

Guidelines for Preventing Health-Care-- Associated Pneumonia, 2003

Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee

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Summary

This report updates, expands, and replaces the previously published CDC Guideline for Prevention of Nosocomial Pneumonia."The new guidelines are designed to reduce the incidence of pneumonia and other severe, acute lower respiratory tract infections in acute-care hospitals and in other health-care settings (e.g., ambulatory and long-term care institutions) and other facilities where health care is provided.

Among the changes in the recommendations to prevent bacterial pneumonia, especially ventilator-associated pneumonia, are the preferential use of oro-tracheal rather than naso-tracheal tubes in patients who receive mechanically assisted ventilation, the use of noninvasive ventilation to reduce the need for and duration of endotracheal intubation, changing the breathing circuits of ventilators when they malfunction or are visibly contaminated, and (when feasible) the use of an endotracheal tube with a dorsal lumen to allow drainage of respiratory secretions; no recommendations were made about the use of sucralfate, histamine-2 receptor antagonists, or antacids for stress-bleeding prophylaxis. For prevention of health-care--associated Legionnaires disease, the changes include maintaining potable hot water at temperatures not suitable for amplification of Legionella spp., considering routine culturing of water samples from the potable water system of a facility's organ-transplant unit when it is done as part of the facility's comprehensive program to prevent and control health-care--associated Legionnaires disease, and initiating an investigation for the source of Legionella spp. when one definite or one possible case

of laboratory-confirmed health-care--associated Legionnaires disease is identified in an inpatient hemopoietic stem-cell transplant (HSCT) recipient or in two or more HSCT recipients who had visited an outpatient HSCT unit during all or part of the 2--10 day period before illness onset. In the section on aspergillosis, the revised recommendations include the use of a room with high-efficiency particulate air filters rather than laminar airflow as the protective environment for allogeneic HSCT recipients and the use of high-efficiency respiratory-protection devices (e.g., N95 respirators) by severely immunocompromised patients when they leave their rooms when dust-generating activities are ongoing in the facility. In the respiratory syncytial virus (RSV) section, the new recommendation is to determine, on a case-by-case basis, whether to administer monoclonal antibody (palivizumab) to certain infants and children aged <24 months who were born prematurely and are at high risk for RSV infection. In the section on influenza, the new recommendations include the addition of oseltamivir (to amantadine and rimantadine) for prophylaxis of all patients without influenza illness and oseltamivir and zanamivir (to amantadine and rimantadine) as treatment for patients who are acutely ill with influenza in a unit where an influenza outbreak is recognized.

In addition to the revised recommendations, the guideline contains new sections on pertussis and lower respiratory tract infections caused by adenovirus and human parainfluenza viruses and refers readers to the source of updated information about prevention and control of severe acute respiratory syndrome.

Introduction

Because of the high morbidity and mortality associated with health-care--associated pneumonia, several guidelines for its prevention and control have been published. The first CDC Guideline for Prevention of Nosocomial Pneumonia was published in 1981 and addressed the main infection-control problems related to hospital-acquired pneumonia at the time: the use of large-volume nebulizers that were attached to mechanical ventilators and improper reprocessing (i.e., cleaning and disinfection or sterilization) of respiratory-care equipment. The document also covered the prevention and control of hospital-acquired influenza and respiratory syncytial virus (RSV) infection.

In 1994, the Healthcare Infection Control Practices Advisory Committee (HICPAC) (then known as the Hospital Infection Control Practices Advisory Committee) revised and expanded the CDC Guideline for Prevention of Nosocomial Pneumonia to include Legionnaires disease and pulmonary aspergillosis (1). HICPAC advises the secretary of Health and Human Services and the directors of CDC about the prevention and control of health-care--associated infections and related adverse events. The 1994 guideline addressed concerns related to preventing ventilator-associated pneumonia (VAP) (e.g., the role of stress-ulcer prophylaxis in the causation of pneumonia and the contentious roles of selective gastrointestinal decontamination and periodic changes of ventilator tubings in the prevention of the infection). The report also presented major changes in the recommendations to prevent and control hospital-acquired pneumonia caused by *Legionella* spp. and aspergilli.

In recent years, demand has increased for guidance on preventing and controlling pneumonia and other lower respiratory tract infections in health-care settings other than the acute-care hospital, probably resulting in part from the progressive shift in the burden and focus of health care in the United States away from inpatient care in the acute-care hospital and towards outpatient and long-term care in other health-care settings. In response to this demand, HICPAC revised the guideline to cover these other settings. However, infection-control data about the acute-care hospital setting are more abundant and well-analyzed; in comparison, data are limited from long-term care, ambulatory, and psychiatric facilities and other health-care settings.

This report consists of Parts II and III of a three-part document (2) and contains the consensus HICPAC recommendations for the prevention of the following infections: bacterial pneumonia,

Legionnaires disease, pertussis, invasive pulmonary aspergillosis (IPA), lower respiratory tract infections caused by RSV, parainfluenza and adenoviruses, and influenza. Part III provides suggested performance indicators to assist infection-control personnel in monitoring the implementation of the guideline recommendations in their facilities.

Part I of the guideline provides the background for the recommendations and includes a discussion of the epidemiology, diagnosis, pathogenesis, modes of transmission, and prevention and control of the infections (3). Part I can be an important resource for educating health-care personnel. Because education of health-care personnel is the cornerstone of an effective infection-control program, health-care agencies should give high priority to continuing infection-control education programs for their staff members.

HICPAC recommendations address such issues as education of health-care personnel about the prevention and control of health-care--associated pneumonia and other lower respiratory tract infections, surveillance and reporting of diagnosed cases of infections, prevention of person-to-person transmission of each disease, and reduction of host risk for infection.

Lower respiratory tract infection caused by *Mycobacterium tuberculosis* is not addressed in this document; however, it is covered in a separate publication (3).

The document was prepared by CDC; reviewed by experts in infection control, intensive-care medicine, pulmonology, respiratory therapy, anesthesiology, internal medicine, and pediatrics; and approved by HICPAC. The recommendations are endorsed by the American College of Chest Physicians, American Healthcare Association, Association for Professionals of Infection Control and Epidemiology, Infectious Diseases Society of America, Society for Healthcare Epidemiology of America, and Society of Critical Care Medicine.

Key Terms Used In the Guideline

Protective environment (PE) is a specialized patient-care area, usually in a hospital, with a positive air flow relative to the corridor (i.e., air flows from the room to the outside adjacent space). The combination of high-efficiency particulate air (HEPA) filtration, high numbers (≥ 12) of air changes per hour (ACH), and minimal leakage of air into the room creates an environment that can safely accommodate patients who have received allogeneic hemopoietic stem-cell transplant (HSCT).

Immunocompromised patients are those patients whose immune mechanisms are deficient because of immunologic disorders (e.g., human immunodeficiency virus [HIV] infection, congenital immune deficiency syndrome, and chronic diseases [(diabetes mellitus, cancer, emphysema, or cardiac failure)], or immunosuppressive therapy (e.g., radiation, cytotoxic chemotherapy, anti-rejection medication, and steroids). Immunocompromised patients who are identified as patients at high risk have the greatest risk for infection and include persons with severe neutropenia (i.e., an absolute neutrophil count [ANC] of ≤ 500 cells/mL) for prolonged periods of time, recipients of allogeneic HSCT, and those who receive the most intensive chemotherapy (e.g., patients with childhood acute myelogenous leukemia).

Abbreviations Used In the Guideline

ACIP	Advisory Committee on Immunization Practices
ANC	absolute neutrophil count
COPD	chronic obstructive pulmonary disease
CSF	cerebrospinal fluid
DTAP	diphtheria, tetanus, and acellular pertussis
DTP	diphtheria, tetanus, and pertussis
FDA	Food and Drug Administration
GCSF	granulocyte colony stimulating factor

HEPA	high-efficiency particulate air
HICPAC	Healthcare Infection Control Practices Advisory Committee
HIV	human immunodeficiency virus
HME	heat-moisture exchanger
HSCT	hemopoietic stem-cell transplant
ICU	intensive-care unit
IPA	invasive pulmonary aspergillosis
LAF	laminar airflow
NIV	noninvasive ventilation
NNIS	National Nosocomial Infection Surveillance
PE	protective environment
RSV	respiratory syncytial virus
SARS	severe acute respiratory syndrome
SDD	selective decontamination of the digestive tract
SOP	standing orders program
VAP	ventilator-associated pneumonia

Categorization of Recommendations

In this document, each recommendation is categorized on the basis of existing scientific evidence, theoretical rationale, applicability, and potential economic impact. In addition, a new category accommodates recommendations that are made on the basis of existing national or state health regulations. The following categorization scheme is applied in this guideline:

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 certain clinical or epidemiologic studies and by strong theoretical rationale.

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

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

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

Prevention of Health-Care--Associated Bacterial Pneumonia

I. Staff Education and Involvement in Infection Prevention

Educate health-care workers about the epidemiology of, and infection-control procedures for, preventing health-care--associated bacterial pneumonia to ensure worker competency according to the worker's level of responsibility in the health-care setting, and involve the workers in the implementation of interventions to prevent health-care--associated pneumonia by using performance-improvement tools and techniques (IA) (4--11).

II. Infection and Microbiologic Surveillance

A. Conduct surveillance for bacterial pneumonia in intensive care unit (ICU) patients who are at high risk for health-care--related bacterial pneumonia (e.g., patients with mechanically assisted ventilation or selected postoperative patients) to determine trends and help identify outbreaks and other potential infection-control problems (12,13). The use of the new National Nosocomial Infection Surveillance (NNIS) system's surveillance definition of pneumonia is recommended (14). Include data on the

causative microorganisms and their antimicrobial susceptibility patterns (15). Express data as rates (e.g., number of infected patients or infections per 100 ICU days or per 1,000 ventilator days) to facilitate intrahospital comparisons and trend determination (12,16,17). Link monitored rates and prevention efforts and return data to appropriate health-care personnel (IB) (18).

B. In the absence of specific clinical, epidemiologic, or infection-control objectives, do not routinely perform surveillance cultures of patients or of equipment or devices used for respiratory therapy, pulmonary-function testing, or delivery of inhalation anesthesia (II) (19--22).

III. Prevention of Transmission of Microorganisms

A. Sterilization or Disinfection and Maintenance of Equipment and Devices

1. General measures

a. Thoroughly clean all equipment and devices to be sterilized or disinfected (IA) (23,24).

b. Whenever possible, use steam sterilization (by autoclaving) or high-level disinfection by wet heat pasteurization at >158 F (>70°C) for 30 minutes for reprocessing semicritical equipment or devices (i.e., items that come into direct or indirect contact with mucous membranes of the lower respiratory tract) that are not sensitive to heat and moisture (Box). Use low-temperature sterilization methods (as approved by the Office of Device Evaluation, Center for Devices and Radiologic Health, Food and Drug Administration [FDA]) for equipment or devices that are heat- or moisture-sensitive (24--28). After disinfection, proceed with appropriate rinsing, drying, and packaging, taking care not to contaminate the disinfected items in the process (IA) (23,24).

c. Preferentially use sterile water for rinsing reusable semicritical respiratory equipment and devices when rinsing is needed after they have been chemically disinfected. If this is not feasible, rinse the device with filtered water (i.e., water that has been through a 0.2 μ filter) or tap water, and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet (IB) (24).

d. Adhere to provisions in FDA's enforcement document for single-use devices that are reprocessed by third parties (IC) (24,29).

2. Mechanical ventilators

Do not routinely sterilize or disinfect the internal machinery of mechanical ventilators (II).

3. Breathing circuits, humidifiers, and heat-and-moisture exchangers (HMEs)

a. Breathing circuits with humidifiers

1) Do not change routinely, on the basis of duration of use, the breathing circuit (i.e., ventilator tubing and exhalation valve and the attached humidifier) that is in use on an individual patient. Change the circuit when it is visibly soiled or mechanically malfunctioning (IA) (30--35).

2) Breathing-circuit--tubing condensate

a) Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to drain toward the patient (IB) (36).

b) Wear gloves to perform the previous procedure and/or when handling the fluid (IB) (37,38).

c) Decontaminate hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub after performing the procedure or handling the fluid (IA) (38,39).

3) No recommendation can be made for placing a filter or trap at the distal end of the expiratory-phase tubing of the breathing circuit to collect condensate (Unresolved issue).

4) Humidifier fluids

a) Use sterile (not distilled, nonsterile) water to fill bubbling humidifiers (II) (36,40--43).

b) No recommendation can be made for the preferential use of a closed, continuous-feed humidification system (Unresolved issue).

b. Ventilator breathing circuits with HMEs

1) No recommendation can be made for the preferential use of either HMEs or heated humidifiers to prevent pneumonia in patients receiving mechanically assisted ventilation (Unresolved issue) (IB) (44--49).

2) Changing HME

a) Change an HME that is in use on a patient when it malfunctions mechanically or becomes visibly soiled (II).

b) Do not routinely change more frequently than every 48 hours an HME that is in use on a patient (II) (50--52).

3) Do not change routinely (in the absence of gross contamination or malfunction) the breathing circuit attached to an HME while it is in use on a patient (II) (53).

4. Oxygen humidifiers

a. Follow manufacturers' instructions for use of oxygen humidifiers (II,C) (29;54--56).

b. Change the humidifier-tubing (including any nasal prongs or mask) that is in use on one patient when it malfunctions or becomes visibly contaminated (II).

5. Small-volume medication nebulizers: in-line and hand-held nebulizers

a. Between treatments on the same patient clean, disinfect, rinse with sterile water (if rinsing is needed), and dry small-volume in-line or hand-held medication nebulizers (IB) (57--59).

b. Use only sterile fluid for nebulization, and dispense the fluid into the nebulizer aseptically (IA) (40--42,58,60--62).

c. Whenever possible, use aerosolized medications in single-dose vials. If multidose medication vials are used, follow manufacturers' instructions for handling, storing, and dispensing the medications (IB) (60,62--67).

6. Mist tents

a. Between uses on different patients, replace mist tents and their nebulizers, reservoirs, and tubings with those that have been subjected to sterilization or high-level disinfection (II) (68).

b. No recommendation can be made about the frequency of routinely changing mist-tent nebulizers, reservoirs, and tubings while in use on one patient (Unresolved issue).

c. Subject mist-tent nebulizers, reservoirs, and tubings that are used on the same patient to daily low-level disinfection (e.g., with 2% acetic acid) or pasteurization followed by air-drying (II) (69).

7. Other devices used in association with respiratory therapy

a. Respirometer and ventilator thermometer: between their uses on different patients, sterilize or subject to high-level disinfection portable respirometers and ventilator thermometers (IB) (70--74).

b. Resuscitation bags

1) Between their uses on different patients, sterilize or subject to high-level disinfection reusable hand-powered resuscitation bags (IB) (75--79).

2) No recommendation can be made about the frequency of changing hydrophobic filters placed on the connection port of resuscitation bags (Unresolved issue).

8. Anesthesia machines and breathing systems or patient circuits

a. Do not routinely sterilize or disinfect the internal machinery of anesthesia equipment (IB) (80).

b. Between uses on different patients, clean reusable components of the breathing system or patient circuit (e.g., tracheal tube or face mask) inspiratory and expiratory breathing tubing, y-piece, reservoir bag, humidifier, and tubing, and then sterilize or subject them to high-level liquid chemical disinfection or pasteurization in accordance with the device manufacturers' instructions for their reprocessing (IB) (24,26).

c. No recommendation can be made about the frequency of routinely cleaning and disinfecting unidirectional valves and carbon dioxide absorber chambers (Unresolved issue) (81).

d. Follow published guidelines or manufacturers' instructions about in-use maintenance, cleaning, and disinfection or sterilization of other components or attachments of the breathing system or patient circuit of anesthesia equipment (IB) (82,83).

e. No recommendation can be made for placing a bacterial filter in the breathing system or patient circuit of anesthesia equipment (Unresolved issue) (4,84--89).

9. Pulmonary-function testing equipment

a. Do not routinely sterilize or disinfect the internal machinery of pulmonary-function testing machines between uses on different patients (II) (90,91).

b. Change the mouthpiece of a peak flow meter or the mouthpiece and filter of a spirometer between uses on different patients (II) (24,92).

10. Room-air "humidifiers" and faucet aerators

a. Do not use large-volume room-air humidifiers that create aerosols (e.g., by venturi principle, ultrasound, or spinning disk, and thus actually are nebulizers) unless they can be sterilized or subjected to high-level disinfection at least daily

and filled only with sterile water (II) (40,93,94).

b. Faucet aerators

1) No recommendation can be made about the removal of faucet aerators from areas for immunocompetent patients (see also section on Legionnaires Disease, Part II, Section I-C-1-d) (Unresolved issue).

2) If *Legionella* spp. are detected in the water of a transplant unit and until *Legionella* spp. are no longer detected by culture, remove faucet aerators in the unit (see also section on Legionnaires Disease, Part II, Section I-C-1-d) (II) (95).

B. Prevention of Person-to-Person Transmission of Bacteria

1. Standard Precautions

a. Hand hygiene: Decontaminate hands by washing them with either antimicrobial soap and water or with nonantimicrobial soap and water (if hands are visibly dirty or contaminated with proteinaceous material or are soiled with blood or body fluids) or by using an alcohol-based waterless antiseptic agent (e.g., hand rub) if hands are not visibly soiled after contact with mucous membranes, respiratory secretions, or objects contaminated with respiratory secretions, whether or not gloves are worn. Decontaminate hands as described previously before and after contact with a patient who has an endotracheal or tracheostomy tube in place, and before and after contact with any respiratory device that is used on the patient, whether or not gloves are worn (IA) (37,39).

b. Gloving

1) Wear gloves for handling respiratory secretions or objects contaminated with respiratory secretions of any patient (IB) (37).

2) Change gloves and decontaminate hands as described previously between contacts with different patients; after handling respiratory secretions or objects contaminated with secretions from one patient and before contact with another patient, object, or environmental surface; and between contacts with a contaminated body site and the respiratory tract of, or respiratory device on, the same patient (IA) (37,39,96--98).

c. When soiling with respiratory secretions from a patient is anticipated, wear a gown and change it after soiling occurs and before providing care to another patient (IB) (37,97).

2. Care of patients with tracheostomy

- a. Perform tracheostomy under aseptic conditions (II).
 - b. When changing a tracheostomy tube, wear a gown, use aseptic technique, and replace the tube with one that has undergone sterilization or high-level disinfection (IB) (23,24,37).
 - c. No recommendation can be made for the daily application of topical antimicrobial agent(s) at the tracheostoma (Unresolved issue) (99).
3. Suctioning of respiratory tract secretions
(See also Section IV-B-1-d)
- a. No recommendation can be made for the preferential use of either the multiuse closed-system suction catheter or the single-use open-system suction catheter for prevention of pneumonia (Unresolved issue) (44,100-102).
 - b. No recommendation can be made about wearing sterile rather than clean gloves when performing endotracheal suctioning (Unresolved issue).
 - c. No recommendation can be made about the frequency of routinely changing the in-line suction catheter of a closed-suction system in use on one patient (Unresolved issue) (103).
 - d. If the open-system suction is employed, use a sterile, single-use catheter (II).
 - e. Use only sterile fluid to remove secretions from the suction catheter if the catheter is to be used for re-entry into the patient's lower respiratory tract (II).

