyelitis	C	DI	
Pressure ulcer (decubitus ulcer, pressure sore) infected			
Major	C	DI	If no dressing or containment of drainage; until drainage stops or can be contained by dressing.
Minor or limited	S		If dressing covers and contains drainage.
Prion disease (See Creutzfeldt-Jacob Disease)			
Psittacosis (ornithosis) (<i>Chlamydia psittaci</i>)	S		Not transmitted from person to person.
Q fever	S		
Rabies	S		Person-to-person transmission is rare; transmission via corneal, tissue and organ transplants has been reported. ^{537,1084} If patient has bitten another individual or saliva has contaminated an open wound or mucous membrane, wash exposed area thoroughly and administer postexposure prophylaxis. ¹⁰⁸⁵

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Rat-bite fever (<i>Streptobacillus moniliformis</i> disease, <i>Spirillum minus</i> disease)	S		Not transmitted from person to person.
Relapsing fever	S		Not transmitted from person to person.
Resistant bacterial infection or colonization (see multidrug-resistant organisms)			
Respiratory infectious disease, acute (if not covered elsewhere)			
Adults	S		
Infants and young children	C	DI	Also see syndromes or conditions listed in Table 2.
Respiratory syncytial virus infection, in infants, young children and immunocompromised adults	C	DI	Wear mask according to Standard Precautions ^{24,116,117} In immunocompromised patients, extend the duration of Contact Precautions due to prolonged shedding. ⁹²⁶ Reliability of antigen testing to determine when to remove patients with prolonged hospitalizations from Contact Precautions uncertain.
Reye's syndrome	S		Not an infectious condition.
Rheumatic fever	S		Not an infectious condition.
Rhinovirus	D	DI	Droplet most important route of transmission. ^{104,1086} Outbreaks have occurred in NICUs and LTCFs. ^{411,1087,1088} Add Contact Precautions if copious moist secretions and close contact likely to occur (eg, young infants). ^{111,831}
Rickettsial fevers, tickborne (Rocky Mountain spotted fever, tickborne typhus fever)	S		Not transmitted from person to person except rarely through transfusion.
Rickettsialpox (vesicular rickettsiosis)	S		Not transmitted from person to person.
Ringworm (dermatophytosis, dermatomycosis, tinea)	S		Rarely, outbreaks have occurred in health care settings, (eg, NICU, ¹⁰⁸⁹ rehabilitation hospital ¹⁰⁹⁰). Use Contact Precautions for outbreak.
Ritter's disease (staphylococcal scalded skin syndrome)	C	DI	See staphylococcal disease and scalded skin syndrome below.
Rocky Mountain spotted fever	S		Not transmitted from person to person except rarely through transfusion.
Roseola infantum (exanthem subitum; caused by HHV-6)	S		
Rotavirus infection (see gastroenteritis)			
Rubella (German measles) (also see congenital rubella)	D	U 7 days after onset of rash	Susceptible HCWs should not enter room if immune caregivers are available. No recommendation for wearing face protection (eg, a surgical mask) if immune. Pregnant women who are not immune should not care for these patients. ^{17,33} Administer vaccine within 3 days of exposure to nonpregnant susceptible individuals. Place exposed susceptible patients on Droplet Precautions; exclude susceptible health care personnel from duty from day 5 after first exposure to day 21 after last exposure, regardless of postexposure vaccine.
Rubeola (see measles)			
Salmonellosis (see gastroenteritis)			
Scabies	C	U 24	
Scalded skin syndrome, staphylococcal	C	DI	See staphylococcal disease and scalded skin syndrome below.
Schistosomiasis (bilharziasis)	S		
Severe acute respiratory syndrome (SARS)	A, D, C	DI plus 10 days after resolution of fever, provided respiratory symptoms are absent or improving	Airborne Precautions preferred; D if AIIR unavailable. N95 or higher-level respiratory protection; surgical mask if N95 is unavailable; eye protection (goggles, face shield); aerosol-generating procedures and "supershedders" are at highest risk for transmission through small droplet nuclei and large droplets. ^{93,94,96} Vigilant environmental disinfection necessary (see http://www.cdc.gov/ncidod/sars).
Shigellosis (see gastroenteritis)			

