

Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care

WHO Interim Guidelines

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Guidance updates

- The present guidelines supersede the document “*Hospital Infection Control Guidance for Severe Acute Respiratory Syndrome (SARS)*”, revised 24 April 2003, previously available at <http://www.who.int/csr/sars/infectioncontrol/en/>
- These guidelines relate to, and can be used in conjunction with, the document “*Avian Influenza, Including Influenza A (H5N1): WHO Interim Infection Control Guidelines for Health-care Facilities*” published by the WHO Regional Office for the Western Pacific on 10 March 2004, and updated in May 2007, available at http://www.who.int/csr/disease/avian_influenza/guidelines/infectioncontrol1/en/index.html
- Please make sure the version being used is the most recent version available at: <http://www.who.int/csr/resources/publications/csrpublications/en/index7.html>.
- After the conclusion of the pilot tests, to be conducted in 200/2008, a revised version of these guidelines will be published.
- In the event of new epidemics or pandemics, additional recommendations will be forthcoming.

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Foreword

The purpose of this document is to provide infection control guidance to help prevent the transmission of acute infectious respiratory diseases during health care, with emphasis on acute respiratory diseases that may constitute a public health emergency of international concern as defined in the International Health Regulations (2005; Annex 1). Managers of health-care facilities may also consider using this guidance to assist them in preparation for epidemics and pandemics.

This document is intended to be used by government planners, health-care facility administrators, infection control professionals, occupational health specialists, other professionals involved in patient care and direct care providers.

The infection control advice provided in the guidelines is based on available information on the main routes of transmission of pathogens, and is intended to provide guidance for continuous and sustainable improvement in safety of health care. These guidelines are designed to offer Member States a conceptual framework for individual adaptation according to local regulations, settings, needs and resources. Health-care facilities are encouraged to review the recommendations and to adapt them accordingly.

The guidelines were developed after performing a systematic review of the scientific literature (in English) identified through PubMed (US National Library of Medicine) and the Cochrane Library, and secondary papers (in English, and also in Chinese, French, Portuguese and Spanish) identified from existing relevant guidelines. International and national infection control guidelines and infection control textbooks were also consulted. The document has undergone internal and external peer reviews. The Guideline Steering Group¹ evaluated the comments suggested by the reviewers providing guidance when opinions differed, and oversaw the incorporation of amendments and finalization of the document.

Pilot tests of the guidelines will be conducted in 2007 and 2008 in each of the six WHO Regions to help provide local data on clarity of the document and generate information on resources required to carry out the recommendations, feasibility, and validity of the interventions concerned. The pilot tests may also help provide information for implementation and dissemination strategies. The guidelines will be reviewed and updated after the conclusion of the pilot tests.

As in many other areas, the knowledge on modes of transmission of respiratory diseases is evolving rapidly. In addition, case surveillance and case and contact investigation are critical in defining and identifying changes in the epidemiology of human infections and will continue to inform infection control recommendations. Modifications to these guidelines will be made, as necessary, as additional information becomes available.

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I. List of acronyms and definition of terms used in the document

Acronyms

ACH	air changes per hour
AORN	Professional Organization of Perioperative Registered Nurses (USA)
ARD	acute respiratory disease
ASTM	American Society for Testing and Materials (former name)
BFE	bacterial filtration efficiency
BiPAP	bilevel positive airway pressure
BSL	biosafety level
CDC(US)	Centers for Disease Control and Prevention, Atlanta, United States of America
CE	Conformité Européenne (European Conformity)
Co-V	coronavirus
CPAP	continuous positive airway pressure
EU	European Union
FDA	Food and Drug Administration (United States of America)
FFP	filtering face piece
HCF	health-care facility
HCW	health-care worker
HVAC	heating, ventilation, and air conditioning
IHR	International Health Regulations
ILI	influenza-like illness
NIOSH(US)	National Institute for Occupational Safety and Health
OR	operating room
PFE	particulate filtration efficiency
PPE	personal protective equipment
ppm	parts per million
RSV	respiratory syncytial virus
RT-PCR	reverse transcription polymerase chain reaction
SARS	severe acute respiratory disease
SIGN(WHO)	Safe Injection Global Network
WHO	World Health Organization

Definitions of terms

The following terms have been defined for the purpose of this document.

Acute respiratory diseases

Acute respiratory diseases (ARDs) are upper or lower respiratory tract illnesses, usually infectious in etiology, which can result in a spectrum of illnesses ranging from asymptomatic or mild infection to severe and fatal disease, depending on the causative pathogen, environmental, and host factors. However, for the purposes of this document, an ARD is defined as an acute respiratory tract illness that is caused by an infectious agent transmitted from person to person. The onset of symptoms is typically rapid, over a period of hours to several days. Symptoms include fever, cough, and often sore throat, coryza, shortness of breath, wheezing, or difficulty breathing. Examples of pathogens causing ARDs included in these guidelines are rhinovirus, respiratory syncytial virus, parainfluenza virus, severe acute respiratory syndrome-associated coronavirus (SARS-CoV) and influenza virus.

Acute respiratory diseases of potential concern

Acute respiratory diseases of potential concern (ARDs of potential concern) refer to 1- SARS-CoV (see section III.1) 2- new influenza virus causing human infection (see section III.2); and 3- novel ARDs that can cause large-scale outbreaks and outbreaks with high morbidity and mortality (see section III.3).

Adequately ventilated single room

A single room, or a side room in the ward, with ≥ 12 air changes per hour (ACH) without controlled direction of air flow.

Aerosol-generating procedures associated with pathogen transmission

Procedures that have been reported to be aerosol-generating and associated with a documented increased risk of pathogen transmission. These include intubation and related procedures, cardiopulmonary resuscitation, bronchoscopy, autopsy and surgery where high-speed devices (e.g. saw) are used (see Annex A for details).

Airborne precaution room

An airborne precaution room is a room with ≥ 12 air changes per hour (ACH) and controlled direction of air flow, and can be used to contain airborne infections (1-3) and ARDs caused by a novel agent with the potential to have a high public health impact. An airborne precaution room can be naturally or mechanically ventilated. In addition to the requirement of ≥ 12 ACH, in a mechanically ventilated airborne precaution room, negative pressure is created to control the direction of air flow. It is equivalent to the “airborne infection isolation room” described by the United States Centers for Disease Control and Prevention (CDC)(4). In naturally ventilated airborne precaution rooms the air flow should be directed to areas free of transit, or permit the rapid dilution of contaminated air into the surrounding areas and the open air. For details of airborne precaution rooms, refer to section V and Annex B.

Airborne transmission

Airborne transmission of infectious agents refers to the transmission of disease caused by dissemination of droplet nuclei that remain infectious when suspended in air over long distance and time. Airborne transmission can be further categorized into obligate or preferential airborne transmission(5).

Obligate airborne transmission refers to pathogens that are transmitted only by deposition of droplet nuclei under natural conditions (e.g. pulmonary tuberculosis).

Preferential airborne transmission refers to pathogens that can initiate infection by multiple routes, but are predominantly transmitted by droplet nuclei (e.g. measles, chickenpox).

Air changes per hour (ACH)

Volume of air moved in one hour. One air change per hour in a room, home, or building means that all the air in that environment will be replaced in one hour (6).

Alcohol-based hand rub

An alcohol-containing preparation designed for application to the hands for hand antisepsis.

Anteroom

A small room leading from a corridor into another room, often an isolation room.

Caregiver

A person who provides support and assistance, formal or informal, with various activities to people with disabilities or long-term conditions, or elderly people. This person may provide emotional or financial support, as well as hands-on help with different tasks (7).

Cleaning

The removal of dirt from a device or surface, using either the physical action of scrubbing with a surfactant or detergent and water, or an energy-based process (e.g. ultrasonic cleaners) with appropriate agents.

Clinical waste

Also known as infectious waste, it refers to hazardous waste capable of causing infections in humans. This includes: contaminated animal waste; human blood and blood products; waste from isolation areas; pathological waste (e.g. human tissues); and discarded sharps (needles, scalpels or broken medical instruments). The definition may vary depending on local legislations and regulations.

Cohorting and special measures

Cohorting refers to placing patients infected or colonized with the same known pathogen in the same designated unit (same space and staff in the unit) to which patients without the pathogen are not admitted.

Special measures refer to the placing of patients with the same suspected diagnosis (similar epidemiological and clinical information) in the same unit, but when the etiological agent is not yet laboratory-confirmed.

Contact transmission

Contact transmission can be direct and indirect. Direct contact transmission involves both a direct body surface to body surface contact and physical transfer of microorganisms between an infected or colonized person and a susceptible host. Indirect contact transmission involves contact of a susceptible host with a contaminated intermediate object (e.g. contaminated hands), that carry and transfer the microorganisms (3).

Disinfection

A process that eliminates all pathogenic microorganisms, with the exception of bacterial spores, from inanimate objects, for the purpose of minimizing risk of infection.

Droplet transmission

Droplets are generated from an infected (source) person primarily during coughing, sneezing, and talking. Transmission occurs when these droplets containing microorganisms are propelled a short distance (usually < 1m) through the air and deposited on the conjunctivae, mouth, nasal, throat or pharynx mucosa of another person. Because droplets do not remain suspended in the air, special air handling and ventilation are not required to prevent droplet transmission (3).

Environmental mechanical ventilation

Use of mechanical fans to introduce and distribute outdoor and/or properly treated recycled air into a building or a room.

Environmental natural ventilation

Natural ventilation uses natural forces to introduce and distribute outdoor air into a building. These natural forces can be wind pressure or pressure generated by the density difference between indoor and outdoor air.

Hand hygiene

A general term that applies to hand washing, antiseptic hand washing, antiseptic hand rubbing, or surgical hand antisepsis.

Health-care facility

Any establishment that is engaged in direct patient care on site(7).

Health-care setting

Clinical context where health care is provided (e.g. hospital, outpatient clinic, home).

Health-care worker

A variety of professionals (medical practitioners, nurses, physical and occupational therapists, social workers, pharmacists, spiritual counsellors, etc) who are involved in providing coordinated and comprehensive care (7).

Health personnel

All persons employed or contracted to provide health services (7).

Human influenza

An acute contagious viral infection, commonly occurring in seasonal epidemics (seasonal influenza) or rarely pandemics (pandemic influenza), characterized by inflammation of the respiratory tract, and typically manifested by the sudden onset of fever, chills, muscular pain, severe prostration, sore throat, and cough (8). Transmission of infection occurs at close range, mainly through droplets and occasionally through contact. To date, there is a lack of evidence to suggest that the infection is airborne-transmitted among humans in health-care settings(9).

Infectious respiratory aerosols

Respiratory aerosols which contain infectious particles. Aerosol size is determined by the force and pressure involved in the generation of the particles. The final size depends on the nature of the fluid containing the organism(s), the force and pressure at emission, the initial size of the aerosol, environmental conditions (e.g. temperature, relative humidity, and air flow), the time spent airborne, and the size of the organism(s) within a droplet. The distance and length of time particles remain suspended in the air is determined by the types of organisms, particle size, settling velocity, relative humidity and air flow. Large particles typically remain suspended in the air for limited period of time and settle within 1 m (3 feet) of the source. Smaller particles evaporate quickly, and the resulting dried residues settle from the air slowly, and may remain suspended in the air for variable lengths of time. The definitions and classification of the different types of infectious respiratory aerosols are evolving, and the implications for the infection control measures are not yet clear. However, for the purpose of this document, infectious respiratory aerosols will be classified into:

Droplets: Respiratory aerosols $> 5 \mu\text{m}$ in diameter.

Droplet nuclei: Respiratory aerosols $\leq 5 \mu\text{m}$ in diameter.

Medical mask

A surgical or procedure mask protecting caregivers against droplet-transmitted pathogens and/or as part of facial protection for patient-care activities which are likely to generate splashes or sprays of blood, body fluids, secretions or excretions. Refer to Annex A.4 for details of usage and standards of medical masks.

Mixed-mode environmental ventilation

Well designed combined use of both mechanical and natural ventilation.

Negative pressure room

A room in which the air pressure differential between the room and the adjacent indoor airspace directs the air flowing into the room (i.e. room air is prevented from leaking out of the room and into adjacent areas such as the corridor).

New influenza virus

A new strain of influenza virus that has not previously been circulating among human hosts. For example, avian influenza is an infection of birds caused by avian influenza viruses from one of the 16 type A subtypes. All birds are thought to be susceptible to infection with avian influenza viruses; certain avian influenza viruses (H5 and H7) may cause lethal outbreaks in poultry. Humans can occasionally be infected with avian influenza A viruses (10).

Pandemic

An epidemic occurring worldwide or over a very wide area, crossing boundaries of several countries, and usually affecting a large number of people (11).

Particulate respirator

Also known as a filtering face piece respirator, a particulate respirator is a type of mask that uses a filter as an integral part of the face piece or with the entire face piece composed of the filtering medium and a means of sealing to the face.

Quantum

A quantity or an amount of particles.

Source control

A means of reducing the emission of droplets when a patient with ARD coughs or sneezes, such as covering of mouth and nose with hands or other materials (e.g. tissues, handkerchiefs, cloth masks, or medical masks), in order to reduce the dispersion of droplets from the infected/colonized patient. Hand hygiene should be performed immediately after contact with respiratory secretions.

II. Executive summary

In an era of emerging and re-emerging communicable disease health threats, the importance of infection prevention and control measures in health-care settings should not be underestimated. Transmission of communicable disease/pathogen is an ever-evolving subject, and transmission of pathogens that cause acute respiratory diseases (ARD) is no exception. The main mode of transmission of most ARDs are through droplets, but transmission through contact (including hand contamination followed by self-inoculation) and infectious respiratory aerosols of various sizes and at short range may also occur for some pathogens. Because many symptoms of ARDs are non-specific and rapid diagnostic tests are not always available, the etiology is often not immediately known. In addition, pharmaceutical interventions (vaccine, antivirals, antimicrobials) for ARDs may not be available.

These guidelines provide recommendations for the non-pharmacological aspects of infection prevention and control for ARDs in health care. Other WHO documents address the use of vaccines and antivirals for influenza:

WHO guidelines for the use of seasonal influenza vaccine in humans¹

WHO rapid advice guidelines on pharmacological management of humans infected with avian influenza A (H5N1) virus²

The importance of administrative and environmental controls for decreasing transmission of acute respiratory infections was well-illustrated by SARS. Administrative and infection controls, including early detection, isolation and reporting, and establishment of infection control infrastructure, are key components for containment and mitigation of the impact of pathogens that may constitute a major public health threat. Environmental controls, such as adequate ventilation and proper patient placement, were highlighted during the SARS experience as crucial measures to help to reduce the spread of respiratory pathogens associated with health care. In these guidelines, the options of using natural ventilation and/or exhaust fan assisted ventilation in health-care facilities (HCF) are considered (Part V).

The present document is intended to help policy-makers, administrators and health-care workers (HCWs) in charge of infection control programmes to prioritize infection control measures in health care, especially in settings with limited resources.

This document is composed of six parts: Part I defines the terms used in the guidelines; Part II provides a summary of the main recommendations and rationale; Part III provides an introduction to the concepts that will be discussed in the guidelines; Part IV provides a detailed description of the infection control recommendations; Part V describes the principles of environmental ventilation for airborne infections; and Part VI outlines the main components of HCF preparedness plans to prevent and control the ARD outbreaks that may constitute an international public health concern. The annexes provide background information for the recommendations in Part IV.

¹ Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/seasonal_vaccine/en/

² Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/pharmamangement/en/index.html

Summary of infection control recommendations

- Standard Precautions are basic infection control precautions in health care (see Annex C.1) and should be applied routinely in all health-care settings when providing care for all patients. If these basic precautions are not in place, additional specific precautions will not be effective. The main elements of Standard Precautions include hand hygiene, use of personal protective equipment (PPE) to avoid direct contact with patient's blood, body fluids, secretions and non-intact skin, prevention of needle stick/sharp injury and cleaning and disinfection of the environment and equipment.
- When caring for patients with infectious acute respiratory diseases, Standard and Droplet Precautions (Annex C.2) should be practised whenever possible. If there are insufficient single patient rooms and cohorting of patients with the same known etiological diagnosis is not possible, maintain spatial separation of at least 1 m between the infected patient and other patients.
- In paediatric patients with ARDs, when clinical symptoms and signs suggest a likely diagnosis during the peak season of certain viruses, (e.g. croup and parainfluenza, acute bronchiolitis and respiratory syncytial virus), Contact, Standard and Droplet Precautions (Annex C) should be implemented whenever possible.
- Additional protective measures may be necessary when providing care for patients infected with some specific pathogens (see Table 1). If the patient has indications suggestive of an ARD caused by a novel pathogen with epidemic/pandemic potential (refer to section III.3.3 for the indications) and the route of transmission has not been established, Airborne and Contact Precautions should be added to Standard Precautions (see Annex C for details of Isolation Precautions).

Other important points

Promotion of an institutional safety climate helps to improve conformity with recommended measures and thus subsequent risk reduction. Several strategies should be combined and HCF leadership is key to provide support and to promote compliance with infection control recommendations.

- The key strategies for reducing the risk of pathogen exposure and transmission associated with health care include administrative controls, engineering and environmental controls, and use of PPE (see section III.4).
- Administrative (e.g. provision of adequate staff and supplies, education of health workers, patients and visitors), engineering and environmental controls are fundamental components in the construction of an infection control structure to enable the safest possible health care. Adequate environmental ventilation is a key engineering control for respiratory infections and should be carefully considered (see Section V).
- The use of PPE should be defined by policies and procedures specifically addressing infection control issues (e.g. isolation precautions). Its effectiveness is dependent on adequate and regular supplies, adequate staff training, proper hand hygiene, and in particular, appropriate human behaviour.
- Source control measures should be implemented for all persons with respiratory symptoms through the promotion of respiratory hygiene/cough etiquette (Annex C.1.3).

III. Introduction and scope of the guidelines

III.1 ARDs in health care

ARDs are the leading causes of infectious disease morbidity and mortality in the world. Almost four million people die from ARDs each year, with 98% due to lower respiratory tract infection. The mortality rates are particularly high among infants, children and the elderly, predominantly in low- and middle-income countries (12). Likewise, ARDs are among the most frequent causes of consultation or admission to HCFs, particularly in paediatric services (13).

Bacteria are a major cause of lower respiratory tract infection, with *Streptococcus pneumoniae* being the most common cause of bacterial community-acquired pneumonia in many countries. However, the pathogens that most often cause ARDs are viruses, or mixed viral–bacterial infections. Meanwhile, the threat of ARDs due to novel organisms that have epidemic or pandemic potential warrants special precautions and preparedness (14).

The incidence of specific ARDs varies according to several factors. The distribution and outcomes of the diseases are related to (15–17):

- environmental conditions (e.g. air pollutants, household crowding, humidity, hygiene, season, temperature);
- availability and effectiveness of medical care and infection prevention measures to contain spread (e.g. vaccines, access to HCFs, isolation capacity);
- host factors, such as age, cigarette smoking, host ability to transmit infection, immune status, nutritional status, prior or concurrent infection with other pathogens, underlying medical conditions; and
- pathogenic characteristics, including modes of transmission, transmissibility, virulence factors (e.g. genes encoding toxins), and microbial load (inoculum size).

III.2 Scope of the current guidelines

Acute respiratory diseases may present with a wide range of clinical symptoms. For the purpose of this document, acute infectious respiratory diseases in general, and ARDs of epidemic or pandemic potential will be highlighted. Such ARDs have the potential for rapid spread and may have serious public health impact. According to the International Health Regulations, IHR (2005)¹, respiratory disease events that may constitute a public health emergency of international concern include:

- severe acute respiratory syndrome (SARS)
- human influenza caused by a new subtype, including human episodes of avian influenza
- pneumonic plague
- novel ARD agents that can cause large-scale outbreaks or outbreaks with high morbidity and mortality.

Infection control recommendations for prevention and control of pneumonic plague have been addressed in a previous WHO publication, *Plague Manual. Epidemiology, Distribution, Surveillance and Control*, 1999,² and are not described in these guidelines.

¹ Available at: <http://www.who.int/csr/ihr/en/>

² Available at: http://www.who.int/csr/resources/publications/plague/WHO_CDS_CSR_EDC_99_2_EN/en/index.html

These guidelines focus on infection prevention and control precautions for ARDs that:

- cause acute respiratory tract infection, including pneumonia or acute respiratory distress syndrome;
- cause severe disease in susceptible people with apparently normal immune systems;
- may constitute a public health emergency of international concern as defined by IHR (2005) (above), except plague.

Tuberculosis seldom presents as an ARD, but its spread has been associated with health care and is a major concern. Infection control recommendations for prevention and control of tuberculosis in HCFs have been addressed in previous WHO publications, *Guidelines for the Prevention of Tuberculosis in Health Care Facilities in Resource-Limited Settings*, 1999,¹ and will not be described in these guidelines. The current document focuses on the most common ARDs and highlight ARDs of potential concern.

III.3 ARDs that may constitute a public health emergency of international concern covered in the current document

III.3.1 Severe acute respiratory syndrome (SARS)

Severe acute respiratory syndrome (SARS) is caused by a SARS-associated coronavirus (SARS-CoV) (18), which can infect animals and humans. SARS was first reported in Asia in February 2003 and spread to people in over 24 countries in Asia, North America, South America, and Europe before the outbreak was contained (19). SARS is currently not known to be circulating among humans; however, it could still be circulating in animal hosts and it may re-emerge in humans (20). Human-to-human transmission of SARS occurs mainly through droplets or contact, although transmission through infectious respiratory aerosols of various sizes may occur at short range (21).

III.3.2 New influenza virus causing human infection

When a new influenza virus first emerges in another species, it is not yet adapted to humans, and may circulate in animal hosts and generate sporadic human infections. It may subsequently evolve to have human-to-human transmission. During this period, early detection, isolation, and warning are crucial. Several episodes of sporadic avian influenza infection in humans have been described previously. Avian influenza A viruses typically infect birds, but sometimes can infect other animals and humans, and have been associated with clusters of human cases (22-25). The strain associated with the largest number of human episodes is H5N1. Human episodes of avian influenza A (H5N1) were first reported in China, Hong Kong, Special Administrative Region (Hong Kong SAR) in 1997, and re-emerged and were found in other countries from 2003 onwards. Most instances of avian influenza infection in humans have resulted from contact with infected poultry (e.g. domesticated chickens, ducks, or turkeys) or surfaces contaminated with secretions/excretions from infected birds (22-28). To date, no efficient or sustained human-to-human transmission of avian influenza A (H5N1) has been demonstrated. Among the possible human-to-human episodes, transmission was associated with close and extensive unprotected contact, suggesting spread mainly through respiratory droplets and/or contact (29).

III.3.3 Novel ARD with potential to have a high public health impact

Infectious diseases have spread across populations and regions throughout history and it is likely that newly-emerging infectious diseases will continue to be identified. Many infectious diseases have animal reservoirs and can infect humans under certain circumstances. The following factors have

¹ Available at: <http://www.emro.who.int/stb/media/pdf/WHO99-269.pdf>

been associated with the emergence and spread of infectious diseases (14, 30):

- the changes in human demographics and behaviour
- the impact of new technologies and industries
- economic development and changes in land use
- increased international travel and commerce
- microbial adaptation and change
- the breakdown of public health measures, and
- sharing an environment with domestic or wild animals or birds.

These factors can facilitate the transmission of infectious agents from animal to human and from human to human. When a new infectious disease is recognized, the modes of transmission are not well understood. The epidemiological and microbiological studies to help determine the modes of transmission and identify possible prevention and control measures may be protracted. Due to the lack of information on modes of spread, Airborne and Contact Precautions should be added to the routine standard precautions whenever possible to reduce the risk of transmission of a newly-emerging agent. These precautions should be implemented until further studies reveal the mode(s) of transmission. Indications suggesting that additional precautions are needed include epidemiological and clinical clues, as detailed in section IV.1. These indications may change when additional information is available.

It is very important to maintain close surveillance of HCWs from the very beginning and during an outbreak with a novel pathogen, since it may be an important source of information about means of transmission, both for community and healthcare-associated transmission.

III.4 Infection control guiding principles

The conditions and levels of complexity in HCFs vary within, and between countries. Policy-makers and health administrators should identify strategies with favourable cost–effectiveness ratios based on the HCF characteristics and the potential for sustainable and progressive improvement.

The foundations of infection control for ARD patient care include early and rapid recognition of patients, application of routine infection control precautions for all patients (standard precautions, see Annex C.1), additional precautions in selected patients (e.g. based on the presumptive diagnosis), and establishing an infection control infrastructure for the HCF to support infection control activities

Infection control strategies in HCFs are commonly based on the following types of control:

Reduction/elimination

Infected patients represent the main source of pathogens in health-care settings and reducing/eliminating the dissemination of infectious agent from the source is critical. Examples of reduction and elimination include promotion of respiratory hygiene/cough etiquette (Annex C.1.3) and treatment to render a patient non-infectious.

Administrative controls

It is important for HCF management to warrant the needed resources for the implementation of infection control measures. These include establishment of sustainable infection control infrastructures and activities, clear policies on early recognition of ARDs of potential concern, implementation of appropriate infection control measures (e.g. Standard Precautions for all patients), regular supplies and organization of services (e.g. creation of patient triage system and placement).

The HCF management should also have staff planning to promote an adequate patient-to-staff ratio, provide staff training, and establish staff health programmes (e.g. vaccination, prophylaxis) to enhance the general health of the HCWs.

Environmental and engineering controls

These include methods to reduce the concentration of infectious respiratory aerosols (e.g. droplet nuclei) in the air and to reduce the presence of contaminated surfaces and items according to the epidemiology of the infection. Examples of primary engineering controls for infectious respiratory aerosols include adequate environmental ventilation (≥ 12 ACH) and spatial separation ($> 1\text{m}$) between patients. For infectious agents that spread by contact, cleaning and disinfection of contaminated surfaces and items are important environmental control methods.

