Pan American Health Organization

World Health Organization
REGIONAL OFFICE FOR THE Americas

PREVENTION AND CONTROL OF HEALTHCARE-ASSOCIATED INFECTIONS

Basic Recommendations

This publication was made possible thanks to funding and cooperation from the Infection Control Center, U.S. Centers for Disease Control and Prevention, under Cooperative Agreement CDC-RFA-CK13-1301, "Building Capacity and Networks to Address Emerging Infectious Diseases in the Americas."
Our special thanks go to the Infection Control Program, Department of Patient Quality and Safety, Division of Human Stewardship and Development, Undersecretariat of Health Care Networks, Ministry of Health of Chile, for its technical support in the preparation of this document.

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Original version in Spanish

Prevención y control de infecciones asociadas a la atención de la salud. Recomendaciones Básicas

ISBN: 978-92-75-31954-3

Prevention and control of healthcare–associated infections. Basic Recommendations.

ISBN: 978-92-75-11954-9

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Suggested citation. Pan American Health Organization. *Prevention and control of healthcare–associated infections. Basic Recommendations.* Washington, D.C.: PAHO; 2018.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://iris.paho.org.

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Abbreviations

CFU	colony-forming unit
ESBL	extended-spectrum β-lactamase-producing Enterobacteriaceae
HBV	hepatitis B virus
HAI	healthcare-associated infection
HCV	hepatitis C virus
HEPA	high-efficiency particulate air
MERS	Middle East respiratory syndrome
MRSA	methicillin-resistant *Staphylococcus aureus*
PAHO	Pan American Health Organization
PPE	personal protective equipment
ppm	parts per million
SARS	severe acute respiratory syndrome
VRE	vancomycin-resistant *Enterococcus*
WHO	World Health Organization

Essential elements for implementing infection control measures in health facilities

I

According to available scientific evidence, interventions that yield the best results are those that are allowed to be used only if they are performed correctly, which often require structural and cultural changes on the part of health teams. When interventions of this kind are not feasible, it is necessary to introduce measures that will modify a health team's behavior, can be easily followed and adhered to over time, and will demonstrate long-term effectiveness.

So far, no single method has been discovered that meets all of these requirements with respect to healthcare-associated infections (HAIs). However, there is consensus on some of the basic elements that will help ensure sustained application of standard precautions, as well as other measures designed to reduce the incidence of HAIs. Some of these measures are specific to a particular type of intervention, as discussed later, but there are also a number of general

strategies for implementing interventions to prevent HAIs. The basic elements of the strategies recommended in this document are: (1) availability of a directive or description of what should be done, (2) training, (3) evaluation, and (4) establishment of a culture and changes in behavior.

1. Directives: These are documents that include instructions on how to perform a procedure and under what conditions. They lay the groundwork for conducting an activity or a project, especially when the procedure must always be performed in the same way, systematically, by anyone who carries it out. The directives should be based, whether explicitly or tacitly, on available scientific information and on best practices for dealing with the issue in question. They can be in the form of instructions, protocols, standards, procedure manuals, or clinical guidelines. Their purpose is to direct and support healthcare personnel by describing effective practices for preventing infections and reducing their variability. Below is a list of the desirable characteristics of these directives:

    - They should be prepared locally by each institution. While they should be backed by international scientific publications or national legislation, it is better if they are prepared by staff formally trained in HAI control in the health establishment itself in collaboration with the personnel who will be administering, complying with, or enforcing directives.
    - They should have official status, that is, they should be signed by the highest official in the institution.
    - They should be based on the best available evidence but summarized in easily understood terms for those who will be following them.

- They should be consistent with national legislation.
- They should contain brief, precise instructions and their application should be as uncomplicated as possible.
- They should contain instructions or a list of compulsory, clearly defined steps to be performed.
- They should be made public and widely disseminated, especially among the people who will be performing the procedures or supervising them (health workers and other collaborators in the institution).
- They should be easy to access at all times.
- They should be updated regularly.
- They should be backed by financial support and ongoing resources for implementing them and ensuring that they are maintained.