IV. Modifying Host Risk for Infection

A. Increasing Host Defense Against Infection: Administration of immune modulators

1. Pneumococcal vaccination. Vaccinate patients at high risk for severe pneumococcal infections
 - a. Administer the 23-valent pneumococcal polysaccharide vaccine to persons aged ≥ 65 years; persons aged 5--64 years who have chronic cardiovascular disease (e.g., congestive heart failure or cardiomyopathy), chronic pulmonary disease (e.g., chronic obstructive pulmonary disease [COPD] or emphysema, but not asthma), diabetes mellitus, alcoholism, chronic liver disease (e.g., cirrhosis), or cerebrospinal fluid (CSF) leaks; persons aged 5--64 years who have functional or anatomic asplenia; persons aged 5--64 years who are living in special environments or social settings; immunocompromised persons aged ≥ 5 years with HIV infection, leukemia, lymphoma, Hodgkin's disease, multiple myeloma, generalized malignancy, chronic renal failure, nephrotic syndrome, or other conditions associated with immunosuppression (e.g.,

receipt of HSCT, solid-organ transplant, or immunosuppressive chemotherapy, including long-term systemic corticosteroids); and persons in long-term-care facilities (IA) (104--109).

b. Administer the 7-valent pneumococcal polysaccharide protein-conjugate vaccine to all children aged <2 years and to children aged 24--59 months who are at increased risk for pneumococcal disease (e.g., children with sickle-cell disease or other hemoglobinopathies, or children who are functionally or anatomically asplenic; children with HIV infection; children who have chronic disease, including chronic cardiac or pulmonary disease [except asthma], diabetes mellitus, or CSF leak; and children with immunocompromising conditions including malignancies, chronic renal failure or nephrotic syndrome, receipt of immunosuppressive chemotherapy, including long-term corticosteroids, and receipt of solid-organ transplant). Consider administering the vaccine to children aged 24--59 months, with priority to children aged 24--35 months, children who are American Indians/Alaska Natives or black, and children who attend group child care centers (IB) (104).

c. In nursing homes and other long-term-care facilities, establish a standing order program (SOP) for the administration of 23-valent vaccine to persons at high risk for acquiring severe pneumococcal infections, including pneumococcal pneumonia (IA) (105,110,111).

2. No recommendation can be made for the routine administration of preparations of granulocyte-colony stimulating factor (GCSF) or intravenous gamma globulin for prophylaxis against health-care-associated pneumonia (Unresolved issue) (112--117).

3. No recommendation can be made for the routine enteral administration of glutamine for prevention of health-care-associated pneumonia (Unresolved issue) (118,119).

B. Precautions for prevention of aspiration

As soon as the clinical indications for their use are resolved, remove devices such as endotracheal, tracheostomy, and/or enteral (i.e., oro- or nasogastric or jejunal) tubes from patients (IB) (120--125).

1. Prevention of aspiration associated with endotracheal intubation

a. Use of noninvasive ventilation (NIV) to reduce the need for and duration of endotracheal intubation

1) When feasible and not medically contraindicated, use noninvasive positive-pressure ventilation delivered continuously by face or nose mask, instead of performing endotracheal intubation in patients who are in respiratory failure and are not needing immediate intubation (e.g., those who are in hypercapnic respiratory failure secondary to acute exacerbation of COPD

or cardiogenic pulmonary edema) (II) (126--9).

2) When feasible and not medically contraindicated, use NIV as part of the weaning process (from mechanically assisted ventilation) to shorten the period of endotracheal intubation (II) (130).

b. As much as possible, avoid repeat endotracheal intubation in patients who have received mechanically assisted ventilation (II) (131).

c. Unless contraindicated by the patient's condition, perform orotracheal rather than nasotracheal intubation on patients (IB) (44,132,133).

d. If feasible, use an endotracheal tube with a dorsal lumen above the endotracheal cuff to allow drainage (by continuous or frequent intermittent suctioning) of tracheal secretions that accumulate in the patient's subglottic area (II) (44,134--137).

e. Before deflating the cuff of an endotracheal tube in preparation for tube removal, or before moving the tube, ensure that secretions are cleared from above the tube cuff (II).

2. Prevention of aspiration associated with enteral feeding

a. In the absence of medical contraindication(s), elevate at an angle of 30--45 degrees of the head of the bed of a patient at high risk for aspiration (e.g., a person receiving mechanically assisted ventilation and/or who has an enteral tube in place) (II) (138--140).

b. Routinely verify appropriate placement of the feeding tube (IB) (141--143).

c. No recommendation can be made for the preferential use of small-bore tubes for enteral feeding (Unresolved issue) (144).

d. No recommendation can be made for preferentially administering enteral feedings continuously or intermittently (Unresolved issue) (145--148).

e. No recommendation can be made for preferentially placing the feeding tubes, (e.g., jejunal tubes) distal to the pylorus (Unresolved issue) (149--155).

3. Prevention or modulation of oropharyngeal colonization

a. Oropharyngeal cleaning and decontamination with an antiseptic agent: develop and implement a comprehensive oral-hygiene program (that might include the use of an antiseptic agent) for patients in acute-care settings or residents in long-term-care facilities who are at high risk for health-care--associated pneumonia (II) (156,157).

b. Chlorhexidine oral rinse

1) No recommendation can be made for the routine use of an oral chlorhexidine rinse for the prevention of health-care--associated pneumonia in all postoperative or critically ill patients and/or other patients at high risk for pneumonia (Unresolved issue) (II) (158).

2) Use an oral chlorhexidine gluconate (0.12%) rinse during the perioperative period on adult patients who undergo cardiac surgery (II) (158).

c. Oral decontamination with topical antimicrobial agents.

1) No recommendation can be made for the routine use of topical antimicrobial agents for oral decontamination to prevent VAP (Unresolved issue) (159).

4. Prevention of gastric colonization

a. No recommendation can be made for the preferential use of sucralfate, H₂-antagonists, and/or antacids for stress-bleeding prophylaxis in patients receiving mechanically assisted ventilation (Unresolved issue) (160--167).

b. No recommendation can be made for the routine selective decontamination of the digestive tract (SDD) of all critically ill, mechanically ventilated, or ICU patients (Unresolved issue) (168--200).

c. No recommendation can be made for routinely acidifying gastric feeding (Unresolved issue) (201,202).

C. Prevention of Postoperative Pneumonia

1. Instruct preoperative patients, especially those at high risk for contracting pneumonia, about taking deep breaths and ambulating as soon as medically indicated in the postoperative period. Patients at high risk include those who will have abdominal aortic aneurysm repair, thoracic surgery, or emergency surgery; those who will receive general anesthesia; those who are aged ≥ 60 years; those with totally dependent functional status; those who have had a weight loss $>10\%$; those using steroids for chronic conditions; those with recent history of alcohol use, history of COPD, or smoking during the preceding year; those with impaired sensorium, a history of cerebrovascular accident with residual neurologic deficit, or low ($<8\text{mg/dL}$) or high ($>22\text{ mg/dL}$) blood urea nitrogen level; and those who will have received >4 units of blood before surgery (IB) (203--206).

2. Encourage all postoperative patients to take deep breaths, move about the bed, and ambulate unless medically contraindicated (IB) (205--207).

3. Use incentive spirometry on postoperative patients at high risk for pneumonia (IB) (205--207).

4. No recommendation can be made about the routine use of chest physiotherapy on all postoperative patients at high risk for pneumonia (Unresolved issue) (205--207).

D. Other Prophylactic Procedures for Pneumonia

1. Administration of antimicrobial agents other than in SDD

a. Systemic antimicrobial prophylaxis.

No recommendation can be made about the routine administration of systemic antimicrobial agent(s) to prevent pneumonia in critically ill patients or in those receiving mechanically-assisted ventilation (Unresolved issue) (200, 208).

b. Scheduled changes in the class of antimicrobial agents used for empiric therapy

No recommendation can be made for scheduled changes in the class of antimicrobial agents used routinely for empiric treatment of suspected infections in a particular group of patients (Unresolved issue) (209,210).

2. Turning or rotational therapy

No recommendation can be made for the routine use of turning or rotational therapy, either by "kinetic" therapy or by continuous lateral rotational therapy (i.e., placing patients on beds that turn on their longitudinal axes intermittently or continuously) for prevention of health-care--associated pneumonia in critically ill and immobilized patients (Unresolved issue) (44,211--216).

Prevention and Control of Health-Care--Associated Legionnaires Disease

I. Primary Prevention (Preventing health-care--associated Legionnaires disease when no cases have been documented)

A. Staff Education

1. Educate physicians to heighten their suspicion for cases of health-care--associated Legionnaires disease and to use appropriate methods for its diagnosis (II).

2. Educate patient-care, infection-control, and engineering personnel about measures to prevent and control health-care--associated legionellosis (II).

B. Infection and Environmental Surveillance

1. Maintain a high index of suspicion for the diagnosis of health-care--associated Legionnaires disease and perform laboratory diagnostic tests (both culture of appropriate respiratory specimen and the urine antigen test) for legionellosis on suspected cases, especially in patients who are at high risk for acquiring the disease (e.g., patients who are immunosuppressed, including HSCT or solid-organ--transplant recipients; patients receiving systemic steroids; patients aged ≥ 65 years; or patients who have chronic underlying disease such as diabetes mellitus, congestive

heart failure, and COPD) (IA) (217--226).

2. Periodically review the availability and clinicians' use of laboratory diagnostic tests for Legionnaires disease in the facility, and if clinicians do not routinely use the tests on patients with diagnosed or suspected pneumonia, implement measures to enhance clinicians' use of the tests (e.g., by conducting educational programs) (II) (227,228).

3. Routine culturing of water systems for *Legionella* spp.

a. No recommendation can be made about routinely culturing water systems for *Legionella* spp. in health-care facilities that do not have patient-care areas (i.e., transplant units) for persons at high risk for *Legionella* infection (Unresolved issue) (95,229--238).

b. In facilities with hemopoietic stem-cell- and/or solid-organ--transplantation programs, periodic culturing for legionellae in water samples from the transplant unit(s) can be performed as part of a comprehensive strategy to prevent Legionnaires disease in transplant recipients (II) (95,239--241).

c. If such culturing (as in b) is undertaken:

1) No recommendation can be made about the optimal methods (i.e., frequency or number of sites) for environmental surveillance cultures in transplant units (Unresolved issue).

2) Perform corrective measures aimed at maintaining undetectable levels of *Legionella* spp. in the unit's water system (II).

3) Maintain a high index of suspicion for legionellosis in transplant patients with health-care--associated pneumonia even when environmental surveillance cultures do not yield legionellae (IB) (224,227).

C. Use and Care of Medical Devices, Equipment, and Environment

1. Nebulizers and other devices

a. Preferentially use sterile water for rinsing nebulization devices and other semicritical respiratory-care equipment after they have been cleaned or disinfected (58,242). If this is not feasible, rinse the device with filtered water (i.e., water that has been through a 0.2 μ filter) or tap water and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet (IB) (24).

b. Use only sterile (not distilled, nonsterile) water to fill reservoirs of devices used for nebulization (IA) (40,58,229,242,243).

c. Do not use large-volume room-air humidifiers that create

aerosols (e.g., by venturi principle, ultrasound, or spinning disk and thus are really nebulizers) unless they can be sterilized or subjected to high-level disinfection at least daily and filled only with sterile water (II) (242,243)

d. Faucet aerators

1) No recommendation can be made for the removal of faucet aerators from areas for immunocompetent patients (see also Bacterial Pneumonia, Part II, section III-A-10-b) (Unresolved issue).

2) If *Legionella* spp. are detected in the water of a transplant unit and until *Legionella* spp. are no longer detected by culture, remove faucet aerators in areas for severely immunocompromised patients (II) (95).

2. Cooling towers

a. When a new building is constructed, place cooling towers in such a way that the tower drift is directed away from the facility's air-intake system, and design the cooling towers such that the volume of aerosol drift is minimized (IB) (95,244--5).

b. For cooling towers, install drift eliminators, regularly use an effective biocide, maintain the tower according to manufacturers' recommendations, and keep adequate maintenance records (IB) (95,244--5).

3. Water-distribution system

a. Where practical and allowed by state law, maintain potable water at the outlet at $\geq 51^{\circ}\text{C}$ ($\geq 124^{\circ}\text{F}$) or $< 20^{\circ}\text{C}$ ($< 68^{\circ}\text{F}$), especially in facilities housing organ-transplant recipients or other patients at high-risk (244--248). If water is maintained at $\geq 51^{\circ}\text{C}$ ($\geq 124^{\circ}\text{F}$), use thermostatic mixing valves to prevent scalding (II) (249).

b. No recommendation can be made about the treatment of water with chlorine dioxide, heavy-metal ions, ozone, or ultraviolet light (250--266). Hospitals served by municipalities with monochloramine-treated water have had success in controlling legionella (Unresolved issue) (267--8).

4. Health-care facilities with hemopoietic stem-cell or solid-organ transplantation programs

If legionellae are detected in the potable water supply of a transplant unit, and until legionellae are no longer detected by culture:

a. Decontaminate the water supply as per section II-B-2-b-3)-a)-i to v (IB).

b. Restrict severely immunocompromised patients from taking showers (IB) (239,269).

c. Use water that is not contaminated with *Legionella* spp. for HSCT patients' sponge baths (IB) (270,271).

d. Provide HSCT patients with sterile water for tooth brushing or drinking or for flushing nasogastric tubes (IB) (239,271).

e. Do not use water from faucets with *Legionella*-contaminated water in patients' rooms to avoid creating infectious aerosols (II) (269).

II. Secondary Prevention (Response to identification of laboratory-confirmed health-care--associated Legionellosis)

A. In Facilities with HSCT or Solid-Organ Transplant Recipients:

When one inpatient of an HSCT or solid-organ transplant unit develops a case of laboratory-confirmed definite (i.e., after ≥ 10 days of continuous inpatient stay) or possible (i.e., within 2--9 days of inpatient stay) health-care--associated Legionnaires disease, or when two or more patients develop laboratory-confirmed Legionnaires disease within 6 months of each other and after having visited an outpatient transplant unit during part of the 2--10 day period before illness onset:

1. Contact the local or state health department or CDC if the disease is reportable in the state or if assistance is needed (II, IC).
2. In consultation with the facility's infection-control team, conduct a combined epidemiologic and environmental investigation (as outlined from II-B-2-b-1) through II-B-2-b-5)) to determine the source(s) of *Legionella* spp. (95,239). Include but do not limit the investigation to such potential sources as showers, water faucets, cooling towers, hot-water tanks, and carpet-cleaner water tanks (226,228,272). On its identification, decontaminate or remove the source of *Legionella* spp (II).
3. If the health-care facility's potable water system is found to be the source of *Legionella* spp., observe the measures outlined in Section I-C-4-b to e, about the nonuse of the facility's potable water by recipients of HSCT or solid-organ transplants and decontaminate the water supply as per Section II-B-2-b-3)-a)-i to v (IB).
4. Do not conduct an extensive facility investigation when an isolated case of possible health-care--associated Legionnaires disease occurs in a patient who has had little contact with the inpatient transplant unit during most of the incubation period of the disease (II).

B. In Facilities That Do Not House Severely Immunocompromised Patients (e.g., HSCT or Solid-Organ Transplant Recipients):

When a single case of laboratory-confirmed definite health-care--associated Legionnaires disease is identified, or when two or more cases of laboratory-confirmed, possible health-care--associated Legionnaires' disease occur within 6 months of each other:

1. Contact the local or state health department or CDC if the disease is reportable in the state or if assistance is needed (II, IC).
2. Conduct an epidemiologic investigation through a retrospective review of microbiologic, serologic, and postmortem data to identify previous

cases, and begin an intensive prospective surveillance for additional cases of health-care--associated Legionnaires disease (II).

a. If no evidence of continued nosocomial transmission exists, continue the intensive prospective surveillance for cases for ≥ 2 months after surveillance is begun (II).

b. If evidence of continued transmission exists:

1) Conduct an environmental investigation to determine the source(s) of *Legionella* spp. by collecting water samples from potential sources of aerosolized water and saving and subtyping isolates of *Legionella* spp. obtained from patients and the environment (IB) (40,58,270,273--282).

2) If a source is not identified, continue surveillance for new cases for ≥ 2 months and, depending on the scope of the outbreak, decide to either defer decontamination pending identification of the source(s) of *Legionella* spp. or proceed with decontamination of the hospital's water distribution system, with special attention to the specific hospital areas involved in the outbreak (II).

3) If a source of infection is identified by the epidemiologic and environmental investigations, promptly decontaminate the source (IB).

a) If the heated water system is implicated:

i. Decontaminate the heated water system either by superheating or by hyperchlorination. To superheat, raise the hot water temperature to 71°C--77°C (160°F--170°F) and maintain at that level while progressively flushing each outlet around the system. A minimum flush time of 5 minutes has been recommended; however, the optimal flush time is not known and longer flush times might be required. Post warning signs at each outlet being flushed to prevent scald injury to patients, staff, or visitors.

If possible, perform flushing when the building has the fewest occupants (e.g., nights and weekends). For systems on which thermal shock treatment is not possible, use shock chlorination as an alternative. Add chlorine, preferably overnight, to achieve a free chlorine residual of ≥ 2 mg/L (≥ 2 ppm) throughout the system. This might require chlorination of the water heater or tank to levels of 20--50 mg/L (20--50 ppm). Maintain the water pH between 7.0 and 8.0 (IB) (230,244, 246,248,277,283--285).

ii. Depending on local and state regulations about potable water temperature in public buildings (247), circulate potable water at temperatures not conducive to amplification of *Legionella*; store and distribute cold water at $< 20^{\circ}\text{C}$ ($< 68^{\circ}\text{F}$); and store hot water at $> 60^{\circ}\text{C}$ ($> 140^{\circ}\text{F}$) and circulate it at a minimum return temperature of 51°C (124°F) (II) (95,245--248).

iii. If the methods described in 3a-i and 3a-ii are not successful in decontaminating the hospital's water, seek expert consultation for review of decontamination procedures and assistance with further efforts (II).

iv. No recommendation can be made for the treatment of water with chlorine dioxide, heavy-metal ions, ozone, or ultraviolet light (250--266). Hospitals have reported successful decontamination using each of these methods (Unresolved issue).

v. Clean hot-water storage tanks and water heaters to remove accumulated scale and sediment (IB) (95).

b) If cooling towers or evaporative condensers are implicated, decontaminate the cooling-tower system (IB) (95,244).

4) Assess the efficacy of implemented measures in reducing or eliminating *Legionella* spp. by collecting specimens for culture at 2-week intervals for 3 months (II).

a) If *Legionella* spp. are not detected in cultures during 3 months of monitoring at 2-week intervals, collect cultures monthly for another 3 months (II).

b) If *Legionella* spp. are detected in one or more cultures, reassess the implemented control measures, modify them accordingly, and repeat decontamination procedures. Options for repeat decontamination include the intensive use of the same technique used for the initial decontamination or a combination of superheating and hyperchlorination (II) (284).

5) Keep adequate records of all infection-control measures, including maintenance procedures, and of environmental test results for cooling towers and potable-water systems (II).

Prevention and Control of Health-Care--Associated Pertussis

I. Staff Education

Educate appropriate personnel in accordance with their level of responsibility in the

health-care setting about the epidemiology, modes of transmission, and means of preventing the spread of pertussis (IB) (286,287).

II. Case-Reporting, Disease Surveillance, and Case-Contact Notification

- A. Report to the local and/or state health department all confirmed and suspected cases of pertussis (II, IC) (286).
- B. Conduct active surveillance for cases of pertussis until 42 days after the onset of the last pertussis case (II) (288).
- C. Notify persons who have had close contact with a case of pertussis in the health-care setting so that they can be monitored for symptoms of pertussis and/or administered appropriate chemoprophylaxis. Close contact includes face-to-face contact with a patient who is symptomatic (e.g., in the catarrhal or paroxysmal period of illness); sharing a confined space in close proximity for a prolonged period of time (e.g., ≥ 1 hour) with a symptomatic patient; or direct contact with respiratory, oral, or nasal secretions from a symptomatic patient (e.g., an explosive cough or sneeze on the face, sharing food, sharing eating utensils during a meal, kissing, mouth-to-mouth resuscitation, or performing a full medical examination of the nose and throat) (II) (288).

III. Prevention of Pertussis Transmission

A. Vaccination for Primary Prevention

1. No recommendation can be made for routinely vaccinating adults, including health-care workers, with the acellular pertussis vaccine at regular intervals (e.g., every 10 years) (Unresolved issue) (288--292).
2. In long-term-care facilities for children and for children with prolonged stay in acute-care facilities, follow the recommendations of the Advisory Committee on Immunization Practices (ACIP) for vaccinating children according to their chronologic age (IB) (288,293).