Personal protective equipment (PPE)

The above strategies reduce, but do not eliminate the possibility of exposure to biological risks. Therefore, to further reduce these risks to HCWs and other persons interacting with the patients in the HCF, PPE should be used together with the above strategies in specific situations that pose an increased risk of pathogen transmission. The use of PPE should be defined by policies and procedures specifically addressing infection control (e.g. isolation precautions). The effectiveness of PPE is dependent on adequate and regular supplies, adequate staff training, proper hand hygiene, and in particular, appropriate human behaviour.

The above mentioned types of control are deeply interrelated. They should be harmonized to promote a safety institutional climate, the foundation for safe behaviours.

III.5 Environmental ventilation

Environmental ventilation refers to the process of introducing and distributing outdoor air, and/or properly treated recirculated air into a building or a room. Ventilation and air conditioning are two different concepts. The purpose of air conditioning is to maintain a thermally-comfortable indoor environment. The purpose of ventilation is to maintain good indoor air quality, i.e. ensuring that indoor air is safe for breathing purposes. Isolation rooms with adequate ventilation controls and controlled uni-directional flow of air should be available whenever possible in HCFs. This is especially important to reduce the transmission of pathogens that are transmitted through the obligate or preferential airborne route (e.g. pulmonary tuberculosis, measles, chickenpox). Most respiratory diseases (e.g. parainfluenza virus, RSV, influenza virus) do not spread readily by the airborne route over longer distances in health care settings, and patients can be adequately contained without environmental ventilatory controls. However, as transmission by the airborne route may occur for some ARDs, for patients infected by a novel agent causing an ARD of potential concern, Airborne Precautions should be practised until the route of transmission is clarified. Thus, if airborne precaution rooms are available, these patients should also be placed in them. If airborne precaution rooms are not available, the accommodation of these patients in adequately ventilated single rooms, which have ≥ 12 ACH but not necessarily controlled directional flow of air, should be considered.

Some infection control texts suggest that a mechanically ventilated negative pressure room is needed for proper isolation of patients with an airborne infection (1-3). However, there may be other possible options that are effective in removing airborne contaminants and potentially more affordable (e.g. natural ventilation). Details about environmental ventilation for respiratory infections are discussed in section V.

IV. Infection prevention and control recommendations

IV.1 Early recognition, isolation, reporting, and surveillance of episodes of ARD of potential international public health concern

Early recognition, isolation, reporting, and surveillance of episodes of ARD of potential concern are administrative control measures. Recommendations related to these issues are placed first and as a separate section because they are most critical for the prevention of spread of ARDs of potential concern, both in the health-care settings and within the international community. HCFs should:

- ⇒ Prioritize the establishment of methods ensuring early recognition and investigation of persons possibly suffering from ARDs of potential concern (see Figure 1)(31, 32).
- ⇒ Reinforce infection control precautions promptly when an ARD of potential concern is suspected (see Table 1)(33).
- ⇒ Link the hospital-based infection surveillance systems to the public health infection surveillance system and immediately report all available essential information regarding possible episodes of ARDs of potential concern to public health authorities via the local surveillance system (34). This is in line with the requirements of the IHR (2005) in force since June 2007. The IHR (2005) require the international notification to WHO by States Parties of events that may constitute a public health emergency of international concern.
- ⇒ The public health authorities should also establish channels to inform HCFs and the community about ongoing epidemic ARDs, in order to keep the HCFs aware of the extent and types of problems to be encountered and be prepared.
- ⇒ All patients suspected or confirmed to have an ARD of potential concern should be placed in a room or area separate from other patients and evaluated as soon as possible (35, 36).

Although the case definition may vary according to the specific disease, there are some general epidemiological and clinical clues to prompt suspicion.

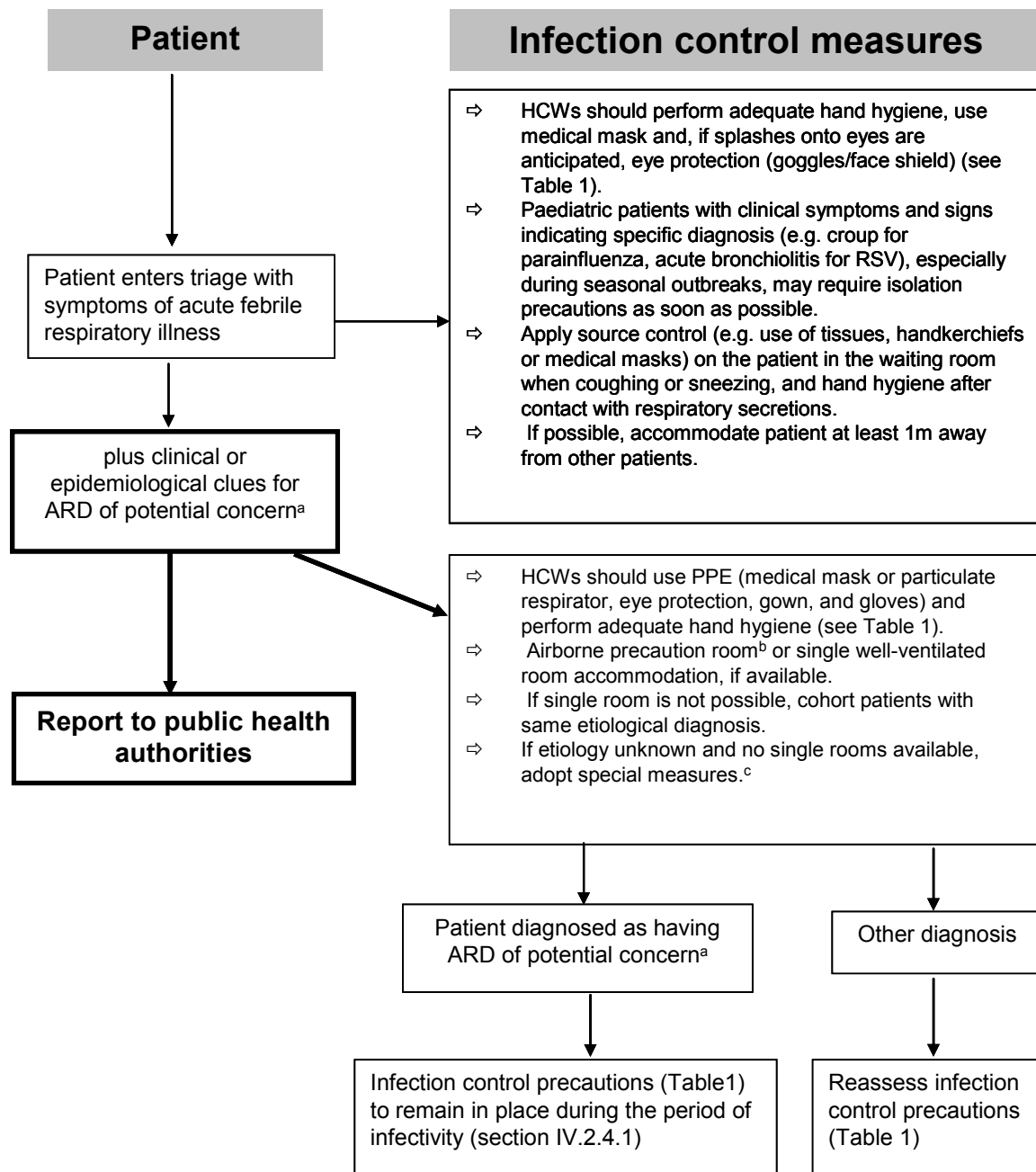
- **Epidemiological clues:** Indications suggesting that isolation precautions are needed include a patient's history of travel to countries where there are patients known to be suffering from an ARD of potential concern within the known or suspected incubation period, possible occupational exposure to pathogens or novel agents causing ARDs of potential concern, and unprotected contact with patients with ARDs of potential concern within the known or suspected incubation period, or being part of a rapidly spreading cluster of patients with ARD of unknown cause (35, 37-41). The last would include exposure to household members with ARDs. For novel agents, the epidemiological clues may change when additional information is available.
- **Clinical clues:** In all patients who present with, or who have died of, unexplained severe acute febrile respiratory illness (e.g. fever > 38°C, cough, shortness of breath), or other severe unexplained illness (e.g. encephalopathy or diarrhoea)(35, 41-46), with an exposure history consistent with the ARD of potential concern mentioned above within the known or suspected incubation period.

- ⇒ Family members who live with ARD patients and accompany ARD patients to the HCF can be assumed to have been potentially exposed to the same ARD and should also be evaluated for infection (35, 41-48).

Rationale

Patients with severe acute respiratory diseases tend to seek care at HCFs, so HCFs play a critical role in identifying early signals of newly emerging ARDs that may constitute a public health emergency of concern locally or internationally. Early identification and reporting offers an opportunity for successful containment. Prompt identification and management of patients, HCWs, or visitors who may be infected with an ARD of potential concern with pandemic and epidemic potential are key administrative control measures and are **critical** to minimize the risk of healthcare-associated transmission and to enable an efficient public health response. The response includes patient isolation, implementation of adequate infection control measures, treatment, and immediate reporting. The recognition of possible episodes depends on the ARD case definition, which may evolve as additional epidemiological and clinical information becomes available.

Figure 1. Decision tree for infection control measures for patients known or suspected to be infected with an acute infectious respiratory disease



^aFor the purpose of this document, ARDs of potential concern include: SARS, new influenza virus causing human infection (e.g., human cases of avian influenza), and novel organism causing ARDs that can cause outbreaks with high morbidity and mortality. Clinical and epidemiologic clues (Section IV.1): e.g., severe disease in a previously healthy host, exposure to household member or close contact with severe ARD, cluster of cases, travel, exposure to ill animals or laboratory.

^bAirborne precaution rooms include both mechanically and naturally ventilated rooms with ≥ 12 ACH and controlled direction of airflow (Section V).

^cThe term “special measures” means allowing patients with epidemiological and clinical information suggestive of a similar diagnosis to share a room, but with a spatial separation of ≥ 1 m.

Table 1. Infection control precautions for HCWs and caregivers providing care for patients with ARDs according to a sample of pathogens

Precaution	No pathogen identified, no risk factor for ARD of potential concern (e.g. influenza-like illness without risk factor for ARD of potential concern)	Pathogen					
		Bacterial ARD ^a	Parainfluenza RSV & adenovirus	Influenza virus with sustained human-to-human transmission (e.g. seasonal influenza, pandemic influenza)	New influenza virus with no sustained human-to-human transmission (e.g. avian influenza)	SARS	Novel organisms causing ARD ^b
Hand hygiene ^c	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gloves	Risk assessment ^d	Yes	Risk assessment ^d	Yes	Yes	Yes	Yes
Gown ^e	Risk assessment ^d	Yes	Risk assessment ^d	Yes	Yes	Yes	Yes
Eye protection	Risk assessment ^f	Risk assessment ^f	Risk assessment ^f	Yes	Yes	Yes	Yes
Medical mask on HCWs and caregivers	Yes	Risk assessment ^f	Yes	Yes	Yes ^g	Yes ^h	Not routinely ^p
Particulate respirator on HCWs and caregivers	for room entry	No	No	No	Not routinely ^q	Not routinely ^h	Yes
	within 1m of patient	No	No	No	Not routinely ^q	Not routinely ^h	Yes
for aerosol-generating procedures ⁱ	Yes	Not routinely ^l	Not routinely ^l	Yes	Yes	Yes	Yes
Medical mask on patient when outside isolation areas ^k	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Single room	Yes, if available ^m	No	Yes, if available ^m	Yes, if available ^m	Yes	Yes	Not routinely ^p
Airborne Precaution room ⁿ	No	No	No	No	Not routinely ^o	Not routinely ^o	Yes
Summary of infection control precautions for routine patient care, excluding aerosol-generating procedures ⁱ	Standard plus Droplet Precautions	Standard Precautions	Standard plus Droplet Contact Precautions	Standard plus Droplet Precautions	Standard plus Droplet Contact Precautions	Standard plus Droplet Contact Precautions	Standard plus Airborne Contact Precautions

- a. Bacterial ARD refers to common bacterial respiratory infections caused by organisms such as *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Chlamydia* spp., and *Mycoplasma pneumoniae*.
- b. When a novel ARD is newly identified, the mode of transmission is usually unknown. Implement the highest available level of infection control precautions, until the situation and mode of transmission is clarified.
- c. Perform hand hygiene in accordance with Standard Precautions (see Annex C).
- d. Gloves and gowns should be worn in accordance with Standard Precautions (see Annex C). If glove demand is likely to exceed supply, glove use should always be prioritized for contact with blood and body fluids (nonsterile gloves), and contact with sterile sites (sterile gloves).
- e. If splashing with blood or other body fluids is anticipated and gowns are not fluid-resistant, a waterproof apron should be worn over the gown.
- f. Facial protection (medical masks and eye protection) should be used in accordance with Standard Precautions by HCWs if activities are likely to generate splashes or sprays of blood, body fluids, secretions and excretions on to mucosa of eyes, nose or mouth; or if in close contact with a patient with respiratory symptoms (e.g. coughing/sneezing) and sprays of secretions may reach the mucosa of eyes, nose or mouth.
- g. As of the date of this document, no sustained efficient human-to-human transmission of avian influenza A is known to have occurred, and the available evidence does not suggest airborne transmission from humans to humans. Therefore a medical mask is adequate for routine care.
- h. The current evidence suggests that SARS transmission in health-care settings occurs mainly by droplet and contact routes. Therefore a medical mask is adequate for routine care.
- i. See Table 6.
- j. Some aerosol-generating procedures have been associated with increased risk of transmission of SARS and tuberculosis (Table 6). To date, the infectious risk associated with aerosol-generating procedures in patients with bacterial ARDs, ARDs caused by rhinovirus, parainfluenza, RSV and adenovirus is not defined. As a minimum, a tightly-fitted medical mask should be used.
- k. If medical masks are not available, use other methods for source control (e.g. handkerchiefs, tissues or hands) when coughing and sneezing.
- l. These are common pathogens in children, who may not be able to comply with this recommendation.
- m. Cohort patients with the same diagnosis. If this is not possible, place patient beds at least 1 m apart.
- n. Airborne precaution rooms can be naturally or mechanically ventilated, with adequate air change rate of at least 12 ACH and controlled direction of air flow.
- o. Airborne precaution rooms, if available, should be prioritized for patients with airborne infections (e.g. pulmonary tuberculosis, chickenpox, measles) and for those with novel organisms causing ARD.

IV.2 Administrative control strategies for HCFs

- ⇒ Strengthen or establish an infection control committee and infection control programmes with trained personnel to keep infection control policies current and to monitor compliance with them (35, 41-50).

Provide adequate support for promotion of better infection control practices through the following recommendations:

- ⇒ Use evidence-based methods to increase compliance with infection control precautions, including multimodal strategies (e.g. change in infrastructure, education, posters, reminders, senior management engagement, performance feedback) (51-53).
- ⇒ Educate HCWs to follow infection control precautions with all patients with acute febrile respiratory illness (54-56).
- ⇒ Ensure that adequate infection control supplies are provided (54, 56-58), such as:
 - hand hygiene facilities such as soap and clean running water, alcohol-based hand rub, paper or single use towels;
 - PPE for patient care (e.g. masks/respirators, gowns, gloves, eye protection);
 - PPE for heavy duties (e.g. closed protective footwear, waterproof aprons, and rubber gloves); and
 - an adequate supply of appropriate cleaning and disinfection materials.
- ⇒ Develop plans for the evaluation and management of patients known or suspected to be infected with an ARD of potential concern including rapid screening (establishment of triage) and immediate implementation of infection control precautions (35, 43, 59).
- ⇒ Develop systems to promptly identify and isolate patients with possible ARD of potential concern (35, 43, 54, 59) (see section V.1) and to promptly notify public health authorities (34).
- ⇒ In countries with reported ARDs of potential concern, reinforce the reporting system in HCFs (e.g. post signage at all entrances and clinical evaluation areas such as emergency departments) to alert patients and visitors to report severe acute febrile respiratory illness immediately to health-care providers (60).
- ⇒ Once a patient with a confirmed ARD of potential concern has been admitted to the facility, increase infection control surveillance to detect evidence of transmission to other patients and HCWs (61-63).

Rationale

Hospital administrators and governments play a key role in creating the necessary conditions at the institutional level to promote the prevention of spread of healthcare-associated pathogens. Written guidelines, availability of necessary resources (staff and supplies), promotion of a culture or tradition of adherence to infection control practices, and administrative leadership or support, are all targets for improvement. Enhancing individual and institutional attitudes regarding the feasibility of making changes, obtaining active participation, and promoting a safety climate, all represent major challenges. Lessons from the SARS outbreak show that important factors associated with compliance were the perception of HCWs that their facilities had clear policies and protocols, the perceived attitudes and actions of management regarding the importance of occupational health and safety, having adequate training in infection control procedures, and having fast access to specialists. Education, regular

supplies, adequate staffing, institutional climate, and leadership are the cornerstones for promotion of good infection control practices (57). It is essential that HCFs develop preparedness plans addressing the abovementioned elements (see section VI).

IV.2.1 Isolation precautions

- ⇒ When providing care for ARD patients, proper isolation precautions must be taken. Standard Precautions (Annex C.1) are ROUTINE infection control precautions that should apply to ALL patients, in ALL health-care settings (64). Annex C.1 summarizes the application and principles of Standard Precautions in health care.

The types of additional precautions needed depend on:

- the presence of epidemiological and clinical clues suggesting that patients have ARDs of potential concern,
- the suspected or confirmed causative agents of the ARDs (37, 39-41, 43, 65), and
- the type of contact with patient.

Rationale

Most acute respiratory infections are transmitted predominantly through droplets, but in some, other modes of transmission may play an important role. The type of infection control precautions should be tailored accordingly (Table 1). In addition, transmission of some of these infections has been associated with particular procedures, such as aerosol-generating procedures. These latter procedures have the potential to increase the risk of infection transmission (see Annex A, Table 6). Enhanced personal protection is warranted at least for those procedures with a documented increased risk of infection transmission (Annex A, Table 6).

Details of different types of isolation precautions are described in Annex C.

IV.2.2 Cohorting and special measures

For all ARDs

- ⇒ Cohorting refers to placing patients infected or colonized with the same pathogens in the same designated unit (same space and staff in the unit). Whenever possible, cohorting should be used for implementation of isolation precautions when single rooms are not available (64).
- ⇒ If the etiological diagnosis is not laboratory-confirmed, cohorting, as described above, is not possible. Because of the transmission risk, patients should be housed in single rooms, whenever possible.
- ⇒ However, if sufficient single rooms are not available, apply special measures. Only allow patients with epidemiological and clinical information suggestive of a similar diagnosis to share rooms, and with a spatial separation of at least 1 m from one another.
- ⇒ Avoid sharing of equipment, but if unavoidable, ensure that reusable equipment is appropriately disinfected between patients (64).
- ⇒ Ensure regular cleaning and proper disinfection of common areas (66), and adequate hand hygiene by patients, visitors and caregivers (67, 68).

For ARDs of potential concern

- ⇒ If rooms used for isolation of ARDs of potential concern (single rooms or airborne precaution rooms) are insufficient for individual isolation, apply either cohorting or special measures (see above).
- ⇒ Whenever possible, HCWs assigned to patient-care units for patients with ARDs of potential concern should be experienced and should not “float” or be assigned also to other patient-care areas.
- ⇒ The number of persons entering the assigned unit/area for isolation, cohorting, or special measures should be limited to the minimum number necessary for patient care and support (55, 69).
- ⇒ Consider having designated portable X-ray equipment available in assigned areas.

IV.2.3 Transport of patients inside and outside HCFs

IV.2.3.1 Patient transport within HCFs

For all ARDs

- ⇒ As per respiratory hygiene recommendations (see Annex C), medical masks are appropriate for use by ARD patients to contain respiratory droplets, and should be worn during transport or when care is necessary outside of the isolation room/area (64). If medical masks are not available, instruct the patients (or parents of paediatric patients) to use other methods for source control (e.g. cover their nose/mouth with tissue, handkerchiefs, hands or cloth masks) during coughing/sneezing or use the most practical alternative to contain respiratory secretions (60). Patients should be encouraged to perform hand hygiene after contact with respiratory secretions (67, 68).

For ARDs of potential concern

In addition to the recommendations described above, the following measures should also be implemented:

- ⇒ The movement and transport of patients out of the isolation room/area should be for essential medical purposes only and avoided wherever possible (64). Use routes of transport that minimize exposures of staff, other patients and visitors. The receiving area should be informed as soon as possible prior to the patient’s arrival of the patient’s diagnosis and of the precautions that are indicated.
- ⇒ If there is patient contact with surfaces, these surfaces should be cleaned and disinfected afterwards (66).
- ⇒ HCWs transporting ARD patients should wear appropriate PPE, followed by hand hygiene (64).

IV.2.3.2 Pre-hospital care and transport outside HCFs

For all ARDs

- ⇒ Screen patients with severe acute febrile respiratory illness for risk factors for ARDs of potential concern (35, 38, 70).

- ⇒ As described for standard precautions (see Annex C), follow recommended procedures for disposal of waste and cleaning and disinfecting the emergency vehicle and reusable patient-care equipment after pre-hospital care or transport has been provided (64).
- ⇒ Avoid crowding of patients during examination and in outpatient treatment areas.

For ARDs of potential concern

In addition to the recommendations above, the following measures also should be implemented:

- ⇒ Unless medically necessary to support life, aerosol-generating procedures associated with definite risk of pathogen transmission (e.g. intubation) should be avoided during pre-hospital care, and during transport of such patients (71, 72). (See Annex A.1).
- ⇒ During transport, optimize the vehicle's ventilation to increase the volume of air exchange (e.g. opening the windows). When possible, use vehicles that have separate driver and patient compartments.
- ⇒ Notify the receiving facility as soon as possible before arrival that a patient with a suspected ARD of potential concern is being transported to the facility, and indicate the precautions that are required.

IV.2.4 Duration of infection control precautions and patient discharge

IV.2.4.1 Duration of infection control precautions

The duration of infection control precautions varies based on the known or presumed infectious period of the specific ARD.

Avian and pandemic influenza

Infection control precautions should be implemented according to the patient's age.

- ⇒ Adults and adolescents > 12 years of age – implement precautions at time of admission and continue for 7 days after symptoms have resolved (73).
- ⇒ Infants and children ≤ 12 years of age – implement precautions at time of admission and continue for 21 days after symptom onset (young children can shed seasonal influenza viruses for up to 21 days)(73, 74).

N.B. For immunocompromised patients, pathogen shedding may be protracted and there are no data to define the duration of infectiousness at the moment. Microbiologic monitoring to determine lack of pathogen delectability is advised whenever possible

SARS

The duration of infectivity for SARS is not well defined. Although it has been reported that the reverse transcriptase-polymerase chain reaction (RT-PCR) conversion to negativity may take a long time (median 30 days, longest 81 days), the clinical significance of this RT-PCR conversion is not known. In studies conducted in China, Hong Kong Special Administrative Region, no SARS-CoV was cultured from the clinical specimens from patients proven to be infected once they were asymptomatic (75).

- ⇒ In SARS patients with normal immune system function, infection control precautions should be implemented while patients are symptomatic (75).

Newly-emerging ARDs

- ⇒ Implement precautions at the time of admission and continue until one week after symptoms have resolved, or until there is laboratory evidence of no active infection. The precautions and its duration should follow the available information and the local health authorities' recommendations.

IV.2.4.2 Discharge of patients infected with ARD of potential concern

The following recommendations are suggested, if patients are due to be discharged while still in the infectious period:

- ⇒ The discharge of patients should be based on the patient's clinical condition. If a patient with an ARD of potential concern no longer requires hospital care, the infection risk should be assessed. Do not discharge patients if infection control measures cannot be guaranteed to reduce the risk of transmission in the home setting (47, 48).
- ⇒ Before discharge, carry out a verbal assessment of the patient's home environment. A sample checklist is provided in Annex D. It is essential to ensure that the home environment is suitable to provide safe care at home.
- ⇒ Family members should be educated in personal hygiene and basic infection control measures (e.g. cough etiquette, hand hygiene, use of PPE if necessary, and ventilation of rooms) (76, 77).
- ⇒ Instruct the patient and the caregiver on proper hand hygiene (67, 68).
- ⇒ Immunocompromised persons, pregnant women, people with chronic illness (e.g. heart, lung or kidney disease, and sickle cell disease), young children (< 2 years of age) and elderly (> 65 years of age) should not have contact with the patients until they are asymptomatic. Ask the patient if any household members have any of the conditions described above. If so, discuss alternative housing during the patient's isolation period (78, 79).
- ⇒ Patient/caregiver(s) should be provided with instructions for follow-up clinic visits and a means to contact a health-care provider, if necessary (80, 81).

IV.2.5 Family member/visitor recommendations

- ⇒ Visitors should be advised about the possible risk of ARD transmission and screened before entering the facility (69, 82-84).

For all ARDs

- ⇒ Parents/legal guardians of paediatric patients should be supported to accompany the patient throughout the hospitalization (85, 86).
- ⇒ Parents/relatives/legal guardians may assist in providing care to ARD patients in special situations (e.g. lack of resources, paediatric patients) if adequate supply and training and supervision of PPE use and hand hygiene are ensured (85, 87).

For ARDs of potential concern

In addition to the recommendations described above, the following measures also should be implemented:

- ⇒ Visitors should use PPE according to the HCF guidance, and should be instructed in its use and in hand hygiene practices prior to entry into the isolation room/area (83, 88).

- ⇒ Family members and visitors with respiratory symptoms should be considered as possible ARD cases and should be evaluated for infection (47, 69, 83, 84, 89).

Rationale

The patient's right to receive visits should be guaranteed. The child's right to be accompanied by a parent/legal guardian should be also guaranteed. In addition to the context of visit or company, care of patients in isolation becomes a challenge when there are inadequate resources, and when the patient has poor hygienic habits or cannot be expected to assist in maintaining infection control precautions to limit transmission of microorganisms, and when family members are frequently involved in the care of the patient. In all these situations, visitors and accompanying persons should receive instructions for reducing infectious risk.