2. Training: The aim is to impart information about the contents of institutional directives. Activities should be conducted to promote effective communication (decisive but showing empathy and active listening) for personnel in the health facility where the directives will be applied. The training should be geared toward the development of competency, including knowledge (knowing), skills (doing), and attitudes (recognizing the problem and having the ability to get personnel involved in following the directives). There should be clarity on the following aspects:

   2.1 Objectives

   - Specificity. Choose specific personnel to be trained according to the content of the institutional

directive. Preference should be given to activities with specific content and a clear time frame. It is better to hold several training sessions with different content, targeted toward the particular type of personnel to be trained, than a long training program that covers all areas. Decisions on who should be trained (desired training coverage) should be based on the content of the directive and who has already had training in the particular area (actual coverage), which makes it possible to focus available resources on coverage gaps.

- Knowledge. Limit the content to be covered.

2.2 Time frame. The proposed objectives should be taken into account when estimating the time required for the training process.

2.3 Cost and available budget.

2.4 Competencies of the professionals facilitating the training, to include at minimum:

- An attitude of belief and confidence in the material being presented.
- An ability to share/repeat and disseminate practices and behaviors without supervision.
- A focus on the content of the directives and not on beliefs or opinions.
- Respect for the institutional culture without altering the directives.

2.5 Methods for presenting the content.

- Information
  - Use active oral and body-based means of communication (for example, face-to-face), as

opposed to passive modalities such as screensavers, posters, or pamphlets, which can be used to support the training but should not be the only means of conveying information.

- Give preference to interpersonal communication in small groups when explaining what should be done and why.

- Demonstrations and practice of skills:
  - Select and transmit the knowledge, practices, and behaviors that are expected to result from the training.
  - Offer sufficient and satisfactory explanations to justify the basis for the practices with a view to achieving the expected skills or results.
  - Adjust content to take into account the habitual activities of the personnel.
  - If possible, conduct demonstrations and practices under typical working conditions at the facilities and with the supplies that are normally used.
  - Allow and encourage adaptations of the processes followed in individuals' normal working environment while always adhering to the principles that have to be respected.

3. Evaluation: A system should be in place to measure compliance with the directives based on two complementary types of evaluation, both of which should always be used.
   - Performance audit. Try to measure either the behavior change desired or the number of infections or

colonizations observed in a unit as a result of the behavior.

- Process evaluation. Determine whether or not the planned processes were actually carried out, regardless of the results.

3.1. Elements or strategies that should be evaluated among others:

- Supervision or assessment of individual compliance through observation or some other method, with immediate, non-punitive, instructive feedback to an individual when a flaw in a process is noted.
- Assessment of collective compliance through observation or some other method, with feedback and learning for the entire group.
- Surveys, interviews, or group discussions about the products, supplies, or technologies currently in use (soaps, alcohol solutions, hand-drying systems, types of personal protective equipment) in order to identify problems related to acceptance, application, and use of resources.

4. Development of a culture of safety.

The culture of an organization is the set of references shared by all members, developed over the course of the organization's history and based on the significance attributed to situations and relationships in everyday exchanges. It represents the sum of practices, beliefs, symbols, rituals, values, and expectations about what is considered appropriate that largely prevails in an institution and results in concrete everyday practices that may be negative or positive. The process

of change in a health institution can be seen only as the evolution of its own culture. The critical elements in this process are trust and a feeling by all personnel that they belong to the institution. Understanding the culture, as well as its processes of change, depends on the capacity or willingness of people to cultivate an organizational climate of ongoing learning [1].

The culture of safety in health facilities should be the product of interactions between individual and group values, attitudes, perceptions, competencies, and behavior patterns that determine people's actions and attitudes and the organization's style and efficiency in managing the safety of patients [1].

In a setting where people are aware of the risks associated with clinical activities, some of the following strategies, though not systematically demonstrated to be effective, can be expected to yield good results [2]:

- Identify people who are in a position to assume formal or informal leadership in the institution and get them involved.
- Maintain a climate of non-punitive cooperation and encourage teamwork.
- Set group goals, with or without incentives.
- Incorporate and show appreciation for initiatives to point out solutions by the personnel participating in the clinical exercises.