B. Vaccination for Secondary Prevention

1. No recommendation can be made for vaccinating adults, including health-care workers, during an institutional outbreak of pertussis (Unresolved issue) (288,294).
2. During an institutional outbreak of pertussis, accelerate scheduled vaccinations to infants and children aged < 7 years who have not completed their primary vaccinations, as follows:
 - a. Infants aged < 2 months who are receiving their initial vaccination:
Administer the first dose of the diphtheria, tetanus, and acellular pertussis (DTaP) vaccine as early as age 6 weeks and the second and third doses at a minimum of 4-week intervals between doses. Give the fourth dose on or after age 1 year

and at least 6 months after the third dose (II) (288,295,296).

b. Other children aged <7 years:

Administer DTaP vaccine to all patients who are aged <7 years and are not up-to-date with their pertussis vaccinations, as follows: administer a fourth dose of DTaP if the child has had 3 doses of DTaP or diphtheria, pertussis and tetanus (DPT) vaccine, is ≥ 12 months old, and >6 months have passed since the third dose of DTaP or DTP; administer a fifth dose of DTaP if the child has had four doses of DTaP or DTP, is aged 4--6 years, and received the fourth vaccine dose before the fourth birthday (IB) (287,288,293,295).

3. Vaccination of children with a history of well-documented pertussis disease

No recommendation can be made for administering additional dose(s) of pertussis vaccine to children who have a history of well-documented pertussis disease (i.e., pertussis illness with either a *B. pertussis*-positive culture or epidemiologic linkage to a culture-positive case) (Unresolved issue) (288,293).

C. Patient Placement and Management

1. Patients with confirmed pertussis

Place a patient with diagnosed pertussis in a private room, or if known not to have any other respiratory infection, in a room with other patient(s) with pertussis until after the first 5 days of a full course of antimicrobial treatment or 21 days after the onset of cough if unable to take antimicrobial treatment for pertussis (IB) (37,288).

2. Patients with suspected pertussis

a. Place a patient with suspected pertussis in a private room. After pertussis and no other infection is confirmed, the patient can be placed in a room with other patient(s) who have pertussis until after the first 5 days of a full course of antimicrobial treatment or 21 days after the onset of cough if unable to take antimicrobial treatment for pertussis (IB) (37,288).

b. Perform diagnostic laboratory tests (for confirmation or exclusion of pertussis) on patients who are admitted with or who develop signs and symptoms of pertussis to allow for the earliest possible downgrading of infection-control precautions to the minimum required for each patient's specific infection(s) (IB) (286,297--300).

D. Management of Symptomatic Health-Care Personnel

1. In conjunction with employee-health personnel, perform diagnostic laboratory tests for pertussis in health-care personnel with illness suggestive of pertussis (i.e., unexplained cough illness of >1 week duration and paroxysmal cough) (IB) (286,287,297--300).
2. In conjunction with employee-health personnel, treat symptomatic health-care personnel who are proven to have pertussis or personnel who are highly suspected of having pertussis with the same antimicrobial regimen, as detailed for chemoprophylaxis of case-contacts, in F-1 to F-2 (IB) (286,301).
3. Restrict symptomatic pertussis-infected health-care workers from work during the first 5 days of their receipt of antimicrobial therapy (IB) (287,288,301).

E. Masking

In addition to observing standard precautions, wear a surgical mask when within 3 feet of a patient with confirmed or suspected pertussis, when performing procedures or patient-care activities that are likely to generate sprays of respiratory secretions, or on entering the room of a patient with confirmed or suspected pertussis (IB) (37).

F. Use of a Prophylactic Antibiotic Regimen for Contacts of Persons with Pertussis

1. Administer a macrolide to any person who has had close contact with persons with pertussis and who does not have hypersensitivity or intolerance to macrolides (IB) (287,302).

- a. Except in infants aged ≤ 2 weeks, use erythromycin (i.e., erythromycin estolate, 500 mg four times daily or erythromycin delayed-release tablets, 333 mg three times daily for adults, and 40--50 mg/kg day for children) for 14 days (IB) (287,303--306).

- b. For patients who are intolerant to erythromycin or for infants aged ≤ 2 weeks, use any of the following regimens: azithromycin for 5--7 days (at 10--12 mg/kg/day) or for 5 days (at 10 mg/kg on day one followed by 4 days at 5 mg/kg/day) for infants and young children (307); or clarithromycin for 10--14 days (at 500 mg twice a day for adults or 15--20 mg/kg/day in two divided doses for children) (II) (287,308,309).

2. For chemoprophylaxis of persons who have hypersensitivity or intolerance to macrolides, use (except in the case of a pregnant woman at term, a nursing mother, or an infant aged <2 months) trimethoprim-sulfamethoxazole for 14 days (at one double-strength tablet twice a day for adults and 8 mg/kg/day TMP, 40 mg/kg/day SXT a day in 2 divided doses for children) (II) (303,310).

G. Work Exclusion of Asymptomatic Health-Care Workers Exposed to Pertussis

1. Do not exclude from patient care a health-care worker who remains asymptomatic and is receiving chemoprophylaxis after an exposure to a case of pertussis (i.e., by direct contact of one's nasal or buccal mucosa with the respiratory secretions of an untreated person who is in the catarrhal or paroxysmal stage of pertussis) (II) (287).

2. If mandated by state law or where feasible, exclude an exposed, asymptomatic health-care worker who is unable to receive chemoprophylaxis from providing care to a child aged <4 years during the period starting 7 days after the worker's first possible exposure until 14 days after his last possible exposure to a case of pertussis (II, IC) (287).

H. Other measures

1. Limiting patient movement or transport

Limit the movement and transport of a patient with diagnosed or suspected pertussis from his room to those for essential purposes only. If the patient is transported out of the room, ensure that precautions are maintained to minimize the risk for disease transmission to other patients and contamination of environmental surfaces or equipment (IB) (37).

2. Limiting visitors

Do not allow persons who have symptoms of respiratory infection to visit pediatric, immunosuppressed, or cardiac patients (IB) (37,286,311).

Prevention and Control of Health-Care--Associated Pulmonary Aspergillosis

I. Staff Education and Infection Surveillance

A. Staff Education

Educate health-care personnel according to their level of responsibility about infection-control procedures to decrease the occurrence of health-care--associated pulmonary aspergillosis (II).

B. Surveillance

1. Maintain a high index of suspicion for health-care--associated pulmonary aspergillosis in severely immunocompromised patients (i.e., patients with severe, prolonged neutropenia [ANC <500/mm³ for 2 weeks or <100/mm³ for 1 week], most notably HSCT recipients, and including recipients of solid-organ transplants or patients with hematologic malignancies who are receiving chemotherapy, when they are severely neutropenic as defined previously) and persons receiving prolonged high-dose steroids (IA) (312--319).

2. Maintain surveillance for cases of health-care--associated pulmonary aspergillosis by establishing a system by which the facility's infection-control personnel are promptly informed when *Aspergillus* sp. is isolated from cultures of specimens from patient's respiratory tract and by periodically reviewing the hospital's microbiologic, histopathologic, and postmortem data (II).

3. Surveillance cultures

a. Do not perform routine, periodic cultures of the nasopharynx of asymptomatic patients at high risk (IB) (320,321).

b. Do not perform routine, periodic cultures of equipment or devices used for respiratory therapy, pulmonary function testing, or delivery of inhalation anesthesia in the HSCT unit,

nor of dust in rooms of HSCT recipients (IB) (321).

c. No recommendation can be made about routine microbiologic air sampling before, during, or after facility construction or renovation or before or during occupancy of areas housing immunocompromised patients (Unresolved issue) (95,322).

4. In facilities with PEs, perform surveillance of the ventilation status of these areas either by continuous monitoring or periodic analysis of the following parameters: room air exchanges, pressure relations, and filtration efficacy to ensure that appropriate levels are maintained (IB) (95,323).

II. Prevention of Transmission of *Aspergillus* spp. Spores

A. Planning New Specialized-Care Units for High-Risk Patients

1. PE for allogeneic HSCT recipients

a. When constructing new specialized-care units with PE for HSCT recipients, ensure that patient rooms have adequate capacity to minimize accumulation of fungal spores via

1) HEPA filtration of incoming air (324),

2) directed room airflow,

3) positive air pressure in patient's room in relation to the corridor,

4) well-sealed room, and

5) high (≥ 12) air changes per hour (IB, IC) (95;325-327).

b. Do not use LAF routinely in PE (IB) (95; 328-331).

2. Units for autologous HSCT and solid-organ transplant recipients

No recommendation can be made for constructing PE for recipients of autologous HSCTs or solid-organ-transplants (e.g., heart, liver, lung, kidney) (Unresolved issue) (95;331).

B. In Existing Facilities with HSCT Units, and No Cases of Health-Care--Associated Aspergillosis

1. Placement of patients in PE

a. Place an allogeneic HSCT recipient in a PE that meets the conditions outlined in Section II-A-1 (IB).

b. No recommendation can be made for routinely placing a recipient of autologous HSCT or solid-organ transplant in a PE. (Unresolved issue)

2. Maintain air-handling systems in PE and other high-risk patient-care areas according to previously published CDC recommendations (IB,IC) (95,325,327)

3. Develop a water-damage response plan for immediate execution when water leaks, spills, and moisture accumulation occur to prevent fungal growth in the involved areas (IB) (95,332).
4. Use proper dusting methods for patient-care areas designated for severely immunocompromised patients (e.g., HSCT recipients) (IB) (95,325,327, 328,333).
 - a. Wet-dust horizontal surfaces daily using cloth that has been moistened with an EPA-registered hospital disinfectant (IB) (334).
 - b. Avoid dusting methods that disperse dust (e.g., feather dusting) (IB) (334).
 - c. Keep vacuums in good repair and equip them with HEPA filters for use in areas with patients at high risk (IB) (333,334).
 - d. Use vacuum cleaners that are equipped with HEPA filters in patient-care areas for the severely immunocompromised (IB) (333,334).
5. Do not use carpeting in hallways and rooms occupied by severely immunocompromised patients (IB) (95,239,335)
6. Avoid using upholstered furniture or furnishings in rooms occupied by severely immunocompromised patients (II).
7. Minimize the length of time that immunocompromised patients in PEs are outside their rooms for diagnostic procedures and other activities (II).
 - a. Instruct severely immunocompromised patients to wear a high-efficiency respiratory-protection device (e.g., an N95 respirator) when they leave the PE during periods when construction, renovation, or other dust-generating activities are ongoing in and around the health-care facility (II) (336).
 - b. No recommendation can be made about the specific type of respiratory-protection device (e.g., surgical mask, N95 respirator) for use by a severely immunocompromised patient who leaves the PE during periods when there is no construction, renovation, or other dust-generating activity in progress in or around the health-care facility (Unresolved issue).
8. Systematically review and coordinate infection-control strategies with personnel in charge of the facility's engineering, maintenance, central supply and distribution, and catering services (IB) (95,239,337,338).
9. When planning construction, demolition, and renovation activities in and around the facility, assess whether patients at high-risk for aspergillosis are likely to be exposed to high ambient-air spore counts of *Aspergillus* spp. from construction, demolition, and renovation sites, and if so, develop a plan to prevent such exposures (IA) (95,239,338).
10. During construction, demolition, or renovation activities, construct

impermeable barriers between patient-care and construction areas to prevent dust from entering the patient-care areas (IB) (95, 326,339).

11. Direct pedestrian traffic that come from construction areas away from patient-care areas to limit the opening and closing of doors or other barriers that might cause dust dispersion, entry of contaminated air, or tracking of dust into patient-care areas (IB) (95,239,338--340).

12. Do not allow fresh or dried flowers or potted plants in patient-care areas for severely immunocompromised patients (II) (341).

C. When a Case of Aspergillosis Occurs

1. Assess whether the infection is health-care--related or community-acquired.

a. Obtain and use the following information to help in the investigation: background rate of disease at the facility; presence of concurrent or recent cases, as determined by a review of the facility's microbiologic, histopathologic, and postmortem records; length of patient's stay in the facility before onset of aspergillosis; patient's stay at, visit of, or transfer from, other health-care facilities or other locations within the facility; and the period the patient was exposed outside the health-care facility after the onset of immunosuppression and before onset of aspergillosis (II).

b. Determine if any ventilation deficiency exists in PEs (IB) (95).

2. If no evidence exists that the patient's aspergillosis is facility-acquired, continue routine maintenance procedures to prevent health-care--associated aspergillosis, as in Section II-B-1 through II-B-12 (IB).

3. If evidence of possible facility-acquired infection with *Aspergillus* spp. exists, conduct an epidemiologic investigation and an environmental assessment to determine and eliminate the source of *Aspergillus* spp. (95) (IB). If assistance is needed, contact the local or state health department (IB).

4. Use an antifungal biocide (e.g., copper-8-quinolinolate) that is registered with the Environmental Protection Agency for decontamination of structural materials (IB) (95,329,342--344).

III. Chemoprophylaxis

A. No recommendation can be made for the routine administration of antifungal agents such as itraconazole oral solution (5 mg/kg/day) or capsules (500 mg twice a day), low-dose parenteral amphotericin B (0.1 mg/kg/day), lipid-based formulations of amphotericin B (1 mg/kg/day), or nebulized amphotericin B administered by inhalation as prophylaxis for pulmonary aspergillosis in patients at high-risk for this infection (Unresolved issue) (239,345--356).

B. No recommendation can be made for any specific strategy (e.g., deferral of hematopoietic stem-cell transplantation for a particular length of time or routine prophylaxis with absorbable or intravenous antifungal medications) to prevent

recurrence of pulmonary aspergillosis in patients undergoing hematopoietic stem-cell transplantation who have a history of pulmonary aspergillosis (Unresolved issue) (357--363).

Prevention and Control of Health-Care--Associated Respiratory Syncytial Virus, Parainfluenza Virus, and Adenovirus Infections

I. Staff Education and Monitoring and Infection Surveillance

A. Staff Education and Monitoring

1. Staff education

a. Educate personnel in accordance with their level of responsibility in the health-care setting about the epidemiology, modes of transmission, and means of preventing the transmission of respiratory syncytial virus (RSV) within health-care facilities (IB) (364).

b. Educate personnel in accordance with their level of responsibility in the health-care setting about the epidemiology, modes of transmission, and means of preventing the spread of parainfluenza virus and adenovirus within health-care facilities (II).

2. In acute-care facilities, establish mechanisms by which the infection-control staff can monitor personnel compliance with the facility's infection-control policies about these viruses (II) (364).

B. Surveillance

1. Establish mechanisms by which the appropriate health-care personnel are promptly alerted to any increase in the activity of RSV, parainfluenza virus, adenovirus, or other respiratory viruses in the local community. Establish mechanisms by which the appropriate health-care personnel can promptly inform the local and state health departments of any increase in the activity of the above-named viruses or of influenza-like illness in their facility (IB).

2. In acute-care facilities during periods of increased prevalence of symptoms of viral respiratory illness in the community or health-care facility and during the RSV and influenza season (i.e., December--March), attempt prompt diagnosis of respiratory infections caused by RSV, influenza, parainfluenza, or other respiratory viruses. Use rapid diagnostic techniques as clinically indicated in patients who are admitted to the health-care facility with respiratory illness and are at high risk for serious complications from viral respiratory infections (e.g., pediatric patients, especially infants, and those with compromised cardiac, pulmonary, or immune function) (IA) (364--368).

3. No recommendation can be made for routinely conducting surveillance cultures for RSV or other respiratory viruses in respiratory secretions of patients (including immunocompromised patients, such as recipients of HSCT) (Unresolved issue) (239).

4. In long-term--care facilities, establish mechanism(s) for continuing

surveillance to allow rapid identification of a potential outbreak in the facility (II).

II. Prevention of Transmission of RSV, Parainfluenza Virus, or Adenovirus

A. Prevention of Person-to-Person Transmission

1. Standard and contact precautions for RSV and parainfluenza virus and standard, contact, and droplet precautions for adenovirus

a. Hand hygiene

1) Decontaminate hands after contact with a patient or after touching respiratory secretions or fomites potentially contaminated with respiratory secretions, whether or not gloves are worn. Use soap and water when hands are visibly dirty or contaminated with proteinaceous material or are visibly soiled with blood or other body fluids, and use an alcohol-based hand rub if hands are not visibly soiled (IA) (37,364,369--375).

b. Gloving

1) Wear gloves when entering the room of patients with confirmed or suspected RSV, parainfluenza, or adenovirus infection, or before handling the patients or their respiratory secretions or fomites potentially contaminated with the patients' secretions (IA) (37,97,364,368,371--373,376,377).

2) Change gloves between patients or after handling respiratory secretions or fomites contaminated with secretions from one patient before contact with another patient (37,96,97,364). Decontaminate hands after removing gloves (see II-A-1-a). (IA)

3) After glove removal and hand decontamination, do not touch potentially contaminated environmental surfaces or items in the patient's room (IB) (37).

c. Gowning

1) Wear a gown when entering the room of a patient suspected or proven to have RSV, parainfluenza virus, or adenovirus infection and when soiling with respiratory secretions from a patient is anticipated (e.g., when handling infants with suspected or proven RSV, parainfluenza, or adenovirus infection). Change the gown after such contact and before giving care to another patient or when leaving the patient's room. After gown removal, ensure that clothing does not come

into contact with potentially contaminated environmental surfaces (IB) (37,97).

d. Masking and wearing eye protection

1) Wear a surgical mask and eye protection or a face shield when performing procedures or patient-care activities that might generate sprays of respiratory secretions from any patient whether or not the patient has confirmed or suspected viral respiratory tract infection (IB) (37).

2) Wear a surgical mask and eye protection or a face shield when within 3 feet of a patient with suspected or confirmed adenovirus infection (IB) (37).

e. Patient placement in acute-care facilities

1) Place a patient with diagnosed RSV, parainfluenza, adenovirus, or other viral respiratory tract infection in a private room when possible or in a room with other patients with the same infection and no other infection (IB) (37,367--369, 376,377).

2) Place a patient with suspected RSV, parainfluenza, adenovirus, or other viral respiratory tract infection in a private room (II).

a) Promptly perform rapid diagnostic laboratory tests on patients who are admitted with or who have symptoms of RSV infection after admission to the health-care facility to facilitate early downgrading of infection-control precautions to the minimum required for each patient's specific viral infection (IB) (364,376).

b) Promptly perform rapid diagnostic laboratory tests on patients who are admitted with or who have symptoms of parainfluenza or adenovirus infection after admission to the health-care facility to facilitate early downgrading of infection-control precautions to the minimum required for each patient's specific viral infection and early initiation of treatment when indicated (II).

f. Limiting patient movement or transport in acute-care facilities

1) Limit to essential purposes only the movement

or transport of patients from their rooms when they are diagnosed or suspected to be infected with RSV, parainfluenza virus, or adenovirus (IB) (37).

2) If transport or movement from the room is necessary

a) For a patient with diagnosed or suspected RSV or parainfluenza virus infection, ensure that precautions are maintained to minimize the risk for transmission of the virus to other patients and contamination of environmental surfaces or equipment by ensuring that the patient does not touch other persons' hands or environmental surfaces with hands that have been contaminated with his/her respiratory secretions (IB) (37).

b) For a patient with diagnosed or suspected adenovirus infection, minimize patient dispersal of droplets by having the patient wear a surgical mask, and ensure that contact precautions are maintained to minimize the risk for transmission of the virus to other patients and contamination of environmental surfaces or equipment (IB) (37).

2. Other measures in acute-care facilities

a. Staffing

1) Restrict health-care personnel in the acute stages of an upper respiratory tract infection from caring for infants and other patients at high risk for complications from viral respiratory tract infections (e.g., children with severe underlying cardio-pulmonary conditions, children receiving chemotherapy for malignancy, premature infants, and patients who are otherwise immunocompromised) (II) (37,239,364, 368,369).