IV.2.6 Specimen collection/transport/handling within HCFs

All ARDs

- ⇒ HCWs who collect specimens from such patients should wear PPE as indicated in Table 1.
- ⇒ Specimens for transport must be placed in leak-proof specimen bags, which have a separate sealable pocket for the specimen (i.e. a plastic biohazard specimen bag), with patients' label on the specimen container, and clearly written request form. For details, refer to *Guidance on regulations for the Transport of Infectious Substances 2007-2008*.¹
- ⇒ Personnel who transport specimens should be trained in safe handling practices and spill decontamination procedures.
- ⇒ HCF laboratories should follow best biosafety practices according to the types of organisms being handled (90).

ARDs of potential concern

In addition to the recommendations described above, the following measures also should be implemented:

- ⇒ All specimens should be delivered by hand where possible. Pneumatic tube systems must not be used to transport specimens.
- ⇒ The accompanying request form should clearly state "(suspected) ARD of potential concern", and the laboratory should be notified by telephone or other means that the specimen is "on its way".

Rationale

As outlined in Standard Precautions (see Annex C), all specimens should be regarded as potentially infectious, and HCWs who collect or transport clinical specimens should adhere rigorously to the recommended infection control precautions to minimize the possibility of exposure to pathogens. For further information on specimen handling and collection guidelines, see:

- *WHO laboratory biosafety guidelines for handling specimens suspected of containing avian influenza A virus*²
 - *WHO guidelines for the collection of human specimens for laboratory diagnosis of avian influenza infection*³
- For further information on laboratory biosafety guidelines, see *WHO Laboratory Biosafety Manual*.⁴

¹ Available at: http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_EPR_2007_2/en/index.html

² Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/handlingspecimens/en/index.html

³ Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/humanspecimens/en/index.html

⁴ Available at: http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_CSR_LYO_2004_11/en/

IV.2.7 Occupational health

IV.2.7.1 Recommendations for HCF administrators

- ⇒ Whenever possible, immunize HCWs against seasonal influenza, and monitor vaccine uptake (91, 92).

WHO guidelines for the use of seasonal influenza vaccine in humans are available from the WHO web site.¹

- ⇒ HCWs who are at high risk for complications of ARDs of potential concern (e.g. pregnant women, immunocompromised persons, and persons with cardio-pulmonary or respiratory diseases) should be informed about the medical risks and offered work assignments that do not involve providing care for ARD patients (79, 93, 94).

Special recommendations for HCFs managing patients with ARDs of potential concern

- ⇒ Keep a register of HCWs who have provided care for patients with ARDs of potential concern for contact tracing.
- ⇒ Develop a HCW influenza-like illness (ILI) surveillance system. HCWs with ILI should be excluded from high-risk units (e.g. neonatal intensive care unit, haemopoietic stem cell transplantation unit).
- ⇒ Develop a system to monitor HCWs' health, especially in HCWs providing care for patients with ARDs of potential concern, with self-reporting by symptomatic HCWs (see Annex E). Provide prompt access, to diagnosis, counselling and treatment if these are available.
- ⇒ If antiviral prophylaxis is recommended by local policy, HCF administrators should develop a system to provide antiviral prophylaxis to HCWs exposed to patients with ARDs of potential concern accordingly. If necessary, the HCF administration should contact public health officials for assistance in obtaining adequate supplies for prophylaxis of HCWs providing care for patients with ARDs of potential concern, in line local guidance. Details of appropriate use of antiviral prophylaxis are provided in *WHO Rapid Advice Guidelines on pharmacological management of humans infected with avian influenza A (H5N1) virus*.²
- ⇒ Ensure that HCWs (especially those taking care of patients with ARDs of potential concern) have timely access to newly-developed vaccines to prevent acquisition of ARDs of concern.
- ⇒ Develop methods to provide additional support to HCWs (e.g. emotional and family support), as necessary.

IV.2.7.2 Recommendations for HCWs who have provided care for patients known or suspected to be infected with an ARD of potential concern

- ⇒ Organize HCWs into groups designated for caring for patients and check HCWs' temperature regularly (e.g. before each work shift), and monitor for symptoms of ILI (cough, sore throat, difficulty in breathing) for 7–10 days after last possible exposure to a patient with ARD of potential concern (see Annex E) (63).

¹ Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/seasonal_vaccine/en/

² Available at: http://www.who.int/csr/disease/avian_influenza/guidelines/pharmamanagement/en/index.html

- ⇒ In the event of fever $> 38^{\circ}\text{C}$, or the development of ILI, HCWs should immediately limit their interactions with others, be kept out of work, exclude themselves from public areas, and notify the infection control/occupational health team (and/or their health-care provider) that they are symptomatic and have had contact with patients with an ARD of potential concern (63, 95).

Rationale

HCWs also are members of the community, and during seasonal or pandemic influenza outbreaks they can become infected with influenza either through exposure in the community or in the HCF (not necessarily as a result of patient exposure). Once infected, they can serve as sources of virus transmission to other staff and to their patients, who are at increased risk of complications associated with ARD. While seasonal influenza vaccine does not provide protection against new influenza viruses, such as avian influenza, it will help to prevent concurrent infection with seasonal human influenza and thus reduce confusion in diagnosis and un-necessary work furlough. Prevention of seasonal influenza would also theoretically minimize the possibility of reassortment human and novel influenza viruses within the immunized HCW. Antibody responses usually are developed within 2 weeks after vaccination with seasonal influenza vaccine in adults. In addition, HCWs who provide care for any patient with an ARD of potential concern may potentially be exposed to these pathogens, and should be monitored and supported as needed.

IV.3 Engineering and environmental control for ARDs

IV.3.1 Placement of patients with ARDs

- ⇒ Patients infected with a novel organism causing ARD with potential to have a high public health impact should be placed in airborne precaution rooms (≥ 12 ACH plus safe air flow; see in section V). Patients infected with other ARDs of potential concern (e.g. SARS, human cases of avian influenza) should be accommodated in adequately ventilated (≥ 12 ACH) single rooms.
- ⇒ If airborne precaution rooms are not available for patients infected with a novel organism causing ARD, adequately ventilated single rooms should be given to these patients. If possible, rooms used for isolation of ARDs of potential concern (single rooms or airborne precaution rooms) should be in an area that is clearly segregated from other patient-care areas (21, 55, 66, 96).
- ⇒ Spaces reserved for triage, waiting rooms, areas used for aerosol-generating procedures associated with pathogen transmission, and adequately ventilated single rooms should present a minimal ventilation rate of 12 ACH (1).

Rationale

Patient placement should be planned according to:

- the presence in patients of epidemiological and clinical clues of ARDs of potential concern;
- the precautions undertaken in addition to Standard Precautions for the suspected or confirmed causative agents; and
- availability of facilities.

Airborne precaution rooms should be prioritized for patients with obligate or preferential airborne infections (e.g. pulmonary tuberculosis, measles and chickenpox) and for patients infected with novel agents causing ARD of potential concern with no information on possible routes of transmission. Opportunistic transmission of ARDs through droplet nuclei at short range may occur during aerosol-generating procedures associated with increased risk of pathogen transmission (see Annex A.1) under special situations, (e.g. inadequate use of PPE, poor environmental ventilation). The need to perform these procedures in ARD patients in airborne precaution rooms has not been sufficiently evaluated. Therefore, HCFs that have airborne precaution rooms should use them according to local policies. At the time of this publication, this remains an unresolved issue, and no specific recommendation can be given.

See section IV.2.2 for cohorting and special measures. For details of isolation precautions, see Annex C, and for details of isolation rooms, see Annex F.

IV.3.2 Design of triage and waiting areas

- ⇒ Triage and waiting areas need to be adequately ventilated with at least 12 ACH (1).
- ⇒ Organize the space and process to permit distance (≥ 1 m) between waiting patients and rapid triage of patients with acute febrile respiratory diseases, and screen them for risk factors associated with ARDs of potential concern (35, 55, 59).
- ⇒ The waiting room/area should be adequately cleaned and disinfected after placement of patients suspected or confirmed to have ARDs of potential concern (35, 66).

IV.3.3 Corridors

- ⇒ Corridors with frequent patient transport should be well-ventilated (97).

IV.4 PPE use

- ⇒ PPE should be used in the context of other prevention and control strategies (98), and in accordance with infection control recommendations (e.g. Standard, Contact, Droplet, or Airborne Precautions) (64).
- ⇒ Monitor compliance by HCWs of proper use of PPE (e.g. by using observers). This is particularly important when caring for patients with ARDs of potential concern.
- ⇒ Appropriate training on use of PPE should be provided (56, 98-102).

For details of preparation of isolation room/area and wearing and removing of PPE, refer to Annex F.

IV.4.1 Rational use of PPE

- ⇒ Provision of appropriate PPE supplies should be a national and institutional priority (56, 99, 101, 102).
- ⇒ Reuse of disposable PPE items should be avoided. It is not known whether reusing disposable PPE provides the same protective efficacy and safety as using new PPE and reuse may increase the risk of infection in HCWs (103, 104).
- ⇒ If resources are limited and disposable PPE items are not available, use reusable items (e.g. disinfectable cotton gowns), and properly disinfect after each use (66).
- ⇒ To avoid wastage, evaluate critically situations in which PPE is indicated using the rationale provided in Table 1, and maximize clinical care provision during each entry to the patient's room (64).

Respiratory protection

- ⇒ If patients with ARDs known or suspected to be airborne are cohorted in a common area or in several rooms on a nursing unit, and multiple patients will be visited, it may be practical for a HCW to wear one particulate respirator for the duration of the activity. This type of use requires that the respirator is not removed at any time during the activity and that the user does not touch the respirator. If the respirator gets wet or dirty with secretions, it must be changed immediately.
- ⇒ Specific training on how to put on the respirator, perform the seal check every time the respirator is worn, avoid contamination during use, and remove and dispose of the respirator is necessary to ensure compliance with correct respirator use (105).
- ⇒ If supplies are limited, use of particulate respirators should be prioritized for providing care for patients with obligate and preferential airborne-transmitted diseases, HCWs performing aerosol-generating procedures associated with documented risk of pathogen transmission (Annex A, Table 6). If a particulate respirator is not available, performance of aerosol-generating procedures associated with a documented increased risk of pathogen transmission should be avoided in patients with ARDs of potential concern whenever possible (71, 72, 84, 106, 107).

Medical masks

- ⇒ Medical masks should fit the user's face tightly and be discarded immediately after use (108, 109). If the mask gets wet or dirty with secretions, it must be changed immediately.

Gloves

- ⇒ If supplies of gloves are limited, reserve gloves for situations where there is a likelihood of contact with blood, respiratory secretions, or body fluids, including during aerosol-generating procedures associated with definite risk of pathogen transmission (102, 110, 111).

Gowns

- ⇒ If supplies of HCW gowns are limited, gown use should be prioritized for use when performing aerosol-generating procedures associated with definite risk of pathogen transmission and for activities that involve holding the patient close (e.g. in paediatric settings), or when other extensive direct patient contact is anticipated (102, 110).
- ⇒ If there is a shortage of HCW gowns, HCW gowns also may be worn in the care of more than one patient in a cohort area only, and if the gown does not enter in direct contact with the patient.

Eye protection

- ⇒ Conventional eye glasses are not designed to protect against splashes to eye mucosa, and should not be used as eye protection.
- ⇒ Reusable eye protective equipment can be used (e.g. goggles, face shield). However, it may pose a potential risk of cross-infection if not cleaned and decontaminated properly after each use according to manufacturer's instructions (56). Cleaning must precede disinfection (112-117). Hand hygiene must be performed after disposal or cleaning of eye protection equipment which may be contaminated with splash/spray (67, 68).

Rationale

PPE is meant to provide protection for the user but should not result in increased risk for other individuals or the environment. PPE supplies may be limited, and reuse of PPE items unavoidable, but

such reuse should be performed under safe conditions. In addition, unnecessary use of PPE should be avoided.

IV.5 Care of the deceased

IV.5.1 Removal of the body from the isolation room/area

- ⇒ According to Standard Precautions, PPE use should be applied to avoid direct contact with body fluids (64).
- ⇒ Cultural sensitivity should be practised. If the family of the patient wishes to view the body after removal from the isolation room/area, they may be allowed to do so, and Standard Precautions should be applied (64). See details of recommended PPE and procedures for body packing and transport in Annex G.

IV.5.2 Mortuary care

- ⇒ Mortuary staff and the burial team should apply Standard Precautions i.e. perform proper hand hygiene and use appropriate PPE (use of gown, gloves, facial protection if there is a risk of splashes from patient's body fluids/secretions onto staff's body and face) (64, 67, 68, 118, 119).
- ⇒ Embalming may be conducted according to usual routine, subject to local regulations/legislation.
- ⇒ Hygienic preparation of the deceased (e.g. cleaning of body, tidying of hair, trimming of nails, and shaving) also may be conducted with the application of Standard Precautions (64).

Rationale

Transmission of lethal infectious diseases associated with mortuary care has been reported (120). However, the cultural context of the local community also should be respected (121). It is essential to assess the risk during the mortuary care process, providing adequate explanation to the family. If indicated, PPE should be provided to the family after instruction in its use. Each family should be managed on a case-by-case basis, balancing their rights with the risks of exposure to infection.

IV.5.3 Postmortem examination

- ⇒ Post-mortem examinations and collection of samples for microbiologic analyses are essential to better understanding of ARDs. On the other hand, they are associated with risk of transmitting infections, and should be performed when necessary, and if safety measures are in place (see Annex G).
- ⇒ Appropriate safety measures to protect the persons performing the examination should be put into place in advance (122-124) (see Annex G).
- ⇒ A minimum number of staff should be involved in the procedure. It should only be performed if (125, 126):
 - a well-ventilated room suitable for the procedure is available; and
 - appropriate PPE is available. For details of PPE suggested, and how to put on and take off PPE, refer to Annex G.

IV.5.4 Engineering and environmental controls for autopsy

- ⇒ Perform autopsies in well-ventilated rooms with $ACH \geq 12$ (127).
- ⇒ Minimize aerosols in the autopsy room (e.g. during lung excision) by:
 - avoiding the use of power saws whenever possible (128, 129);
 - avoiding splashes when removing, handling, and/or washing organs, especially lung tissue and the intestines (128, 129);
 - using exhaust ventilation to contain aerosols and reduce the volume of aerosols released into the ambient air environment. Exhaust systems around the autopsy table should direct air and aerosols away from HCWs performing the procedure (e.g. exhaust downward) (129-131).

For details of how to reduce aerosol generation with modification of equipment, refer to Annex G.

- ⇒ Surfaces that have become contaminated with tissues or body fluids should be cleaned and decontaminated by (126):
 - removing most of the tissue or body substance with absorbent materials;
 - cleaning surfaces with water and detergent;
 - applying the disinfectant standardized by the HCF. If sodium hypochlorite solution is used (see Annex H, Table 7), wet the surface with the solution and allow at least 10 minutes contact time; and
 - rinsing thoroughly.

Rationale

Safety procedures for the deceased infected with an ARD of potential concern should be consistent with those used for any autopsy procedure. In general, the acknowledged hazards of work in the autopsy room seem to arise from contact with infectious materials, and particularly with splashes onto body surfaces of HCWs, rather than from inhalation of infectious material. However, if a patient with an ARD of potential concern died during the infectious period, the lungs and other organs may still contain live virus, and additional respiratory protection is needed during procedures that generate small-particle aerosols (e.g. use of power saws, washing intestines). Therefore, postmortem examinations of patients with ARDs of potential concern deserve special caution with regard to the environment.

V. Environmental ventilation for respiratory infections

It has been demonstrated that in a well-designed well-ventilated room with effective removal of contaminated air, the decay in the concentration of infective droplet nuclei in the room can reduce the risk of infection for individuals. The quality of ventilation is one of the major factors in determining the risk of exposure in the isolation room (132). Therefore, it is important to consider the various available methods to achieve adequate ventilation of areas that are used for isolating patients with potentially airborne ARDs. In these guidelines, the term “airborne precaution room” is adopted to designate a room with ≥ 12 ACH and desired air flow direction, which may be achieved with natural or mechanical ventilation. Such a room can be used to isolate patients with infected with airborne pathogens (e.g. pulmonary tuberculosis, measles, chickenpox) and ARDs caused by a novel agent of potential concern before routes of transmission are clarified. The airborne precaution rooms can be naturally or mechanically ventilated. On the other hand, if a room is well ventilated (≥ 12 ACH) but the air flow is not ascertained, it is designated in this document as an “adequately ventilated single room”.

Although the standard for adequate ventilation in isolation rooms has been suggested as 12 ACH (1-3), the actual infection risk reduction deserves further evaluation. It is the ventilation rate (i.e. ACH) in a room or space that is important when droplet nuclei transmission is a concern. Table 2 provides information about how the ventilation rates relate to the decay of droplet nuclei concentrations in an isolation room with different ventilation rates, using the concentration decay equation (133). The assumptions for this equation are: 1) the ACH remains constant; and 2) the concentration of droplet nuclei in the enclosed space is uniform (normally not the case in the real-life situation). Applying the concentration decay equation, there is 10-fold dilution within 10 minutes with 15 ACH. Because the quantity or an amount of particle generation is not uniform in health care settings, adequate ventilation may reduce but not eliminate the risk of infection, and thus appropriate PPE is indicated.

Table 2. Decay in concentration of droplet nuclei in enclosed isolation rooms with different rates and duration of environmental ventilation (133)

Duration of ventilation (min)	% decay in concentration of droplet nuclei at ventilation rates (ACH) of:						
	6	9	12	15	18	21	24
0	10.0	100.0	100.0	100.0	100.0	100.0	100.0
5	60.7	47.2	36.8	28.7	22.37	17.4	13.5
10	36.8	22.3	13.5	8.2	5.0	3.0	1.8
15	22.3	10.5	5.0	2.4	1.1	0.5	0.3
20	13.5	5.0	1.8	0.7	0.3	0.1	0.0
25	8.2	2.4	0.7	0.2	0.1	0.0	0.0
30	5.0	1.1	0.3	0.1	0.0	0.0	0.0
35	3.0	0.5	0.1	0.0	0.0	0.0	0.0
40	1.8	0.3	0.0	0.0	0.0	0.0	0.0
45	1.1	0.1	0.0	0.0	0.0	0.0	0.0
50	0.7	0.1	0.0	0.0	0.0	0.0	0.0
60	0.3	0.0	0.0	0.0	0.0	0.0	0.0

V.1 General concepts and principles

V.1.1 Types of environmental ventilation and factors governing the choice of ventilation methods

There are three main types of ventilation:

1. **Mechanical ventilation** uses fans to drive the air flow through a building. Mechanical ventilation can be combined with air conditioning and filtration systems as is normally done in some buildings.
2. **Natural ventilation** uses natural forces to drive the air flow through a building. Natural forces are wind pressures, and pressures generated by the density differences between indoor and outdoor air, the so-called “chimney effect.”
3. **Mixed-mode ventilation system** combines the use of both mechanical and natural ventilation and provides the opportunity to choose the most appropriate ventilation mode based on the circumstances (134). It is mainly used in modern commercial buildings, and requires expertise in design and construction.

The main factors that govern the choice of the ventilation method to be employed in HCFs are:

- Efficacy of the method to meet the minimal ACH requirement
 - The necessary ACH to help prevent transmission of infectious pathogens through droplet nuclei is suggested to be 12 ACH (1).
 - Both mechanical and well-designed natural ventilation systems can meet effective minimal requirements.
 - Despite being more easily controlled, mechanical ventilation may not be available everywhere, especially in areas or HCFs with limited resources.
 - New developments in natural ventilation have greatly benefited from engineers designing effective ventilation systems. With better design and control, natural ventilation has become more reliable in terms of its performance, and can be effective in preventing the transmission of potentially airborne agents. See Annex B for designs of natural ventilation (135-137).
- HCF infrastructure
 - In existing HCFs that are totally mechanically ventilated with central ventilation systems, the installation of additional controls in isolation rooms (e.g. adequate ACH) may be the best choice among different types of ventilation. Opening windows in a mechanically-ventilated room not designed for natural ventilation is undesirable because the system is not designed for this practice and the ventilation features are not predictable.
 - In existing HCFs without mechanical ventilation systems, effective ventilation may be achieved through adaptation of the existing designs using natural ventilation alone, or in combination with exhaust fans.
 - The planning of HCFs may benefit from recent developments in natural ventilation strategies. After careful assessment, less expensive and more effective systems may be useful for a wide range of HCFs.
- Climatic conditions
 - The effectiveness of natural ventilation depends on the existence of sufficient wind speed and/or the ambient temperature in the environment external to the facility (138).

Areas with extremes of temperature and consistently low wind speed may preclude the use of natural ventilation.

Table 3. Summary of advantages and disadvantages of different types of ventilation systems

Ventilation systems		
	Mechanical ventilation	Natural ventilation
Advantages	<ul style="list-style-type: none"> ▪ Suitable for all climates and weather ▪ More controlled and comfortable environment 	<ul style="list-style-type: none"> ▪ Lower capital, operational, and maintenance costs ▪ Capable of achieving very high ventilation rate for immediate complete removal of indoor pollutants ▪ Control of environment by occupants
Disadvantages	<ul style="list-style-type: none"> ▪ Expensive to install and maintain ▪ Requires expertise 	<ul style="list-style-type: none"> ▪ More difficult to predict, analyse, and design ▪ Reduces comfort level of occupants when weather is hostile, i.e. too hot, humid or cold ▪ Not possible to establish negative pressure in isolation areas if needed ▪ Risk of exposure to insects or vectors

V.2 Use of natural ventilation in isolation rooms

The principle of natural ventilation is to allow and enhance the flow of outdoor air by natural forces such as wind and thermal buoyancy forces from one opening to another to achieve the desirable ACH. Before the advent of central ventilation and air conditioning, hospital wards, including treatment areas for tuberculosis patients, were all naturally ventilated (139). A recent evaluation of natural ventilation strategies in Peru showed that natural ventilation was effective in reducing nosocomial transmission of tuberculosis (140).

For isolation room applications, there are two major concerns with natural ventilation:

- The rate of ACH provided by natural ventilation is variable.
- Negative pressure is suggested for Airborne Precautions (2-4), and natural ventilation may not be able to create negative pressure.

Although in naturally-ventilated rooms, the ACH can vary significantly, buildings with modern natural ventilation systems (if designed and operated properly), can achieve very high air change rates

by natural forces, greatly exceeding the minimum requirements of 12 ACH. In a study conducted in China, Hong Kong Special Administrative Region (Table 4), the ACH in a ward with an open window and open door was shown to be very high (personal communication: Qian, H, Seto WH, and Li Y).

Table 4. Air changes per hour (ACH) in a naturally-ventilated room observed in an experiment in China, Hong Kong SAR

Room conditions	ACH
Completely open window + open door	29.3–93.2
Completely open window + closed door	15.1–31.4
Half-open window + closed door	10.5–24
Closed window + open door	8.8

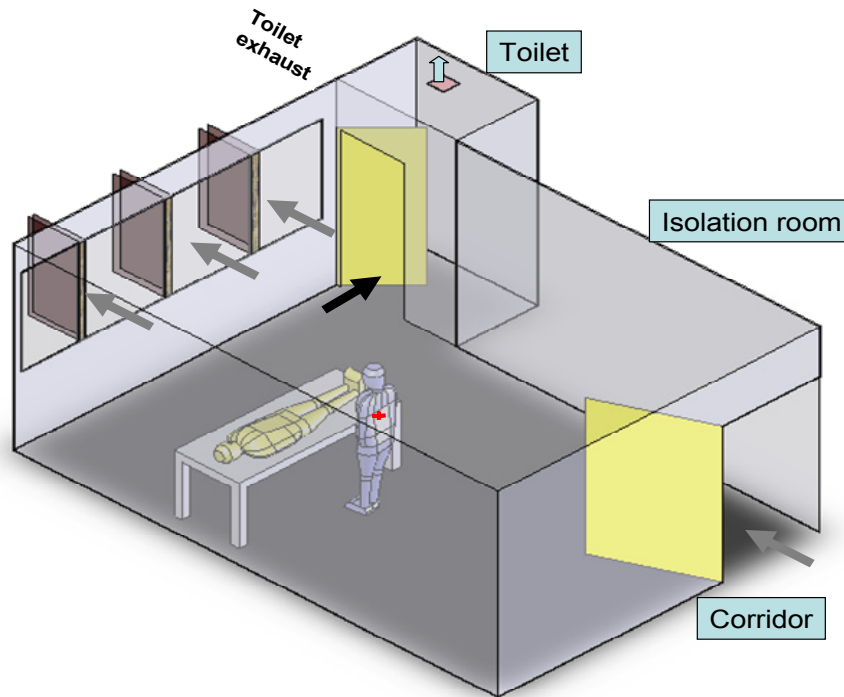
*Personal communication, Qian, H, Seto WH, and Li Y, The University of Hong Kong and Queen Mary Hospital.

With mechanical ventilation, the negative pressure environment in the isolation room is suggested as a means to generate an inward air flow (3). In the absence of negative pressure, the air flow may be multidirectional, in and out of a naturally-ventilated airborne precaution room. However, naturally-ventilated airborne precaution rooms can be designed to provide a desired airflow direction, which is from patient-caring areas to areas free of transit, or permitting the rapid dilution of contaminated air into the surrounding areas and the open air.

The choice of isolation areas and placement of patients within the facility need to be carefully planned and designed to further reduce the risk of infection for people in the surroundings (141). When designing a HCF, it is best if the isolation areas are away from other parts of the hospital, and are built in places predicted to have good prevailing winds year round. The air should be directed from patient-caring areas to outside open areas not regularly used for transit of persons. Inside the airborne precaution room, the patient should be placed near the exterior wall, close to open window(s), instead of close to the inner wall. Figure 2 depicts an airborne precaution room with natural ventilation achieved by opening the windows and the door to the corridor.

Another consideration associated with the use of natural ventilation is exposure of patients to arthropod vectors (e.g. mosquitoes) in endemic areas. Use of mosquito nets and other vector preventive measures may help to reduce the risk of transmission of vector-borne diseases.

Figure 2. Illustration of the desired direction of air flow in a properly designed naturally-ventilated isolation room (achieved by opening the windows, and the door between the isolation room and the corridor)



For details about principles and design of natural ventilation, see Annex B.