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Chain of microorganism transmission in healthcare

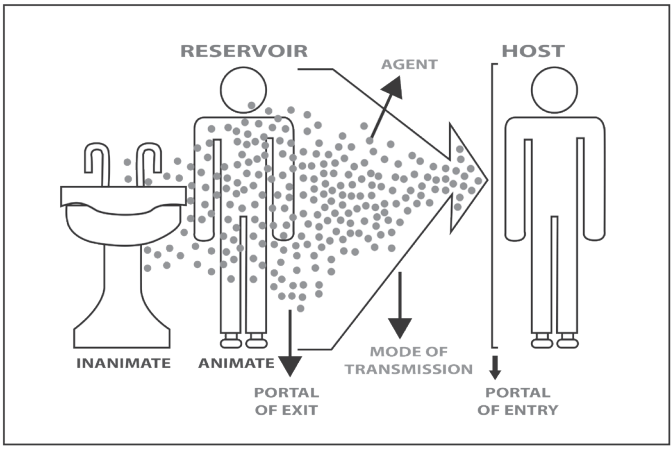
II

In order for an infection or colonization to occur, there must be a sequence of events that come together to transmit an infectious microorganism to a susceptible host. Infections or colonizations can arise in the community or in health institutions.

Healthcare-associated infections (HAIs) originate in health institutions and can affect both patients and personnel during the course of providing care.

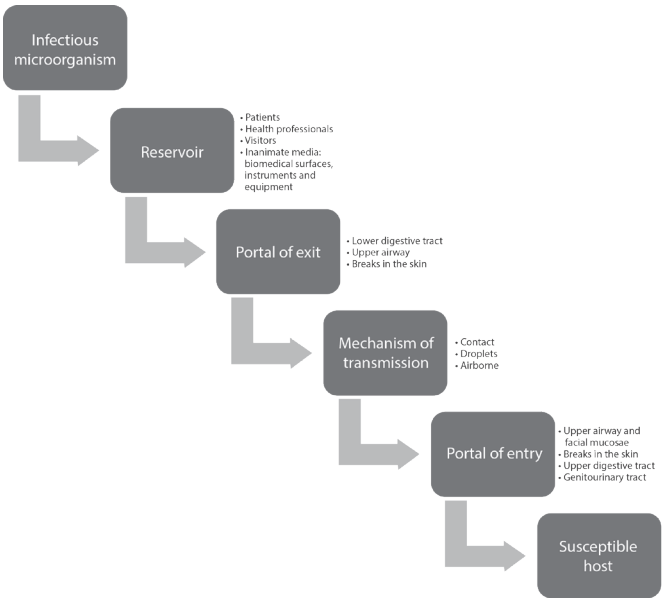
An HAI is the result of a sequence of interactions and special conditions that make it possible for an infectious agent to enter and affect a susceptible host. Specifically, the microorganism must leave the place where it usually lives and reproduces (the reservoir) via a portal of exit; then, through a transmission mechanism, it must find a portal of entry on a person who is likely to acquire the infection (the susceptible host). Then the host has to develop the disease. This sequence of specific interactions is known as the chain of transmission (Figures 1 and 2).

Figure 1. Chain of transmission of HAIs



Source: Chile, Ministerio de Salud. Programa de Control de Infecciones Asociadas a la Atención de Salud. 1989.

Figure 2. Chain of transmission



Below are definitions of the main terms related to the chain of transmission:

- Microorganism: Biological agent capable of colonizing or creating an infection in a host.
  - Infection: Presence of a microorganism in the host tissue, where it lives, grows, multiplies, and induces an immune response in the host that generates signs and symptoms.
  - Colonization: Presence of a microorganism in the host tissue, where it lives, grows, and multiplies but does not show signs or symptoms. It may or may not induce an immune response.

Microorganisms may be bacteria, viruses, fungi, parasites, or prions. An agent that produces an infection has the following characteristics:

  - Infective dose.
  - Virulence: capacity of the agent to cause severe disease or death.
  - Invasiveness: capacity of the agent to penetrate host tissues and multiply.
  - Pathogenicity: capacity of the agent to cause disease through a variety of mechanisms.

- Reservoir: Habitat in which microorganisms live, grow, and multiply. A reservoir may be an inanimate object, the environment, or an animate being, either animal or human. The main reservoir of agents responsible for HAIs is a patient infected or colonized by a microorganism, regardless of whether the agent is sensitive or resistant to antimicrobial drugs. Often the host is a healthy carrier of the microorganism

who does not present symptoms of infectious disease, which makes it more difficult to identify the reservoir.