2) When feasible, perform rapid diagnostic testing on health-care personnel with symptoms of respiratory tract infection, especially those who provide care to patients at high-risk for acquiring or developing severe complications from RSV, parainfluenza, or adenovirus infection, so that their work status can be determined promptly (II).

b. Limiting visitors

Do not allow persons who have symptoms of respiratory infection to visit pediatric, immunosuppressed, or cardiac patients (IB) (37,239,364,376,377).

c. Use of monoclonal antibody (palivizumab) for attenuation of RSV infection

Follow the recommendation of the American Academy of Pediatrics to consider monthly administration of palivizumab, an RSV monoclonal-antibody preparation, to the following infants and children aged <24 months:

1) those born prematurely at ≤ 32 weeks of gestational age that have bronchopulmonary dysplasia and those born prematurely at <32 weeks gestation without chronic lung disease who will be aged <6 months at the beginning of the RSV season.

2) those born at 32--35 weeks gestation if two or more of the following risk factors are present: child-care attendance, school-aged siblings, exposure to environmental pollutants, congenital abnormalities of the airways, or severe neuromuscular disease (II) (378--381).

3. Control of outbreaks in acute-care facilities

a. Perform rapid screening diagnostic tests for the particular virus(es) known or suspected to be causing the outbreak on patients who are admitted with symptoms of viral respiratory illness. Promptly cohort the patients (according to their specific infections) as soon as the results of the screening tests are available (364,365,367--369,376,377). In the interim, when possible, admit patients with symptoms of viral respiratory infections to private rooms (IB).

b. Personnel cohorting

1) During an outbreak of health-care--associated RSV infection, cohort personnel as much as practical (e.g., restrict personnel who give care to infected patients from giving care to uninfected patients) (II) (368,369,377).

2) No recommendation can be made for routinely cohorting personnel during an outbreak of health-care--associated adenovirus or parainfluenza virus infection (Unresolved issue).

c. Use of RSV immune globulin or monoclonal antibody

1) No recommendation can be made for the use of RSV immune globulin or monoclonal antibody to control outbreaks of RSV infection in the health-care setting (Unresolved issue) (378--386).

Prevention and Control of Health-Care--Associated Influenza

I. Staff Education

Provide health-care personnel continuing education or access to continuing education about the epidemiology, modes of transmission, diagnosis, and means of preventing the spread of influenza, in accordance with their level of responsibility in preventing health-care--associated influenza (II) (109,387--389).

II. Surveillance

A. Establish mechanisms by which facility personnel are promptly alerted about increased influenza activity in the community (II).

B. Establish protocols for intensifying efforts to promptly diagnose cases of facility-acquired influenza

1. Determine the threshold incidence or prevalence of influenza or influenza-like illness in the facility at which laboratory testing of patients with influenza-like illness is to be undertaken and outbreak control measures are to be initiated (II) (390).

2. Arrange for laboratory tests to be available to clinicians for prompt diagnosis of influenza, especially during November--April (II) (391--394).

III. Modifying Host Risk for Infection

A. Vaccination

1. In acute-care settings (including acute-care hospitals, emergency rooms, and walk-in clinics) or ongoing-care facilities (including physicians' offices, public health clinics, employee health clinics, hemodialysis centers, hospital specialty-care clinics, outpatient rehabilitation programs, and mobile clinics), offer vaccine to inpatients and outpatients at high risk for complications from influenza beginning in September and throughout the influenza season (108,395--397). Groups at high risk for influenza-related complications include those aged ≥ 65 years; residents of nursing homes and other chronic-care facilities that house persons of any age who have chronic medical conditions; adults and children aged >6 months who have chronic disorders of the pulmonary or cardiovascular system, including asthma; adults and children who have required regular medical follow-up or hospitalization during the preceding year because of chronic metabolic diseases (including diabetes mellitus), renal dysfunction, or hemoglobinopathies, or immunosuppression (including immunosuppression caused by medications or HIV); children and adolescents (aged 6 months--18 years) who are receiving long-term aspirin therapy; and women who will be in the second or third trimester of pregnancy during the influenza season (395,398--403). In addition, offer annual influenza vaccination to all persons aged 50--64 years, close contacts of children aged <24 months, and healthy children aged 6--23 months (IA) (395).

2. In nursing homes and other long-term--care facilities, establish an SOP for timely administration of the inactivated influenza vaccine to persons at high risk as identified in Section III-A-1 (IA) (109--111,395).

a. Obtain consent for influenza vaccination (if such is required by local or state law) from every resident (or his/her guardian) at the time the resident is admitted to the facility or anytime afterwards before the next influenza season (IB) (109,395,404).

b. Routinely vaccinate all residents, except those with medical contraindication(s) to receipt of influenza vaccine (under an SOP or with the concurrence of the residents' respective attending physicians) at one time, annually, before the influenza season. To residents who are admitted during the winter months after completion of the facility's vaccination program, offer the vaccine at the time of their admission (IA) (395,402,404,405).

c. In settings not included in sections II-A-1 and -2, where health care is given (e.g., in homes visited by personnel from home health-care agencies), vaccinate patients for whom vaccination is indicated, as listed in section III-A-1, and refer patient's household members and care givers for vaccination, before the influenza season (IA) (395).

3. Personnel

a. Beginning in October each year, provide inactivated influenza vaccine for all personnel including night and weekend staff (395,406--10). Throughout the influenza season, continue to make the vaccine available to newly hired personnel and to those who initially refuse vaccination. If vaccine supply is limited, give highest priority to staff caring for patients at greatest risk for severe complications from influenza infection, as listed in section III-A-1 (IA) (395).

b. Educate health-care personnel about the benefits of vaccination and the potential health consequences of influenza illness for themselves and their patients (IB) (395).

c. Take measures to provide all health-care personnel convenient access to inactivated influenza vaccine at the work site, free of charge, as part of employee health program (IB) (395).

B. Use of Antiviral Agents (See Section V-C)

IV. Prevention of Person-to-Person Transmission

A. Droplet Precautions

1. Place a patient who is diagnosed with influenza in a private room or in a room with other patients with confirmed influenza, unless medical contraindications exist (IB) (37).

2. Place a patient who is suspected to have influenza in a private room, and promptly perform rapid diagnostic laboratory tests to facilitate early downgrading of infection-control precautions to the minimum required for the patient's infection (II) (37).

3. Wear a surgical mask upon entering the patient's room or when working within 3 feet of the patient (IB) (37).

4. Limit the movement and transport of the patient from the room to those for essential purposes only. If patient movement or transport is necessary, have the patient wear a surgical mask, if possible, to minimize droplet dispersal by the patient (II) (37).

B. Eye Protection

No recommendation can be made for wearing an eye-protective device upon entering the room of a patient with confirmed or suspected influenza or when working within 3 feet of the patient (Unresolved issue).

C. Contact Precautions

No recommendation can be made for the observance of contact precautions (in addition to droplet precautions) for patients with confirmed or suspected influenza (Unresolved issue) (37,411).

D. Standard Precautions

1. Decontaminate hands before and after giving care to or touching a patient or after touching a patient's respiratory secretions, whether or not gloves are worn. If hands are visibly dirty or contaminated with proteinaceous material or are visibly soiled with blood or body fluids, wash them with either a nonantimicrobial soap and water or an antimicrobial soap and water. If hands are not visibly soiled, use an alcohol-based hand rub for their decontamination (IA) (39).

2. Wear gloves if hand contact with patient's respiratory secretions is expected (II) (37,411).

3. Wear a gown if soiling of clothes with patient's respiratory secretions is expected (II) (37).

E. Air Handling

No recommendation can be made for maintaining negative air pressure in rooms of patients in whom influenza is suspected or diagnosed, or in placing together persons with influenza-like illness in a hospital area with an independent air-supply and exhaust system (Unresolved issue) (412--414).

F. Personnel Restrictions

In acute-care facilities, use the facility's employee health service or its equivalent to evaluate personnel with influenza-like illness and determine whether they should be removed from duties that involve direct patient contact. Use more stringent criteria for personnel who work in certain patient-care areas (e.g., intensive care units, nurseries, and organ-transplant [especially HSCT]) where patients who are most susceptible to influenza-related complications are located (IB) (415--417).

V. Control of Influenza Outbreaks

A. Determining the Outbreak Strain

Early in the outbreak, perform rapid influenza virus testing on nasopharyngeal swab or nasal-wash specimens from patients with recent onset of symptoms suggestive of influenza. In addition, obtain viral cultures from a subset of patients to determine the infecting virus type and subtype (IB) (391--394).

B. Vaccination of Patients and Personnel

Administer current inactivated influenza vaccine to unvaccinated patients and health-care personnel (IA) (395,402,406,408).

C. Antiviral Agent Administration

1. When a facility outbreak of influenza is suspected or recognized:
 - a. Administer amantadine, rimantadine, or oseltamivir as prophylaxis to all patients without influenza illness in the involved unit for whom the antiviral agent is not contraindicated (regardless of whether they received influenza vaccinations during the previous fall) for a minimum of 2 weeks or until approximately 1 week after the end of the outbreak. Do not delay administration of the antiviral agent(s) for prophylaxis unless the results of diagnostic tests to identify the infecting strain(s) can be obtained within 12--24 hours after specimen collection (IA) (395,405, 418,419).
 - b. Administer amantadine, rimantadine, oseltamivir, or zanamivir to patients acutely ill with influenza within 48 hours of illness onset. Choose the agent appropriate for the type of influenza virus circulating in the community (IA) (395,405,418--421).
 - c. Offer antiviral agent(s) (amantadine, rimantadine, or oseltamivir) for prophylaxis to unvaccinated personnel for whom the antiviral agent is not contraindicated and who are in the involved unit or taking care of patients at high risk (IB) (395,405,418,419,422).
 - d. Consider prophylaxis for all health-care personnel, regardless of their vaccination status, if the outbreak is caused by a variant of influenza that is not well matched by the vaccine (IB) (395).
 - e. No recommendation can be made about the prophylactic administration of zanamivir to patients or personnel (Unresolved issue) (395,423--425).
 - f. Discontinue the administration of influenza antiviral agents to patients or personnel if laboratory tests confirm or strongly suggest that influenza is not the cause of the facility outbreak (IA) (426).
 - g. If the cause of the outbreak is confirmed or believed to be influenza and vaccine has been administered only recently to susceptible patients and personnel, continue prophylaxis with an antiviral agent until 2 weeks after the vaccination (IB) (395,427).
2. To reduce the potential for transmission of drug-resistant virus, do not allow contact between persons at high risk for complications from influenza and patients or personnel who are taking an antiviral agent for treatment of confirmed or suspected influenza during and for 2 days after the latter discontinue treatment (IB) (428--432).

D. Other Measures in Acute-Care Facilities

When influenza outbreaks, especially those characterized by high attack rates and severe illness, occur in the community and/or facility:

1. Curtail or eliminate elective medical and surgical admissions (II) (416).
2. Restrict cardiovascular and pulmonary surgery to emergency cases only (II) (416).
3. Restrict persons with influenza or influenza-like illness from visiting patients in the health-care facility (II) (416).
4. Restrict personnel with influenza or influenza-like illness from patient care (IB) (416).

Severe Acute Respiratory Syndrome

Updated information about prevention and control of severe acute respiratory syndrome in health-care facilities is available in a separate publication (433).

Part III: Performance Indicators

To assist infection-control personnel in assessing personnel adherence to the recommendations, the following performance measures are suggested:

1. Monitor rates of VAP; can use established benchmarks and definitions of pneumonia (e.g., NNIS definitions and rates) (14). Provide feedback to the staff about the facility's VAP rates and reminders about the need for personnel to adhere to infection-control practices that reduce the incidence of VAP.
2. Establish a SOP for influenza vaccination and monitor the percentage of eligible patients in acute-care settings or patients or residents in long-term-care settings who receive the vaccine.
3. Before and during the influenza season, monitor and record the number of eligible health-care personnel who receive the influenza vaccine and determine the desired unit- and facility-specific vaccination rates as recommended by ACIP.
4. Monitor the number of cases of health-care--associated RSV infections by geographic location within the facility and give prompt feedback to appropriate staff members to improve adherence to recommended infection-control precautions.
5. Periodically review clinicians' use of laboratory diagnostic tests (both culture of appropriate respiratory specimen and the urine antigen test) for legionellosis, especially in patients who are at high risk for acquiring the disease (e.g., patients who are immunosuppressed, including recipients of HSCT or solid-organ transplant, or patients receiving systemic steroids; patients aged >65 years; or patients who have chronic underlying disease such as diabetes mellitus, congestive heart failure, and COPD). Provide feedback on the use of these tests to clinicians.
6. During construction or renovation activities in the facility, monitor personnel adherence to infection-control measures (e.g., use of barriers, maintenance of negative room pressure) that are aimed at minimizing dust dispersion in patient-care areas. Review all cases of health-care--associated aspergillosis to

determine the presence of remediable environmental risks.

7. Periodically monitor the frequency of diagnostic testing for pertussis and the time interval between suspicion of the infection and initiation of isolation precautions for patients in whom pertussis is suspected.

References

1. [CDC. Guideline for prevention of nosocomial pneumonia. MMWR 1997;46\(No. RR-1\).](#)
2. CDC. Guidelines for preventing health-care--associated pneumonia, 2003. Atlanta, GA: U.S. Department of Health and Hman Services, CDC, 2004.
3. [CDC. Guidelines for preventing the transmission of tuberculosis in health-care facilities, 1994. MMWR 1994;43\(No. RR-13\).](#)
4. Brooks K, Whitten S, Quigley D. Reducing the incidence of ventilator-related pneumonia. *J Health Qual* 1998;20:14--19.
5. Halm EA, Atlas SJ, Borowsky LH, et al. Understanding physician adherence with a pneumonia practice guideline: effects of patient, system, and physician factors. *Arch Intern Med* 2000;160:98--104.
6. Katz DA. Barriers between guidelines and improved patient care: an analysis of AHCPR's Unstable Angina Clinical Practice Guideline. *Health Serv Res* 1999;34:377--89.
7. Kaye J, Ashline V, Erickson D, et al. Critical care bug team: a multidisciplinary team approach to reducing ventilator-associated pneumonia. *Am J Infect Control* 2000;28:197--201.
8. Kelleghan SI, Salemi C, Padilla S, et al. An effective continuous quality improvement approach to the prevention of ventilator-associated pneumonia. *Am J Infect Control* 1993;21:322--30.
9. Joiner GA, Salisbury D, Bollin GE. Utilizing quality assurance as a tool for reducing the risk of nosocomial ventilator-associated pneumonia. *Am J Med Qual* 1996;11:100--3.
10. Nicotra D, Ulrich C. Process improvement plan for the reduction of nosocomial pneumonia in patients on ventilators. *J Nurs Care Qual* 1996;10:18--23.
11. Zack JE, Garrison T, Trovillion E, et al. Effect of an education program aimed at reducing the occurrence of ventilator-associated pneumonia. *Crit Care Med* 2002; 30:2407--12.
12. Haley RW, Culver DH, White J.W., et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in U.S. hospitals. *Am J Epidemiol* 1985;121:182--205.
13. Haley RW, Morgan WM, Culver DH, et al. Hospital infection control: recent progress and opportunities under prospective payment. *Am J Infect Control* 1985;13:97--108.
14. CDC. NNIS criteria for determining nosocomial pneumonia. Atlanta, GA: U.S.

Department of Health and Human Services, CDC, 2003.

15. Horan TC, White JW, Jarvis WR, et al. Nosocomial infection surveillance, 1984. *MMWR* 1986;35(SS-1):17--29.
16. Gaynes RP, Solomon S. Improving hospital-acquired infection rates: the CDC experience. *Jt Comm J Qual Improv* 1996;22:457--67.
17. Josephson A, Karanfil L, Alonso H, Watson A, Blight J. Risk-specific nosocomial infection rates. *Am J Med* 1991;91:131--7.
18. Gaynes R, Richards C, Edwards J, et al. Feeding back surveillance data to prevent hospital-acquired infections. *Emerging Infect Dis* 2001;7:295--8.
19. American Hospital Association Committee on Infection within Hospitals. Statement on microbiologic sampling in the hospital. *Hospitals* 1974; 48:125--6.
20. Eickhoff TC. Microbiologic sampling. *Hospitals* 1970; 44:86--7.
21. Finelli L, Livengood JR, Saiman L. Surveillance of pharyngeal colonization: detection and control of serious bacterial illness in low birth weight infants. *Pediatr Infect Dis J* 1994;13:854--9.
22. Glupczynski Y. Usefulness of bacteriologic surveillance cultures for monitoring infection in hospitalized patients. *Acta Clin Belg* 2001; 56:38-45.
23. Favero MS, Bond WW. Clinical disinfection of medical and surgical materials. In: Block S, ed. *Disinfection, sterilization, and preservation*. Philadelphia, PA: Lea and Febiger, 1991.
24. Rutala WA, Weber DJ, Healthcare Infection Control Practices Advisory Committee: guideline for disinfection and sterilization in healthcare facilities. *MMWR* (in press).
25. Cefai C, Richards J, Gould FK, McPeake P. An outbreak of *Acinetobacter* respiratory tract infection resulting from incomplete disinfection of ventilatory equipment. *J Hosp Infect* 1990;15:177--82.
26. Craig DB, Cowan SA, Forsyth W, Parker SE. Disinfection of anesthesia equipment by a mechanized pasteurization method. *Can Anaesth Soc J* 1975;22:219--23.
27. McDonald WL, Welch HJ, Keet JE. Antisepsis of endotracheal tubes and face masks. *Anesthesiology* 1955; 16:206--13.
28. Spaulding EH. Studies on the chemical sterilization of surgical instruments. *Surg Gynecol Obstet* 1939;69:738--44.
29. Food and Drug Administration. Enforcement priorities for single-use devices reprocessed by third parties and hospitals. Rockville, MD: US DHHS, FDA, 2000.
30. Dreyfuss D, Djedaini K, Weber P, et al. Prospective study of nosocomial pneumonia and of patient and circuit colonization during mechanical ventilation with circuit changes every 48 hours versus no change. *Am Rev Respir Dis* 1991;143:738--43.
31. Fink JB, Krause SA, Barrett L, Schaaff D, Alex CG. Extending ventilator circuit change interval beyond 2 days reduces the likelihood of ventilator-associated

pneumonia. Chest 1998;113:405--11.

32. Hess D, Burns E, Romagnoli D, Kacmarek RM. Weekly ventilator circuit changes: a strategy to reduce costs without affecting pneumonia rates. Anesthesiology 1995;82:903--11.

33. Kollef MH, Shapiro D, Fraser VJ, et al. Mechanical ventilation with or without 7-day circuit changes: a randomized controlled trial. Ann Intern Med 1995;123:168--74.

34. Kotilainen HR, Keroack MA. Cost analysis and clinical impact of weekly ventilator circuit changes in patients in intensive care unit. Am J Infect Control 1997;25:117--20.

35. Long MN, Wickstrom G, Grimes A, Benton CF, Belcher B, Stamm AM. Prospective, randomised study of ventilator-associated pneumonia in patients with one versus three ventilator circuit changes per week. Infect Control Hosp Epidemiol 1996;17:14--19.

36. Craven DE, Goularte TA, Make BJ. Contaminated condensate in mechanical ventilator circuits: a risk factor for nosocomial pneumonia? Am Rev Respir Dis 1984;129:625--8.

37. Garner JS. Guideline for isolation precautions in hospitals: the Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 1996;17:53--80.

38. Gorman LJ, Sanai L, Notman AW, Grant IS, Masterton RG. Cross infection in an intensive care unit by *Klebsiella pneumoniae* from ventilator condensate. J Hosp Infect 1993;23:27--34.

39. [CDC. Guideline for hand hygiene in health-care settings. MMWR 2002;51\(No. RR-16\).](#)

40. Arnow PM, Chou T, Weil D, Shapiro EN, Kretzschmar C. Nosocomial Legionnaires' disease caused by aerosolized tap water from respiratory devices. J Infect Dis 1982;146:460--7.

41. Carson LA, Favero MS, Bond WW, Petersen NJ. Morphological, biochemical and growth characteristics of *Pseudomonas cepacia* from distilled water. Appl Microbiol 1973;25:476--83.

42. Favero MS, Carson LA, Bond WW. *Pseudomonas aeruginosa*: growth in distilled water from hospitals. Science 1971;173:836--8.