V.3 Use of exhaust fans in isolation rooms

Rapid creation of temporary isolation wards using exhaust fans was practised during the SARS outbreaks (142). The major purpose of installing exhaust fans is to assist in increasing the ACH to the desirable level and creating negative pressure (54, 143). However, careful design and planning, and an adequate number of exhaust fans are needed to achieve such results. The environmental ventilation rates achieved by installation of exhaust fans in an isolation room with different room conditions are shown in Table 5.

Table 5. Ventilation rates (ACH) in a naturally-ventilated room observed in an experiment in China, Hong Kong SAR, under different test conditions*

Exhaust fan is:	The door connecting the room to the corridor is:	The door and windows connecting room to the balcony and outside air is:	ACH
Off	Closed	Closed	0.71
Off	Closed	Open	14.0
Off	Open	Open	8.8–18.5
On	Closed	Closed	12.6
On	Closed	Open	14.6
On	Open	Open	29.2

*Personal communication, WH Seto, Department of Microbiology, The University of Hong Kong and Queen Mary Hospital.

In countries where natural ventilation is not suitable, and fully mechanically-ventilated airborne precaution rooms cannot be installed due to limited resources, the use of exhaust fans (with adequate pre-testing and planning) may help to increase ACH rates and generate negative pressure in the rooms. The fans should be installed on exterior wall(s) where room air can be exhausted directly to the outdoor environment free of transit of persons. The size and number of exhaust fans needed depend on the targeted ACH, which must be measured and tested before use.

The shortcomings associated with the use of exhaust fans include installation difficulties (especially for large fans), noise associated with high-power fans, uncertainties in effects on the existing air conditioning system and temperature control in the room.

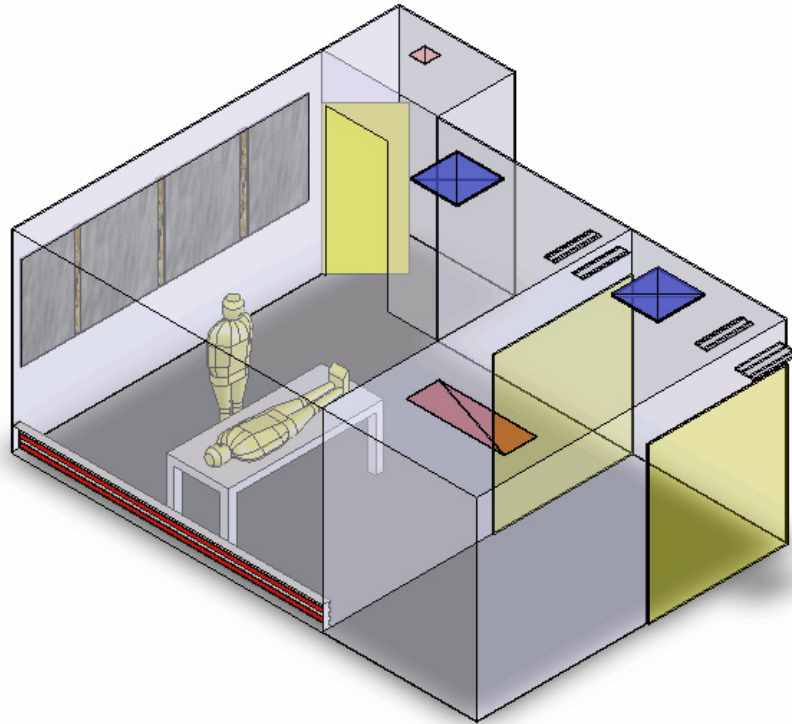
V.4 Use of mechanical ventilation in isolation rooms

HCFs using mechanically-ventilated airborne precaution rooms should warrant the necessary controls to achieve adequate ventilation rate and controlled direction of air flow. Mechanically-ventilated airborne precaution rooms are equivalent to the 'Airborne Infection Isolation Room' described by CDC (US) (4). Specific guidelines for environmental mechanical ventilation are available and state that a mechanically-ventilated airborne precaution room should be a private room that has (1, 4):

- monitored negative air pressure in relation to the surrounding areas;
- 12 ACH; and
- appropriate discharge of air outdoors, or monitored high-efficiency particulate air (HEPA) filtration of room air before it is recirculated to other areas in the hospital.

The room door must be kept closed and the patient should remain in the room. Figure 3 depicts an example of an ideal mechanically-ventilated airborne precaution room¹.

Figure 3. Schematic diagram of an ideal ventilated isolation room with a mechanical ventilation system



V.5 Conclusions

- The types of environmental ventilation should be carefully considered when designing a HCF. Ventilation is an important control strategy for diseases possibly transmitted through droplet nuclei, and its benefits are applicable not only to isolation purposes, but in several areas of the HCF (3).
- If the airborne precaution room is mechanically ventilated, it is important to ensure that the ventilation system is functioning properly through regular monitoring.
- There are insufficient data on the impact of different types of ventilation on the reduction of infectious risks. The comparability between the types of ventilation regarding their effectiveness is yet to be defined.

¹ For more details, please refer to http://www.cdc.gov/ncidod/dhqp/gl_environmentinfection.html

VI. HCF preparedness planning for ARD epidemics

The recent SARS outbreak and the threat of an influenza pandemic have highlighted the importance of communicable disease preparedness activities. HCFs should prepare for communicable disease emergencies through (144-147):

- organizing permanent infection control activities, surveillance and training of dedicated personnel and clinical staff;
- creating a multidisciplinary HCF group to develop a preparedness plan;
- developing a HCF preparedness plan;
- performing a plan evaluation, monitoring exercise, and updating; and
- strengthening liaison with other levels of the health care system/public health authorities.

Rationale

If the initial containment of a new epidemic/pandemic-prone respiratory virus fails, and given that most people will have no immunity against such a pathogen, a substantial proportion of the population, including HCWs, may fall ill and require different levels of health care. This will pose a challenge to manage patients and to contain the risk of spread associated with health care. Preparedness of HCFs is considered an essential part of general pandemic preparedness plans (148, 149). The main goals are:

- identifying, isolating and reporting early cases of a putative epidemic/pandemic ARD virus;
- keeping the health-care system functioning for pandemic and non-pandemic patients; and
- reducing the risk of pandemic ARD transmission associated with health care.

HCF capacity to respond efficiently to epidemic or pandemic threats at any given moment is highly dependant on existing standards of practice. The implementation of additional measures during the outbreak setting is very challenging, and the lack of baseline good standards may hamper epidemic/pandemic response efforts. Thus, preparedness for response to an ARD pandemic threat lies in a continuous strengthening of early detection of episodes and safe care in the HCF. Promotion of routine Standard Precautions in health care is the cornerstone of reducing the spread of pathogens, and should be enhanced worldwide to help HCF preparedness for a potential pandemic.

VI.1 Components of HCF pandemic ARD preparedness plans

HCF pandemic ARD preparedness plans should take into account the geographical location of the HCF and the progress of the pandemic, and include actions to be taken before, during and after the pandemic event. Plans should address:

a. Surveillance

- Make it a facility priority to establish methods to ensure early recognition and investigation of possible pandemic ARD patients (31, 32).
- Link the hospital-based infectious diseases surveillance system to the public health infectious diseases surveillance system, and report immediately all available essential information regarding possible pandemic ARD cases to public health authorities via the local surveillance system, as per Annex 1 of the International Health Regulations (2005)¹
- Public health authorities should also keep HCFs informed about the ongoing epidemics.

¹ Available at: http://www.who.int/gb/ebwha/pdf_files/WHA58/A58_55-en.pdf

- For preparedness of pandemic influenza, in addition to the above, HCFs should:
 - enhance ILI surveillance (see Annex E) (144, 150);
 - define criteria that would shift surveillance of episodes of influenza of potential concern (e.g. human episodes of avian influenza) from passive to active (144, 147, 151).
- b. Triage within HCFs**
 - Organize front-line services (e.g. Emergency Department) to perform triage of patients with respiratory symptoms (35, 151).
 - Promptly initiate infection control precautions when a possible epidemic/pandemic ARD episode is suspected (33, 148, 152).
- c. Plan for surge capacity**
 - HCFs should plan for surge capacity according to the estimated impact of a potential pandemic on health care (see Annex I for estimates) (153-157).
 - HCFs also should outline the limits of their surge capacity (e.g. human and space capacities) to provide care, and suggest thresholds when alternative sites for provision of health care (off-site care facilities) should be implemented (153-157).
- d. Surge capacity needs should be outlined regarding (153-157):**
 - supplies (pharmaceuticals, PPE, etc.);
 - ventilators, supplemental oxygen;
 - staff: develop plans to maintain sufficient personnel to carry out HCF activities (e.g. by planning alternative shifts/staffing assignments, supplemental staffing plan);
 - HCF infrastructure;
 - laboratory and diagnostic capacity; and
 - security policies to handle an unexpected increase in demand for services.
- e. Establish policies for access to the HCF (82) for**
 - the public
 - visitors (those who are allowed to enter should be educated on respiratory hygiene and risk of disease transmission, and screened/surveyed for ARDs)
 - HCWs (HCW flow); and
 - patients (patient flow).
- f. Risk communication policy (158)**
 - within HCF
 - with other HCFs
 - with other public health bodies, government agencies and ministries
 - with other societal bodies (e.g. media, professional societies, nongovernmental organizations).
- g. Infection control measures**
 - Engage HCWs in prioritization of resources and training (e.g. PPE/PPE use).
 - Engage HCWs into process of work in order to decrease the infection risk.
 - Reinforce Standard Precautions (Annex C) to promote a culture of safe practices (101).

- Educate HCWs about pandemic ARDs: main pathogens, epidemiology, morbidity, routes of transmission, how to break the chain of transmission, and PPE use (risk assessment, proper ways to put on and take off, and safe disposal) (54, 55, 95, 105).
- Plan HCF areas to be used for pandemic ARD patients.
- Apply infection control precautions according to pandemic pathogen (see Table 1) (64, 159).
- Define duration of isolation precautions according to the causative pathogen (73, 74).
- Specimen collection/transport/handling within HCF: HCWs should use infection control precautions according to pandemic pathogen (Table 1) for specimen collection. Use Standard Precautions for specimen transport to the laboratory. All laboratories should follow the appropriate biosafety practices (160).
- Define safe patient transport within HCF and between HCFs.

h. Occupational health programme

- Monitor and support for HCWs' health.
- Consider appropriate vaccination (e.g. seasonal influenza vaccine) (149, 161, 162).
- Consider vaccination against new ARD of potential concern when available.
- Provide antiviral prophylaxis, if available (163-165).
- ILI surveillance among HCWs should be emphasized and may help to provide early signals of human-to-human transmission of a new ARD agent (161).
- Treat and follow up epi/pandemic ARD-infected HCWs (163, 166).
- Plan staff reassignment according to risk assessment (79, 93, 94, 167).
- Provide psychosocial support.

i. Patient flow within the HCF and discharge planning

- Heighten awareness of the ARD's clinical presentation during an outbreak period to enhance early recognition of possible cases (35).
- Plan a safe patient flow of patients to help prevent dissemination of ARD pathogens (35).
- Plan the discharge of patients based on patient's clinical conditions, assessment of patient's home conditions and capability of home caregivers to comply with instructions (see IV.2.4.2 for details).

j. Mortuary

- Mass fatalities/how to conduct burials.
- Cultural/religious aspects should be taken into consideration (121).

k. Promotion of outpatient care of ARD patients in the event of pandemic

HCFs should liaise with the health-care system (e.g. community health centres) to help support outpatient care when the patient needs higher levels of care. Likewise, acute care HCFs may refer patients to ambulatory care facilities for diagnosis, treatment and follow-up, according to the patient's clinical status (147). For additional information about infection control across the continuum of health care, see Annex J.

Annex A. Respiratory protection

A.1 High-risk aerosol-generating procedures

Aerosols are produced when air currents moves across the surface of a film of liquid, generating small particles at the air–liquid interface. The particle size is inversely related to the velocity of air. Therefore, if a procedure causes air to travel at high velocity over the respiratory mucosa and epithelium, there is potential risk of the production of tiny aerosols (e.g. droplet nuclei).

An aerosol-generating procedure is defined as any procedure on a patient that can induce the production of aerosols of various sizes, including droplet nuclei. Several medical procedures have been reported to generate aerosols (71, 72, 100, 107, 143, 168-178), and some were suggested to be associated with increased risk of pathogen transmission (Table 6) (71, 72, 100, 107, 130, 143, 168, 169, 171, 172, 174-182). Many of the latter studies have significant methodological flaws that preclude the use of their conclusions to draw recommendations. In fact, the risk associated with many of the aerosol-generating procedures is not yet well-defined, and the understanding of the aerosol-generating procedures' aerobiology may change and evolve with further studies in the area. Table 6 describes some of the studies evaluating the infection risk associated with these procedures. For the purpose of this document, the term “aerosol-generating procedure associated with documented increase in risk of pathogen transmission” refers to the performance of the following procedures in ARD patients:

- intubation and related procedures (e.g. manual ventilation, suctioning) (71, 72, 169);
- cardiopulmonary resuscitation (169);
- bronchoscopy (174, 175);
- surgery and autopsy (130, 178).

Table 6 . Risk of transmission of respiratory pathogens during aerosol-generating procedures

Procedure	Ref no.	Type of study
Documented increase in risk of respiratory pathogen transmission		
○ Intubation, cardiopulmonary resuscitation and related procedures (e.g. manual ventilation, suction)	(71, 169, 179)	Epidemiological studies on tuberculosis and SARS
○ Bronchoscopy	(174, 175)	Epidemiological studies on tuberculosis
○ Autopsy/surgery	(130, 178)	Epidemiological studies on tuberculosis
Controversial/possible increase in risk of respiratory pathogen transmission		
○ Non-invasive positive-pressure ventilation and bilevel positive airway pressure	(71, 107)	Epidemiological studies on SARS
○ High-frequency oscillating ventilation	(71)	Epidemiological studies on SARS
○ Nebulization	(107)	Epidemiological studies on SARS

Additional precautions for HCWs performing aerosol-generating procedures on ARD patients appear warranted (183).

A.1.1 PPE for aerosol-generating procedures

- PPE should cover the torso, arms, hands, eyes, nose, and mouth, and should include long-sleeved gown, single-use gloves, eye protection (e.g. goggle, face shield) and respiratory protection. Use of a hair cover is optional.
- A particulate respirator at least as protective as a NIOSH-certified N95, EU FFP2 or equivalent (see section A2 for details) is the minimum level of respiratory protection required for HCWs performing aerosol-generating procedures associated with a documented increased risk of respiratory pathogen transmission.

A.1.2 Environmental controls for aerosol-generating procedures

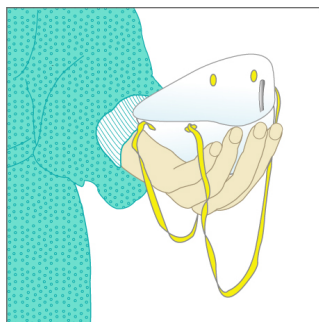
- Perform the procedure in an adequately-ventilated single room and away from other patients.
- For ARD of potential concern patients receiving high flow oxygen supplement or non-invasive positive pressure ventilation, addition of an expiratory port with a bacterial/viral filter (e.g. HEPA filter) can reduce aerosol emission.
- For ARD of potential concern patients receiving intermittent positive pressure ventilation, bacterial/viral filters (e.g. HEPA filters) could be attached to the expiratory ports of the ventilations and, whenever possible, use a closed tracheal suctioning system for aspiration of respiratory secretions.

A.2 Selection of respiratory protection equipment

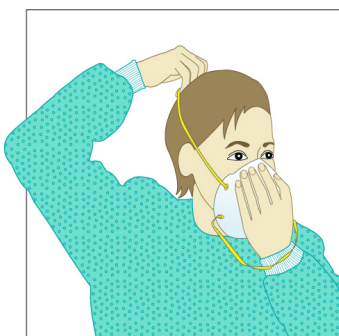
Particulate respirators

- HCWs caring for patients infected with an organism of unknown transmission mode, or known or suspected airborne pathogen, or when undertaking aerosol-generating procedures, should select the highest level of respiratory protection equipment available, preferably a particulate respirator.
- The fit and seal of disposable particulate respirators is important for effective function. If there is not a good fit and seal, airborne particles may be inhaled from leaks, and the particulate respirator may not be effective.
- Particulate respirator wearers should be trained how to use the device (e.g. putting on of respirator, avoidance of self-contamination during use and upon removal, and ways to achieve the best seal) (105). The application of fit testing to improve HCWs' ability to comply with adequate use of respirators has been evaluated and has not been shown to be an effective means to improve compliance. Hospitals should follow local regulations regarding the regular performance of the fit test.
- A user seal check should be performed each time a disposable particulate respirator is worn (see Figure 4).

Figure 4. Sequence of a particulate respirator seal check



- 1** Cup the respirator in your hand with the nosepiece at your fingertips allowing the headbands to hang freely below your hand



- 2** Position the respirator under your chin with the nosepiece up



- 3** Pull the top strap over your head resting it high at the back of your head. Pull the bottom strap over your head and position it around the neck below the ears



- 4** Place fingertips of both hands at the top of the metal nosepiece. Mould the nosepiece (USING TWO FINGERS OF EACH HAND) to the shape of your nose. Pinching the nosepiece using one hand may result in less effective respirator performance



- 5** Cover the front of the respirator with both hands, being careful not to disturb the position of respirator

5A Positive seal check

- Exhale sharply. A positive pressure inside the respirator = no leakage. If leakage, adjust position and/or tension straps. Retest the seal.
- Repeat the steps until respirator is sealed properly

5B Negative seal check

- Inhale deeply. If no leakage, negative pressure will make respirator cling to your face.
- Leakage will result in loss of negative pressure in the respirator due to air entering through gaps in the seal

- Facial hair impedes good fit, and seal may not be achieved, decreasing the efficiency of the particulate respirator. HCWs with facial structure abnormalities also may be unable to obtain a good seal and need alternative approaches for respiratory protection.
- Examples of acceptable disposable particulate respirators in use in various parts of the world include:
 - Australia/New Zealand: P2 (94%), P3 (99.95%)
 - China: II (95%), I (99%)
 - European Union: CE-certified filtering face-piece class 2 (FFP2) (95%), or class 3 (FFP3) (99.7%)
 - Japan: 2nd class (95%), 3rd class (99.9%)
 - Republic of Korea: 1st class (94%), special (99.95%)
 - United States: NIOSH-certified N95 (95%), N99 (99%), N100 (99.7%).
- Some factors to consider when choosing particulate respirators in the health-care setting include affordability, availability, impact on mobility, impact on patient care, potential for exposure to higher levels of aerosolized respiratory secretions, and potential for reusable particulate respirators to serve as fomites for transmission.
- Particulate respirators should be changed if they become wet or dirty.

Medical (surgical or procedure) masks

- Medical masks are flat/pleated masks (some are like cups) affixed to the head with straps. Medical masks are indicated when providing care for patients infected by droplet-transmitted pathogens and/or as part of facial protection during patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions or excretions.
- Medical masks may not offer adequate respiratory protection against small-particle aerosols (droplet nuclei) and should not be used when caring for patients with diseases caused by pathogens transmitted by the airborne route unless particulate respirators are not available (*184-186*).
- Medical masks are not designed to provide a face seal and thus do not prevent leakage around the edge of the mask when the user inhales, which is a potential major limitation for protection against droplet nuclei (*187*).
- Medical masks should be changed if they become wet or dirty.

Medical mask standards

Medical masks protect the wearer's nose and mouth from inadvertent exposures (i.e. splashes) to blood and other body fluids. However, there are no minimum standards or standardized testing methods for mask filter efficiency, and there is a wide variety of filter efficiencies among available masks. As an example of standards, AORN recommends that surgical masks filter particles at least 0.3 μ for regular use and 0.1 μ for laser use (i.e. to protect the wearer against laser smoke), or have 90–95% bacterial filtration efficiency. Furthermore, surgical masks are classified as medical devices in the United States and are regulated by the Food and Drug Administration (FDA). The FDA standards for surgical masks are as follows:

- Fluid resistance
 - American Society for Testing and Materials (ASTM) F 1862-00a: standard test method for resistance of surgical mask to penetration by synthetic blood.

- Filtration efficiency
 - particulate filtration efficiency (PFE) – 0.1 μ polystyrene latex sphere
 - bacterial filtration efficiency (BFE) – ASTM F 2101-01: standard test method for evaluating the BFE of surgical masks using a biological aerosol of *Staphylococcus aureus*.
- Air exchange (differential pressure, delta-P)
 - measure of breathability and comfort of surgical masks
- Flammability
 - Class 1 and Class 2 flammability rating material for use in the operating room (OR).
 - Class 4 flammability rating is not appropriate for use in OR (would be labelled as “**not for OR use**”).
- Biocompatibility¹

¹ For more information, see: <http://www.fda.gov/cdrh/ode/guidance/094.html>

Annex B. Principles and design of natural ventilation

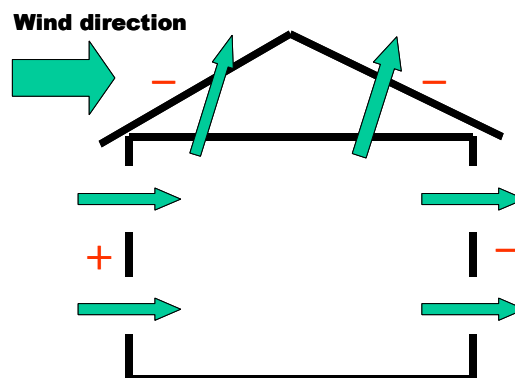
B.1 Principles of natural ventilation

Two forces drive natural ventilation; wind pressure and stack pressure (188).

Wind pressure

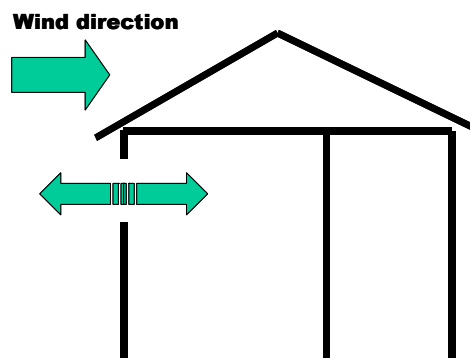
When wind strikes a building, it induces positive pressure on the windward face, and negative pressure on the leeward face. This drives the air to flow in through windward openings in the building to the low pressure openings at the leeward face (Figure 5). It is possible to estimate the wind pressures for simple buildings (189). For simple buildings, existing data from wind tunnel tests may be used directly. For complex buildings, either wind tunnel tests (188) or computational fluid dynamics (190) may be needed.

Figure 5 . Wind-induced air flow directions in a building (189)



For single-sided ventilation, as shown in Figure 6, there is no contribution from mean wind pressures, but only from the fluctuating components. Correspondingly, the resulting ventilation flow rate may be significantly lower than that which can be achieved with cross ventilation. This single-sided ventilation design, which is the most commonly seen design in hospitals, cannot establish the pressure difference to drive constant air flow across the building, but can introduce pressure fluctuation and turbulent flow. The conditions can be improved by installing vent openings or exhaust fans to enhance ACH (189).

Figure 6. Turbulence and pressure fluctuation generate single-sided air flow (189)



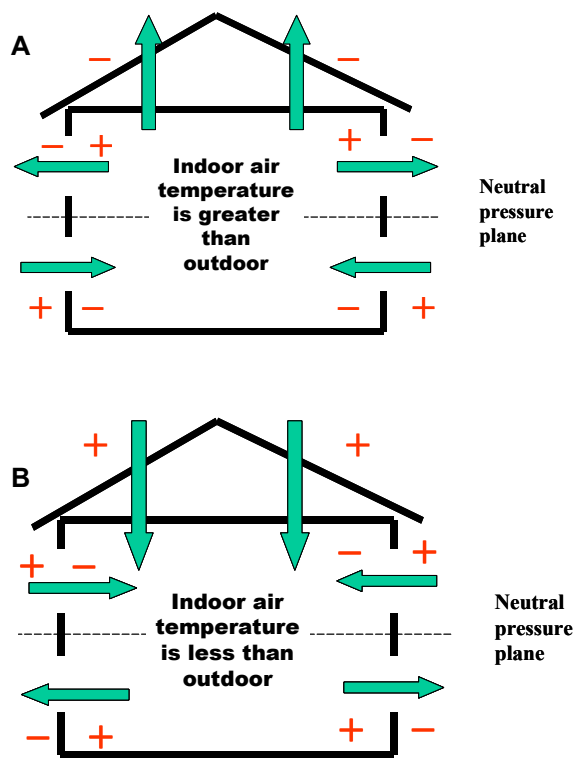
Stack pressure

Stack pressure is generated by air temperature and humidity differences between indoor and outdoor air. These differences are associated with the different air densities between indoor and outdoor air that result in an imbalance in the pressure gradients of the interior and exterior air columns. This imbalance results in a vertical pressure difference.

As shown in Figure 7A, when the room air is warmer than the outside air, the room air is lighter and rises. Air enters the building through lower openings, and escapes from upper openings.

The flow direction reverses when the room air is cooler than the outside air (Figure 7B). In this situation, the room air is heavier than the outside air. Air enters the building through the upper openings, and escapes from the lower openings. In practice, wind and stack pressures can interact, either assisting or opposing each other (191).

Figure 7. Stack driving air flow in a building: A) indoor air is warmer than outdoor air; and B) indoor air is cooler than outdoor air



B.2 Design of natural ventilation

As mentioned previously, the design of natural ventilation is important to achieve adequate ventilation, and also to reduce the risk of spread of respiratory infection. Careful analysis should be done of the prevailing winds (availability of winds). There are three hierarchies of design processes related to natural ventilation design (135-137):

1. Site design

Site design involves the building location, layout, orientation, and landscaping, which would best use the natural air flow patterns on the site to increase the potential for natural ventilation.

2. Building design

Building design includes the type of building, building function, building form, envelope, natural ventilation strategy, internal distribution of space and functions, thermal mass, heating, ventilation, and air conditioning (HVAC) system (if present).

There are a number of basic natural ventilation techniques. A list of options for natural ventilation may be useful to engineers, and allows them to adapt, as a design solution, a specific technique for a specific building based on the pros and cons of each option. For a particular design, various combinations may be possible for the site and building design. The basic methods most commonly adopted include the cross ventilation design and the passive stack method.