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Smallpox (variola; see vaccinia for management of vaccinated persons)	A,C	DI	Until all scabs have crusted and separated (3 to 4 weeks). Nonvaccinated HCWs should not provide care when immune HCWs are available; N95 or higher-level respiratory protection for susceptible and successfully vaccinated individuals; postexposure vaccine within 4 days of exposure protective. ^{108,129,1034-1036}
Sporotrichosis	S		
Spirillum minor disease (rat-bite fever)	S		Not transmitted from person to person.
Staphylococcal disease (<i>S. aureus</i>)			
Skin, wound, or burn			
Major	C	DI	No dressing, or dressing does not adequately contain drainage.
Minor or limited	S		Dressing adequately cover and contain drainage.
Enterocolitis	S		Use Contact Precautions for diapered or incontinent children for duration of illness.
Multidrug-resistant (see multidrug-resistant organisms)			
Pneumonia	S		
Scalded skin syndrome	C	DI	Consider health care personnel as potential source of nursery, NICU outbreak. ¹⁰⁹¹
Toxic shock syndrome	S		
<i>Streptobacillus moniliformis</i> disease (rat-bite fever)	S		Not transmitted from person to person.
Streptococcal disease (group A streptococcus)			
Skin, wound, or burn			
Major	C,D	U 24 hours	No dressing, or dressing does not adequately contain drainage.
Minor or limited	S		Dressing covers and adequately contains drainage.
Endometritis (puerperal sepsis)	S		
Pharyngitis in infants and young children	D	U 24 hours	
Pneumonia	D	U 24 hours	
Scarlet fever in infants and young children	D	U 24 hours	
Serious invasive disease	D	U24 hours	Outbreaks of serious invasive disease have occurred secondary to transmission among patients and HCWs. ^{162,968,1092-1094}
			Contact Precautions for draining wound as above; follow recommendations for antimicrobial prophylaxis in selected conditions. ¹⁶⁰
Streptococcal disease (group B streptococcus), neonatal	S		
Streptococcal disease (not group A or B) unless covered elsewhere	S		
Multidrug-resistant (see multidrug-resistant organisms)			
Strongyloidiasis	S		
Syphilis			
Latent (tertiary) and seropositivity without lesions	S		
Skin and mucous membrane, including congenital, primary, secondary	S		
Tapeworm disease			
<i>Hymenolepis nana</i>	S		Not transmitted from person to person.
<i>Taenia solium</i> (pork)	S		
Other	S		
Tetanus	S		Not transmitted from person to person.
Tinea (eg, dermatophytosis, dermatomycosis, ringworm)	S		Rare episodes of person-to-person transmission.

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Toxoplasmosis	S		Transmission from person to person is rare; vertical transmission from mother to child, transmission through organs and blood transfusion rare.
Toxic shock syndrome (staphylococcal disease, streptococcal disease)	S		Droplet Precautions for the first 24 hours after implementation of antibiotic therapy if group A streptococcus is a likely etiology.
Trachoma, acute	S		
Transmissible spongiform encephalopathy (see Creutzfeld-Jacob disease, CJD, vCJD)			
Trench mouth (Vincent's angina)	S		
Trichinosis	S		
Trichomoniasis	S		
Trichuriasis (whipworm disease)	S		
Tuberculosis (<i>M. tuberculosis</i>)			
Extrapulmonary, draining lesion)	A,C		Discontinue precautions only when patient is improving clinically and drainage has ceased or there are 3 consecutive negative cultures of continued drainage. ^{1021,1022} Examine for evidence of active pulmonary tuberculosis.
Extrapulmonary, no draining lesion, meningitis	S		Examine for evidence of pulmonary tuberculosis. For infants and children, use Airborne Precautions until active pulmonary tuberculosis in visiting family members ruled out. ⁴²
Pulmonary or laryngeal disease, confirmed	A		Discontinue precautions only when patient on effective therapy is improving clinically and has three consecutive sputum smears negative for acid-fast bacilli collected on separate days (see http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm?s_cid=rr5417a1_e). ¹²
Pulmonary or laryngeal disease, suspected	A		Discontinue precautions only when the likelihood of infectious TB disease is deemed negligible, and either there is another diagnosis that explains the clinical syndrome or the results of three sputum smears for AFB are negative. The 3 sputum specimens should be collected 8 to 24 hours apart, and at least 1 specimen should be an early-morning specimen
Skin-test positive with no evidence of current active disease	S		
Tularemia			
Draining lesion	S		Not transmitted from person to person.
Pulmonary	S		Not transmitted from person to person.
Typhoid (<i>Salmonella typhi</i>) fever (see gastroenteritis)			
Typhus			
<i>Rickettsia prowazekii</i> (Epidemic or Louse-borne typhus)	S		Transmitted from person to person through close personal or clothing contact.
<i>Rickettsia typhi</i>	S		Not transmitted from person to person.
Urinary tract infection (including pyelonephritis), with or without urinary catheter	S		
Vaccinia (vaccination site, adverse events after vaccination)*			Only vaccinated HCWs have contact with active vaccination sites and care for persons with adverse vaccinia events; if unvaccinated, only HCWs without contraindications to vaccine may provide care.
Vaccination site care (including autoinoculated areas)	S		Vaccination recommended for vaccinators; for newly vaccinated HCWs: semipermeable dressing over gauze until scab separates, with dressing change as fluid accumulates, ~3 to 5 days; gloves, hand hygiene for dressing change; vaccinated HCW or HCW without contraindication to vaccine for dressing changes. ^{205,221,225}
Eczema vaccinatum	C	Until lesions dry and crusted, scabs separated	For contact with virus-containing lesions and exudative material.
Fetal vaccinia	C		
Generalized vaccinia	C		
Progressive vaccinia	C		