43. Rhame FS, Streifel A, McComb C, Boyle M. Bubbling humidifiers produce microaerosols which can carry bacteria. Infect Control 1986;7:403--7.

44. Cook D, De Jonghe B, Brochard L, Brun-Buisson C. Influence of airway management on ventilator-associated pneumonia: evidence from randomized trials. JAMA 1998;279:781--7.

45. Dreyfuss D, Djedaini K, Gros I, et al. Mechanical ventilation with heated humidifiers or heat and moisture exchangers: effects on patient colonization and incidence of nosocomial pneumonia. Am J Respir Crit Care Med 1995; 151:986--92.

46. Hurni JM, Feihl F, Lazor R, Leuenberger P, Perret C. Safety of combined heat and moisture exchanger filters in long-term mechanical ventilation. Chest 1997;111:686--91.

47. Kirton OC, DeHaven B, Morgan J, Morejon O, Civetta J. A prospective, randomised comparison of an in-line heat moisture exchange filter and heated wire humidifiers: rates of ventilator-associated early-onset (community-acquired) or late-onset (hospital-acquired) pneumonia and incidence of endotracheal tube occlusion. *Chest* 1997;112:1055--9.
48. Roustan JP, Kienlen J, Aubas P, Aubas S, du Cailar J. Comparison of hydrophobic heat and moisture exchangers with heated humidifier during prolonged mechanical ventilation. *Intensive Care Med* 1992;18:97--100.
49. Thomachot L, Viviand X, Arnaud S, Boisson C, Martin CD. Comparing two heat and moisture exchangers, one hydrophobic and one hygroscopic, on humidifying efficacy and the rate of nosocomial pneumonia. *Chest* 1998;114:1383--9.
50. Boisson C, Viviand X, Arnaud S, Thomachot L, Miliani Y, Martin C. Changing a hydrophobic heat and moisture exchanger after 48 hours rather than 24 hours: a clinical and microbiologic evaluation. *Intensive Care Med* 1999;25:1237--43.
51. Daumal F, Colpart E, Manoury B, Mariani M, Daumal M. Changing heat and moisture exchangers every 48 hours does not increase the incidence of nosocomial pneumonia. *Infect Control Hosp Epidemiol* 1999;20:347--9.
52. Thomachot L, Vialet R, Viguier JM, Sidier B, Roulier P, Martin C. Efficacy of heat and moisture exchangers after changing every 48 hours rather than 24 hours. *Crit Care Med* 1998;26:477--81.
53. Salemi C, Padilla S, Canola T, Reynolds D. Heat-and-moisture exchangers used with biweekly circuit tubing changes: effect on costs and pneumonia rates. *Infect Control Hosp Epidemiol* 2000;21:737--9.
54. Golar SD, Sutherland LLA, Ford GT. Multipatient use of prefilled disposable oxygen humidifiers for up to 30 days: patient safety and cost analysis. *Respir Care* 1993;38:343--7.
55. Henderson E, Ledgerwood D, Hope KM, et al. Prolonged and multipatient use of prefilled disposable oxygen humidifier bottles: safety and cost. *Infect Control Hosp Epidemiol* 1993;14:463--8.
56. Seto WH, Ching TY, Yuen KY, Lam WK. Evaluating the sterility of disposable wall oxygen humidifiers, during and between use on patients. *Infect Control* 1990;11:604--5.
57. Craven DE, Lichtenberg DA, Goularte TA, Make BJ, McCabe WR. Contaminated medication nebulizers in mechanical ventilation circuits. Source of bacterial aerosols. *Am J Med* 1984;77:834--8.
58. Mastro TD, Fields BS, Breiman RF, Campbell J, Plikaytis BD, Spika JS. Nosocomial Legionnaires' disease and use of medication nebulizers. *J Infect Dis* 1991;163:667--71.
59. Reboli AC, Koshinski R, Arias K, Marks-Austin K, Stieritz D, Stull TL. An outbreak of *Burkholderia cepacia* lower respiratory tract infection associated with contaminated albuterol nebulization solution. *Infect Control Hosp Epidemiol* 1996;17:741--3.
60. Mertz JJ, Scharer L, McClement JH. A hospital outbreak of Klebsiella pneumonia from inhalation therapy with contaminated aerosol solutions. *Am Rev Respir Dis*

1967;95:454--60.

61. Moffet HL, Williams T. Bacteria recovered from distilled water and inhalation therapy equipment. *Am J Dis Child* 1967;114:7--12.
62. Sanders CV Jr., Luby JP, Johanson WG Jr., Barnett JA, Sanford JP. *Serratia marcescens* infections from inhalation therapy medications: nosocomial outbreak. *Ann Intern Med* 1970;73:15--21.
63. Hamill RJ, Houston ED, Georghiou 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.
64. 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.
65. Longfield R, Longfield J, Smith LP, Hyams KC, Strohmer ME. Multidose medication vial sterility: an in-use study and a review of literature. *Infect Control* 1984;5:165--9.
66. Ramsey AH, Skonieczny P, Coolidge DT, Kurzynski TA, Proctor ME, Davis JP. *Burkholderia cepacia* lower respiratory tract infection associated with exposure to a respiratory therapist. *Infect Control Hosp Epidemiol* 2001;22:423--6.
67. Sheth NK, Post GT, Wisniewski TR, Uttech BV. Multi-dose vials versus single-dose vials: a study in sterility and cost-effectiveness. *J Clin Microbiol* 1983;17:377--9.
68. Moffet HL, Allan D. Survival and dissemination of bacteria in nebulizers and incubators. *Am J Dis Chil Child* 1967;114:13--20
69. Jakobsson B, Hjelte L, Nystrom B. Low level of bacterial contamination of mist tents used in home treatment of cystic fibrosis patients. *J Hosp Infect* 2000;44:37--41.
70. Cunha BA, Klimek JJ, Gracewski J, McLaughlin JC, Quintiliani R. A common source outbreak of *Acinetobacter* pulmonary infection traced to Wright respirometers. *Postgrad Med J* 1980;56:169--72.
71. Irwin RS, Demers RR, Pratter MR, et al. An outbreak of *Acinetobacter* infection associated with the use of a ventilator spirometer. *Respir Care* 1980;25:232--7.
72. Kaul R, Burt JA, Cork L, et al. Investigation of a multiyear multiple critical care unit outbreak due to relatively drug-sensitive *Acinetobacter baumannii*: risk factors and attributable mortality. *J Infect Dis* 1996; 174:1279--87.
73. Rogues AM, Maugein J, Allery A, et al. Electronic ventilator temperature sensors as a potential source of respiratory tract colonization with *Stenotrophomonas maltophilia*. *J Hosp Infect* 2001;49:289--92.
74. 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.
75. Fierer J, Taylor PM, Gezon HM. *Pseudomonas aeruginosa* epidemic traced to delivery-room resuscitators. *N Engl J Med* 1967;276:991--6.
76. Stone JW, Das BC. Investigation of an outbreak of infection with *Acinetobacter*

calcoaceticus in a special care baby unit. J Hosp Infect 1986;7:42--8.

77. Thompson AC, Wilder BJ, Powner DJ. Bedside resuscitation bags: a source of bacterial contamination. Infect Control 1985;6:231--2.
78. Weber DJ, Wilson MB, Rutala WA, Thomann CA. Manual ventilation bags as a source for bacterial colonization of intubated patients. Am Rev Respir Dis 1990;142:892--4.
79. Van Der Zwet WC, Parlevliet GA, Savelkoul PH, et al. Outbreak of *Bacillus cereus* infections in a neonatal intensive care unit traced to balloons used in manual ventilation. J Clin Microbiol 2000;38:4131--6.
80. Du Moulin GC, Sauberman AJ. The anesthesia machine and circle system are not likely to be sources of bacterial contamination. Anesthesiology 1977;47:353--8.
81. Bengtson JP, Brandberg A, Brinkhoff B, Sonander H, Stenqvist O. Low-flow anesthesia does not increase the risk of microbial contamination through the circle absorber system. Acta Anaesth Scand 1989;33:89--92.
82. American Association of Nurse Anesthetists. Infection control guide. 2nd ed, 1993. Chicago, Illinois, 1993.
83. American Society for Anesthesiologists. Prevention of nosocomial infections in patients: recommendations for Infection Control for the Practice of Anesthesiology. Park Ridge, Illinois: American Society of Anesthesiologists, 1991.
84. Berry AJ, Nolte FS. An alternative strategy for infection control of anesthesia breathing circuits: a laboratory assessment of the Pall HME Filter. Anesth Analg 1991;72:651--5.
85. Feeley TW, Hamilton WK, Xavier B, Moyers J, Eger EI. Sterile anesthesia breathing circuits do not prevent postoperative pulmonary infection. Anesthesiology 1981;54:369--72.
86. Garibaldi RA, Britt MR, Webster C, Pace NL. Failure of bacterial filters to reduce the incidence of pneumonia after inhalation anesthesia. Anesthesiology 1981;54:364--8.
87. Luttrupp HH, Berntman L. Bacterial filters protect anaesthetic equipment in a low-flow system. Anaesthesia 1993;48:520--3.
88. Ping FC, Oulton JL, Smith JA, Skidmore AG, Jenkins LC. Bacterial filters---are they necessary on anesthetic machines? Anaesth Soc J 1979;26:415--9.
89. Vezina DP, Trepanier CA, Lessard MR, Gourdeau M, Tremblay C. Anesthesia breathing circuits protected by the DAR Barrierbac S breathing filter have a low bacterial contamination rate. Can J Anaesth 2001;48:748--54.
90. Hiebert T, Miles J, Okeson GC. Contaminated aerosol recovery from pulmonary function testing equipment. Am J Respir Crit Care Med 1999;159:610--2.
91. Rutala DR, Rutala WA, Weber DJ, Thomann CA. Infection risks associated with spirometry. Infect Control Hosp Epidemiol 1991;12: 89--92.
92. Ahmed J, Brutus A, D'Amato RF, Glatt AE. *Acinetobacter calcoaceticus anitratus* outbreak in the intensive care unit traced to a peak flow meter. Am J Infect Control 1994;22:319--21.

93. Griebble HG, Colton FR, Thomas MS, et al. Fine-particle humidifiers: source of *Pseudomonas aeruginosa* infections in a respiratory-disease unit. *N Engl J Med* 1970;282:531--3.
94. Smith PW, Massanari RM. Room humidifiers as the source of *Acinetobacter* infections. *JAMA* 1977;237:795--7.
95. [CDC. Guidelines for environmental control in health-care facilities. MMWR 2003;52\(No. RR--10\).](#)
96. 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.
97. 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.
98. 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.
99. Morar P, Makura Z, Jones A, et al. Topical antibiotics on tracheostoma prevents exogenous colonization and infection of lower airways in children. *Chest* 2000; 117(2):513--8.
100. Combes P, Fauvage B, Oleyer C. Nosocomial pneumonia in mechanically ventilated patients: a prospective randomised evaluation of the Stericath closed suctioning system. *Intensive Care Med* 2000;26:878--82.
101. Deppe SA, Kelly JW, Thoi LL, et al. Incidence of colonization, nosocomial pneumonia, and mortality in critically ill patients using a Trach Care closed-suction system versus open-suction system: prospective, randomized study. *Crit Care Med* 1990;18:1389--93.
102. Johnson KL, Kearney PA, Johnson SB, Niblett JB, MacMillan NL, McClain RE. Closed versus open endotracheal suctioning: costs and physiologic consequences. *Crit Care Med* 1994;22:658--66.
103. Kollef MH, Prentice D, Shapiro SD, et al. Mechanical ventilation with or without daily changes of in-line suction catheters. *Am J Respir Crit Care Med* 1997;156:466--72.
104. [CDC. Preventing pneumococcal disease among infants and young children. MMWR 2000;49\(No. RR-9\).](#)
105. [CDC. Prevention of pneumococcal disease: recommendations of the Advisory Committee on Immunization Practices \(ACIP\). MMWR 1997;46\(No. RR-8\).](#)
106. [CDC. Outbreak of pneumococcal pneumonia among unvaccinated residents of a nursing home---New Jersey, April 2001. MMWR 2001;50:707--10.](#)
107. Shapiro ED, Clemens JD. A controlled evaluation of the protective efficacy of pneumococcal vaccine for patients at high risk of serious pneumococcal infections. *Ann Intern Med* 1984;101:325--30.
108. Williams WW, Hickson MA, Kane MA, Kendal AP, Spika JS, Hinman AR.

Immunization policies and vaccine coverage among adults: the risk for missed opportunities. *Ann Intern Med* 1988;108:616--25.

109. Nichol KL, Grimm MB, Peterson DC. Immunizations in long-term care facilities: policies and practice. *J Am Geriatr Soc* 1996;44:349--55.

110. [CDC. Use of standing orders programs to increase adult vaccination rates: recommendations of the Advisory Committee on Immunization Practices \(ACIP\). MMWR 2000;49\(No. RR-1\).](#)

111. Centers for Medicare and Medicaid Services H. Medicare and Medicaid programs; conditions of participation: immunization standards for hospitals, long-term care facilities, and home health agencies: final rule with comment period. *Federal Register* 2002;67:61808--14.

112. Donta ST, Peduzzi P, Cross AS, et al. Immunoprophylaxis against *Klebsiella* and *Pseudomonas aeruginosa* infections. *J Infect Dis* 1996;174:537--43.

113. Gruson D, Hilbert G, Vargas F, et al. Impact of colony-stimulating factor therapy on clinical outcome and frequency rate of nosocomial infections in intensive care unit neutropenic patients. *Crit Care Med* 2000; 28:3155--60.

114. Heard SO, Fink MP, Gamelli RL, et al. Effect of prophylactic administration of recombinant human granulocyte colony-stimulating factor (filgrastim) on the frequency of nosocomial infections in patients with acute traumatic brain injury or cerebral hemorrhage. *Crit Care Med* 1998;26:748--54.

115. Maher DW, Lieschke GJ, Green M, et al. Filgrastim in patients with chemotherapy-induced febrile neutropenia: a double-blind, placebo-controlled trial. *Ann Intern Med* 1994;121:492--501.

116. Mitchell PL, Morland B, Stevens MC, et al. Granulocyte colony-stimulating factor in established febrile neutropenia: a randomized study of pediatric patients. *J Clin Oncol* 1997;15:1163--70.

117. The Intravenous Immunoglobulin Collaborative Study Group. Prophylactic intravenous administration of standard immune globulin as compared with core-lipopolysaccharide immune globulin in patients at high risk of postsurgical infection. *N Engl J Med* 1992;327: 234--40.

118. Houdijk APJ, Rijnsburger ER, Jansen J, et al. Randomised trial of glutamine-enriched enteral nutrition on infectious morbidity in patients with multiple trauma. *Lancet* 1998;352:772--6.

119. van der Hulst RRWJ, van Kreel BK, Von Meyenfeldt MF, et al. Glutamine and the preservation of gut integrity. *Lancet* 1993;341: 1363--5.

120. Celis R, Torres A, Gatell JM, Almela M, Rodriguez-Riosin R, Agusti-Vidal A. Nosocomial pneumonia: a multivariate analysis of risk and prognosis. *Chest* 1988;93:318--24.

121. Craven DE, Kunches LM, Kilinsky V, Lichtenberg DA, Make BJ, McCabe WR. Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. *Am Rev Respir Dis* 1986;133:792--6.

122. Kingston GW, Phang PT, Leathley MJ. Increased incidence of nosocomial

- pneumonia in mechanically ventilated patients with subclinical aspiration. *Am J Surg* 1991;161:589--92.
123. Metheny NA, Eisenberg P, Spies M. Aspiration pneumonia in patients fed through nasoenteral tubes. *Heart Lung* 1986;15:256--61.
124. Pingleton SK, Hinthorn DR, Liu C. Enteral nutrition in patients receiving mechanical ventilation: multiple sources of tracheal colonization include the stomach. *Am J Med* 1986;80:827--32.
125. Treloar DM, Stechmiller J. Pulmonary aspiration of tube-fed patients with artificial airways. *Heart Lung* 1984; 13:667--71.
126. Brochard L, Mancebo J, Wysocki M, et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. *N Engl J Med* 1995;333:817--22.
127. Girou E, Schortgen F, Delcaux C, et al. Association of noninvasive ventilation with nosocomial infections and survival in critically ill patients. *JAMA* 2000;284:2361--7.
128. Carlucci A, Richard JC, Wysocki M, Lopage E, Brochard L. Noninvasive versus conventional mechanical ventilation: an epidemiologic survey. *Am J Respir Crit Care Med* 2001; 163:874--80.
129. Keenan SP. Noninvasive positive pressure ventilation in acute respiratory failure. *JAMA* 2000;284:2376--8.
130. Nava S, Ambrosino N, Clini E, et al. Noninvasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease: a randomized, controlled trial. *Ann Intern Med* 1998; 128:721--8.
131. Torres A, Gatell JM, Aznar E, et al. Re-intubation increases the risk of nosocomial pneumonia in patients needing mechanical ventilation. *Am J Respir Crit Care Med* 1995;152:137--41.
132. Holzapfel L, Chevret S, Madinier G, et al. Influence of long-term oro- or nasotracheal intubation on nosocomial maxillary sinusitis and pneumonia: results of a prospective, randomized clinical trial. *Crit Care Med* 1993;21:1132--8.
133. Rouby JJ, Laurent P, Gosnach M, et al. Risk factors and clinical relevance of nosocomial maxillary sinusitis in the critically ill. *Am J Respir Crit Care Med* 1994;150:776--83.
134. Kollef MH, Skubas NJ, Sundt TM. A randomized clinical trial of continuous aspiration of subglottic secretions in cardiac surgery patients. *Chest* 1999;116:1339--46.
135. Mahul P, Auboyer C, Jospe R, et al. Prevention of nosocomial pneumonia in intubated patients: respective role of mechanical subglottic drainage and stress ulcer prophylaxis. *Intensive Care Med* 1992;18:20--5.
136. Smulders K, van der Hoeven H, Weers-Pothoff I, Vanderbroucke-Grauls C. A randomized clinical trial of intermittent subglottic secretion drainage in patients receiving mechanical ventilation. *Chest* 2002;121:858--62.
137. Valles J, Artigas A, Rello J, et al. Continuous aspiration of subglottic secretions in preventing ventilator-associated pneumonia. *Ann Intern Med* 1995;122:179--86.