Cross ventilation

Cross ventilation allows outdoor air to flow across a room from one side to another by wind forces. This can generally be achieved by placing two openings opposite one another, one in the windward and another in the leeward face. Large windows for living spaces in the windward side would create a funnel effect to induce more incoming air. Interior partitions and furniture should not block the air flow. Large open spaces should always have large windows in opposite walls.

As a rule of thumb, the ACH for wind-driven natural ventilation through a room with two opposite openings (e.g. a window and a door), can be calculated as:

$$\text{Air change rate} = \frac{0.8 \times \text{wind speed (m/s)} \times \text{the smaller opening area} \times 3600}{\text{room volume}}$$

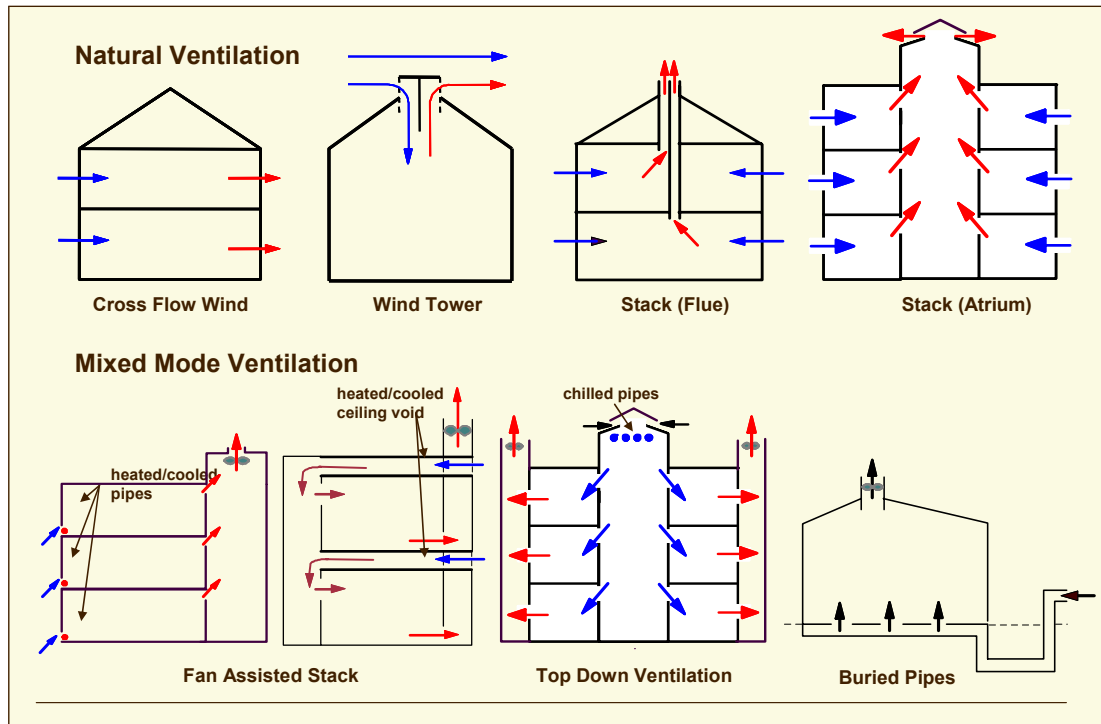
Passive stack ventilation

Passive stack ventilation allows outdoor air to be driven through the stack by a combination of stack pressure and wind-induced suction pressure. Stack means a vertical pipe or duct. Air enters the building through lower vents provided for this purpose and is exhausted through the stack. For the system to work properly, each room is equipped with a separate stack, particularly in rooms where extraction is needed. Sometimes, a central stack links stack branches from each room, but this can create a risk of cross contamination between connected rooms. Stacks will not work alone. Air inlets also must be provided through intentional openings. The stack termination on the roof should be located in negative pressure regions to provide additional suction. If not designed properly, flow reversal can occur. If this flow reversal only occurs temporarily, it should not result in an indoor air quality problem, provided that the flow path is designed properly.

Other methods

Other methods include atria ventilation, solar chimneys, and wind towers, and can be integrated in the building design to enhance the effectiveness of natural ventilation (see Figure 8).

Figure 8. Illustration of different natural and mixed mode ventilation systems (courtesy of Professor Martin Liddament, personal communication) (189)



3. Vent opening design

Vent opening design involves the position of openings, types of openings, size of openings, and control strategy. These elements are briefly described below.

- The total area of inlets should be as close as possible to the total area of outlets.
- Vent openings should be positioned to avoid possible conflict between cross and stack ventilation, human cooling, or thermal mass cooling.
- Types of openings (windows, screens, louvers, solar chimneys, passive stacks) should be determined by the ventilation requirements. The two main requirements are minimum ventilation requirements and transient high ventilation requirements.
 - Minimum ventilation requirements require permanently open vents. This requirement can be calculated based on the specifications in ventilation standards for acceptable indoor air quality (e.g. 12 ACH).
 - Transient high ventilation requirements require controllable large openings. There are no regulations to specify these requirements. Achieving a transient high ventilation rate is one of the most important benefits of natural ventilation. The transient high ventilation rate may also be needed when there are renovation activities in the building which generate very large amounts of pollutants in the air. Windows and doors that can be opened, and louvers, are the openings suitable for this purpose.
- Size of openings should be designed to achieve the required ventilation flow rates based on certain geometry, climate, and building design data. Size of openings is also a function of the opening distribution, which is a part of the ventilation strategy.
- The methods to estimate the ventilation flow rate can be direct and indirect.

- Direct methods, also referred to as “explicit methods,” (192) are derived from the analytical solutions for ventilation in simple buildings. The ventilation flow rate can be a simple function of the governing parameters.
- Indirect methods use network models to estimate the effect of different opening size combinations, and then identify the optimum size (193).
- The effect of the temperature difference between the indoor and outdoor air also is worthy of discussion. Generally, the indoor air temperature should be maintained at comfort levels (194), e.g. between 20 °C and 28 °C. This means that the amount of the air temperature difference is a function of outdoor air temperature. During winter in a cold climate, the outdoor air temperature can be very low, and there will be a greater driving force for natural ventilation. This means that a small opening area may be used in cold climate. Care also should be taken to ensure that no cold draughts are introduced and some preheating of the outdoor air may be useful, such as placing a heater just below the ventilation inlet, e.g. below a window opening. During spring and autumn in moderate climates, the outdoor air temperature can be very close to the indoor air temperature, and the driving force (pressure differential) may be very small.

Annex C. Routine and specific infection control precautions

C.1 Standard Precautions

Standard Precautions (64) are **routine** infection control precautions that should apply to **ALL** patients, in **ALL** health-care settings.

Rationale

Standard Precautions are the basic infection control precautions in health care. They are meant to minimize spread of infection associated with health care and to avoid direct contact with patient's blood, body fluids, secretions and non-intact skin. The SARS outbreak illustrated the critical importance of basic infection control precautions in HCFs. Transmission of SARS in HCFs was often associated with noncompliance with Standard Precautions. The threat of emerging respiratory infectious diseases makes the promotion of Standard Precautions more important than ever, and it should be a priority in all HCFs.

For additional information on Standard Precautions, see:

Practical guidelines for infection control in health care facilities 2004,¹

Prevention of hospital-acquired infections: A practical guide, 2002,²

Aide-memoire, Infection control standard precautions in health care, 2006.³

Detailed recommendations for each of the Standard Precautions components are described below.

C.1.1 Hand hygiene

Hand hygiene is one of the most important measures to prevent and control spread of disease in HCFs and is a major component of Standard Precautions. Although it is a simple procedure, numerous studies have shown that compliance with hand hygiene is low. Its implementation is complex, requiring continued reinforcement and multidisciplinary team coordination. The use of alcohol-based hand rubs in HCFs has been implemented in recent years in an attempt to increase compliance with hand hygiene. The main points are:

- Routine hand hygiene is performed by using an alcohol-based hand rub if hands are not visibly soiled, or by washing hands with soap and water and using a single-use towel for drying hands.
- If hands are visibly dirty or soiled with blood, or other body fluids, or if broken skin might have been exposed to potentially infectious material, hands should be washed thoroughly with soap and water.

Indications for hand hygiene:

- Before and after any direct patient care.
- Immediately after gloves are removed.
- Before handling an invasive device not requiring a surgical procedure, including central intravascular catheters, urinary catheters, or peripheral vascular catheters.
- After touching blood, body fluids, secretions, excretions, non-intact skin, and contaminated items, even if gloves are worn.

¹ Available at : http://www.wpro.who.int/publications/PUB_9290222387.htm

² Available at http://www.who.int/csr/resources/publications/drugresist/WHO_CDS_CSR_EPH_2002_12/en/

³ Available at : http://www.who.int/csr/resources/publications/4EPR_AM2.pdf

- When moving from a contaminated to a clean body site during patient care, within the same patient.
- After contact with inanimate objects in the immediate vicinity of the patient.
- After using the lavatory.

For additional information on hand hygiene, see:

WHO guidelines on hand hygiene in health care (advanced draft), 2006¹

C.1.2 Selection of PPE based on risk assessment

- ROUTINELY ASSESS THE RISK of exposure to body substances or contaminated surfaces BEFORE any anticipated health-care activity.
- Select PPE based on the assessment of risk.
- Have appropriate PPE available in the event of an unexpected emergency.

Gloves

- Gloves should be worn whenever contact with blood, body fluids, secretions, excretions, mucous membranes, or non-intact skin is anticipated.
- Change gloves between tasks and procedures on the same patient after contact with potentially infectious material.
- Remove gloves after use, before touching non-contaminated items and surfaces, and before going to another patient.
- Perform hand hygiene immediately after glove removal.

Facial protection

Wear facial protection, including a medical mask and eye protection (face shield, goggles), to protect the conjunctivae and the mucous membranes of the nose, eyes and mouth during activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. When providing care, in close contact with a patient with respiratory symptoms (e.g. coughing/sneezing), sprays of secretions may occur and eye protection should be used.

Gowns

- Wear gowns to protect skin and prevent soiling of clothing during activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions.
- Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. If the gown in use is not fluid-resistant, a waterproof apron should be worn over the gown if splashing or spraying of potentially infectious material is anticipated.
- Remove soiled gown as soon as possible, place it in a waste or laundry receptacle (as appropriate), and perform hand hygiene.

C.1.3 Respiratory hygiene/cough etiquette

Controlling the spread of pathogens from infected patients (source control) is key to avoid transmission to unprotected contacts. For diseases transmitted through large droplets and/or droplet nuclei, respiratory hygiene/cough etiquette should be applied by all individuals with respiratory symptoms (60). All individuals (HCWs, patients and visitors) with signs and symptoms of a respiratory infection should:

¹ Available at: http://www.who.int/patientsafety/information_centre/ghhad_download/en/index.html

- cover their mouth and nose when coughing/sneezing;
- use tissues, handkerchiefs, cloth masks or medical masks if available, as source control to contain respiratory secretions, and dispose of them into the waste containers;
- use a medical mask on a coughing/sneezing person when tolerated and appropriate; and
- perform hand hygiene.

HCF management should promote respiratory hygiene/cough etiquette:

- promote the use of respiratory hygiene/cough etiquette by all HCWs, patients and family members with acute febrile respiratory illness;
- educate HCWs, patients, family members, and visitors on the importance of containing respiratory aerosols and secretions to help prevent the transmission of respiratory diseases;
- consider providing resources for hand hygiene (e.g. dispensers of alcohol-based hand rubs, hand-washing supplies) and respiratory hygiene (e.g. tissues); areas of gathering, such as waiting rooms, should be prioritized.

C.1.4 Environmental controls: cleaning and disinfection

The viruses and bacteria that cause ARDs can survive in the environment for variable periods of time (hours to days), the environmental bioburden can be reduced by cleaning, and infectious agents can be inactivated by the use of standard hospital disinfectants. Environmental cleaning and disinfection is intended to remove pathogens or significantly reduce their numbers on contaminated surfaces and items, thus breaking the chain of transmission. Disinfection is a physical or chemical means of killing microorganisms (but not spores).

- Cleaning MUST precede disinfection. Items and surfaces cannot be disinfected if they are not first cleaned of organic matter (patient excretions, secretions, dirt, soil, etc).
- The cleaning process should be performed so as to avoid possible aerosolization. This process alone reduces significantly the environmental bioburden.
- Follow the manufacturers' recommendations for use/dilution, contact time, and handling of disinfectants.
- The viruses and bacteria that cause ARDs are inactivated by a range of disinfectants (66, 195-199). However, in some countries, regulatory agencies will control the types of disinfectant available for hospital use. Common hospital disinfectants include:
 - sodium hypochlorite (household bleach) (Annex H)
 - alcohol (Annex H)
 - phenolic compounds
 - quaternary ammonium compounds
 - peroxygen compounds.
- Sodium hypochlorite and alcohol are available in most countries. The use of these two disinfectants is detailed in Annex H.

C.1.4.1 Cleaning the patient-care environment

- Horizontal surfaces in isolation rooms/areas, particularly those where the patient has been lying and/or has frequently touched, and immediately around the patient's bed, should be cleaned regularly and on discharge (200).
- To avoid possible aerosolization of ARD pathogens, damp cleaning (moistened cloth) rather than dry dusting or sweeping should be performed.
- During wet cleaning, cleaning solutions and equipment soon become contaminated; change cleaning solutions, cleaning cloths, and mop heads frequently according to HCF policies.
- Equipment used for cleaning and disinfection must be cleaned and dried after each use.
- Mop heads should be laundered daily and dried thoroughly before storage or reuse (201).
- To facilitate daily cleaning, keep areas around the patient free of unnecessary supplies and equipment.

- Use disinfectant to wipe down the table and surrounding areas after attendance by patients known or suspected to be infected with an ARD of potential concern (35). If available, paper sheeting that is changed between patients may be useful for patient examination tables, after cleaning between patients.
- Do not spray (i.e. fog) occupied or unoccupied rooms with disinfectant. This is a potentially dangerous practice that has no proven disease control benefit (202).
- To facilitate cleaning, and to reduce the potential for aerosolization caused by use of a vacuum cleaner, accommodate patients in uncarpeted rooms/areas, if possible. If vacuuming is necessary, use a vacuum cleaner with a high-efficiency particulate air (HEPA) filter, if available.

C.1.4.2 Patient-care equipment

- If equipment is reused, follow general protocols for disinfection and sterilization (203, 204).
- If not visibly soiled, wipe external surfaces of large portable equipment (e.g. X-ray machines, ultrasound machines) that has been used in the isolation room/area with an approved hospital disinfectant upon removal from the patient's room/area.
- Proper cleaning and disinfection of reusable respiratory equipment is essential in ARD patient care (205-209). See Annex H for further details on use of disinfectants.

C.1.4.3 Dishes and eating utensils

- When possible, wash reusable items in a dishwasher (210, 211). If dishwashers are not available, the items should be washed by hand with detergents. Nonsterile rubber gloves should be used if washing items by hand.
- Dishes and eating utensils for the patient should be washed after each meal/use.
- Disposable items should be discarded as waste, classified as directed by the relevant state/territory or national legislation and regulations (4).

C.1.4.4 Linen and laundry

- Remove large amounts of solid material (e.g. faeces) from heavily soiled linen (wearing appropriate PPE) and place the solid wastes into a toilet for disposal before linen is placed into the laundry bag (212-214).
- Avoid sorting linens in patient-care areas. Place contaminated linen directly into a laundry bag in the isolation room/area with minimal manipulation or agitation to avoid contamination of air, surfaces, and persons (4).
- Wash and dry linen according to routine HCF standards and procedures. For hot-water laundry cycles, wash with detergent/disinfectant in water at 70 °C (160 °F) for at least 25 minutes. Choose a chemical suitable for low-temperature washing at proper use concentration if low-temperature < 70 °C (< 160 °F) laundry cycles are used (215-217).

C.1.5 Waste management

Waste disposal should be safe for those handling the waste and for the environment.

Definitions of clinical (infectious) waste may differ according to local regulations and legislations.

- Waste should be classified as directed by relevant state/territory or national legislation, and regulations. If waste from ARD infected patients is classified as infectious, then all waste from the patient-care area should be considered as clinical waste, and should be treated and disposed of according to HCF policy, and in accordance with national regulations pertaining to such waste (4).
- Faeces should be handled with caution to avoid possible aerosolization (e.g. during removal of faeces from bedpan, commode, clothing, or spraying reusable incontinence pads with water) (212).
- Liquid waste such as urine, or solid faecal waste, can be flushed into the sewerage system, if there is an adequate system in place (218, 219).

- HCWs should use appropriate PPE whenever there is risk of splash/spray during handling of waste (64).

C.1.6 Packing and transporting patient-care equipment, linen and laundry, and wastes from isolation areas

- Place used equipment and soiled linen and waste directly into containers or bags in the isolation room/area.
- Contain the used equipment and soiled linen and waste in a manner that prevents the containers or bags from opening or bursting during transport.
- One layer of packing is adequate providing the used equipment and soiled linen and waste can be placed in the bag without contaminating the outside of the bag. Double bagging is unnecessary.
- All personnel handling the used equipment and soiled linen and waste should use Standard Precautions, and perform hand hygiene after removing PPE.

C.1.7 Prevention of needle stick/sharp injuries

Although it may not be crucial for prevention and control of ARDs, prevention of needle stick/sharp injuries is a component of Standard Precautions, and targets the reduction and elimination of transmission of bloodborne pathogens to HCWs, other patients, and persons with any possible contact with the related waste. Detailed recommendations are addressed by the Safe Injection Global Network (SIGN) Alliance, at:¹

- Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning used instruments, or when disposing of used needles.
- Never recap used needles.
- Never direct the point of a needle towards any part of the body except prior to injection.
- Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand.
- Dispose of syringes, needles, scalpel blades, and other sharp items in appropriate puncture-resistant containers, which should be located as close as practical to the area in which the items were used.
- Avoid the use of reusable syringes.

C.2 Droplet Precautions (64)

Respiratory pathogens that are transmitted through large droplets include adenovirus, human influenza, SARS and avian influenza A (H5N1). Adenovirus infections are more common among children, and influenza and SARS can affect both adults and children. During an influenza pandemic, the circulating human virus is expected to be transmitted in the same manner as seasonal influenza viruses, and so Droplet Precautions should be applied in addition to Standard Precautions.

Droplet Precautions include:

- **PPE:** the use of a medical mask if working within 1 m of the patient (101, 220-222). For practical purposes, use of a medical mask when entering the patient's room is advised.
- **Patient placement:** in single rooms or cohort patients with the same etiological diagnosis. If an etiological diagnosis is not possible, group patients with similar clinical diagnosis and based on epidemiological risk factors, with a spatial separation ≥ 1 m.

¹ http://www.who.int/injection_safety/sign/en/ and are summarized below:

- **Patient transport:** limit patient movement; the patient should wear medical mask outside their room.

C.3 Contact Precautions (64)

In addition to transmission by large droplets, some common respiratory pathogens [e.g., parainfluenza and respiratory syncytial virus (RSV)] can be transmitted through contact; particularly hand contamination and self-inoculation into conjunctival or nasal mucosa. Contact transmission may also play a role in SARS and avian influenza A (H5N1) infections.

Contact Precautions include:

- **PPE:** (put on when entering the room and removed when leaving)
 - Gloves: clean, nonsterile, latex gloves should be used, and worn and be disposed after each patient contact
 - Gown:
 - A disposable gown made of synthetic fibre, or a washable cloth gown may be used. Ensure that gowns are of the appropriate size to fully cover the areas to be protected.
 - Gowns should preferably be worn once and then placed in a waste or laundry receptacle, as appropriate, and hand hygiene performed.
 - Aprons should only be used when the gown is permeable to reduce fluid penetration. They should not be used alone to prevent contact contamination.
- **Equipment and environment**
 - If possible, use either disposable equipment or dedicate equipment, such as stethoscopes, blood pressure cuffs, thermometers, etc, to patients under Contact Precautions. If equipment needs to be shared among patients, it must be cleaned and disinfected between each patient use.
 - HCWs should refrain from touching their eyes, nose, or mouth with potentially contaminated gloved or ungloved hands (223).
 - Avoid contaminating environmental surfaces that are not directly related to patient care (e.g. door handles, light switches).
- **Patient placement:** use of single rooms or cohorting patients with the same etiological diagnosis may facilitate the application of infection control measures.
- **Patient transport:** limit patient movement ; contact with other non-infected persons should be minimized.

C.4 Airborne Precautions

Airborne pathogens are transmitted through inhalation of droplet nuclei that remain infectious over a long distance (e.g. > 1m), and require special air handling (2, 3). Their transmission is further classified as obligate or preferential (5). Obligate airborne transmission applies to agents naturally transmitted exclusively through droplet nuclei deposited in the distal part of the lung (e.g. *Mycobacterium tuberculosis* causing pulmonary tuberculosis) (5). Preferential airborne transmission applies to pathogens which are transmitted by droplet nuclei deposited in the airways but which can also be transmitted by other routes (e.g. measles) (5).

Transmission of droplet nuclei at short range may also occur with human influenza, and perhaps other respiratory viral infections, during special circumstances, such as the performance of aerosol-generating procedures associated with pathogen transmission (see Annex A.1) performed in inadequately ventilated rooms or lack of adequate use of PPE (e.g. SARS). This type of transmission has been referred to as "opportunistic airborne transmission" (5), and DOES NOT constitute the classical airborne transmission which involves transmission over a long distance (2).

C.4.1 Infection control precautions for airborne diseases

For airborne pathogens (2, 3, 224, 225), the following should be added to Standard Precautions:

- **PPE:** When entering the isolation room/area or when providing care to a patient with an obligate/preferential airborne infectious disease in other settings, use a particulate respirator that is at least as protective as a US National Institute for Occupational Safety and Health (NIOSH) certified N95 or equivalent (Annex A).
- **Patient placement:**
 - Place the patient in a airborne precaution room (see Section V) (1).
 - If a ventilated isolation room is not available, place patients in separate well-ventilated rooms.
 - If single rooms are not available, cohort patients according to the same etiological diagnosis in well-ventilated places.
 - Aerosol-generating procedures associated with pathogen transmission should be performed using appropriate PPE in an airborne precaution room.
- **Patient transport:** limit patient movement; the patient should wear a medical mask outside their room/area.

C.4.2 Infection control precautions for diseases that can be opportunistically transmitted through droplet nuclei

For most of these diseases, Droplet Precautions should be added to Standard Precautions, and special measures should be taken regarding room ventilation and PPE during aerosol-generating procedures associated with pathogen transmission.

- **PPE:**
 - At a minimum, use a tightly-fitting medical mask (surgical or procedure mask) when entering the patient's room; masking is mandatory if working at ≤ 1 m of the patient (226-228).
 - When performing aerosol-generating procedures associated with pathogen transmission, use a particulate respirator that is at least as protective as a NIOSH-certified N95, EU FFP2 or equivalent, and gloves, gowns and eye protection (e.g. goggles) (55, 88, 168).
- **Patient placement:**
 - Airborne precaution rooms are not obligatory. If they are available, they should be prioritized for patients with airborne transmitted diseases (21, 96);
 - Single rooms should be used if possible; if not available, may cohort according to the etiological diagnosis (21, 96). If etiological diagnosis is not possible, place patients so that they are > 1 m apart;
 - aerosol-generating procedures associated with pathogen transmission should be performed in well-ventilated single rooms (71, 72, 100, 169).
- **Patient transport:** limit patient movement; patient should wear medical mask when outside their room/area.

Annex D. Sample checklist assessment of environmental conditions for home care of patients with ARDs of potential concern

Infrastructure

Functioning telephone	Y	N
Any other means to rapidly communicate with the health system	Y	N
Potable water	Y	N
Sewerage system	Y	N
Cooking source (and fuel)	Y	N
Operable electricity	Y	N
Operable heat source	Y	N
Air conditioning	Y	N

Accommodation

Separate room/bedroom for the patient	Y	N
Accessible bathroom in the home	Y	N

Resources

Food	Y	N
Necessary medications	Y	N
Medical masks (patient)	Y	N
Medical masks (care providers, household contacts)	Y	N
Gloves	Y	N
Hand hygiene items (soap, alcohol-based hand rub)	Y	N
Household cleaning products	Y	N

Primary care and support

Person to provide care and support	Y	N
Access to medical advice/care	Y	N
Any at-risk people at home (e.g. children < 2 years of age, elderly > 65 years of age, immunocompromised people)	Y	N

Annex E. Sample HCW influenza-like illness monitoring form for HCW exposed to patients with ARDs of potential concern

Name: _____ Home telephone number: _____

Job title: _____ Work location: _____

Date/s of exposure (list all, use back of page if necessary): ____/____/____ ____/____/____

Type of contact with patient with ARD of potential concern, with patient's environment, or with virus:

Was the following personal protective equipment (PPE) used:

PPE	Yes	No	Don't know
Gown	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gloves	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Particulate respirator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medical mask	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Eye protection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (Please specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

List any non-occupational exposures (i.e. exposure to birds or persons with severe acute febrile respiratory illness): _____

Please check your temperature twice a day, in the morning (AM) and evening (PM), for 10 days after providing care for a patient infected with an ARD of potential concern (including 10 days after your last exposure), and also monitor yourself for any of the following influenza-like illness (ILI) symptoms including:

- fever > 38 °C
- cough
- acute onset of respiratory illness
- sore throat
- arthralgia
- myalgia or prostration
- gastrointestinal symptoms (e.g. diarrhoea, vomiting, abdominal pain)

If any symptoms of ILI occur, immediately limit your interactions with others, exclude yourself from public areas, and notify _____ at _____

Day 1	Day 2	Day 3	Day 4	Day 5
Date ____/____/____	Date ____/____/____	Date ____/____/____	Date ____/____/____	Date ____/____/____
AM temperature:	AM temperature:	AM temperature:	AM temperature:	AM temperature:
PM temperature:	PM temperature:	PM temperature:	PM temperature:	PM temperature:
ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____

Day 6	Day 7	Day 8	Day 9	Day 10
Date ____/____/____	Date ____/____/____	Date ____/____/____	Date ____/____/____	Date ____/____/____
AM temperature:	AM temperature:	AM temperature:	AM temperature:	AM temperature:
PM temperature:	PM temperature:	PM temperature:	PM temperature:	PM temperature:
ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____	ILI symptoms: No ____ Yes ____

F. Isolation rooms/areas

F.1 Preparation of the isolation room/area

- Ensure appropriate hand-washing facilities.
- Ensure appropriate room ventilation (e.g. 12 ACH).
- Post signage on the door.
- Before being allowed into the isolation areas, visitors should consult the nurse in charge, who is also responsible for keeping a visitor record. A roster of all staff working in the isolation areas should also be kept for possible outbreak investigation and contact tracing.
- Remove all non-essential furniture; the remaining furniture should be easy to clean, and should not conceal or retain dirt or moisture within or around it.
- Stock PPE supply and linen outside the isolation room/area (e.g. in the change room).
- Stock the sink area with suitable supplies for hand washing, and with alcohol-based hand rub near the point-of-care and room door.
- Place appropriate waste bags in a bin. If possible, use a touch-free bin. Dirty bins should remain inside the isolation rooms.
- Place a puncture-proof container for sharps disposal inside the isolation room/area.
- Keep the patient's personal belongings to a minimum. Keep water pitchers and cups, tissue wipes, and all items necessary for attending to personal hygiene within the patient's reach.
- Non-critical patient-care equipment (e.g. stethoscope, thermometer, blood pressure cuff, sphygmomanometer) should be dedicated to the patient, if possible. Any patient-care equipment that is required for use by other patients should be thoroughly cleaned and disinfected before use.
- Set up a trolley outside the door to hold PPE. A checklist may be useful to ensure that all equipment is available (see sample checklist).
- Place an appropriate container with a lid outside the door for equipment that requires disinfection or sterilization.
- Keep adequate equipment required for cleaning or disinfection inside the isolation room/area and ensure scrupulous daily cleaning of the isolation room/area.
- A telephone or other method of communication should be set up in the isolation room/area to enable patients or family members/visitors to communicate with HCWs in order to minimize the necessity for HCWs to enter the room/area.