- Portal of exit: Point where the microorganism leaves the host, which tends to be the site where the agent is usually located. The main portals of exit are the upper respiratory tract, the lower digestive tract, and areas near breaks in the skin that are colonized or infected.
- Mechanism or mode of transmission: Manner or component by means of which the microorganism travels from the reservoir's portal of exit to the portal of entry on the susceptible host (see examples of infections based on the mechanism of transmission in Chapter IV, Additional precautions based on mode of transmission). In the case of HAIs, the main mechanisms of transmission are as follows:

Contact

- Direct: The microorganism travels from the reservoir's portal of exit to the susceptible host without the mediation of other elements to accomplish the transmission. For example, this can occur through (1) direct contact between the blood or body fluids containing the infective microorganism in a patient with Ebola virus disease and the mucous membranes or skin lesions of a caregiver or nearby patient who was not using protective barriers or performing hand hygiene; (2) direct contact without gloves between a health worker or another patient and a nearby patient who has scabies; (3) direct hand contact, without gloves, between a health worker and a patient with oral herpes simplex 1 lesions, leading to subsequent appearance of a herpes whitlow on the finger that was in contact with the patient's mouth; or (4)

a microorganism-contaminated drug that is injected into the bloodstream of a host.

- Indirect: The infective microorganism ends up reaching the susceptible host through an inanimate intermediary (clothes, surfaces in the room, other fomites) or an animate one (for example, the contaminated hands of a health worker touching another patient). Transmission cannot occur unless the agent has the capacity to survive in the environment; its mere presence in the environment is not sufficient for transmission to take place. Thus, identifying a microorganism in the environment does not necessarily mean that it will have retained its infective capacity or that it will participate in the chain of transmission.

  Examples of transmission by indirect contact are (1) transmission of *Clostridium difficile* spores on the hands of a health worker from a symptomatic infected patient to a susceptible host (for example, by handling feces without using gloves), (2) transmission of syncytial respiratory virus particulates on a toy that was in contact with a symptomatic patient and passed on to a susceptible host who touched the toy and then touched his or her facial mucous membranes, and (3) transmission of hepatitis C virus from an infected dialysis patient to other susceptible dialysis patients by administering a drug from a multidose syringe shared by health workers with more than one patient.

- Aerosols: These clusters of particles are produced when an air current passes across the surface of a liquid, creating small particles at the interface between the air and the liquid. Their size is inversely related to

the speed of the air: events that cause the air to travel across the respiratory mucous membrane and the epithelium at high speeds are likely to produce smaller particles [1]. Depending on their size, the microorganism-bearing particles are classified as follows:

- Droplets: These are created when an infective patient transmits microorganisms within particles (droplets) ranging from 5 μm (microns) to 100 μm in diameter. They usually come from the respiratory tract (mouth or nose) in the course of coughing, sneezing, or speaking and measure 20 μm in diameter, which means that they can remain in suspension for only a few seconds (smaller droplets can stay in suspension for up to a few minutes). They do not have the capacity to travel farther than 1 meter from the person who emits them [2]. Droplet transmission, as with contact transmission, can be indirect (through an intermediary) or direct (without one).
- Droplet nuclei (airborne transmission): Alternatively, when microorganisms are transmitted via particles smaller than 5 μm in diameter, they can stay airborne for prolonged periods and are capable of traveling longer distances than droplets when moved by air currents [3]. Once they are airborne, they can be inhaled and enter the alveoli of individuals sharing the same room, even if these individuals have not had direct contact with the infected patient. Droplet nuclei can be generated directly by patients through a cough or sneeze (as in the case of tuberculosis) or during procedures on patients carrying microorganisms not normally transmitted via these mechanisms. These procedures might include tracheal intubation, noninvasive positive-pressure

ventilation, invasive high-frequency ventilation, pre- and post-intubation airway aspiration, tracheotomy, respiratory kinesiotherapy, nebulization, fibrobronchoscopy, sputum induction, or centrifugation of samples and instruments used to cut tissues. While there is strong evidence from epidemiological studies on transmission of the SARS (severe acute respiratory syndrome) coronavirus, the procedures that entail the greatest risk are tracheal intubation, noninvasive ventilation, tracheotomy, and manual preintubation ventilation [4]. In addition, studies of tuberculosis cite the risk of procedures in which saws are used to cut tissues (surgeries, autopsies) [1].