138. Drakulovic MB, Torres A, Bauer TT, Nicolas JM, Nogue S, Ferrer M. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial. *Lancet* 1999; 354(9193):1851--58.
139. Orozco-Levi M, Torres A, Ferrer M, et al. Semirecumbent position protects from pulmonary aspiration but not completely from gastroesophageal reflux in mechanically ventilated patients. *Am J Respir Crit Care Med* 1995;152:1387--90.
140. Torres A, Serra-Batlles J, Ros E, et al. Pulmonary aspiration of gastric contents in patients receiving mechanical ventilation: the effect of body position. *Ann Intern Med* 1992;116:540--3.
141. Gharpure V, Meert KL, Sarnaik AP, Metheny NA. Indicators of postpyloric feeding tube placement in children. *Crit Care Med* 2000;28:2962--6.
142. Hand RW, Kempster M, Levy JH, Rogol PR, Spirn P. Inadvertent transbronchial insertion of narrow-bore feeding tubes into the pleural space. *JAMA* 1984;251:2396--7.
143. McClave SA, DeMeo MT, DeLegge MH, et al. North American summit on aspiration in the critically ill patient: consensus statement. *J Parenter Enter Nutr* 2002;26:80--5.
144. Ferrer M, Bauer TT, Torres A, Hernandez C, Piera C. Effect of nasogastric tube size on gastroesophageal reflux and microaspiration in intubated patients. *Ann Intern Med* 1999;130:991--4.
145. Bonten MJM, Gaillard CA, van der Hulst R, et al. Intermittent enteral feeding: the influence on respiratory and digestive tract colonization in mechanically ventilated intensive-care-unit patients. *Am J Respir Crit Care Med* 1996;154:394--9.
146. Jacobs S, Chang RW, Lee B, Bartlett FW. Continuous enteral feeding: a major cause of pneumonia among ventilated intensive care unit patients. *J Parenter Enter Nutr* 1990;14:353--6.
147. Lee B, Chang RWS, Jacobs S. Intermittent nasogastric feeding: a simple and effective method to reduce pneumonia among ventilated ICU patients. *Clin Intensive Care* 1990;1:100--2.
148. Skiest DJ, Khan N, Feld R, Metersky ML. The role of enteral feeding in gastric colonisation: a randomised controlled trial comparing continuous to intermittent enteral feeding in mechanically ventilated patients. *Clin Intensive Care* 1996;7:138--43.
149. Heyland DK, Drover JW, MacDonald S, Novak F, Lam M. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration. *Crit Care Med* 2001;29:1495--500.
150. Heyland DK, Drover JW, Dhaliwal R, Greenwood J. Optimizing the benefits and minimizing the risks of enteral nutrition in the critically ill: role of small bowel feeding. *J Parenter Enter Nutr* 2002;26:S51--7.
151. Kearns PJ, Chin D, Mueller L, Wallace K, Jensen WA, Kirsch CM. The incidence of ventilator-associated pneumonia and success in nutrient delivery with gastric versus small intestinal feeding: a randomized clinical trial. *Crit Care Med* 2000;28:1742--6.
152. Montecalvo M, Steger KA, Farber HW, et al. Nutritional outcome and pneumonia in critical care patients randomized to gastric versus jejunal tube feedings. *Crit Care*

153. Montejo JC, Grau T, Acosta J, et al. Multicenter, prospective, randomized, single-blind study comparing the efficacy and gastrointestinal complications of early jejunal feeding with early gastric feeding in critically ill patients. *Crit Care Med* 2002;30:796--800.
154. Spain DA, DeWeese RC, Reynolds MA, Richardson JD. Transpyloric passage of feeding tubes in patients with head injuries does not decrease complications. *J Trauma* 1995;39:1000--2.
155. Strong RM, Condon SC, Solinger MR, Namihias BN, Ito-Wong LA, Leuty JE. Equal aspiration rates from postpylorus and intragastric-placed small-bore nasogastric feeding tubes: a randomized, prospective study. *J Parent Enter Nutr* 1992;16:59--63.
156. Schleder B, Stott K, Lloyd RC. The effect of a comprehensive oral care protocol on patients at risk for ventilator-associated pneumonia. *J Advocate Health Care* 2002;4:27--30.
157. Yoneyama T, Yoshida M, Ohru T, et al. Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc* 2002;50:430--3.
158. DeRiso AJII, Ladowski JS, Dillon TA, Justice JW, Peterson AC. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infections and nonprophylactic antibiotic use in patients undergoing heart surgery. *Chest* 1996;109:1556--61.
159. Bergmans D, Bonten M, Gaillard C, et al. Prevention of ventilator-associated pneumonia by oral decontamination: a prospective, randomised, double-blind, placebo-controlled study. *Am J Respir Crit Care Med* 2001;164:382--8.
160. Bonten MJM, Gaillard CA, van der Geest S, et al. The role of intragastric acidity and stress ulcer prophylaxis on colonization and infection in mechanically ventilated patients: a stratified, randomized, double-blind study of sucralfate versus antacids. *Am J Respir Crit Care Med* 1995;152:1825--34.
161. Cook D, Guyatt G, Marshall J, et al. A comparison of sucralfate and ranitidine for the prevention of upper gastrointestinal bleeding in patients requiring mechanical ventilation. *N Engl J Med* 1998;338: 791--7.
162. Cook DJ, Reeve BK, Guyatt GH, et al. Stress ulcer prophylaxis in critically ill patients: resolving discordant meta-analyses. *JAMA* 1996;275:308--14.
163. Messori A, Trippoli SI, Vaiani M, Gorini M, Corrado A. Bleeding and pneumonia in intensive care patients given ranitidine and sucralfate for prevention of stress ulcer: meta-analysis of randomised controlled trials. *Brit Med J* 2000;321:1103--6.
164. Simms HH, DeMaria E, McDonald L, Peterson D, Robinson A, Burchard KW. Role of gastric colonization in the development of pneumonia in critically ill trauma patients: results of a prospective randomized trial. *J Trauma* 1991;31:531--6.
165. Thomason MH, Payseur ES, Hakenewerth AM, et al. Nosocomial pneumonia in ventilated trauma patients during stress ulcer prophylaxis with sucralfate, antacid, and ranitidine. *J Trauma-Injury Infect Crit Care* 1996; 41:503--8.
166. Tryba M. Risk of acute stress bleeding and nosocomial pneumonia in ventilated

intensive care unit patients: sucralfate versus antacids. *Am J Med* 1987;83:117--24.

167. Yildizdas D, Yapicioglu H, Yilmaz HL. Occurrence of ventilator-associated pneumonia in mechanically ventilated pediatric intensive care patients during stress ulcer prophylaxis with sucralfate, ranitidine, and omeprazole. *J Crit Care* 2002;17:240--5.
168. Abele-Horn M, Dauber A, Bauernfeind A, et al. Decrease in nosocomial pneumonia in ventilated patients by selective oropharyngeal decontamination: a prospective, blinded, randomized trial of the effect of a novel regimen. *Intensive Care Med* 1997;23:187--95.
169. D'Amico R, Pifferi S, Leonetti C, Torri V, Tinazzi A, Liberati A. Effectiveness of antibiotic prophylaxis in critically ill patients: systemic review of randomised controlled trials. *Brit Med J* 1998;316:1275--85.
170. Langlois-Karaga A, Bues-Charbit M, Davignon A, et al. Selective digestive decontamination in multiple trauma patients: cost and efficacy. *Pharmacy World and Science* 1995;17:12--6.
171. Nathens AB, Marshall JC. Selective decontamination of the digestive tract in surgical patients: a systematic review of the evidence. *Arch Surg* 1999;134:170--6.
172. Quinio B, Albanese J, Bues-Charbit M, Viviand X, Martin C. Selective decontamination of the digestive tract in multiple trauma patients: a prospective double-blind, randomized, placebo-controlled study. *Chest* 1996;109:765--72.
173. Stoutenbeek CP, Van Saene HKF, Miranda DR, Zandstra DF. The effect of selective decontamination of the digestive tract on colonisation and infection rate in multiple trauma patients. *Intensive Care Med* 1984;10:185--92.
174. Unertl K, Ruckdeschel G, Selbmann HK, et al. Prevention of colonization and respiratory infections in long-term ventilated patients by local antimicrobial prophylaxis. *Intensive Care Med* 1987;13:106--13.
175. Kerver JH, Rommes JH, Mevissen-Verhage EAE, et al. Prevention of colonization and infection in critically ill patients: a prospective randomized study. *Crit Care Med* 1988;16:1087--93.
176. Ledingham IM, Alcock SR, Eastaway AT, McDonald JC, McKay IC, Ramsay G. Triple regimen of selective decontamination of the digestive tract, systemic cefotaxime, and microbiological surveillance for prevention of acquired infection in intensive care. *Lancet* 1988;1:785--90.
177. Brun-Buisson C, Legrand P, Rauss A, et al. Intestinal decontamination for control of nosocomial multiresistant gram-negative bacilli: study of an outbreak in an intensive care unit. *Ann Intern Med* 1989;110:873--81.
178. Ulrich C, Harinck-de Weerd JE, Bakker NC, Jacz K, Doornbos L, de Ridder VA. Selective decontamination of the digestive tract with norfloxacin in the prevention of ICU-acquired infections: a prospective randomized study. *Intensive Care Med* 1989;15:424--31.
179. Flaherty J, Nathan C, Kabins SA, Weinstein RA. Pilot trial of selective decontamination for prevention of bacterial infection in an intensive care unit. *J Infect Dis* 1990;162:1393--7.

180. Godard J, Guillaume C, Reverdy ME, et al. Intestinal decontamination in a polyvalent ICU: a double-blind study. *Intensive Care Med* 1990;16:307--11.
181. McClelland P, Murray AE, Williams PS, et al. Reducing sepsis in severe combined acute renal and respiratory failure by selective decontamination of the digestive tract. *Crit Care Med* 1990;18:935--9.
182. Rodriguez-Roldan JM, Altuna-Cuesta A, Lopez A, et al. Prevention of nosocomial lung infection in ventilated patients: use of an antimicrobial pharyngeal non-absorbable paste. *Crit Care Med* 1990;18: 1239--42.
183. Tetteroo GWM, Wagenvoort JHT, Castelein A, Tilanus HW, Ince C, Bruining HA. Selective decontamination to reduce gram-negative colonisation and infections after oesophageal resection. *Lancet* 1990;335:704--7.
184. Aerdt SJA, van Daelen R, Clasener HAL, Festen J, Van Lier HJJ, Vollaard EJ. Antibiotic prophylaxis of respiratory tract infection in mechanically ventilated patients: a prospective, blinded, randomized trial of the effect of a novel regimen. *Chest* 1991;100:783--91.
185. Blair P, Rowlands BJ, Lowry K, Webb H, Armstrong P, Smilie J. Selective decontamination of the digestive tract: a stratified, randomized, prospective study in a mixed intensive care unit. *Surgery* 1991; 110:303--10.
186. Fox MA, Peterson S, Fabri BM, Van Saene HKF, Williets T. Selective decontamination of the digestive tract in cardiac surgical patients. *Crit Care Med* 1991;19:1486--90.
187. Hartenauer U, Thulig B, Diemer W, et al. Effect of selective flora suppression on colonization, infection and mortality in critically ill patients: a one-year, prospective, consecutive study. *Crit Care Med* 1991;19:463--73.
188. Pugin J, Auckenthaler R, Lew DP, Suter PM. Oropharyngeal decontamination decreases incidence of ventilator-associated pneumonia: a randomized, placebo-controlled, double-blind clinical trial. *JAMA* 1991;265:2704--10.
189. Vandenbroucke-Grauls CMJE, Vandenbroucke JP. Effect of selective decontamination of the digestive tract on respiratory tract infections and mortality in the intensive care unit. *Lancet* 1991;338:859--62.
190. Cockerill FR, Muller SM, Anhalt JP, et al. Prevention of infection on critically ill patients by selective decontamination of the digestive tract. *Ann Intern Med* 1992;117:545--53.
191. Gastinne H, Wolff M, Delatour F, Faurisson F, Chevret S. A controlled trial in intensive care units of selective decontamination of the digestive tract with nonabsorbable antibiotics. *N Engl J Med* 1992;326:594--9.
192. Hammond MJM, Potgieter PD, Saunders GL, Forder AA. Double-blind study of selective decontamination of the digestive tract in intensive care. *Lancet* 1992;340:5--9.
193. Rocha LA, Martin MJ, Pita S, et al. Prevention of nosocomial infection in critically ill patients by selective decontamination of the digestive tract. A randomized, double-blind, placebo-controlled study. *Intensive Care Med* 1992;18:398--404.

194. Winter R, Humphreys H, Pick A, MacGowan P, Willatts SM, Speller DCE. A controlled trial of selective decontamination of the digestive tract in intensive care and its effect on nosocomial infection. *J Antimicrob Chemother* 1992;30:73--87.
195. Korinek AM, Laisne MJ, Nicolas MH, Raskine L, Deroin V, Sanson-Lepors MJ. Selective decontamination of the digestive tract in neurosurgical intensive care unit patients: a double-blind, randomized, placebo-controlled study. *Crit Care Med* 1993;21:1466--73.
196. Selective Decontamination of the Digestive Tract Trialists' Collaborative Group. Meta-analysis of randomised controlled trials of selective decontamination of the digestive tract. *Brit Med J* 1993;307: 525--32.
197. Ferrer M, Torres A, Gonzalez J, et al. Utility of selective digestive decontamination in mechanically ventilated patients. *Ann Intern Med* 1994;120:389--95.
198. Nau R, Ruchel R, Mergerian H, Wegener U, Winkelmann T, Prange HW. Emergence of antibiotic-resistant bacteria during selective decontamination of the digestive tract. *J Antimicrob Chemother* 1990;25:881--3.
199. Sanchez Garcia M, Cambronero Galache JA, Lopez Diaz J, et al. Effectiveness and cost of selective decontamination of the digestive tract in critically ill intubated patients. A randomized, double-blind, placebo-controlled, multicenter trial. *Am J Respir Crit Care Med* 1998;158:908--16.
200. Krueger WA, Lenhart FP, Neeser G, Ruckdeschel G, Schreckhase H, Eissner HJ et al. Influence of combined intravenous and topical antibiotic prophylaxis on the incidences of infections, organ dysfunction, and mortality in critically ill surgical patients: a prospective, stratified, randomized, double-blind, placebo-controlled clinical trial. *Am J Respir Crit Care Med* 2002; 166:1029--37.
201. Heyland DK, Bradley C, Mandell LA. Effect of acidified enteral feedings on gastric colonization in the critically ill patient. *Crit Care Med* 1992;20:1388--94.
202. Heyland DK, Cook DJ, Schoenfeld PS, Frietag A, Varon J, Wood G. The effect of acidified enteral feeds on gastric colonization in critically ill patients: results of a multicenter randomized trial. *Crit Care Med* 1999;27:2399--406.
203. Arozullah AM, Khuri SF, Henderson WG, Daley J, Participants in the National Veterans Affairs Surgical Quality Improvement Program: development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. *Ann Intern Med* 2001;135:847--57.
204. Brooks-Brunn JA. Predictors of postoperative pulmonary complications following abdominal surgery. *Chest* 1997;111:564--71.
205. Chumillas S, Ponce JL, Delgado F, Viciano V, Mateu M. Prevention of postoperative pulmonary complications through respiratory rehabilitation: a controlled clinical study. *Arch Phys Med Rehab* 1998;79:5--9.
206. Thomas JA, McIntosh JM. Are incentive spirometry, intermittent positive pressure breathing, and deep breathing exercises effective in the prevention of postoperative pulmonary complications after upper abdominal surgery? A systematic overview and meta-analysis. *Physical Therapy* 1994;74:3--10.
207. Hall JC, Tarala RA, Tapper J, Hall JL. Prevention of respiratory complications

after abdominal surgery: a randomised clinical trial. *Br Med J* 1996;312:148--52.

208. Sirvent JM, Torres A, El-ebiary M, Castro P, de Batlle J, Bonet A. Protective effect of intravenously administered cefuroxime against nosocomial pneumonia in patients with structural coma. *Am J Respir Crit Care Med* 1997;155:1729--34.

209. Gruson D, Hilbert G, Vargas F, et al. Rotation and restricted use of antibiotics in a medical intensive care unit: impact on the incidence of ventilator-associated pneumonia caused by antibiotic-resistant gram-negative bacteria. *Am J Respir Crit Care Med* 2000;162:837--43.

210. Kollef MH, Vlasnik J, Sharpless L, Pasque C, Murphy D, Fraser V. Scheduled change of antibiotic classes: a strategy to decrease the incidence of ventilator-associated pneumonia. *Am J Respir Crit Care Med* 1997;156:1040--8.

211. deBoisblanc BP, Castro M, Everret B, Grender J, Walker CD, Summer WR. Effect of air-supported, continuous, postural oscillation on the risk of early ICU pneumonia in nontraumatic critical illness. *Chest* 1993;103:1543--7.

212. Fink MP, Helmsmoortel CM, Stein KL, Lee PC, Cohn SM. The efficacy of an oscillating bed in the prevention of lower respiratory tract infection in critically ill victims of blunt trauma: a prospective study. *Chest* 1990;97:132--7.

213. Gentilello L, Thompson DA, Tonnesen AS, et al. Effect of a rotating bed on the incidence of pulmonary complications in critically ill patients. *Crit Care Med* 1988;16:783--6.

214. Kirschenbaum L, Azzi E, Sfeir T, Tietjen P, Astiz M. Effect of continuous lateral rotational therapy on the prevalence of ventilator-associated pneumonia in patients requiring long term ventilatory care. *Crit Care Med* 2002;30:1983--6.

215. Summer WR, Curry P, Haponik EF, Nelson S, Elston R. Continuous mechanical turning of intensive care unit patients shortens length of stay in some diagnostic-related groups. *J Crit Care* 1989;4:45--53.

216. Whiteman K, Nachtmann L, Kramer D, Sereika S, Bierman M. Effects of continuous lateral rotation therapy on pulmonary complications in liver transplant patients. *Am J Crit Care* 1995;4:133--9.

217. Le Saux NM, Sekla L, McLeod J, et al. Epidemic of nosocomial Legionnaires' disease in renal transplant recipients: a case-control and environmental study. *Can Med Assoc J* 1989;140:1047--53.

218. Marston BJ, Lipman HB, Breiman RF. Surveillance for Legionnaires' disease: risk factors for morbidity and mortality. *Arch Intern Med* 1994;154:2417--22.

219. Kirby BD, Snyder KM, Meyer RD, Finegold SM. Legionnaires' disease: report of sixty-five nosocomially acquired cases and review of the literature. *Medicine* 1980;59:188--205.

220. Haley CE, Cohen ML, Halter J, Meyer RD. Nosocomial Legionnaires' disease: a continuing common-source epidemic at Wadsworth Medical Center. *Ann Int Med* 1979;90:583--6.

221. Bock BV, Kirby BD, Edelstein PH, et al. Legionnaires' disease in renal transplant recipients. *Lancet* 1978;1:410--3.

222. Brady MT. Nosocomial Legionnaires' disease in a children's hospital. *J Pediatr* 1989;115:46--50.
223. Jimenez ML, Aspa J, Padilla B, et al. Fiberoptic bronchoscopic diagnosis of pulmonary disease in 151 HIV-infected patients with pneumonitis. *Eur J Clin Microbiol Infect Dis* 1991;10:491--7.
224. Chow JW, Yu VL. Legionella: a major opportunistic pathogen in transplant recipients. *Seminars Respir Infect* 1998;13:132--9.
225. Brennen C, Vickers RM, Yu VL, Puntereri A, Yee YC. Discovery of occult legionella pneumonia in a long-stay hospital: results of prospective serologic survey. *Br Med J* 1987;295:306--7.
226. Lepine LA, Jernigan DB, Butler JC, et al. A recurrent outbreak of nosocomial Legionnaires' disease detected by urinary antigen testing: evidence for long-term colonization of a hospital plumbing system. *Infect Control Hosp Epidemiol* 1998;19:905--10.
227. Fiore AE, Butler JC, Emori TG, Gaynes RP. A survey of methods used to detect nosocomial legionellosis among participants in the National Nosocomial Infections Surveillance System. *Infect Control Hosp Epidemiol* 1999;20:412--6.
228. Kool JL, Fiore AE, Kioski CM, et al. More than 10 years of unrecognized nosocomial transmission of Legionnaires' disease among transplant patients. *Infect Control Hosp Epidemiol* 1998;19:898--904.
229. Alary MA, Joly JR. Factors contributing to the contamination of hospital water distribution systems by *Legionellae*. *J Infect Dis* 1992;165:565--9.
230. Best MG, Yu VL, Stout J, Goetz A, Muder RR, Taylor F. *Legionellaceae* in the hospital water supply: epidemiologic link with disease and evaluation of a method for control of nosocomial Legionnaires' disease and Pittsburgh pneumonia. *Lancet* 1983;2:307--10.
231. Goetz AM, Yu VL. Screening for nosocomial legionellosis by culture of the water supply and targeting of high risk patients for specialized laboratory testing. *Am J Infect Control* 1991;19:63--6.
232. Johnson JT, Yu VL, Best MG, et al. Nosocomial legionellosis in surgical patients with head and neck cancer: implications for epidemiological reservoir and mode of transmission. *Lancet* 1985;2:298--300.
233. Marrie TJ, Haldane D, Bezanson G, Peppard R. Each water outlet is a unique ecologic niche for *Legionella pneumophila*. *Epidemiol Infect* 1992;108:261--70.
234. Marrie TJ, MacDonald S, Clarke K, Haldane D. Nosocomial Legionnaires' disease: lessons from a four year prospective study. *Am J Infect Control* 1991;19:79--85.
235. Redd SC, Cohen ML. Legionella in water: what should be done? *JAMA* 1987;257:1221--2.
236. Tobin JO, Swann RA, Bartlett CLR. Isolation of *Legionella pneumophila* from water systems: methods and preliminary results. *Br Med J* 1981;282:515--7.
237. Yu VL. Nosocomial legionellosis: current epidemiologic issues. In: Remington JS, Swartz MN, eds. *Current Clinical Topics in Infectious Diseases*. New York, New York:

McGraw-Hill, 1986.