Continued

Appendix A. Continued

Infection/Condition	Precaution		
	Type*	Duration†	Comments
Postvaccinia encephalitis	S		
Blepharitis or conjunctivitis	S/C		Use Contact Precautions if copious drainage is present.
Iritis or keratitis	S		
Vaccinia-associated erythema multiforme (Stevens-Johnson syndrome)	S		Not an infectious condition.
Secondary bacterial infection (eg, <i>S. aureus</i> , group A beta hemolytic streptococcus)	S/C		Follow organism-specific (streptococcal and staphylococcal most frequent) recommendations and consider magnitude of drainage.
Varicella zoster	A,C	Until lesions dry and crusted	Susceptible HCWs should not enter room if immune caregivers are available; no recommendation for face protection of immune HCWs; no recommendation for type of protection (ie, surgical mask or respirator) for susceptible HCWs. In an immunocompromised host with varicella pneumonia, prolong the duration of precautions for duration of illness. Postexposure prophylaxis: Provide postexposure vaccine as soon as possible but within 120 hours; for susceptible exposed persons for whom vaccine is contraindicated (immunocompromised persons, pregnant women, newborns whose mother's varicella onset is ≤ 5 days before delivery or within 48 hours after delivery) provide VZIG, when available, within 96 hours; if unavailable, use IVIG. Provide Airborne Precautions for exposed susceptible persons and exclude exposed susceptible health care workers beginning 8 days after first exposure until 21 days after last exposure or 28 if received VZIG, regardless of postexposure vaccination. ¹⁰³²
Variola (see smallpox)			
<i>Vibrio parahaemolyticus</i> (see gastroenteritis)			
Vincent's angina (trench mouth)	S		
Viral hemorrhagic fevers due to Lassa, Ebola, Marburg, Crimean-Congo fever viruses	S, D, C	DI	Single-patient room preferred. Emphasize: use of sharps safety devices and safe work practices, hand hygiene; barrier protection against blood and body fluids on entry into room (single gloves and fluid-resistant or impermeable gown, face/eye protection with masks, goggles or face shields), and appropriate waste handling. Use N95 or higher-level respirator when performing aerosol-generating procedures. Largest viral load in final stages of illness when hemorrhage may occur; additional PPE, including double gloves, leg and shoe coverings may be used, especially in resource-limited settings where options for cleaning and laundry are limited. Notify public health officials immediately if Ebola is suspected. ^{212,313,738,770} Also see Table 3 for Ebola as a bioterrorism agent.
Viral respiratory diseases (not covered elsewhere)			
Adults	S		
Infants and young children (see respiratory infectious disease, acute)			
Whooping cough (see pertussis)			
Wound infections			
Major	C	DI	No dressing or dressing does not contain drainage adequately.
Minor or limited	S		Dressing covers and contains drainage adequately.
<i>Yersinia enterocolitica</i> gastroenteritis (see gastroenteritis)			
Zoster (varicella-zoster) (see herpes zoster)			
Zygomycosis (phycomycosis, mucormycosis)	S		Not transmitted person to person.

*Type of precautions: A, airborne precautions; C, contact; D, droplet; S, standard; when A, C, and D are specified, also use S.

†Duration of precautions: CN, until off antimicrobial treatment and culture-negative; DI, duration of illness (with wound lesions, DI means until wounds stop draining); DE, until environment completely decontaminated; U, until time specified in hours (hrs) after initiation of effective therapy; Unknown: criteria for establishing eradication of pathogen has not been determined