- Portal of entry: This is the point at which the microorganism enters the susceptible host, which must then provide conditions under which the microorganism can survive and reproduce while also setting the stage for its toxins and other pathogenic factors to act. The main portals of entry are the upper respiratory tract, the digestive system, and breaks in the skin. Agents can also be transported to normally healthy cavities or sterile tissues via invasive instruments.
- Susceptible host: This is the final link in the chain. Whether or not the microorganism causes infection and disease in its host will depend on a number of constitutional, genetic, immune-related, and other nonspecific factors. In the event of an invasion of microorganisms, all of these factors come together to determine whether the host will perish or find the capacity to fight off the infection.

Prevention and treatment interventions seek to interrupt the chain of transmission at one or more of its links. There

are two main types of interventions: standard precautions and those that are based on the transmission mechanisms of specific microorganisms:

- Standard precautions: These measures apply to all patients regardless of diagnosis or whether or not they are known to have an infection or are colonized by an agent. Their purpose is to reduce the transmission of pathogenic microorganisms by preventing exposure to body fluids. The standard precautions are hand hygiene, use of personal protective equipment (PPE), prevention of exposure due to accidents with sharp instruments, and care in managing the environment and handling apparel, waste, solutions, and equipment.
- Precautions based on the mechanism of transmission: These measures are used when patients have a known diagnosis of infection or colonization by an epidemiologically important infectious microorganism or its presence is suspected.

In order for an infection or colonization to occur, each link in the chain of transmission must be present; if one is missing, the chain will be interrupted and there will be no transmission (Table 1).

Table 1. Components in the chain of transmission and interventions to prevent transmission

Component in the chain	Possible interventions
Microorganism	• If an infection has developed, specific treatment of the disease to shorten the infectious period. • Elimination of the microorganism from surfaces in the environment through cleaning, use of disinfectants, and sterilization when the microorganism is part of the chain of transmission.
Reservoir	• Animate (patients, health workers): immunization, training in eradication. • Antisepsis. • Environment, surfaces: cleaning, disinfection, sterilization.
Portal of exit	• Aseptic technique, standard precautions, additional precautions.
Transmission mechanism	• Standard precautions, additional precautions depending on mode of transmission.
Portal of entry	• Aseptic technique, standard precautions, additional precautions depending on mode of transmission.
Host	• Immunization, specific prophylaxis, proper treatment of any underlying disease or other condition that affects immunity.

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Standard precautions

III

A. Hand hygiene

Why are hands a source of transmission of microorganisms that can cause HAIs?

Two types of microbial flora or microbiota can be found on the hands, those that reside there and transitory ones. Both participate in the transmission of HAIs when the hands of health personnel touch patients or objects of their environment.

- Resident flora or microbiota. The skin of the hands is normally colonized with microorganisms, most often bacteria such as *Propionibacterium* spp., *Corynebacterium* spp., coagulase-negative *Staphylococcus*, and *Acinetobacter* spp. Yeasts such as *Candida parapsilosis* can also be found under the nails [1]. The resident flora consists of microorganisms that usually live on the superficial levels of the horny layer of the skin and cannot be totally removed. They can cause HAIs upon contact with normally sterile cavities, mucous membranes, conjunctiva, or breaks in the skin of the susceptible host (2).

- Transitory flora or microbiota. These microorganisms do not typically reside on the skin. They are acquired through contact with animate or inanimate surfaces contaminated with microorganisms. They do not remain permanently, and they can be removed via hand hygiene. They may be of various types, including the bacterium *Staphylococcus aureus*, Gram-negative bacilli, fungi, viruses, and others. Many of these agents are pathogenic and can subsist on the skin of the hands. They are the microorganisms most often associated with HAIs (2).

What should we know about the transmission of pathogens by the hands?