F.2 Wearing and removing PPE

Before entering the isolation room/area:

- Collect all equipment needed.
- Perform hand hygiene with an alcohol-based hand rub (preferably) or soap and water.
- Put on PPE in the order that ensures adequate placement of PPE items and prevents self-contamination and self-inoculation while using PPE, and when taking PPE off. As an example and shown in Figure 9, PPE can be put on in the following order: hand hygiene; gown; mask or respirator; eye protection; gloves.

Leaving the isolation room/area:

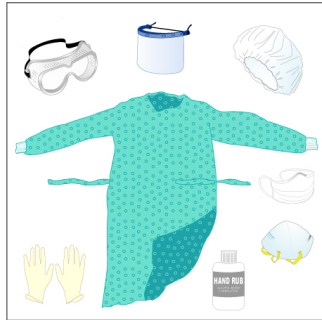
- Remove PPE either in the anteroom, or if there is no anteroom, make sure that neither the environment outside the isolation room/area nor other persons can get contaminated.
- Remove PPE in a manner that prevents self-contamination or self-inoculation with contaminated PPE or hands. General principles are:
 - Remove the most contaminated PPE items first.
 - Hand hygiene must be performed immediately after glove removal.
 - The last PPE item to be removed should be the mask or particulate respirator by grasping the ties and discarding in rubbish bin.

- Discard disposable items in a closed rubbish bin.
- Put reusable items in a dry (e.g. without any disinfectant solution) closed container. As an example of the order in which to take PPE off, it can be removed as follows (Figure 9): gloves (if gowns are disposable, gloves can be peeled off altogether with gown upon removal); hand hygiene; gown; eye protection; mask or respirator; hand hygiene.

Perform hand hygiene with an alcohol-based hand rub (preferably) or soap and water whenever ungloved hands touch contaminated PPE items.

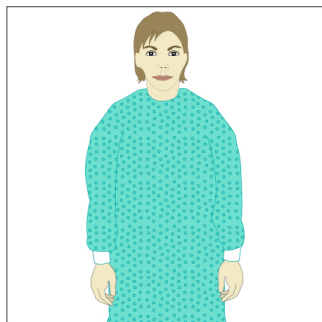
Figure 9. Putting on and removing PPE

9A. Putting on PPE (when all PPE items are needed)



1

- Identify hazards & manage risk. Gather the necessary PPE.
- Plan where to put on & take off PPE.
- Do you have a buddy? Mirror?
- Do you know how you will deal with waste?



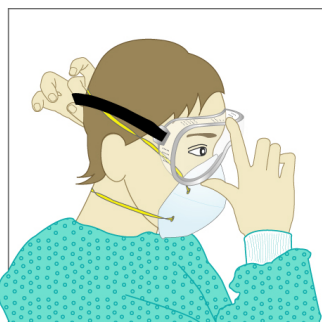
2

Put on a gown



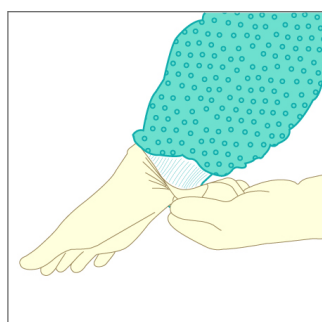
3

Put on particulate respirator or medical mask;
perform user seal check if using a respirator



4

Put on eye protection e.g. face shield/goggles
(consider anti-fog drops or fog-resistant goggles)
Caps are optional: if worn, put on after eye protection



5

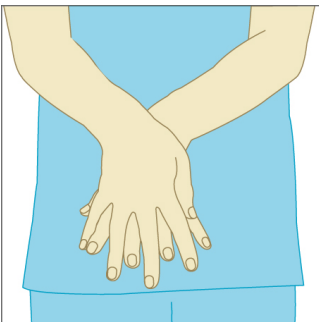
Put on gloves
(over cuff)

9B. Taking off PPE



- 1**
- Avoid contamination of self, others & the environment
 - Remove the most heavily contaminated items first

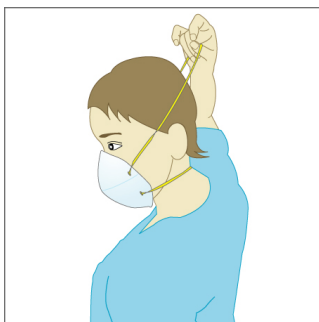
Remove gloves & gown:
- peel off gown & gloves and roll inside, out
- dispose gloves and gown safely



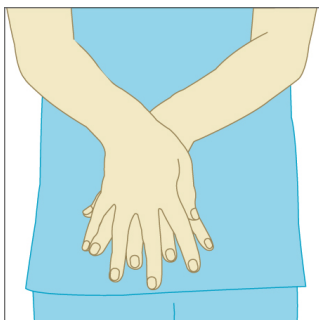
- 2** **Perform hand hygiene**



- 3**
- Remove cap (if worn)
 - Remove goggles from behind
 - Put goggles in a separate container for reprocessing



- 4** Remove respirator from behind



- 5** **Perform hand hygiene**

F.3 Suggested checklist for isolation room/area trolley/table

The following items should be kept on the trolley at all times so that PPE always is available for HCWs.

Equipment	Stock present
Face shield/visor/goggles	
Gloves <ul style="list-style-type: none"> reusable vinyl or rubber gloves for environmental cleaning latex single-use gloves for clinical care 	
Hair covers (optional)	
Particulate respirators (N95, FFP2, or equivalent)	
Medical (surgical or procedure) masks	
Gowns and aprons: <ul style="list-style-type: none"> Single-use long-sleeved fluid-resistant or reusable non-fluid-resistant gowns Plastic aprons (for use over non-fluid-resistant gowns if splashing is anticipated and if fluid-resistant gowns are not available) 	
Alcohol-based hand rub	
Plain soap (liquid if possible, for washing hands in clean water)	
Clean single-use towels (e.g. paper towels)	
Sharps containers	
Appropriate detergent for environmental cleaning and disinfectant for surface or instrument/equipment disinfection	
Large plastic bags	
Appropriate clinical waste bags	
Linen bags	
Collection container for used equipment	

For more information on isolation precautions, see:

*Practical guidelines for infection control in health care facilities*¹

*Prevention of hospital-acquired infections: A practical guide*²

For additional information on hand hygiene, see:

*WHO guidelines on hand hygiene in health care (advanced draft): a summary*³

¹ Available at : http://www.wpro.who.int/publications/PUB_9290222387.htm

² Available at: http://www.who.int/csr/resources/publications/drugresist/WHO_CDS_CSR_EPH_2002_12/en/

³ Available at: http://www.who.int/patientsafety/events/05/global_challenge/en/index.html

Annex G. Mortuary care and postmortem examination

G.1 Packing and transport of dead body to mortuary, crematorium and burial

- The body should be fully sealed in an impermeable body bag before removal from the isolation room/area and before transfer to pathology department or the mortuary to avoid leakage of body fluid.
- Transfer to the mortuary should occur as soon as possible after death.
- The body, when properly packed in the body bag, can be safely removed for storage in the mortuary, sent to the crematorium, or placed in a coffin for burial.
- If an autopsy is being considered, the body may be held under refrigeration in the mortuary and be conducted only when a safe environment can be provided for the autopsy (see section V.5).

G.2 Recommended PPE for HCWs handling the dead bodies

- Disposable long-sleeved, cuffed gown, (waterproof, if the outside of body is visibly contaminated with body fluids, excretions or secretions). Alternatively, if no waterproof gown is available, a waterproof apron should be used in addition to the gown.
- Nonsterile, latex gloves (single layer) should cover cuffs of gown.
- If splashing of body fluids is anticipated, use facial protection: face shield (preferably) or goggles and a medical mask.
- Perform hand hygiene after removal of PPE.

G.3 Recommended PPE during autopsy

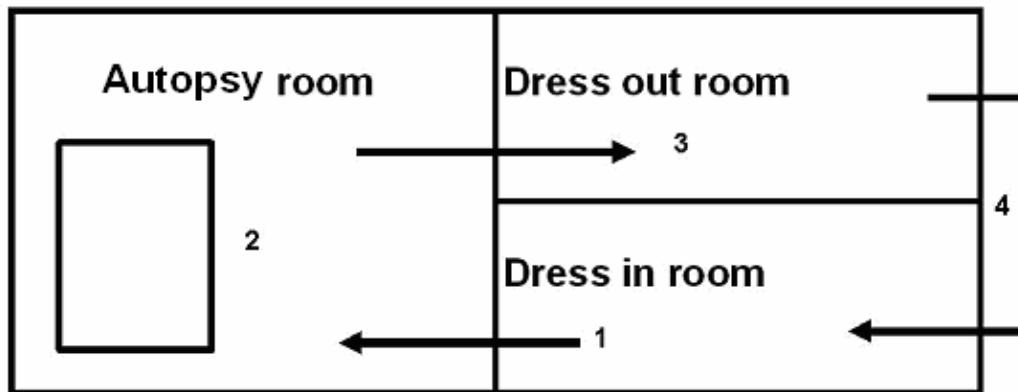
G.3.1 PPE to be provided

- scrub suits: tops and trousers, or equivalent garments
- single-use, fluid-resistant, long-sleeved gowns
- surgical masks, or if small particle aerosols might be generated during autopsy procedures, a particulate respirator at least as protective as a NIOSH-certified N95, EU FFP2 or equivalent
- face shield (preferably) or goggles
- either autopsy gloves (cut-proof synthetic mesh gloves) or two pairs of nonsterile gloves
- knee-high boots.

G.3.2 PPE placement

- HCWs should put on PPE in the dress in room (see Figure 10) before proceeding to the autopsy room where the body is located.
- In the dress in room, HCWs should replace their outer street clothes and shoes with scrub suits, or equivalent coverall garments, plus boots.
- Proceed to the autopsy room where the body is located.

Figure 10. Movement of the autopsy team undertaking a postmortem examination in a HCF



G.3.3 PPE removal

- Exit the autopsy room to the dress out room as suggested in Figure 10.
- Remove PPE in designated dress out room, dispose of the PPE in accordance with recommendations and perform hand hygiene.

G.4 Suggested methods to reduce aerosol-generation during autopsy

- Containment devices should be used whenever possible (e.g. biosafety cabinets for the handling and examination of smaller specimens).
- Vacuum shrouds should be used for oscillating saws.
- High pressure water sprays should not be used.
- Open intestines under water.

Annex H. Use of disinfectants: alcohol and bleach

In different countries, there are different disinfection protocols. HCFs with limited resources may not have access to the different types of hospital disinfectants. Alcohol and bleach are acceptable chemical disinfectants if used appropriately. As with any other disinfectants, soiled surfaces need to be cleaned with water and detergent before applying alcohol or bleach.

Alcohol

Alcohol is effective against influenza virus (229). Ethyl alcohol (70%) is a powerful broad-spectrum germicide and is considered generally superior to isopropyl alcohol. Alcohol is often used to disinfect small surfaces (e.g. rubber stoppers of multiple-dose medication vials, and thermometers) and occasionally external surfaces of equipment (e.g. stethoscopes and ventilators). Because alcohol is flammable, its use as a surface disinfectant should be limited to small surface areas and it should be used in well-ventilated spaces only. Alcohol may also cause discoloration, swelling, hardening, and cracking of rubber and certain plastics after prolonged and repeated use.

Sodium hypochlorite (bleach)

Bleach is a strong and effective disinfectant, but it is readily inactivated in the presence of organic material. Its active ingredient, sodium hypochlorite, is effective in killing bacteria, fungi and viruses, including influenza virus. Diluted household bleach disinfects within 10–60 minutes contact time (see Table 7 for concentrations and contact times), is widely available at a low cost, and may be recommended for surface disinfection in HCFs. However, bleach irritates mucous membranes, the skin and the airways, decomposes under heat and light, and reacts readily with other chemicals. Therefore, caution is advised when bleach is used. Ventilation should be adequate and consistent with relevant occupational health and safety guidance. Improper use of bleach, including deviation from recommended dilutions (either stronger or weaker), may reduce its effectiveness for disinfection and can result in HCW injury.

Procedures for preparing/using diluted bleach

- Use a mask, rubber gloves, and waterproof apron. Goggles also are recommended to protect the eyes from splashes.
- Mix and use bleach solutions in well-ventilated areas.
- Mix bleach with cold water because hot water decomposes the sodium hypochlorite and renders it ineffective.
- Bleach containing 5% sodium hypochlorite should be diluted as shown in Table 7 below.

Table 7. Sodium hypochlorite: concentration and use

Starting solution

Most household bleach solutions contain 5% sodium hypochlorite (50 000 ppm^a available chlorine)

Recommended dilution

1:100 dilution of 5% sodium hypochlorite is the usual recommendation. Use 1 part bleach to 99 parts cold tap water (1:100 dilution) for disinfection of surfaces

Adjust ratio of bleach to water as needed to achieve appropriate concentration of sodium hypochlorite, e.g. for bleach preparations containing 2.5% sodium hypochlorite, use twice as much bleach (i.e. 2 parts bleach to 98 parts water)

Available chlorine after dilution

For bleach preparations containing 5% sodium hypochlorite, a 1:100 dilution will yield 0.05% or 500 ppm available chlorine

Bleach solutions containing other concentrations of sodium hypochlorite will contain different amounts of available chlorine when diluted

Contact times for different uses

Disinfection by wiping of nonporous surfaces: a contact time of ≥ 10 min is recommended

Disinfection by immersion of items: a contact time of 30 min is recommended

N.B. Surfaces must be cleaned of organic materials, such as secretions, mucus, vomit, faeces, blood, or other body fluids before disinfection or immersion.

^appm: parts per million

Precautions for the use of bleach

- Bleach can corrode metals and damage painted surfaces.
- Avoid touching the eyes. If bleach gets into the eyes, immediately rinse with water for at least 15 minutes, and consult a physician.
- Bleach should not be used together with, or mixed with, other household detergents because this reduces its effectiveness and can cause chemical reactions.
- A toxic gas is produced when bleach is mixed with acidic detergents, such as those used for toilet cleaning, and this gas can cause death or injury. If necessary, use detergents first, and rinse thoroughly with water before using bleach for disinfection.
- Undiluted bleach liberates a toxic gas when exposed to sunlight and should be stored in a cool, shaded place, out of the reach of children.
- Sodium hypochlorite decomposes with time. To ensure its effectiveness, purchase recently-produced bleach, and avoid over-stocking.
- Diluted bleach should be made fresh daily, labelled, dated, and unused portions discarded 24 hours after preparation.
- Organic materials inactivate bleach; surfaces must be cleaned of organic materials before disinfection with bleach.
- Keep diluted bleach covered, protected from sunlight, in a dark container (if possible), and out of the reach of children.

Annex I. Surge capacity: HCF PPE needs during epidemics/pandemics

Providing guidance for hospitals wishing to stockpile PPE for epidemic/pandemic ARDs is extremely difficult. This Annex is meant to provide a step-by-step approach for estimating additional HCF PPE needs. Some key steps include:

- definition of assumptions;
- producing estimates; and
- definition of a purchasing strategy to meet the planned needs, replenishment and monitoring of stock expiration and utilization.

In this section we provide an example of assumptions and respective estimates. Each HCF should follow the national assumptions, and adapt to its local policies and rationale.

Planning assumptions

The assumptions to be taken into consideration include the rationale on the use of PPE, the expected impact of an epidemic (e.g. proportion of the population diseased, seeking care, being hospitalized), organization of health services (e.g. frequency of HCW–patient encounters), recommended infection control precautions and duration of the epidemic.

Medical masks

Medical masks should be changed between uses and whenever they become wet, damaged, or visibly soiled. In conditions of increased air temperature and humidity, it can be assumed that masks will become wet with perspiration more quickly (surgical mask standards are described in Annex A). Wearing additional PPE, such as gowns and gloves will also increase perspiration.

Respirators

There are no published data on the length of time respirators are effective for the wearer. Respirators are disposable, but can be reused repeatedly by the same HCW when working with tuberculosis patients because tuberculosis has not been documented to spread by contact, and contamination of the respirator is not a concern in tuberculosis transmission. Humidity, dirt, and crushing reduce the efficiency of the respirator, and respirators should be stored in a clean, dry location. When used in the care of tuberculosis patients, respirators can be reused until they are wet, soiled, damaged, or difficult to breathe through (the filter will eventually become "clogged" with trapped particles making it difficult to breathe through). Filtration efficiency actually increases as more particles are trapped in the filter. However, because many ARD pathogens, including SARS, avian or pandemic influenza, also can be spread by contact in addition to respiratory aerosols, contaminated respirators could play a role in disease transmission. The concern about the reuse of respirators and other equipment relates to surface contamination and the possible risks of self-contamination and self-inoculation that may result when HCWs handle potentially contaminated equipment. Educating HCWs on how to safely remove, store, handle and re-apply potentially contaminated equipment is critical.

At this time, there are no recommendations on the reuse of respirators in the care of patients with ARDs that can be spread by different sizes of respiratory aerosol particles and by contact. Currently, it is recommended that medical masks and respirators be discarded after each use when used in the care of such patients.

Entry of HCWs into the isolation room/area

Another issue that must be considered when making planning assumptions is the anticipated number of HCW entries into the isolation room/area, whether any PPE will be reused by the same HCW during a shift, and how many different HCWs will enter the isolation room/area. All of these factors have a direct relationship to how much PPE will be used. The number of different HCWs entering the

isolation room/area and the number of entries of each HCW should be limited to the minimum necessary for patient care. To minimize the number of different HCWs who enter the isolation room/area, tasks should be carried out by the minimum number of HCWs possible. Another way to reduce the number of HCW isolation room/area entries is to have a means of communication between the patient/family in the room and HCWs outside the room via phone or other device. Cohorting of patients may result in less need for some PPE, since several patients could be attended without the HCW leaving the isolation room/area. It should also be anticipated that HCWs providing care to patients with ARDs of potential concern will need "PPE breaks" because wearing PPE is hot and fatiguing, and these factors may contribute to inadvertent infection control breaches.

Assumptions about factors such as these must be built into any mathematical model used for estimating the amounts of PPE needed. For example:

- Number of epidemic/pandemic ARD patients per day for an average of X number of days.
- Number of HCW entries into the isolation room/area per shift; length of shifts.
- Number of different HCWs with direct contact with epidemic/pandemic patients per day.
- Infection control precautions recommended.
- Duration of the epidemic/pandemic wave.
- Estimated numbers of cohorted patients (e.g. X patients per cohort unit vs. X patients in single rooms).
- Number of times items can be reused (e.g., cloth gowns, goggles, face shields). Fewer masks may be needed on patient cohort units because the same respiratory protection equipment could be worn during the care of multiple patients.
- Whether medical masks would be provided for patients/visitors.

A **sample calculation** for additional PPE required for an epidemic/pandemic ARD response is provided below. For this purpose, an example of scenario during a pandemic influenza wave is used. Routine PPE needs for Standard and other Specific Precautions not related to ARD patient care are not included in these estimates. HCFs should use the regular estimates that are applied in non-epidemic/pandemic situations.

Sample calculation for HCF PPE needs in human influenza pandemic

Several countries have developed planning assumptions ("National Influenza Pandemic Plans" available at <http://www.who.int/csr/disease/influenza/nationalpandemic/en/index.html>). The example below is based on some of these plans, but above all, this example is meant to provide the step-by-step of calculations, and the national planning assumptions should be used for local application.

Scenario for sample calculation*	
Infection control recommendations for routine care of pandemic influenza patients	Standard + Droplet Precautions Main points: <ul style="list-style-type: none"> ▪ reinforce respiratory hygiene/cough etiquette ▪ HCWs use medical masks when in close contact with patients ▪ reinforce hand hygiene
Infection control recommendations when performing aerosol-generating procedures (see Annex A)	PPE should include long-sleeved gown, single-use gloves, eye protection (e.g. goggle, face shield) and respiratory protection.
Population	100 000 persons
Duration of pandemic wave	90 days
Duration of infectious period/hospital days per patient	7 days
% population developing clinical symptoms	30% (30 000 persons)
% persons with symptoms seeking care	100% (30 000 persons)
% persons with symptoms seeking hospital care	2% (600, of whom 480 in wards and 120 in intensive care units)
% patients with symptoms receiving home care	98% (29 400 persons)

*Note: the PPE estimates will change if any of the individual assumptions are changed.

Sample calculation of PPE needs in HCF according to the scenario above		
Item	Assumptions	Needs
Medical masks for hospital inpatients		
No. of inpatients in wards = 480	Patient to use mask when out of isolation room; allow 1 mask/patient/day for 7 days	3 360
No. of patients in intensive care = 120	Most patients will not be able to use masks; all will survive and will use masks for 4 days (overestimate)	480
Masks for visitors		
600 inpatients each receive 2 visitors/day; no. of visits/day = 1200; no. of days = 7	1 medical mask/visitor/visit; 2 visits/patient/day for 7 days	8 400
Masks for HCWs		
Medical masks for HCWs caring for 600 patients for 7 days	12 HCW entries/isolation room/day + 2 aerosol-generating procedures/patient/day	50 400
TOTAL medical masks		62 640
Other PPE for HCWs when performing aerosol-generating procedures		
Respirators	2/patient/day	8 400
Disposable face shields or goggles	2/patient/day disposable	8 400
or		
Re-usable face shields	2/patient/day reprocessed* 10 times	840
or		or
Re-usable goggles	2/patient/day reprocessed* 50 times	168
Long-sleeved gowns		
Disposable (no reuse and discarded) gowns	2/patient/day	8 400
or		or
Cloth gowns (no reuse on same day; laundered i.e. reprocessed up to 50 times)	2/patient/day	168
Gloves		
Non-sterile, single-use gloves	2 pairs/patient/day	8 400

*Items may be reprocessed more or fewer times depending on type of reprocessing used and the ability of the equipment to withstand reprocessing.

Annex J. Cleaning and disinfection of respiratory equipment

Respiratory therapy equipment is considered semi-critical (i.e. items that come into contact with mucous membranes), and it is recommended that semi-critical items receive a minimum of high-level disinfection between patients (204). After cleaning, high-level disinfection of respiratory equipment is typically accomplished by chemical germicides or physical methods (230).

Chemical germicides used for high-level disinfection include glutaraldehyde-based formulations (2%), stabilized hydrogen peroxide (6%), peracetic acid (variable concentrations, but $\leq 1\%$ is sporicidal), and sodium hypochlorite 5.25%, 1000 ppm available chlorine (1:50 dilution) (204). The most appropriate chemical germicide for a particular situation should be selected on the basis of the object to be disinfected, its composition, intended use, the level of disinfection needed, and the scope of services, physical facilities, the HCF resources and personnel available.

Physical methods to accomplish high-level disinfection include hot water disinfection (pasteurization) or steam (e.g. autoclaving at lower temperature). Pasteurization is a non-toxic, cost-effective alternative to high-level disinfection with chemical germicides. Equipment should be submerged for ≥ 30 minutes in water ≥ 70 °C (less than the temperature that typically damages plastic). Pasteurization can be accomplished using a commercial washer/pasteurizer (231), and after pasteurization, wet equipment is typically dried in hot-air drying cabinets before storage. Steam sterilization is an inexpensive and effective method for sterilization or high-level disinfection. Steam sterilization is unsuitable, however, for processing plastics with low melting points, powders, or anhydrous oils. Bacterial spores may survive after high-level disinfection. Microbiological sampling can verify that a high-level disinfection process has resulted in the destruction of vegetative bacteria; however, this sampling is not routinely recommended.

Steps for cleaning and disinfection of plastic pieces of respiratory equipment:

PPE is required when cleaning or processing equipment and instruments to protect against splashing, spraying or aerosols.

1. **Wash** the equipment with soap (e.g. liquid dish soap) and clean water.
2. **Rinse** completely with clean water.
3. **Disinfect** equipment to inactivate any remaining pathogens.