238. Yu VL, Beam TR, Jr., Lumish RM, et al. Routine culturing for *Legionella* in the hospital environment may be a good idea: a three-hospital prospective study. *Am J Med Sci* 1987;294:97--9.

239. [CDC. Guidelines for the prevention of opportunistic infections \(OIs\) in hematopoietic stem cell transplant \(HSCT\) recipients. MMWR 2000;49:\(No. RR-10\).](#)

240. Pannuti CS. Hospital environment for high-risk patients. In: Wenzel RP, ed. *Prevention of Nosocomial Infections*. Baltimore, Maryland: Williams & Wilkins, 1997.

241. Patterson WJ, Hay J, Seal DV, McLuckie JC. Colonization of transplant unit water supplies with *Legionella* and protozoa: precautions required to reduce the risk of legionellosis. *J Hosp Infect* 1997;37:7--17.

242. Woo AH, Yu VL, Goetz A. Potential in-hospital modes of transmission of *Legionella pneumophila*. Demonstration experiments for dissemination by showers, humidifiers, and rinsing of ventilation bag apparatus. *Am J Med* 1986;80:567--73.

243. Zuravleff JJ, Yu VL, Shonnard JW, Rihs JD, Best M. *Legionella pneumophila* contamination of a hospital humidifier: demonstration of aerosol transmission and subsequent subclinical infection in exposed guinea pigs. *Am Rev Respir Dis* 1983;128:657--61.

244. American Society for Heating, Refrigerating, and Air-Conditioning Engineers. ASHRAE Guideline 12-2000: minimizing the risk of legionellosis associated with building water systems. Atlanta, GA: ASHRAE, Inc, 2000.

245. Department of Health and Social Security and the Welsh Office. *The control of Legionellae in health care premises: a code of practice*. Her Majesty's Stationery Office. London, HMSO, 1991.

246. Ezzeddine H, Van Ossel C, Delmee M, Wauters G. *Legionella spp.* in a hospital hot water system: effect of control measures. *J Hosp Infect* 1989;13:121--31.

247. Mandel AS, Sprauer MA, Sniadack DH, Ostroff SM. State regulation of hospital water temperature. *Infect Control Hosp Epidemiol* 1993;14:642--5.

248. Snyder MB, Siwicki M, Wireman J, et al. Reduction of *Legionella pneumophila* through heat flushing followed by continuous supplemental chlorination of hospital hot water. *J Infect Dis* 1990;162:127--32.

249. Health and Safety Commission. *Legionnaires' disease: the control of Legionella bacteria in water systems. Approved code of practice and guidance*. 3rd ed. United Kingdom: HSA Books, 2000.

250. Biurrun A, Caballero M, Pelaz C, Leon E, Gago A. Treatment of a *Legionella pneumophila*-colonized water distribution system using copper-silver ionization and continuous chlorination. *Infect Control Hosp Epidemiol* 1999;20:426--8.

251. Domingue EL, Tyndall RL, Mayberry WR, Pancorbo OC. Effects of three oxidizing biocides of *Legionella pneumophila* serogroup 1. *Appl Environ Microbiol* 1988;54:741--7.

252. Edelstein PH, Whittaker RE, Kreiling RL, Howell CL. Efficacy of ozone in eradication of *Legionella pneumophila* from hospital plumbing fixtures. *Appl Environ*

Microbiol 1982;44:1330--3.

253. Goetz AM, Yu VL. Copper-silver ionization: cautious optimism for *Legionella* disinfection and implications for environmental culturing. *Am J Infect Control* 1997;25:449--51.
254. Hall KK, Giannetta ET, Getchell-White SI, Durbin LJ, Farr BM. Ultraviolet light disinfection of hospital water for preventing nosocomial *Legionella* infection: a 13-year follow-up. *Infect Control Hosp Epidemiol* 2003;24:580--3.
255. Landeen LK, Yahya MT, Gerba CP. Efficacy of copper and silver ions and reduced levels of free chlorine in inactivation of *Legionella pneumophila*. *Appl Environ Microbiol* 1989; 55(12):3045--50.
256. Lin YS, Stout JE, Yu VL, Vidic RD. Disinfection of water distribution systems for *Legionella*. *Seminars Respir Infect* 1998;13:147--59.
257. Liu Z, Stout JE, Tedesco L, et al. Controlled evaluation of copper-silver ionization in eradicating *Legionella pneumophila* from a hospital water distribution system. *J Infect Dis* 1994;169:919--22.
258. Matulonis U, Rosenfield CS, Shaddock RK. Prevention of *Legionella* infections in a bone marrow transplant unit: multifaceted approach to decontamination of a water system. *Infect Control Hosp Epidemiol* 1993;14:571--5.
259. Mietzner S, Schwille RC, Farley A, et al. Efficacy of thermal treatment and copper-silver ionization for controlling *Legionella pneumophila* in high-volume hot water plumbing systems in hospitals. *Am J Infect Control* 1997;25:452--7.
260. Muraca P, Stout JE, Yu VL. Comparative assessment of chlorine, heat, ozone, and UV light for killing *Legionella pneumophila* within a model plumbing system. *Appl Environ Microbiol* 1987;53:447--53.
261. Muraca PW, Yu VL, Goetz A. Disinfection of water distribution systems for *Legionella*: a review of application procedures and methodologies. *Infect Control Hosp Epidemiol* 1990;11:79--88.
262. Rohr U, Senger M, Selenka F, Turley R, Wilhelm M. Four years of experience with silver-copper ionization for control of *Legionella* in a German university hospital hot water plumbing system. *Clin Infect Dis* 1999;29:1507--11.
263. Srinivasan A, Bova G, Ross T, et al. A 17-month evaluation of a chlorine dioxide water treatment system to control *Legionella* species in a hospital water supply. *Infect Control Hosp Epidemiol* 2003;24:575--9.
264. Stout JE, Lin YS, Goetz AM, Muder RR. Controlling *Legionella* in hospital water systems: experience with the superheat-and-flush method and copper-silver ionization. *Infect Control Hosp Epidemiol* 1998;19:911--4.
265. Stout J, Yu VL. Experiences of the first 16 hospitals using copper-silver ionization for *Legionella* control: implications for the evaluation of other disinfection modalities. *Infect Control Hosp Epidemiol* 2003;24:563--8.
266. Heffelfinger JD, Kool JL, Fridkin S, et al. Risk of hospital-acquired Legionnaires' disease in cities using monochloramine versus other water disinfectants. *Infect Control Hosp Epidemiol* 2003;24:569--74.

267. Walker JT, Mackerness C.W., Mallon D, Makin T, Williets T, Keevil CW. Control of *Legionella pneumophila* in a hospital water system by chlorine dioxide. J Indust Microbiol 1995;15:384--90.
268. Kool JL, Carpenter JC, Fields BS. Effect of monochloramine disinfection of municipal drinking water on risk of nosocomial Legionnaires' disease. Lancet 1999; 353(9149):272--7.
269. Bollin GE, Plouffe JF, Para MF, Hackman B. Aerosols containing *Legionella pneumophila* generated by shower heads and hot-water faucets. Appl Environ Microbiol 1985;50:1128--31.
270. Breiman RF, VanLoock FL, Sion JP, et al. Association of "sink bathing" and Legionnaires' disease. Abstracts of the 91st Meeting of the American Society for Microbiology 1991.
271. Marrie TJ, Haldane D, MacDonald S, et al. Control of endemic nosocomial Legionnaires' disease by using sterile potable water for high risk patients. Epidemiol Infect 1991;107:591--605.
272. Fiore AE, Nuorti JP, Levine OS, et al. Epidemic Legionnaires' disease two decades later: old sources, new diagnostic methods. Clin Infect Dis 1998;26:426--33.
273. Breiman RF, Fields BS, Sanden GN, Volmer L, Meier A, Spika JS. Association of shower use with Legionnaires' disease: possible role of amoebae. JAMA 1990;263:2924--6.
274. Dondero TJ, Rendtorff RC, Mallison GF, et al. An outbreak of Legionnaires' disease associated with a contaminated air-conditioning cooling tower. N Engl J Med 1980;302:365--70.
275. Garbe PL, Davis BJ, Weisfeld JS, et al. Nosocomial Legionnaires' disease: epidemiologic demonstration of cooling towers as a source. JAMA 1985;254:521--4.
276. Hanrahan JP, Morse DL, Scharf VB, et al. A community hospital outbreak of legionellosis: transmission by potable hot water. Am J Epidemiol 1987; 125:639--49.
277. Johnston JM, Latham RH, Meier FA, et al. Nosocomial outbreak of Legionnaires' disease: molecular epidemiology and disease control measures. Infect Control 1987;8:53--8.
278. O'Mahony MC, Stanwell-Smith RE, Tillett HE, et al. The Stafford outbreak of Legionnaires' disease. Epidemiol Infect 1990;104:361--80.
279. Pruckler JM, Mermel LA, Benson RF, et al. Comparison of *Legionella pneumophila* isolates by arbitrarily primed PCR and pulsed-field electrophoresis: analysis from seven epidemic investigations. J Clin Microbiol 1995;33:2872--5.
280. Schoonmaker D, Heimberger T, Birkhead G. Comparison of ribotyping and restriction enzyme analysis using pulsed-field gel electrophoresis for distinguishing *Legionella pneumophila* isolates obtained during a nosocomial outbreak. J Clin Microbiol 1992;30:1491--8.
281. Struelens MJ, Maes N, Rost F, et al. Genotypic and phenotypic methods for the investigation of a nosocomial *Legionella pneumophila* outbreak and efficacy of control measures. J Infect Dis 1992;166:22--30.

282. Whitney CG, Hofmann J, Pruckler JM, et al. The role of arbitrarily primed PCR in identifying the source of an outbreak of Legionnaires' disease. *J Clin Microbiol* 1997;35:1800--4.
283. Best MG, Goetz A, Yu VL. Heat eradication measures for control of nosocomial Legionnaires' disease. Implementation, education and cost analysis. *Infect Control* 1984;12:26--30.
284. [CDC. Sustained transmission of nosocomial Legionnaires' disease---Arizona and Ohio. MMWR 1997;46:416--21.](#)
285. Helms CM, Massanari RM, Wenzel RP, Pfaller MA, Moyer NP, Hall N. Legionnaires' disease associated with a hospital water system: a five-year progress report on continuous hyperchlorination. *JAMA* 1988;259:2423--7.
286. 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.
287. Haiduven DJ, Hench CP, Simpkins SM, Stevens DA. Standardized management of patients and employees exposed to pertussis. *Infect Control Hosp Epidemiol* 1998;19:861--4.
288. CDC. Guidelines for the control of pertussis outbreaks. 2002. Atlanta, GA: US DHHS, CDC, 2002. Available at <http://www.cdc.gov/mip/publications/pertussis/guide.htm>.
289. Gardner P. Indications for acellular pertussis vaccines in adults: the case for selective, rather than universal, recommendations. *Clin Infect Dis* 1999;28:S131--5.
290. Linnemann CC, Jr., Ramundo N, Perlstein PH, Minton SD, Englender GS. Use of pertussis vaccine in an epidemic involving hospital staff. *Lancet* 1975;2:540--3.
291. Orenstein WA. Pertussis in adults: epidemiology, signs, symptoms, and implications for vaccination. *Clin Infect Dis* 1999;28:S147--50.
292. Wright SW, Decker MD, Edwards KM. Incidence of pertussis infection in healthcare workers. *Infect Control Hosp Epidemiol* 1999;20:120--3.
293. [CDC. Pertussis vaccination: use of acellular pertussis vaccines among infants and young children: recommendations of the Advisory Committee on Immunization Practices \(ACIP\). MMWR 1997;46\(No. RR-7\).](#)
294. Shefer A, Dales L, Nelson M, Werner B, Baron R, Jackson R. Use and safety of acellular Pertussis vaccine among adult hospital staff during an outbreak of pertussis. *J Infect Dis* 1995;171:1053--6.
295. [CDC. Recommended childhood immunization schedule---United States, 2002. MMWR 2002;51:574.](#)
296. Halsey N, Galazka A. The efficacy of DPT and oral poliomyelitis immunization schedules initiated from birth to 12 weeks of age. *Bull WHO* 1985;63:1151--69.
297. Grimprel E, Begue P, Anjak I, Betsou F, Guiso N. Comparison of polymerase chain reaction, culture, and western immunoblot serology for diagnosis of *Bordetella pertussis* infection. *J Clin Microbiol* 1993;31:2745--50.

298. Mastrantonio P, Stefanelli P, Giuliano M. Polymerase chain reaction for the detection of *Bordetella pertussis* in clinical nasopharyngeal aspirates. *J Med Microbiol* 1996;44:261--6.
299. Matlow AG, Nelson S, Wray R, Cox P. Nosocomial acquisition of pertussis diagnosed by polymerase chain reaction. *Infect Control Hosp Epidemiol* 1997;18:715--6.
300. van der Zee A, Agterberg C, Peeters M, Mooi F, Schellekens J. A clinical validation of *Bordetella pertussis* and *Bordetella parapertussis* polymerase chain reaction: comparison with culture and serology using samples from patients with suspected whooping cough from a highly immunized population. *J Infect Dis* 1996;174:89--96.
301. 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.
302. Halperin SA, Bortolussi R, Langley JM, Eastwood BJ, De Serres G. A randomized, placebo-controlled trial of erythromycin estolate chemoprophylaxis for household contacts of children with culture-positive *Bordetella pertussis* infection. [Abstract] *Pediatrics* 1999;104:953.
303. [CDC. Diphtheria, tetanus, and pertussis: recommendations for vaccine and other preventive measures: recommendations of the Advisory Committee on Immunization Practices. MMWR 1991;40\(No. RR-10\).](#)
304. Cooper WO, Griffin MR, Arbogast P, Hickson GB, Gautam S, Ray WA. Very early exposures to erythromycin and infantile hypertrophic pyloric stenosis. *Arch Ped Adol Med* 2002;156:647--50.
305. Halperin SA, Bortolussi R, Langley JM, Miller B, Eastwood BJ. Seven days of erythromycin estolate is as effective as fourteen days for the treatment of *Bordetella pertussis* infection. *Pediatrics* 1997;100:65--71.
306. Honein MA, Paulozzi LJ, Himelright IM, et al. Infantile hypertrophic pyloric stenosis after pertussis prophylaxis with erythromycin: a case review and cohort study. *Lancet* 1999;354:2101--5.
307. Halperin SA. Pertussis control in Canada. *Canad Med Assoc J* 2003; 168:1389--90.
308. Aoyama T, Sumakawa K, Iwata S, Takeuchi Y, Fuji R. Efficacy of short-term treatment of pertussis with clarithromycin and azithromycin. *J Pediatr* 1996;129:761--4.
309. Hoppe JE, Bryskier A. In vitro susceptibilities of *Bordetella pertussis* and *Bordetella parapertussis* to two ketolides (HMR 3004 and HMR 3647), four macrolides (azithromycin, clarithromycin, erythromycin A, and roxithromycin), and two ansamycins (rifampin and rifapentine). *Antimicrob Agents Chemother* 1998;42:965--6.
310. Hoppe JE, Halm U, Hagedorn HJ, Kraminer-Hagedorn A. Comparison of erythromycin ethylsuccinate and co-trimoxazole for treatment of pertussis. *Infection* 1989;17:227--31.
311. Valenti WM, Pincus PH, Messner MK. Nosocomial pertussis: possible spread by a

hospital visitor. *Am J Dis Child* 1980;134:520--1.

312. Gerson SL, Talbot GH, Hurwitz S, Strom BL, Lusk EJ, Cassileth PA. Prolonged granulocytopenia: the major risk factor for invasive pulmonary aspergillosis in patients with acute leukemia. *Ann Intern Med* 1984;100:345--51.

313. Marr KA, Carter RA, Boeckh M, Martin P, Corey L. Invasive aspergillosis in allogeneic stem cell transplant recipients: changes in epidemiology and risk factors. *Blood* 2002;100:4358--66.

314. Pannuti CS, Gingrich R, Pfaller MA, Kao C, Wenzel RP. Nosocomial pneumonia in patients having bone marrow transplant: attributable mortality and risk factors. *Cancer* 1992;69:2653--62.

315. Paterson DL, Singh N. Invasive aspergillosis in transplant recipients. *Medicine* 1999;78:123--38.

316. Wald A, Leisenring W, van Burik JA, Bowden RA. Epidemiology of *Aspergillus* infections in a large cohort of patients undergoing bone marrow transplantation. *J Infect Dis* 1997;175:1459--66.

317. Wingard JR, Beals SU, Santos GW, Mertz WG, Saral R. *Aspergillus* infections in bone marrow transplant recipients. *Bone Marrow Transplant* 1987;2:175--81.

318. Kramer MR, Marshall SE, Starnes VA, Gamberg P, Amitai Z, Theodore J. Infectious complications in heart-lung transplantation: analysis of 200 episodes. *Arch Intern Med* 1993;153:2010--6.

319. Gustafson TL, Schaffner W, Lavelly GB, Stratton CW, Johnson HK, Hutcheson RH, Jr. Invasive aspergillosis in renal transplant recipients: correlation with corticosteroid therapy. *J Infect Dis* 1983;148: 230--8.

320. Riley DK, Pavia AT, Beatty PG, Denton D, Carroll KC. Surveillance cultures in bone marrow transplant recipients: worthwhile or wasteful? *Bone Marrow Transplant* 1995;15:469--73.

321. Walsh TJ. Role of surveillance cultures in prevention and treatment of fungal infections. *NCI Monogr* 1990;9:43--5.

322. Richardson MD, Rennie S, Marshall I, et al. Fungal surveillance of an open haematology ward. *J Hosp Infect* 2000;45:288--92.

323. Streifel AJ. Design and maintenance of hospital ventilation systems and the prevention of airborne nosocomial infections. In: Mayhall CG, ed. *Hospital epidemiology and infection control*. Philadelphia, PA: Lippincott Williams & Wilkins, 1999.

324. Oren I, Haddad N, Finkelstein R, Rowe JM. Invasive pulmonary aspergillosis in neutropenic patients during hospital construction: before and after chemoprophylaxis and institution of HEPA filters. *Am J Hematol* 2001; 66:257--62.

325. Rice N, Streifel A, Vesley D. An evaluation of hospital special-ventilation-room pressures. *Infect Control Hosp Epidemiol* 2001;22:19--23.

326. Sherertz RJ, Belani A, Kramer BS, et al. Impact of air filtration on nosocomial *Aspergillus* infections: unique risk of bone marrow transplant recipients. *Am J Med* 1987;83:709--18.