1. In order to cause infection or colonization, the microorganisms have to be present on the skin of the health worker's hands at the time care is being administered.
2. The main source of contamination of a health worker's hands is an infected patient. Another possible source is a patient colonized with pathogenic microorganisms, as with a newborn in a neonatal intensive care unit [3, 4, 5, 6].
3. These microorganisms can be found on objects, equipment, instruments, or environmental surfaces, most often in the environment surrounding patients or on articles used in their care. When touched by health workers, they become part of the transitory flora on the hand.
4. In order to cause an infection or colonization, the microorganisms present on the hands must be able to survive through the time during which care is being provided.

5. The microorganisms can be removed from the hands through hand hygiene.

Is hand hygiene sufficient to prevent HAIs?

- Hand hygiene reduces the number of microorganisms present on the hands (mainly transitory flora), it is one of the most effective strategies for preventing cross-transmission of the microorganisms that cause HAIs. However, while it is the most important component of the standard precautions, hand hygiene alone is not always sufficient to prevent HAIs.
- Hand hygiene is a necessary component in the prevention of HAIs, but there are many others—for example, precautions taken during access to cavities or normally sterile tissues during invasive procedures or when touching parts of the urinary system or the blood vessels.
- While the HAI prevention strategy requires a multifaceted approach, hand hygiene is fundamental.

How is hand hygiene achieved?

In the case of the standard precautions, two types of hand hygiene methods have been described[a]: (1) washing the hands with water and detergent or soap, with or without an antiseptic, and (2) rubbing the hands with an alcohol-based solution. Both of these methods are designed to remove dirt, organic matter, and transitory flora or microbiota (Table 2).

a. Hand hygiene in specific contexts such as surgery is not covered here.

Table 2. Characteristics of the two main hand hygiene methods used as a standard precaution

Hand washing	Application of alcohol-based solution
Scrubbing of the hands with soap and water and then rinsing, usually under a stream of water, to remove microorganisms by wiping them away and removing the chemical product.	Scrubbing or rubbing of the hands with an alcohol-based solution to remove microorganisms through the microbicidal effect of the alcohol.
Between 0.6 and 1.1 $\log_{10}$ CFUs are removed in 15 seconds and between 1.8 and 2.8 $\log_{10}$ CFUs are removed in 30 seconds.	Between 3.2 and 5.8 $\log_{10}$ CFUs are removed in 10 seconds.

Note. CFUs = colony-forming units.
Adapted from: Widmer AF. Replace hand washing with use of a waterless alcohol hand rub? Clin Infect Dis. 2000;31(1):136-43.

Hand washing

What are the properties of the necessary elements in hand washing?

Hand washing requires the following specific elements: water, soap, a washing installation, and a drying method.

1. ***Water***. Although water is essential for hand washing, it cannot by itself remove grease or dirt, which means that soap is needed.
    - Microorganism load. According to national and international standards, the water should be potable [7]. Hence, it should not have been used for other purposes, as there is no assurance that it still meets the standard.

- Temperature. It should be possible to regulate the temperature for the comfort of the user. Very cold or very hot water will discourage its use.
- Flow. The pressure of the water coming from the pipe should be low enough that the water does not spatter the user. Conversely, if the flow is very weak or clean water from containers is being used, it will take longer to remove soap from the hands, which may discourage hand washing and reduce adherence. Also, if running water is not available, the use of dispensers (Victoria Bucket type) is recommended to create a unidirectional flow and avoid stagnation (Figure 3).

Figure 3. Example of a unidirectional-flow water dispenser

2. ***Soap***. The two main soap types are solid and liquid. Attributes of the soap such as color, emollient, and scent can make a difference in acceptance or rejection by personnel and therefore affect hand-washing adherence. The preferences of personnel should be considered when selecting the soap to be used. There are soap formulations with and without antiseptic content for use in hand washing.