There are several ways to disinfect equipment, and the available products at the HCF should be used. Safe methods of disinfection include:

- Heat for "heat resistant" equipment which can withstand high temperature, e.g. 80 °C. Such equipment can be disinfected by washer-disinfector.
- If washer/pasteurizer is not available, a high-end or commercial dishwasher with a "sanitize" feature that can reach 70 °C may be used.
- For plastic equipment which may not tolerate 80 °C and for equipment that may be damaged by boiling, or if the above named facilities are not available, chemical disinfection may be used [(e.g. soak in 1:100 sodium hypochlorite solution for 30 minutes (see Annex H)].

4. **Rinse** (ONLY IF CHEMICAL DISINFECTION) with sterile or clean water (water boiled for 5 minutes and cooled). Sterile water is preferred to tap or unsterilized distilled water for rinsing off residual liquid chemical disinfectant from a respiratory device that has been chemically disinfected for reuse, because tap or distilled water may harbour microorganisms that can cause pneumonia. However, when rinsing with sterile water is not feasible, rinsing with tap water or filtered water (water passed through a 0.2 μ filter), followed by an alcohol rinse and forced-air drying may be done.

5. Dry

- Physical methods frequently have this feature within the machine (e.g. washer/pasteurizer, autoclave).
- For chemical methods let equipment parts air dry on a clean towel or cloth.

6. Store dry in closed packages.

Summary: wash with soap and clean water, rinse, disinfect, rinse (if chemical method), dry, and store.

Cleaning and disinfection of mechanical ventilators:

- The controls and entire outside of mechanical ventilators should be wiped down with a compatible HCF disinfectant (e.g. sodium hypochlorite solution for non-metal surfaces).
- Disinfection of tubing can be accomplished using sodium hypochlorite solution, ensuring that the entire lumen of the tubing is flushed (see "Steps for cleaning and disinfection of plastic pieces of respiratory equipment" above).
- Inspiratory and pressure lines within a ventilator are not routinely cleaned between patients because they are not exposed to the patient or their respiratory secretions.

Usually the entire expiratory side tubing is removable (the expiratory end has a valve to control the escape of gas from the circuit and also may have a flow measurement device and/or a water trap). This tubing should be disassembled and cleaned first with a detergent, rinsed clean, and then subjected to either high-level disinfection or sterilization. High-level disinfection is the minimum required procedure for these items, but due to the practicability of some sterilization methods and HCF protocols (e.g. steam), these items can be, if suitably-designed, submitted to sterilization.

When mechanical ventilators are used in the care of a patient with an ARD of potential concern, bacterial/viral filters are recommended on exhalation valves. See section A.3 of Annex A for details.

Annex K. Infection control across the continuum of health care

The principles of infection control are the same across the continuum of health care. Areas that require particular attention are listed below.

K.1 Emergency and outpatient care

In countries without reported ARDs of potential concern:

- Post signage to alert persons with severe acute febrile respiratory illness to notify staff immediately and to use respiratory hygiene/cough etiquette.¹
- Evaluate patients with acute febrile respiratory illness as promptly as possible.
- Consider scheduling outpatient clinic patients with acute febrile respiratory disease in different locations from other patients, either totally separate, or ≥ 1 m (3 feet) between each patient in the waiting area.
- Provide tissues in the waiting area to contain respiratory secretions when coughing or sneezing whenever possible. Provide receptacles for disposal of used tissues (no-touch receptacles if possible).
- Mask persons with acute febrile respiratory illness upon entry, if possible.
- Encourage hand hygiene after contact with respiratory secretions and provide hand hygiene facilities (e.g. sinks equipped with water, soap and single use towel, alcohol-based hand rub) in waiting areas whenever possible.
- Eliminate or decrease the use of items shared by patients such as pens, clipboards, telephones, etc.
- Clean and disinfect environmental surfaces in waiting and patient-care areas at least daily and when visibly soiled.
- Ensure that patient-care equipment is appropriately cleaned and disinfected between patients.
- HCWs should use Standard and Droplet Precautions when providing care, in close contact, for patients with acute febrile respiratory illness.
- If a patient known or suspected to be infected with an ARD of potential concern is referred to another HCF, notify the receiving HCF staff of the necessary infection control precautions.
-

In countries with reported ARDs of potential concern, in addition to the above measures, also:

- Educate the public about the clues (i.e. signs or symptoms) of ARDs of potential concern and ask them to seek medical care promptly for assessment and admission.
- Establish triage criteria to promptly identify persons at risk of infection with an ARD of potential concern.
- If an ARD of potential concern is suspected, HCWs should use appropriate PPE (see Table 1), as available.
- High-risk aerosol-generating procedures in patients with severe acute febrile respiratory illness (Annex A) should not be performed in the ambulatory-care setting, unless they are necessary to save life and no alternative exists.
- If such a procedure is performed in this setting, a well-ventilated separate room should be used, and participating HCWs should use appropriate PPE.
- After a patient known or suspected to be infected with an ARD of potential concern has left the ambulatory-care setting, clean and disinfect environmental surfaces in the examination room or other areas where the patient was located and clean and disinfect any patient-care equipment used for the patient.

¹ <http://www.cdc.gov/flu/protect/covercough.htm>

K.2 Paediatric acute care

Several aspects are particular to paediatric patients and should be taken into consideration when implementing infection control measures.

- Family members are essential for the emotional support of hospitalized paediatric patients (36, 232). The child's right to be accompanied by a parent/relative/legal guardian at all times should be guaranteed (233).
- Family members may be critical in assisting in the care of hospitalized paediatric patients, particularly if there is a shortage of HCWs (85).
- Paediatric patients are likely to be infectious with ARDs longer than adults; this will impact the duration of infection control precautions (74).
- Paediatric patients may not be able to comply with respiratory hygiene.
- Some pathogens are more prevalent among paediatric patients and require additional precautions (e.g. Contact Precautions required for RSV or parainfluenza virus; and Contact plus Droplet Precautions for adenovirus or metapneumovirus) (222).
- Contamination of the environment may be more prominent compared to that with adult or continent patients.
- Toys should be cleaned and disinfected between different children, and precautions should be taken when gathering patients in the playroom (follow the same principles as for cohorting) (234-237).

K.3 "Home care" for ARD patients

- During a public health emergency, such as a pandemic, it may not be possible to provide acute or ambulatory-care services for all persons who might need them. It is possible that acute care HCFs will triage patients and may only be able to provide care for the most severely ill patients who are considered to have a chance of survival (238). It also is possible that ambulatory-care facilities may be unable to meet the demand for health-care services.
- Patients infected with ARDs of potential concern may require care in the home setting. Such patients may be quite ill. In addition, such patients will be infectious to others for a period of time and could transmit pathogens and secondary infection or disease to their household contacts (239, 240).

Infection control recommendations for the home setting

ARDs can spread easily within a household. Everyone in contact with an ill person who has not already been infected is at risk for infection. Household members should observe the following recommendations:

- Limit contact with the ill person as much as possible. Stay in a different room or if that is not possible, stay as far away from the ill person as possible, e.g. sleep in a separate bed and bedroom, if possible.
- Shared spaces (restrooms, kitchen, bathroom, etc) should be well ventilated (e.g. natural ventilation, keeping windows open).
- Cleaning of the environment is important to prevent indirect transmission, particularly in shared spaces.
- If close contact care must be provided to the ill person, the ill person should cover their mouth/nose with hands or other materials (e.g. tissues, handkerchiefs, or, if available, a cloth or medical mask). If available, the caregiver also should wear a medical mask or the best available protection against respiratory droplets when in close contact with the ill person.
- Materials used to cover the mouth/nose should be discarded or cleaned appropriately.
- Avoid direct contact with body fluids. If contact occurs, perform hand hygiene immediately afterwards.
- Hand hygiene can be performed by means of hand washing with soap and water or an alcohol-based hand rub. There are safety concerns (i.e. accidental ingestion, fire hazards) that must be addressed before alcohol-based hand rubs can be recommended for household use.

- Persons at increased risk of severe disease should not care for the ill person or be in close contact with the ill person. For seasonal influenza, persons at increased risk include those with heart, lung or kidney disease, diabetes, immunosuppression, blood disease (e.g. sickle cell anaemia), pregnant women, people > 65 years of age or children < 2 years of age.
- Other types of possible exposure to the ill person or contaminated items should be avoided, e.g. sharing toothbrushes, cigarettes, eating utensils, drinks, towels, washcloths, or bed linens.
- Public health recommendations in place at the time should be followed if a household member develops symptoms. Symptoms of ARD include fever, cough, sore throat, and difficulty breathing.
- People caring for a family member suffering from an ARD of potential concern should limit their contact with others and should follow national/local policies regarding home quarantine recommendations.

If the ill person needs medical care, he/she should:

- Notify health-care provider of diagnosis and receive instructions on where to seek care, when/where to enter the HCF, and the infection control precautions that are to be followed.
- Avoid public transportation, if possible. Call an ambulance or transport with own vehicle and open vehicle windows.
- Always perform respiratory hygiene/cough etiquette.
- Try to stand or sit as far away from others as possible (≥ 1 m), when in transit and when in the HCF.
- Use hand hygiene whenever appropriate.

References

1. The American Institute of Architects Academy of Architecture for Health. Guidelines for design and construction of hospitals and health care facilities. Washington: The American Institute of Architects; 2001.
2. Mayhall CG. Hospital epidemiology and infection control. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2004.
3. Wenzel RP. Prevention and Control of Nosocomial Infections. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2003.
4. CDC. Guidelines for Environmental Infection Control in Health-Care Facilities, 2003. MMWR 2003;52(RR-10).
5. Roy CJ, Milton DK. Airborne transmission of communicable infection--the elusive pathway. N Engl J Med 2004;350(17):1710-2.
6. Indoor air pollution: an introduction for health professionals. New York, N.Y.: Environmental Protection Agency: Consumer Product Safety Commission; American Lung Association; 1995.
7. A glossary of terms for community health care and services for older persons. Kobe: World Health Organization Centre for Health Development; 2004.
8. Stedman TL. Stedman's medical dictionary. 28th ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
9. Brankston G, Gitterman L, Hirji Z, Lemieux C, Gardam M. Transmission of influenza A in human beings. Lancet Infect Dis 2007;7(4):257-65.
10. Avian Influenza, Including Influenza A (H5N1), in Humans: WHO Interim Infection Control Guidelines for Health Care Facilities. WHO Regional Office for the Western Pacific, 2007. (Accessed 25 May 2007, at http://www.who.int/csr/disease/avian_influenza/guidelines/infectioncontrol1/en/index.html.)
11. Last J. A dictionary of epidemiology. New York: Oxford University Press; 2001.
12. World Health Report 2004 - Changing History [electronic resource]. Geneva: World Health Organization; 2004.
13. Berman S. Epidemiology of acute respiratory infections in children of developing countries. Rev Infect Dis 1991;13 Suppl 6:S454-62.
14. Lederberg J, Shope R, Oakes S. Emerging Infections: Microbial Threats to Health in the United States. Washington, D.C.: The Institute of Medicine; 1992.
15. Graham M. Frequency and duration of handwashing in an intensive care unit. Am J Infect Control 1990;18(2):77-81.
16. Fraser C, Riley S, Anderson RM, Ferguson NM. Factors that make an infectious disease outbreak controllable. Proc Natl Acad Sci U S A 2004;101(16):6146-51.
17. Bauch CT, Lloyd-Smith JO, Coffee MP, Galvani AP. Dynamically modeling SARS and other newly emerging respiratory illnesses: past, present, and future. Epidemiology 2005;16(6):791-801.
18. Peiris JS, Lai ST, Poon LL, et al. Coronavirus as a possible cause of severe acute respiratory syndrome. Lancet 2003;361(9366):1319-25.
19. CDC. Outbreaks of severe acute respiratory virus - worldwide 2003. MMWR 2003;52:226-8.
20. Guan Y, Zheng BJ, He YQ, et al. Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. Science 2003;302(5643):276-8.

21. Booth TF, Kournikakis B, Bastien N, et al. Detection of airborne severe acute respiratory syndrome (SARS) coronavirus and environmental contamination in SARS outbreak units. *J Infect Dis* 2005;191(9):1472-7.
22. Yuen KY, Wong SS. Human infection by avian influenza A H5N1. *Hong Kong Med J* 2005;11(3):189-99.
23. Peiris M, Yuen KY, Leung CW, et al. Human infection with influenza H9N2. *Lancet* 1999;354(9182):916-7.
24. Akey BL. Low-pathogenicity H7N2 avian influenza outbreak in Virginia during 2002. *Avian Dis* 2003;47(3 Suppl):1099-103.
25. Koopmans M, Wilbrink B, Conyn M, et al. Transmission of H7N7 avian influenza A virus to human beings during a large outbreak in commercial poultry farms in the Netherlands. *Lancet* 2004;363(9409):587-93.
26. Dinh PN, Long HT, Tien NTK, et al. Risk factors for human infection with avian influenza A H5N1, Vietnam 2004. *Emerg Infect Dis* 2006;12(12):1841-7.
27. Areechokchai D, Jiraphongsa C, Laosiritaworn Y, Hanshaoworakul W, O'Reilly M. Investigation of avian influenza (H5N1) outbreak in humans--Thailand, 2004. *MMWR Morb Mortal Wkly Rep* 2006;55 Suppl 1:3-6.
28. Mounts AW, Kwong H, Izurieta HS, et al. Case-control study of risk factors for avian influenza A (H5N1) disease, Hong Kong, 1997. *J Infect Dis* 1999;180(2):505-8.
29. Ungchusak K, Auewarakul P, Dowell SF, et al. Probable person-to-person transmission of avian influenza A (H5N1). *N Engl J Med* 2005;352(4):333-40.
30. Ostroff D, McDade J, LeDuc J, Hughes J. Emerging and reemerging infectious disease threats. In: Dolin R, ed. *Principles and Practice of Infectious Disease*. Philadelphia: Elsevier Churchill Livingstone; 2005:173-92.
31. Jacobsen D, Ackerman P, Payne NR. Rapid identification of respiratory syncytial virus infections by direct fluorescent antibody testing: reliability as a guide to patient cohorting. *Am J Infect Control* 1991;19(2):73-8.
32. 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(8827):1079-83.
33. Lipsitch M, Cohen T, Cooper B, et al. Transmission dynamics and control of severe acute respiratory syndrome. *Science* 2003;300(5627):1966-70.
34. International Health Regulations (2005). Geneva: World Health Organization; 2006.
35. Chen SY, Chiang WC, Ma MH, et al. Sequential symptomatic analysis in probable severe acute respiratory syndrome cases. *Ann Emerg Med* 2004;43(1):27-33.
36. Leung TF, Ng PC, Cheng FW, et al. Infection control for SARS in a tertiary paediatric centre in Hong Kong. *J Hosp Infect* 2004;56(3):215-22.
37. Olsen SJ, Chang HL, Cheung TY, et al. Transmission of the severe acute respiratory syndrome on aircraft. *N Engl J Med* 2003;349(25):2416-22.
38. Wang TL, Jang TN, Huang CH, et al. Establishing a clinical decision rule of severe acute respiratory syndrome at the emergency department. *Ann Emerg Med* 2004;43(1):17-22.
39. 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):1-6.
40. Donnelly CA, Ghani AC, Leung GM, et al. Epidemiological determinants of spread of causal agent of severe acute respiratory syndrome in Hong Kong. *Lancet* 2003;361(9371):1761-6.

41. Tran TH, Nguyen TL, Nguyen TD, et al. Avian influenza A (H5N1) in 10 patients in Vietnam. *N Engl J Med* 2004;350(12):1179-88.
42. Rainer TH, Cameron PA, Smit D, et al. Evaluation of WHO criteria for identifying patients with severe acute respiratory syndrome out of hospital: prospective observational study. *Bmj* 2003;326(7403):1354-8.
43. Chen SY, Su CP, Ma MH, et al. Predictive model of diagnosing probable cases of severe acute respiratory syndrome in febrile patients with exposure risk. *Ann Emerg Med* 2004;43(1):1-5.
44. de Jong MD, Bach VC, Phan TQ, et al. Fatal avian influenza A (H5N1) in a child presenting with diarrhea followed by coma. *N Engl J Med* 2005;352(7):686-91.
45. Apisarnthanarak A, Erb S, Stephenson I, et al. Seroprevalence of anti-H5 antibody among Thai health care workers after exposure to avian influenza (H5N1) in a tertiary care center. *Clin Infect Dis* 2005;40(2):16-8.
46. Steininger C, Popow-Kraupp T, Laferl H, et al. Acute encephalopathy associated with influenza A virus infection. *Clin Infect Dis* 2003;36(5):567-74.
47. Lau JT, Lau M, Kim JH, Tsui HY, Tsang T, Wong TW. Probable secondary infections in households of SARS patients in Hong Kong. *Emerg Infect Dis* 2004;10(2):235-43.
48. Goh DL, Lee BW, Chia KS, et al. Secondary household transmission of SARS, Singapore. *Emerg Infect Dis* 2004;10(2):232-4.
49. Haley RW, Hooton TM, Schoenfelder JR, et al. Effect of an infection surveillance and control program on the accuracy of retrospective chart review. *Am J Epidemiol* 1980;111(5):543-55.
50. Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. *Chemotherapy* 1988;34(6):553-61.
51. Larson EL, Bryan JL, Adler LM, Blane C. A multifaceted approach to changing handwashing behavior. *Am J Infect Control* 1997;25(1):3-10.
52. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Infection Control Programme*. *Lancet* 2000;356(9238):1307-12.
53. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003;31(2):85-92.
54. Pang X, Zhu Z, Xu F, et al. Evaluation of control measures implemented in the severe acute respiratory syndrome outbreak in Beijing, 2003. *Jama* 2003;290(24):3215-21.
55. Chen MI, Leo YS, Ang BS, Heng BH, Choo P. The outbreak of SARS at Tan Tock Seng Hospital--relating epidemiology to control. *Ann Acad Med Singapore* 2006;35(5):317-25.
56. Lau JT, Fung KS, Wong TW, et al. SARS transmission among hospital workers in Hong Kong. *Emerg Infect Dis* 2004;10(2):280-6.
57. Yassi A, Bryce E, Moore D. Protecting the faces of health care workers: Knowledge Gaps and Research Priorities for Effective Protection Against Occupationally-Acquired Respiratory Infectious Diseases: The Change Foundation; 2004 30 April, 2004.
58. Imai T, Takahashi K, Hasegawa N, Lim MK, Koh D. SARS risk perceptions in healthcare workers, Japan. *Emerg Infect Dis* 2005;11(3):404-10.
59. Ho PL, Tang XP, Seto WH. SARS: hospital infection control and admission strategies. *Respirology* 2003;8 Suppl:S41-5.
60. Respiratory Hygiene/Cough Etiquette in Healthcare Settings. Centres for Disease Control and Prevention. (Accessed 25 May 2007, 2006, at <http://www.cdc.gov/flu/professionals/infectioncontrol/resphygiene.htm>.)

61. Dooley SW, Jr., Castro KG, Hutton MD, Mullan RJ, Polder JA, Snider DE, Jr. Guidelines for preventing the transmission of tuberculosis in health-care settings, with special focus on HIV-related issues. *MMWR Recomm Rep* 1990;39(RR-17):1-29.
62. Puro V, Girardi E, Daglio M, Simonini G, Squarcione S, Ippolito G. Clustered cases of pneumonia among healthcare workers over a 1-year period in three Italian hospitals: applying the WHO SARS alert. *Infection* 2006;34(4):219-21.
63. Tan CC. SARS in Singapore--key lessons from an epidemic. *Ann Acad Med Singapore* 2006;35(5):345-9.
64. Garner JS. Guideline for isolation precautions in hospitals. The Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1996;17(1):53-80.
65. Olsen SJ, Ungchusak K, Sovann L, et al. Family clustering of avian influenza A (H5N1). *Emerg Infect Dis* 2005;11(11):1799-801.
66. Lai MY, Cheng PK, Lim WW. Survival of severe acute respiratory syndrome coronavirus. *Clin Infect Dis* 2005;41(7):67-71.
67. Luby SP, Agboatwalla M, Feikin DR, et al. Effect of handwashing on child health: a randomised controlled trial. *Lancet* 2005;366(9481):225-33.
68. Hammond B, Ali Y, Fendler E, Dolan M, Donovan S. Effect of hand sanitizer use on elementary school absenteeism. *Am J Infect Control* 2000;28(5):340-6.
69. Gopalakrishna G, Choo P, Leo YS, et al. SARS transmission and hospital containment. *Emerg Infect Dis* 2004;10(3):395-400.
70. Reynolds MG, Anh BH, Thu VH, et al. Factors associated with nosocomial SARS-CoV transmission among healthcare workers in Hanoi, Vietnam, 2003. *BMC Public Health* 2006;6:2071-9.
71. Fowler RA, Guest CB, Lapinsky SE, et al. Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation. *Am J Respir Crit Care Med* 2004;169(11):1198-202.
72. Scales DC, Green K, Chan AK, et al. Illness in intensive care staff after brief exposure to severe acute respiratory syndrome. *Emerg Infect Dis* 2003;9(10):1205-10.
73. Douglas RG. Influenza in Man. In: Kilbourne ED, ed. *The influenza viruses and influenza*. New York City: Academic Press; 1975:395-447.
74. Hall CB, Douglas RG, Jr. Nosocomial influenza infection as a cause of intercurrent fevers in infants. *Pediatrics* 1975;55(5):673-7.
75. Chan KH, Poon LL, Cheng VC, et al. Detection of SARS coronavirus in patients with suspected SARS. *Emerg Infect Dis* 2004;10(2):294-9.
76. Bloomfield SF. Home hygiene: a risk approach. *Int J Hyg Environ Health* 2003;206(1):1-8.
77. Rheinbaben F, Schunemann S, Gross T, Wolff MH. Transmission of viruses via contact in a household setting: experiments using bacteriophage straight phiX174 as a model virus. *J Hosp Infect* 2000;46(1):61-6.
78. Tang CS, Wong CY. An outbreak of the severe acute respiratory syndrome: predictors of health behaviors and effect of community prevention measures in Hong Kong, China. *Am J Public Health* 2003;93(11):1887-8.
79. Chemaly RF, Ghosh S, Bodey GP, et al. Respiratory viral infections in adults with hematologic malignancies and human stem cell transplantation recipients: a retrospective study at a major cancer center. *Medicine (Baltimore)* 2006;85(5):278-87.
80. Kallander K, Nsungwa-Sabiiti J, Balyeku A, Pariyo G, Tomson G, Peterson S. Home and community management of acute respiratory infections in children in eight Ugandan districts. *Ann Trop Paediatr* 2005;25(4):283-91.

81. Richards DA, Toop LJ, Epton MJ, et al. Home management of mild to moderately severe community-acquired pneumonia: a randomised controlled trial. *Med J Aust* 2005;183(5):235-8.
82. Quinlan B, Loughrey S, Nicklin W, Roth VR. Restrictive visitor policies: feedback from healthcare workers, patients and families. *Hosp Q* 2003;7(1):33-7.
83. Lee NE, Siriarayapon P, Tappero J, et al. Infection control practices for SARS in Lao People's Democratic Republic, Taiwan, and Thailand: experience from mobile SARS containment teams, 2003. *Am J Infect Control* 2004;32(7):377-83.
84. Mukhopadhyay A, Tambyah PA, Singh KS, Lim TK, Lee KH. SARS in a hospital visitor and her intensivist. *J Hosp Infect* 2004;56(3):249-50.
85. Melnyk BM, Alpert-Gillis L, Feinstein NF, et al. Creating opportunities for parent empowerment: program effects on the mental health/coping outcomes of critically ill young children and their mothers. *Pediatrics* 2004;113(6):597-607.
86. Saunders RP, Abraham MR, Crosby MJ, Thomas K, Edwards WH. Evaluation and development of potentially better practices for improving family-centered care in neonatal intensive care units. *Pediatrics* 2003;111(4 Pt 2):e437-49.
87. Griffin T. Family-centered care in the NICU. *J Perinat Neonatal Nurs* 2006;20(1):98-102.
88. Chaovavanich A, Wongsawat J, Dowell SF, et al. Early containment of severe acute respiratory syndrome (SARS); experience from Bamrasnaradura Institute, Thailand. *J Med Assoc Thai* 2004;87(10):1182-7.
89. Svoboda T, Henry B, Shulman L, et al. Public health measures to control the spread of the severe acute respiratory syndrome during the outbreak in Toronto. *N Engl J Med* 2004;350(23):2352-61.
90. Lim PL, Kurup A, Gopalakrishna G, et al. Laboratory-acquired severe acute respiratory syndrome. *N Engl J Med* 2004;350(17):1740-5.
91. Dey P, Halder S, Collins S, Benons L, Woodman C. Promoting uptake of influenza vaccination among health care workers: a randomized controlled trial. *J Public Health Med* 2001;23(4):346-8.
92. Lester RT, McGeer A, Tomlinson G, Detsky AS. Use of, effectiveness of, and attitudes regarding influenza vaccine among house staff. *Infect Control Hosp Epidemiol* 2003;24(11):839-44.
93. Davis MM, Taubert K, Benin AL, et al. Influenza vaccination as secondary prevention for cardiovascular disease: a science advisory from the American Heart Association/American College of Cardiology. *J Am Coll Cardiol* 2006;48(7):1498-502.
94. Cox S, Posner SF, McPheeters M, Jamieson DJ, Kourtis AP, Meikle S. Hospitalizations with respiratory illness among pregnant women during influenza season. *Obstet Gynecol* 2006;107(6):1315-22.
95. Lloyd-Smith JO, Galvani AP, Getz WM. Curtailing transmission of severe acute respiratory syndrome within a community and its hospital. *Proc Biol Sci* 2003;270(1528):1979-89.
96. Tsai MC, Arnold JL, Chuang CC, Chi CH, Liu CC, Yang YJ. Impact of an outbreak of severe acute respiratory syndrome on a hospital in Taiwan. *Emerg Med J* 2004;21(3):311-6.
97. Riley E, Murphy G, Riley R. Airborne spread of measles in a suburban elementary school. *Am J Epidemiol* 1978;107(5):421-32.
98. Green-McKenzie J, Gershon RR, Karkashian C. Infection control practices among correctional healthcare workers: effect of management attitudes and availability of protective equipment and engineering controls. *Infect Control Hosp Epidemiol* 2001;22(9):555-9.
99. Moore D, Gamage B, Bryce E, Copes R, Yassi A. Protecting health care workers from SARS and other respiratory pathogens: organizational and individual factors that affect adherence to infection control guidelines. *Am J Infect Control* 2005;33(2):88-96.
100. Ofner M, Lem M, Sarwal S, Vearncombe M, Simor A. Cluster of severe acute respiratory syndrome cases among protected health care workers-Toronto, April 2003. *Can Commun Dis Rep* 2003;29(11):93-7.

101. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet* 2003;361(9368):1519-20.
102. Chia SE, Koh D, Fones C, et al. Appropriate use of personal protective equipment among healthcare workers in public sector hospitals and primary healthcare polyclinics during the SARS outbreak in Singapore. *Occup Environ Med* 2005;62(7):473-7.
103. Rengasamy A, Zhuang Z, Berryann R. Respiratory protection against bioaerosols: literature review and research needs. *Am J Infect Control* 2004;32(6):345-54.
104. Committee on the Development of Reusable Facemasks for Use During an Influenza Pandemic. *Reusability of Facemasks During an Influenza Pandemic - Facing the Flu*. Washington: The National Academies Press; 2006.
105. Hannum D, Cysan K, Jones L, et al. The effect of respirator training on the ability of healthcare workers to pass a qualitative fit test. *Infect Control Hosp Epidemiol* 1996;17(10):636-40.
106. Varia M, Wilson S, Sarwal S, et al. Investigation of a nosocomial outbreak of severe acute respiratory syndrome (SARS) in Toronto, Canada. *CMAJ* 2003;169(4):285-92.
107. Lee N, Hui D, Wu A, et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. *N Engl J Med* 2003;348(20):1986-94.
108. Chen SK, Vesley D, Brosseau LM, Vincent JH. Evaluation of single-use masks and respirators for protection of health care workers against mycobacterial aerosols. *Am J Infect Control* 1994;22(2):65-74.
109. McCullough NV, Brosseau LM, Vesley D. Collection of three bacterial aerosols by respirator and surgical mask filters under varying conditions of flow and relative humidity. *Ann Occup Hyg* 1997;41(6):677-90.
110. Ho AS, Sung JJ, Chan-Yeung M. An outbreak of severe acute respiratory syndrome among hospital workers in a community hospital in Hong Kong. *Ann Intern Med* 2003;139(7):564-7.
111. Lu YT, Chen PJ, Sheu CY, Liu CL. Viral load and outcome in SARS infection: the role of personal protective equipment in the emergency department. *J Emerg Med* 2006;30(1):7-15.
112. Alfa MJ, DeGagne P, Olson N, Puchalski T. Comparison of ion plasma, vaporized hydrogen peroxide, and 100% ethylene oxide sterilizers to the 12/88 ethylene oxide gas sterilizer. *Infect Control Hosp Epidemiol* 1996;17(2):92-100.
113. Cronmiller JR, Nelson DK, Salman G, et al. Antimicrobial efficacy of endoscopic disinfection procedures: a controlled, multifactorial investigation. *Gastrointest Endosc* 1999;50(2):152-8.
114. Nystrom B. Disinfection of surgical instruments. *J Hosp Infect* 1981;2(4):363-8.
115. Parker HHT, Johnson RB. Effectiveness of ethylene oxide for sterilization of dental handpieces. *J Dent* 1995;23(2):113-5.
116. Kampf G, Bloss R, Martiny H. Surface fixation of dried blood by glutaraldehyde and peracetic acid. *J Hosp Infect* 2004;57(2):139-43.
117. Rutala WA, Gergen MF, Jones JF, Weber DJ. Levels of microbial contamination on surgical instruments. *Am J Infect Control* 1998;26(2):143-5.
118. Pittet D, Allegranzi B, Sax H, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis* 2006;6(10):641-52.
119. WHO guidelines on hand hygiene in health care (advanced draft). World Health Organization, 2006. (Accessed 25 May 2007, at http://whqlibdoc.who.int/hq/2006/WHO_EIP_SPO_QPS_05.2.REV.1_eng.pdf.)
120. Collins CH, Grange JM. Tuberculosis acquired in laboratories and necropsy rooms. *Commun Dis Public Health* 1999;2(3):161-7.

121. Marris E. Marburg workers battle to win trust of locals. *Nature* 2005;434(7036):946.
122. Claydon SM. The high risk autopsy. Recognition and protection. *Am J Forensic Med Pathol* 1993;14(3):253-6.
123. Li L, Gu J, Shi X, et al. Biosafety level 3 laboratory for autopsies of patients with severe acute respiratory syndrome: principles, practices, and prospects. *Clin Infect Dis* 2005;41(6):815-21.
124. Nolte KB, Taylor DG, Richmond JY. Biosafety considerations for autopsy. *Am J Forensic Med Pathol* 2002;23(2):107-22.
125. SARS. Supplement I: Infection Control in Healthcare, Home, and Community Settings. VIII. Infection Control for Laboratory and Pathology Procedures. Centres for Disease Control and Prevention, 2005. (Accessed 25 May 2007, at <http://www.cdc.gov/ncidod/sars/guidance/I/laboratory.htm>.)
126. Guidelines on autopsy practice. Report of a working group of the Royal College of Pathologists. London: Royal College of Pathologists; 2002.
127. Burton J, Rutty, GN. Autopsy suite design and construction. In: Burton J, Rutty, GN, ed. *The hospital autopsy*. London: Arnold; 2001:37-41.
128. Healing TD, Hoffman PN, Young SE. The infection hazards of human cadavers. *Commun Dis Rep CDR Rev* 1995;5(5):R61-8.
129. Newsom SW, Rowlands C, Matthews J, Elliot CJ. Aerosols in the mortuary. *J Clin Pathol* 1983;36(2):127-32.
130. Kantor HS, Poblete R, Pusateri SL. Nosocomial transmission of tuberculosis from unsuspected disease. *Am J Med* 1988;84(5):833-8.
131. Al-Wali W, Kibbler CC, McLaughlin JE. Bacteriological evaluation of a down-draught necropsy table ventilation system. *J Clin Pathol* 1993;46(8):746-9.
132. Fennelly K, Nardell E. The relative efficacy of respirators and room ventilation in preventing occupational tuberculosis. *Infect Control Hosp Epidemiol* 1998;19(10):754-9.
133. Etheridge D, Sandberg M. *Building Ventilation: Theory and Measurement*. Chichester: John Wiley & Sons Ltd.; 1996.
134. Principles of Hybrid Ventilation Final Report. Denmark: International Energy Agency, Department of Building Technology and Structural Engineering, Aalborg University; 2002.
135. BS 5925: Code of Practice for Ventilation Principles and Designing for Natural Ventilation. British Standards Institute, 1991. (Accessed at http://www.standardsdirect.org/standards/standards4/StandardsCatalogue24_view_4477.html.)
136. CIBSE. Design Data. In: *CIBSE Guide: Air Infiltration and Natural Ventilation*. London: The Chartered Institution of Building Services Engineering; 1988:Volume A, Section A4.
137. CIBSE. Natural Ventilation in Non-domestic Buildings. In: *CIBSE Applications Manual*. London: The Chartered Institute of Building Services Engineering; 1997:99.
138. Priolo C. Design guidelines and technical solutions for natural ventilation. In: Allard F, ed. *Natural ventilation in buildings - a design handbook*. London: James & James; 1998:195-254.
139. Waxham F. Outdoor treatment of tuberculosis. *JAMA* 1902;39:1392-3.
140. Escombe A, Oeser C, Martinez C. Natural ventilation to reduce nosocomial transmission of tuberculosis and other airborne infections. *Int J Tuberc Lung Dis* 2005;9(Suppl 1):S56-7.
141. Jiang Y, Li X, Zhao B, Zhang Z, Zhang Y. SARS and ventilation. In: *4th International Symposium on HVAC*; 2003 9-11 October; Beijing, China; 2003. p. 27-36.
142. Fung CP, Hsieh TL, Tan KH, et al. Rapid creation of a temporary isolation ward for patients with severe acute respiratory syndrome in Taiwan. *Infect Control Hosp Epidemiol* 2004;25(12):1026-32.

143. Dwosh HA, Hong HH, Austgarden D, Herman S, Schabas R. Identification and containment of an outbreak of SARS in a community hospital. *CMAJ* 2003;168(11):1415-20.
144. Foldy SL, Barthell E, Silva J, et al. SARS Surveillance Project--Internet-enabled multiregion surveillance for rapidly emerging disease. *MMWR Morb Mortal Wkly Rep* 2004;53 Suppl:215-20.
145. Coker R, Mounier-Jack S. Pandemic influenza preparedness in the Asia-Pacific region. *Lancet* 2006;368(9538):886-9.
146. Clothier H, Turner J, Hampson A, Kelly H. Geographic representativeness for sentinel influenza surveillance: implications for routine surveillance and pandemic preparedness. *Aust N Z J Public Health* 2006;30(4):337-41.
147. Juckett G. Avian influenza: preparing for a pandemic. *Am Fam Physician* 2006;74(5):783-90.
148. A practical tool for the preparation of a hospital crisis preparedness plan, with special focus on pandemic influenza. Copenhagen: WHO Regional Office for Europe; 2006.
149. WHO checklist for influenza pandemic preparedness planning. World Health Organization, 2005. (Accessed 25 May 2007, at http://whqlibdoc.who.int/hq/2005/WHO_CDS_CSR_GIP_2005.4.pdf.)
150. Heymann DL, Rodier GR. Hot spots in a wired world: WHO surveillance of emerging and re-emerging infectious diseases. *Lancet Infect Dis* 2001;1(5):345-53.
151. Borgundvaag B, Ovens H, Goldman B, et al. SARS outbreak in the Greater Toronto Area: the emergency department experience. *Cmaj* 2004;171(11):1342-4.
152. Riley S, Fraser C, Donnelly CA, et al. Transmission dynamics of the etiological agent of SARS in Hong Kong: impact of public health interventions. *Science* 2003;300(5627):1961-6.
153. Asplin BR, Flottemesch TJ, Gordon BD. Developing Models for Patient Flow and Daily Surge Capacity Research. *Acad Emerg Med* 2006.
154. Baumann AO, Blythe JM, Underwood JM. Surge capacity and casualization: Human resource issues in the post-SARS health system. *Can J Public Health* 2006;97(3):230-2.
155. Schull MJ, Stukel TA, Vermeulen MJ, Guttman A, Zwarenstein M. Surge Capacity Associated with Restrictions on Nonurgent Hospital Utilization and Expected Admissions during an Influenza Pandemic: Lessons from the Toronto Severe Acute Respiratory Syndrome Outbreak. *Acad Emerg Med* 2006;13(11):1228-31.
156. Bartlett JG. Planning for avian influenza. *Ann Intern Med* 2006;145(2):141-4.
157. Hick JL, O'Laughlin DT. Concept of operations for triage of mechanical ventilation in an epidemic. *Acad Emerg Med* 2006;13(2):223-9.
158. Smith RD. Responding to global infectious disease outbreaks: Lessons from SARS on the role of risk perception, communication and management. *Soc Sci Med* 2006;63(12):3113-23.
159. Responding to the avian influenza pandemic threat. World Health Organization, 2005. (Accessed 25 May 2007, at http://whqlibdoc.who.int/hq/2005/WHO_CDS_CSR_GIP_2005.8_eng.pdf.)
160. Williams WW. CDC guidelines for the prevention and control of nosocomial infections. Guideline for infection control in hospital personnel. *Am J Infect Control* 1984;12(1):34-63.
161. Harper SA, Fukuda K, Uyeki TM, Cox NJ, Bridges CB. Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2005;54(RR-8):1-40.
162. Hehme N, Engelmann H, Kunzel W, Neumeier E, Sanger R. Pandemic preparedness: lessons learnt from H2N2 and H9N2 candidate vaccines. *Med Microbiol Immunol (Berl)* 2002;191(3-4):203-8.
163. WHO rapid advice guidelines on pharmacological management of humans infected with avian influenza A (H5N1) virus. World Health Organization, 2006. (Accessed 25 May 2007, at http://whqlibdoc.who.int/hq/2006/WHO_PSM_PAR_2006.6_eng.pdf.)

164. Hirji Z, O'Grady S, Bonham J, et al. Utility of zanamivir for chemoprophylaxis of concomitant influenza A and B in a complex continuing care population. *Infect Control Hosp Epidemiol* 2002;23(10):604-8.
165. Jefferson T, Demicheli V, Rivetti D, Jones M, Di Pietrantonj C, Rivetti A. Antivirals for influenza in healthy adults: systematic review. *Lancet* 2006;367(9507):303-13.
166. Jefferson T, Demicheli V, Di Pietrantonj C, Rivetti D. Amantadine and rimantadine for influenza A in adults. *Cochrane Database Syst Rev* 2006(2):CD001169.
167. Bhat N, Wright JG, Broder KR, et al. Influenza-associated deaths among children in the United States, 2003-2004. *N Engl J Med* 2005;353(24):2559-67.
168. Cheung TM, Yam LY, So LK, et al. Effectiveness of noninvasive positive pressure ventilation in the treatment of acute respiratory failure in severe acute respiratory syndrome. *Chest* 2004;126(3):845-50.
169. Christian MD, Loutfy M, McDonald LC, et al. Possible SARS coronavirus transmission during cardiopulmonary resuscitation. *Emerg Infect Dis* 2004;10(2):287-93.
170. Wan GH, Tsai YH, Wu YK, Tsao KC. A large-volume nebulizer would not be an infectious source for severe acute respiratory syndrome. *Infect Control Hosp Epidemiol* 2004;25(12):1113-5.
171. Somogyi R, Vesely AE, Azami T, et al. Dispersal of respiratory droplets with open vs closed oxygen delivery masks: implications for the transmission of severe acute respiratory syndrome. *Chest* 2004;125(3):1155-7.
172. Hui DS, Ip M, Tang JW, et al. Airflows around oxygen masks: A potential source of infection? *Chest* 2006;130(3):822-6.
173. Harrel SK, Molinari J. Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. *J Am Dent Assoc* 2004;135(4):429-37.
174. Catanzaro A, Jackson M. Preventing nosocomial transmission of tuberculosis. *Lancet* 1995;345(8944):204-5.
175. Malasky C, Jordan T, Potulski F, Reichman LB. Occupational tuberculous infections among pulmonary physicians in training. *Am Rev Respir Dis* 1990;142(3):505-7.
176. Nogler M, Lass-Florl C, Ogon M, Mayr E, Bach C, Wimmer C. Environmental and body contamination through aerosols produced by high-speed cutters in lumbar spine surgery. *Spine* 2001;26(19):2156-9.
177. Nogler M, Lass-Florl C, Wimmer C, Bach C, Kaufmann C, Ogon M. Aerosols produced by high-speed cutters in cervical spine surgery: extent of environmental contamination. *Eur Spine J* 2001;10(4):274-7.
178. Burton JL. Health and safety at necropsy. *J Clin Pathol* 2003;56(4):254-60.
179. Beggs CB, Noakes CJ, Sleigh PA, Fletcher LA, Siddiqi K. The transmission of tuberculosis in confined spaces: an analytical review of alternative epidemiological models. *Int J Tuberc Lung Dis* 2003;7(11):1015-26.
180. Mehta AC, Prakash UB, Garland R, et al. American College of Chest Physicians and American Association for Bronchology [corrected] consensus statement: prevention of flexible bronchoscopy-associated infection. *Chest* 2005;128(3):1742-55.
181. Yu IT, Xie ZH, Tsoi KK, et al. Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others? *Clin Infect Dis* 2007;44(8):1017-25.
182. Loeb M, McGeer A, Henry B, et al. SARS among critical care nurses, Toronto. *Emerg Infect Dis* 2004;10(2):251-5.
183. Cooper A, Joglekar A, Adhikari N. A practical approach to airway management in patients with SARS. *CMAJ* 2003;169(8):785-7.
184. Pippin DJ, Verderame RA, Weber KK. Efficacy of face masks in preventing inhalation of airborne contaminants. *J Oral Maxillofac Surg* 1987;45(4):319-23.

185. Kaye K, Weber D, Rutala W. Nosocomial infections associated with respiratory therapy. In: Mayhall C, ed. *Hospital Epidemiology and Infection Control*. 3 ed. Philadelphia: Lippincott Williams & Wilkins; 2004:1207-22.
186. Derrick JL, Gomersall CD. Protecting healthcare staff from severe acute respiratory syndrome: filtration capacity of multiple surgical masks. *J Hosp Infect* 2005;59(4):365-8.
187. Lenhart SW, Seitz T, Trout D, Bollinger N. Issues affecting respirator selection for workers exposed to infectious aerosol: emphasis on healthcare settings. *Applied Biosafety* 2004;9(1):20-36.
188. Allard F, Santamouris M, eds. *Natural Ventilation in Buildings: A Design Handbook*. London: James and James, Ltd.; 1998.
189. Liddament MW. *A Guide to Energy Efficient Ventilation*. Coventry: The Air Infiltration and Ventilation Centre, University of Warwick Science Park; 1996.
190. Awbi H. *Ventilation of Buildings*. 2nd ed. New York: Taylor & Francis; 2003.
191. Li Y, and Delsante, A. Natural ventilation induced by combined wind and thermal forces. *Building and Environment* 2001;36:59-71.
192. Irving SJ, Concannon PJ, Dhargalkar HS. An inverse solver for sizing passive ventilation openings; 1995.
193. Axley J. Introduction to the design of natural ventilation systems using loop equations. In: 19th AIVC Conference - Ventilation Technologies in Urban Areas; 1998 28-30 September; Oslo, Norway; 1998. p. 47-56.
194. Fanger P. *Thermal comfort: analysis and applications in environmental engineering*. New York: McGraw-Hill; 1970.
195. Brady MT, Evans J, Cuartas J. Survival and disinfection of parainfluenza viruses on environmental surfaces. *Am J Infect Control* 1990;18(1):18-23.
196. Suarez DL, Spackman E, Senne DA, Bulaga L, Welsch AC, Froberg K. The effect of various disinfectants on detection of avian influenza virus by real time RT-PCR. *Avian Dis* 2003;47(3 Suppl):1091-5.
197. Sattar SA, Jacobsen H, Springthorpe VS, Cusack TM, Rubino JR. Chemical disinfection to interrupt transfer of rhinovirus type 14 from environmental surfaces to hands. *Appl Environ Microbiol* 1993;59(5):1579-85.
198. Sattar SA, Springthorpe VS, Karim Y, Loro P. Chemical disinfection of non-porous inanimate surfaces experimentally contaminated with four human pathogenic viruses. *Epidemiol Infect* 1989;102(3):493-505.
199. Rabenau HF, Kampf G, Cinatl J, Doerr HW. Efficacy of various disinfectants against SARS coronavirus. *J Hosp Infect* 2005;61(2):107-11.
200. Dettenkofer M, Wenzler S, Amthor S, Antes G, Motschall E, Daschner FD. Does disinfection of environmental surfaces influence nosocomial infection rates? A systematic review. *Am J Infect Control* 2004;32(2):84-9.
201. Scott E, Bloomfield SF. Investigations of the effectiveness of detergent washing, drying and chemical disinfection on contamination of cleaning cloths. *J Appl Bacteriol* 1990;68(3):279-83.
202. Medcraft JW, Hawkins JM, Fletcher BN, Dadswell JV. Potential hazard from spray cleaning of floors in hospital wards. *J Hosp Infect* 1987;9(2):151-7.
203. Spaulding EH. Chemical disinfection of medical and surgical materials. In: Lawrence C, Blcock SS, eds., eds. *Disinfection, sterilization, and preservation*. Philadelphia: Lie & Febiger; 1968:517-31.
204. Rutala WA. APIC guideline for selection and use of disinfectants. 1994, 1995, and 1996 APIC Guidelines Committee. Association for Professionals in Infection Control and Epidemiology, Inc. *Am J Infect Control* 1996;24(4):313-42.

205. 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(2):177-82.
206. Craven DE, Lichtenberg DA, Goularte TA, Make BJ, McCabe WR. Contaminated medication nebulizers in mechanical ventilator circuits. Source of bacterial aerosols. *Am J Med* 1984;77(5):834-8.
207. Spach DH, Silverstein FE, Stamm WE. Transmission of infection by gastrointestinal endoscopy and bronchoscopy. *Ann Intern Med* 1993;118(2):117-28.
208. Weber DJ, Rutala WA. Lessons from outbreaks associated with bronchoscopy. *Infect Control Hosp Epidemiol* 2001;22(7):403-8.
209. Wheeler PW, Lancaster D, Kaiser AB. Bronchopulmonary cross-colonization and infection related to mycobacterial contamination of suction valves of bronchoscopes. *J Infect Dis* 1989;159(5):954-8.
210. Poledore AP. The sanitizing efficiency of diswashing machines. *J Foodservice* 1980:17-25.
211. Stahl Wernersson E, Johansson E, Hakanson H. Cross-contamination in dishwashers. *J Hosp Infect* 2004;56(4):312-7.
212. Ijaz MK, Sattar SA, Johnson-Lussenburg CM, Springthorpe VS, Nair RC. Effect of relative humidity, atmospheric temperature, and suspending medium on the airborne survival of human rotavirus. *Can J Microbiol* 1985;31(8):681-5.
213. Marks PJ, Vipond IB, Carlisle D, Deakin D, Fey RE, Caul EO. Evidence for airborne transmission of Norwalk-like virus (NLV) in a hotel restaurant. *Epidemiol Infect* 2000;124(3):481-7.
214. Marks PJ, Vipond IB, Regan FM, Wedgwood K, Fey RE, Caul EO. A school outbreak of Norwalk-like virus: evidence for airborne transmission. *Epidemiol Infect* 2003;131(1):727-36.
215. Battles DR, Vesley D. Wash water temperature and sanitation in the hospital laundry. *J Environ Health* 1981;43(5):244-50.
216. Blaser MJ, Smith PF, Cody HJ, Wang WL, LaForce FM. Killing of fabric-associated bacteria in hospital laundry by low-temperature washing. *J Infect Dis* 1984;149(1):48-57.
217. Christian RR, Manchester JT, Mellor MT. Bacteriological quality of fabrics washed at lower-than-standard temperatures in a hospital laundry facility. *Appl Environ Microbiol* 1983;45(2):591-7.
218. Barker J, Jones MV. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. *J Appl Microbiol* 2005;99(2):339-47.
219. Morawska L. Droplet fate in indoor environments, or can we prevent the spread of infection? *Indoor Air* 2006;16(5):335-47.
220. Karanfil LV, Conlon M, Lykens K, et al. Reducing the rate of nosocomially transmitted respiratory syncytial virus. *Am J Infect Control* 1999;27(2):91-6.
221. Mlinaric-Galinovic G, Varda-Brkic D. Nosocomial respiratory syncytial virus infections in children's wards. *Diagn Microbiol Infect Dis* 2000;37(4):237-46.
222. Thorburn K, Kerr S, Taylor N, van Saene HK. RSV outbreak in a paediatric intensive care unit. *J Hosp Infect* 2004;57(3):194-201.
223. Ibricevic A, Pekosz A, Walter MJ, et al. Influenza virus receptor specificity and cell tropism in mouse and human airway epithelial cells. *J Virol* 2006;80(15):7469-80.
224. CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care facilities, 1994. Centers for Disease Control and Prevention. *MMWR* 1994;43(RR-13):1-132.
225. CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. *MMWR* 2005;54(RR17).
226. Le DH, Bloom SA, Nguyen QH, et al. Lack of SARS transmission among public hospital workers, Vietnam. *Emerg Infect Dis* 2004;10(2):265-8.

227. Park BJ, Peck AJ, Kuehnert MJ, et al. Lack of SARS transmission among healthcare workers, United States. *Emerg Infect Dis* 2004;10(2):244-8.
228. Peck AJ, Newbern EC, Feikin DR, et al. Lack of SARS transmission and U.S. SARS case-patient. *Emerg Infect Dis* 2004;10(2):217-24.
229. Ali Y, Dolan M, Fendler E, Larson E. Alcohols. In: Block S, ed. *Disinfection, Sterilization and Preservation*. 5 ed. Philadelphia: Williams and Wilkins; 2000:229-53.
230. Bell DM. Public health interventions and SARS spread, 2003. *Emerg Infect Dis* 2004;10(11):1900-6.
231. Rutala WA, Weber DJ, Gergen MF, Gratta AR. Efficacy of a washer-pasteurizer for disinfection of respiratory-care equipment. *Infect Control Hosp Epidemiol* 2000;21(5):333-6.
232. Gillis J, Rennick J. Affirming parental love in the pediatric intensive care unit. *Pediatr Crit Care Med* 2006;7(2):165-8.
233. Leidy NK, Margolis MK, Marcin JP, et al. The impact of severe respiratory syncytial virus on the child, caregiver, and family during hospitalization and recovery. *Pediatrics* 2005;115(6):1536-46.
234. Hanrahan KS, Lofgren M. Evidence-based practice: examining the risk of toys in the microenvironment of infants in the neonatal intensive care unit. *Adv Neonatal Care* 2004;4(4):184-201, quiz 2-5.
235. Avila-Aguero ML, German G, Paris MM, Herrera JF. Toys in a pediatric hospital: are they a bacterial source? *Am J Infect Control* 2004;32(5):287-90.
236. Buttery JP, Alabaster SJ, Heine RG, et al. Multiresistant *Pseudomonas aeruginosa* outbreak in a pediatric oncology ward related to bath toys. *Pediatr Infect Dis J* 1998;17(6):509-13.
237. Davies MW, Mehr S, Garland ST, Morley CJ. Bacterial colonization of toys in neonatal intensive care cots. *Pediatrics* 2000;106(2):E18.
238. Hick JL, Hanfling D, Burstein JL, et al. Health care facility and community strategies for patient care surge capacity. *Ann Emerg Med* 2004;44(3):253-61.
239. Hogg W, Lemelin J, Huston P, Dahrouge S. Increasing epidemic surge capacity with home-based hospital care. *Can Fam Physician* 2006;52:563-4, 70-2.
240. Martin SD. Avian flu: should we worry in home healthcare? *Home Healthc Nurse* 2006;24(1):38-45; quiz 6-7.