327. 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.
328. Buckner CD, Clift RA, Sanders JE, et al. Protective environment for marrow transplant recipients: a prospective study. *Ann Intern Med* 1978;89:893--901.
329. Loo VG, Bertrand C, Dixon C, et al. Control of construction-associated nosocomial aspergillosis in an antiquated hematology unit. *Infect Control Hosp Epidemiol* 1996;17:360--4.
330. Walter EA, Bowden RA. Infection in the bone marrow transplant recipient. *Infect Dis Clin N Am* 1995;9:823--47.
331. Walsh TR, Guttendorf J, Dummer S, et al. The value of protective isolation procedures in cardiac transplant recipients. *Ann Thorac Surg* 1989;47:539--44.
332. Vesley D, Streifel AJ. Environmental Services. In: Mayhall CG, ed. *Hospital epidemiology and infection control*. Philadelphia, PA: Lippincott Williams & Wilkins, 1999.
333. Anderson K, Morris G, Kennedy H, et al. Aspergillosis in immunocompromised paediatric patients: associations with building hygiene, design, and indoor air. *Thorax* 1996;51:256--61.
334. Rhame FS, Streifel A, Kersey JH, Jr., McGlave PB. Extrinsic risk factors for pneumonia in the patient at high risk of infection. *Am J Med* 1984;76:42--52.
335. Gerson SL, Parker P, Jacobs MR, Creger R, Lazarus HM. Aspergillosis due to carpet contamination. *Infect Control Hosp Epidemiol* 1994;15:221--3.
336. 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.
337. Walsh TJ, Dixon DM. Nosocomial aspergillosis: environmental microbiology, hospital epidemiology, diagnosis and treatment. *Eur J Epidemiol* 1989;5:131--42.
338. Weems JJ, Jr., Davis BJ, Tablan OC, Kaufman L, Martone WJ. Construction activity: an independent risk factor for invasive aspergillosis and zygomycosis in patients with hematologic malignancy. *Infect Control* 1987;8:71--5.
339. Arnow PM, Anderson RL, Mainous PD, Smith EJ. Pulmonary aspergillosis during hospital renovation. *Am Rev Respir Dis* 1978;118:49--53.
340. Krasinski K, Holzman RS, Hanna B, Greco MA, Graff M, Bhogal M. Nosocomial fungal infection during hospital renovation. *Infect Control* 1985;6:278--82.
341. 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.
342. Aisner J, Schimpff SC, Bennett JE, Young VM, Wiernik PH. *Aspergillus* infections in cancer patients. Association with fireproofing materials in a new hospital. *JAMA* 1976;235:411--2.
343. Opal SM, Asp AA, Cannady PB, Jr., Morse PL, Burton LJ, Hammer PG. Efficacy

of infection control measures during a nosocomial outbreak of disseminated aspergillosis associated with hospital construction. *J Infect Dis* 1986;153:634--7.

344. Streifel AJ, Vesley D, Rhame FS, Murray B. Control of airborne fungal spores in a university hospital. *Environment International* 1989;12:441--4.

345. Bow EJ, Laverdiere M, Lussier N, Rotstein C, Cheang MS, Ioannou S. Antifungal prophylaxis for severely neutropenic chemotherapy recipients: a meta analysis of randomized-controlled clinical trials. *Cancer* 2002;94:3230--46.

346. Conneally E, Cafferkey MT, Daly PA, Keane CT, McCann SR. Nebulized amphotericin B as prophylaxis against invasive aspergillosis in granulocytopenic patients. *Bone Marrow Transpl* 1990;5:403--6.

347. Gotzsche PC, Krogh Johansen H. Meta-analysis of prophylactic or empirical antifungal treatment versus placebo or no treatment in patients with cancer complicated by neutropenia. *Brit Med J* 1997;314:1238--44.

348. Gubbins PO, Bowman JL, Penzak SR. Antifungal prophylaxis to prevent invasive mycoses among bone marrow transplantation recipients. *Pharmacotherapy* 1998;18:549--64.

349. Harousseau JL, Dekker AW, Stamatoullas-Bastard A, et al. Itraconazole oral solution for primary prophylaxis of fungal infections in patients with hematological malignancy and profound neutropenia: a randomized, double-blind, double-placebo, multicenter trial comparing itraconazole and amphoteticin B. *Antimicrob Agents Chemother* 2000;44:1887--93.

350. Kelsey SM, Goldman JM, McCann S, et al. Liposomal amphotericin (AmBisome) in the prophylaxis of fungal infection in neutropenic patients: a randomised, double-blind, placebo-controlled study. *Bone Marrow Transplant* 1999;23:163--8.

351. Minari A, Husni R, Avery RK, et al. The incidence of invasive aspergillosis among solid organ transplant recipients and implications for prophylaxis in lung transplants. *Transplant Infect Dis* 2002;4:195--200.

352. Morgenstern GR, Prentice AG, Prentice HG, Ropner JE, Schey SA, Warnock DW. A randomized controlled trial of itraconazole versus fluconazole for the prevention of fungal infections in patients with haematological malignancies. *Br J Haematol* 1999;105:901--11.

353. Nucci M, Biasoli I, Akiti T, et al. A double-blind, randomized placebo-controlled trial of itraconazole capsules as antifungal prophylaxis for neutropenic patients. *Clin Infect Dis* 2000;30:300--5.

354. Rousey SR, Russler S, Gottlieb M, Ash RC. Low-dose amphotericin B prophylaxis against invasive *Aspergillus* infections in allogeneic marrow transplantation. *Am J Med* 1991;91:484--92.

355. Schwartz S, Behre G, Heinemann V, et al. Aerosolized amphotericin B inhalations as prophylaxis of invasive *Aspergillus* infections during prolonged neutropenia: results of a prospective randomized multicenter trial. *Blood* 1999;93:3654--61.

356. Tsourounis C, Guglielmo BJ. Aerosolized amphotericin B in prophylaxis of pulmonary aspergillosis. *Ann Pharmacother* 1996;30: 1175--6.

357. Karp JE, Burch PA, Merz WG. An approach to intensive antileukemia therapy in patients with previous invasive aspergillosis. *Am J Med* 1988;85:203--6.
358. Lupinetti FM, Behrendt DM, Giller RH, Trigg ME, de Alarcon P. Pulmonary resection for fungal infection in children undergoing bone marrow transplantation. *J Thoracic Cardiovasc Surg* 1992;104:684--7.
359. Martino R, Lopez R, Sureda A, Brunet S, Domingo-Albos A. Risk of reactivation of a recent invasive fungal infection in patients with hematological malignancies undergoing further intensive chemo-radiotherapy: a single-center experience and review of the literature. *Haematologica* 1997;82:297--304.
360. McWhinney PHM, Kibbler CC, Hamon MD, et al. Progress in the diagnosis and management of aspergillosis in bone marrow transplantations: 13 years' experience. *Clin Infect Dis* 1993;17:397--404.
361. Michailov G, Laporte JP, Lesage S, et al. Autologous bone-marrow transplantation is feasible in patients with prior history of invasive pulmonary aspergillosis. *Bone Marrow Transplant* 1996;17:569--72.
362. Offner F, Cordonnier C, Ljungman P, et al. Impact of previous aspergillosis on the outcome of bone marrow transplantation. *Clin Infect Dis* 1998; 26:1098--103.
363. Richard C, Romon I, Baro J, et al. Invasive pulmonary aspergillosis prior to BMT in acute leukemia patients does not predict a poor outcome. *Bone Marrow Transplant* 1993;12:237--41.
364. 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.
365. Beekmann SE, Engler HD, Collins AS, Canosa J, Henderson DK, Freifeld A. Rapid identification of respiratory viruses: impact on isolation practices and transmission among immunocompromised pediatric patients. *Infect Control Hosp Epidemiol* 1996;17:581--6.
366. Glezen WP, Greenberg SB, Atmar RL, Piedra PA, Couch RB. Impact of respiratory virus infections on persons with chronic underlying conditions. *JAMA* 2000;283:499--505.
367. Krasinski K, LaCouture R, Holzman RS, Waithe E, Bonk S, Hanna B. Screening for respiratory syncytial virus and assignment to a cohort at admission to reduce nosocomial transmission. *J Pediatr* 1990;116:894--8.
368. 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.
369. Hall CB, Geiman JM, Douglas RG, Jr., Meagher MP. Control of nosocomial respiratory syncytial viral infections. *Pediatrics* 1978; 62:728--32.
370. 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.
371. Hall CB, Douglas RG, Jr. Modes of transmission of respiratory syncytial virus. *J Pediatr* 1981;99:100--3.

372. Hall CB, Douglas RG, Jr., Geiman JM. Possible transmission by fomites of respiratory syncytial virus. *J Infect Dis* 1980;141:98--102.
373. Hall CB. The nosocomial spread of respiratory syncytial viral infections. *Ann Rev Med* 1983;34:311--9.
374. Korniewicz DM, Laughon BE, Cyr WH, Lytle CD, Larson E. Leakage of virus through used vinyl and latex examination gloves. *J Clin Microbiol* 1990;28:787--8.
375. Lowbury EJJ, Lilly HA, Bull JP. Disinfection of hands: removal of transient organisms. *Br Med J* 1964;2:230--3.
376. 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.
377. Snyderman DR, Greer C, Meissner HC, McIntosh K. Prevention of nosocomial transmission of respiratory syncytial virus in a newborn nursery. *Infect Control Hosp Epidemiol* 1988;9:105--8.
378. American Academy of Pediatrics. Respiratory syncytial virus. In: Pickering LK, editor. *The red book 2003 report of the Committee on Infectious Diseases*. Elk Grove, IL: American Academy of Pediatrics, 2003: 523--8.
379. Groothuis JR, Simoes EA, Levin MJ, et al. Prophylactic administration of RSVIG to high risk infants and young children. *N Engl J Med* 1993;329:1524--30.
380. Anonymous. Palivizumab, a humanized respiratory syncytial virus monoclonal antibody, reduces hospitalization from respiratory syncytial virus infection in high-risk infants. *Pediatrics* 1998;102:531--7.
381. Anonymous. Reduction of RSV hospitalization among premature infants and infants with bronchopulmonary dysplasia using respiratory syncytial virus immune globulin prophylaxis. *Pediatrics* 1997;99:93--9.
382. American Academy of Pediatrics Committee on Infectious Diseases. Prevention of respiratory syncytial virus infections: indications for the use of palivizumab and update on the use of RSV-IGIV. *Pediatrics* 1998;102:1211--6.
383. Clark SJ, Beresford MW, Subhedar NV, Shaw NJ. Respiratory syncytial virus infection in high-risk infants and the potential impact of prophylaxis in a United Kingdom cohort. *Arch Dis Child* 2000; 83:313--6.
384. Kamal-Bahl S, Doshi J, Campbell J. Economic analyses of respiratory syncytial virus immunoprophylaxis in high-risk infants: a systematic review. *Arch Pediatr Adolesc Med* 2002;156:1034--41.
385. Lofland JH, O'Connor JP, Chatterton ML, et al. Palivizumab for respiratory syncytial virus prophylaxis in high-risk infants: a cost-effectiveness analysis. *Clin Therapeutics* 2000;22:1357--69.
386. Robbins JM, Tilford JM, Jacobs RF, Wheeler JG, Gillaspay SR, Schutze GE. A number-needed-to-treat analysis of the use of respiratory syncytial virus immune globulin to prevent hospitalization. *Arch Pediatr Adolesc Med* 1998;152:358--66.
387. Kim CS, Kristopaitis RJ, Stone E, Pelter M, Sandhu M, Weingarten SR. Physician education and report cards: do they make the grade? Results from a randomized

controlled trial. *Am J Med* 1999;107:556--60.

388. Nichol KL. Preventing influenza: the physician's role. *Seminars Respir Infect* 1992;7:71--7.

389. Pachucki CT, Lentino JR, Jackson GG. Attitudes and behavior of health care personnel regarding the use and efficacy of influenza vaccine. *J Infect Dis* 1985;151:1170--1.

390. Weingarten S, Friedlander M, Rascon D, Ault M, Morgan M, Meyer RD. Influenza surveillance in an acute-care hospital. *Arch Intern Med* 1988;148:113--6.

391. Anonymous. Rapid diagnostic tests for influenza. *Medical Letter on Drugs & Therapeutics* 1999; 41:121--2.

392. Covalciuc KA, Webb KH, Carlson CA. Comparison of four clinical specimen types for detection of influenza A and B viruses by optical immunoassay (FLU OIA test) and cell culture methods. *J Clin Microbiol* 1999;37:3971--4.

393. Leonardi GP, Leib H, Birkhead GS, Smith C, Costello P, Conron W. Comparison of rapid detection methods for influenza A virus and their value in health-care management of institutionalized geriatric patients. *J Clin Microbiol* 1994; 32:70--4.

394. Noyola DE, Clark B, O'Donnell FT, Atmar RL, Greer J, Demmler G.J. Comparison of a new neuraminidase detection assay with an enzyme immunoassay, immunofluorescence, and culture for rapid detection of Influenza A and B viruses in nasal wash specimens. *J Clin Microbiol* 2000;38:1161--5.

395. [CDC. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices \(ACIP\). *MMWR* 2003;52\(No. RR-8\).](#)

396. Arden N, Patriarca PA, Kendal AP. Experiences in the use and efficacy of inactivated vaccines in nursing homes. In: Kendal AP, Patriarca PA, ed. *Options for the Control Of Influenza*. New York, New York: Alan Liss, 1985.

397. Fedson DS. Immunizations for health care workers and patients in hospitals. In: Wenzel RP, ed. *Prevention and control of nosocomial infection*. Baltimore, MD: Williams and Wilkins, 1987.

398. Fraund S, Wagner D, Pethig K, Drescher J, Girgsdies OE, Haverich A. Influenza vaccination in heart transplant recipients. *J Heart Lung Transplantation* 1999;18:220--5.

399. Gross PA, Hermogenes AW, Sacks HS, Lau J, Levandowski RA. The efficacy of influenza vaccine in elderly persons: a meta-analysis and review of the literature. *Ann Intern Med* 1995;123:518--27.

400. Neuzil KM, Reed GW, Mitchel EF, Simonsen L, Griffin MR. Impact of influenza on acute cardiopulmonary hospitalizations in pregnant women. *Am J Epidemiol* 1998;148:1094--1102.

401. Nichol KL, Baken L, Nelson A. Relation between influenza vaccination and outpatient visits, hospitalization, and mortality in elderly persons with chronic lung disease. *Ann Intern Med* 1999;130:397--403.

402. Ohmit SE, Arden NH, Monto AS. Effectiveness of inactivated influenza vaccine among nursing home residents during an influenza type A (H3N2) epidemic. *J Am*

Geriatr Soc 1999;47:165--71.

403. Tasker SA, Treanor JJ, Paxton WB, Wallace MR. Efficacy of influenza vaccination in HIV-infected persons: a randomized, double-blind, placebo-controlled trial. *Ann Intern Med* 1999;131:430--3.

404. McArthur MA, Simor AE, Campbell B, McGreer A. Influenza vaccination in long-term care facilities: structuring programs for success. *Infect Control Hosp Epidemiol* 1999;20:499--503.

405. Libow LS, Neufeld RR, Olson E, Breuer B, Starer P. Sequential outbreak of influenza A and B in a nursing home: efficacy of vaccine and amantadine. *J Am Geriatr Soc* 1996;44:1153--7.

406. 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 randomized controlled trial. *Lancet* 2000;355:93--7.

407. Nichol KL, Lind A, Margolis KL, et al. The effectiveness of vaccination against influenza in healthy, working adults. *N Engl J Med* 1995;333:889--93.

408. 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.

409. Saxen H, Virtanen M. Randomized placebo-controlled double blind study on the efficacy of influenza immunization on absenteeism of health care workers. *Pediatr Infect Dis J* 1999;18:779--83.

410. 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.

411. Bean B, Moore BM, Sterner B, Peterson LR, Gerding DN, Balfour HH, Jr. Survival of influenza viruses on environmental surfaces. *J Infect Dis* 1982;146:47--51.

412. Alford RH, Kasel JA, Gerone PJ, Knight V. Human influenza resulting from aerosol inhalation. *Proc Soc Exp Biol Med* 1966;122:800--4.

413. Blumenfeld HL, Kilbourne ED, Louria DB, et al. Studies on influenza in the pandemic of 1957--1958: an epidemiologic, clinical, and serologic investigation of an intra-hospital epidemic, with a note on vaccine efficacy. *J Clin Invest* 1959;38:199--212.

414. 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.

415. Berlinberg CD, Weingarten SR, Bolton LB, Waterman SH. Occupational exposure to influenza---introduction of an index case to a hospital. *Infect Control Hosp Epidemiol* 1989;10:70--3.

416. Valenti WM, Betts RF, Hall CB, Hruska JF, Douglas RG, Jr. Nosocomial viral infections: II: guidelines for prevention and control of respiratory viruses, herpesviruses and hepatitis viruses. *Infect Control* 1980;1:165--78.

417. Whimbey E, Elting LS, Couch RB, et al. Influenza A virus infections among hospitalized adult bone marrow transplant recipients. *Bone Marrow Transpl*

1994;13:437--40.

418. Dolin R, Reichman RC, Madore HP, Maynard R, Linton PN, Webber-Jones J. A controlled trial of amantadine and rimantadine prophylaxis of influenza A infection. *N Engl J Med* 1982;307:580--4.
419. Welliver R, Monto AS, Carewicz O, Oseltamivir Post Exposure Prophylaxis Investigator Group. Effectiveness of oseltamivir in preventing influenza in household contacts: a randomized controlled trial. *JAMA* 2001;285:748--54.
420. Hayden FG, Treanor JJ, Fritz RS, et al. Use of oral neuraminidase inhibitor oseltamivir in experimental human influenza: randomized controlled trials for prevention and treatment. *JAMA* 1999;282:1240--6.
421. The MIST (Management of influenza in the Southern Hemisphere Trialists) Study Group. Randomized trial of efficacy and safety of inhaled zanamivir in treatment of influenza A and B virus infections. *Lancet* 1998;352:1877--81.
422. Hayden FG, Atmar RL, Schilling M, et al. Use of the selective oral neuraminidase inhibitor oseltamivir to prevent influenza. *N Engl J Med* 1999;341:1336--43.
423. Lee C, Loeb M, Phillips A, et al. Zanamivir use during transmission of amantadine-resistant influenza A in a nursing home. *Infect Control Hosp Epidemiol* 2000;21:700--4.
424. Monto AS, Robinson DP, Herlocher ML, Hinson JM, Jr., Elliott MJ, Crisp A. Zanamivir in the prevention of influenza among healthy adults: a randomized controlled trial. *JAMA* 1999;282:31--5.
425. Schilling M, Povinelli L, Krause P, et al. Efficacy of zanamivir for chemoprophylaxis of nursing home influenza outbreaks. *Vaccine* 1998;16:1771--4.
426. Tominack RL, Hayden FG. Rimantadine hydrochloride and amantadine hydrochloride use in influenza A virus infections. *Infect Dis Clin N Am* 1987;1:459--78.
427. Askonas BA, McMichael AJ, Webster RG. The immune response to influenza viruses and the problem of protection against infection. In: Beare AS, ed. *Basic and applied influenza research*. Boca Raton, FL: CRC Press, 1982.
428. Hall CB, Dolin R, Gala CL, et al. Children with influenza A infection: treatment with rimantadine. *Pediatrics* 1987;80:275--82.
429. Hayden FG, Couch RB. Clinical and epidemiological importance of influenza A viruses resistant to amantadine and rimantadine. *Rev Med Virol* 1992;2:89--96.
430. Hayden FG, Sperber SJ, Belshe RB, Clover RD, Hay AJ, Pyke S. Recovery of drug-resistant influenza A virus during therapeutic use of rimantadine. *Antimicrob Agents Chemother* 1991;35:1741--7.
431. Mast EE, Harmon MW, Gravenstein S, et al. Emergence and possible transmission of amantadine-resistant viruses during nursing home outbreaks of influenza A(H3N2). *Am J Epidemiol* 1991;134: 988--97.
432. Monto AS, Arden NH. Implications of viral resistance to amantadine in control of influenza A. *Clin Infect Dis* 1992;15:362--7.
433. [CDC. Update: outbreak of severe acute respiratory syndrome---worldwide, 2003.](#)

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Box

BOX. Example of semicritical items* used on the respiratory tract

Anesthesia device or equipment including:

- face mask or tracheal tube
 - inspiratory and expiratory tubing
 - Y-piece
 - reservoir bag
 - humidifier
- Breathing circuits of mechanical ventilators
- Bronchoscopes and their accessories, except for biopsy forceps and specimen brush[†]
- Endotracheal and endobronchial tubes
- Laryngoscope blades
- Mouthpieces and tubing of pulmonary-function testing equipment
- Nebulizers and their reservoirs
- Oral and nasal airways
- Probes of CO₂ analyzers, air-pressure monitors
- Resuscitation bags
- Stylets
- Suction catheters
- Temperature sensors

* Items that directly or indirectly contact mucous membranes of the respiratory tract should be sterilized or subjected to high-level disinfection before reuse.

[†] Considered critical items and should be sterilized before reuse.

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