- Bar or liquid soap. There is no difference in effectiveness between liquid and bar soaps in terms of eliminating dirt. Some studies have found that solid soaps have a higher bacterial count, suggesting that they could potentially contribute to infection outbreaks [8, 9]; however, liquid soaps and their dispensers, and not bar soaps, have been implicated in epidemic outbreaks [10, 11]. It is recommended that solid soaps be kept clean and dry—for example, in a wire basket-type soap dish. With liquid soaps, several authors suggest avoiding refillable containers. If that is not possible, there should be a protocol in place for cleaning and disinfecting the container before refilling it [12, 13, 14, 15, 16].
- Soap with or without an antiseptic. From a microbiological standpoint, soaps without antiseptic content do not have a microbicidal effect; they remove microorganisms by dragging them away. It takes 15 seconds of washing to remove between 0.6 and 1.1 $\log_{10}$ colony-forming units (CFUs) and 30 seconds to remove between 1.8 and 2.8 $\log_{10}$ CFUs [17]. Soaps with antiseptic content (chlorhexidine, iodized povidone, etc.) are designed to clean organic matter and remove microorganisms, especially resident and transitory flora. Depending on the particular antiseptic, they have a dragging as well as a microbicidal effect, in addition to a residual effect (for example, soaps that contain chlorhexidine). It is important to keep in mind that some personnel may have skin reactions and others may reject soaps with antiseptics that stain the skin.
- The use of soap for hand washing depends to a large extent on user acceptance. Therefore, it is recommended

that different types of soap be evaluated before and during their incorporation into the healthcare setting.

- When soaps are used continuously, their residue may irritate the skin, which can diminish adherence to any method. Therefore, hands should always be rinsed until all soap residue is removed.

3. ***Hand-washing installations*** should encourage, not hinder, the practice. Failure to meet any of the following conditions will affect adherence to hand washing: (1) close proximity to the healthcare site, (2) easy accessibility and adequate space for performing the movements related to the procedure, (3) ability to regulate water temperature and pressure, (4) close proximity of soap or detergent, (5) good lighting, (6) site cleanliness, and (7) nearby access to supplies for drying the hands. If disposable paper towels are used, there should be a waste bin sufficiently large that the used towels do not overflow and fall on the floor.

Hand drying

There are several methods for drying hands. The most common include [18]:

- ***Disposable paper towels:*** Dispensers either provide individual sheets or allow the user to cut them off at the desired size. Health workers usually prefer paper towels because they are efficient and drying is fast (10 seconds). The dispensers must be kept filled because if towels are not available to health workers, they may not wash their hands.

- ***Cloth towels.*** Two types of systems for cloth towels are used:
  - A dispenser that automatically places used towels in a reserve compartment inside the dispenser itself to prevent them from being used again. The contents of the reserve compartment need to be removed on a regular basis and taken to the laundry, where the used towels are washed and then reloaded in the dispenser.
  - An endless roll of cloth several meters long. A single dry section of the roll is exposed to the user, and, after it is used, it is passed automatically to a compartment inside the dispenser. The cloth is then washed and dried at high temperatures before being returned to the operator for reuse.
  - Regular household towels that different people use multiple times get wet and remain damp. They are rejected by health workers and should not be used.
- ***Air dryers.*** These wall-mounted electrical devices work by generating a current of lukewarm air that dries the hands via evaporation or via jets of high-pressure air that create a drag effect on the moisture. Both forms are slow, taking up to 45 seconds to dry the hands, which reduces their effectiveness. They can produce air currents that scatter dust or other suspended particulates up to a radius of 1 meter. For this reason, some authors do not recommend their use in units with high-risk patients, although it has not been demonstrated that this effect is associated with the incidence of HAIs or epidemic outbreaks.

Studies that have evaluated the capacity to remove residual bacteria after hand washing have not found any significant difference between the various drying methods, although dispersion of particulates has been observed in the case of air-drying systems. None of the methods have been directly associated with epidemic outbreaks or cross-infections. What is important is that the drying method be immediately next to the hand-washing site. Table 3 outlines some of the attributes of the most frequently used drying methods. If it is possible to install more than one acceptable method, preference should be given to the one most widely accepted by users.

Table 3. Drying methods and their main attributes

Drying method	Drying time (seconds)	Acceptance by users	Cost	Noise
Paper towels	10-20	High	High[a]	None
Hot air dryers	40-45	Medium	Low	High
Air jet dryers	40-45	Medium	Low[b]	High
Cloth towels in automatic dispensers	10-20	Low	Not evaluated[c]	None

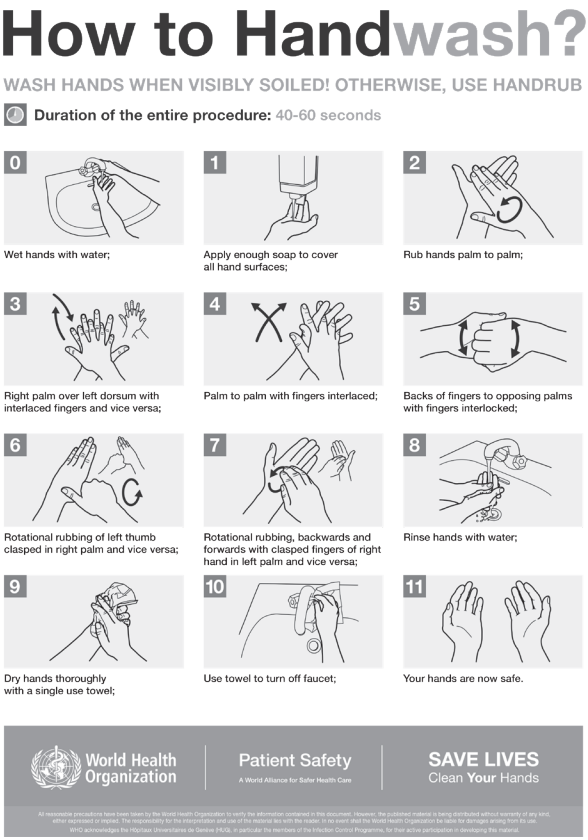
Adapted from: Huang C, Ma W, Stack S. The hygienic efficacy of different hand-drying methods: a review of the evidence. Mayo Clin Proc. 2012;87(8):791-8.

a. Paper towel dispensers should be regularly stocked to ensure ongoing access. Lack of towels discourages hand washing and reduces adherence.
b. Air jet dryers are costly to procure and install but inexpensive to support.
c. No evaluations have compared this method with others.

What hand-washing technique should be used?

1. During hand washing, the entire surface of the hands (palms, fingers, and the spaces between the fingers) should come in contact with the soap and water. The hands are rubbed to remove organic matter and dirt and then rinsed to remove all waste (Figure 4).

Figure 4. How to wash hands with soap and water



Source: World Health Organization. Available from: http://www.who.int/gpsc/5may/How_To_HandWash_Poster.pdf?ua=1.

2. Jewelry (hoop earrings, rings, watches). Although wearing jewelry is not a good clinical practice, since it makes correct hand washing more difficult, studies that have evaluated its association with higher rates of HAIs and disease outbreaks have had inconsistent results. While some studies have associated the use of jewelry with increased colonization by infectious agents such as Enterobacteriaceae and reduced hand hygiene effectiveness [19, 20, 21], others have not found such an association or a higher risk of microorganism transmission via the hands. In fact, no studies have linked wearing jewelry to an increased incidence of HAIs or epidemic outbreaks [22, 23, 24, 25]. Therefore, local decisions on wearing or not wearing jewelry should take into account the perception of risk by users, the cultural acceptance of the practice, and the potential risk of perforating gloves, especially in the case of rings that are not flat.

3. Fingernails. No association has been demonstrated between HAIs and the use of nail polish or artificial nails. Although some studies have linked nail polish and artificial nails to increased colonization by Gram-negative bacteria and fungi and to reduced hand hygiene effectiveness [26, 27], other investigations have not corroborated these results [22]. Other studies have examined the link between the use of nail polish or artificial nails and outbreaks of HAIs in high-risk units (intensive care units, neonatology units, and spinal and heart surgery wings), but no clear mechanisms of transmission could be found. Nor could it be determined whether any apparent risk was directly associated with the practice or, rather, with a failure to follow other standard precautions, difficulty in

verifying hand hygiene, variations in the permeability of gloves, inapparent lesions or infections of the nails, and so forth [1, 6, 28, 29, 30]. It makes sense to avoid wearing artificial nails, especially when health workers are treating patients in high-risk units (intensive care, neonatology, surgery wing) or in a clinical unit that is dealing with an epidemic outbreak. In any case, as with the use of rings, it is important to consider the perception of risk by users and cultural acceptance of the practice.

Use of alcohol-based solutions

Hand hygiene with alcohol-based solutions is subject to certain special conditions depending on the products used, their availability, and access to them when they are needed. If alcohol-based solutions are used, there is no need for other installations.

What properties should alcohol-based solutions have?

These solutions should have a broad-spectrum effect; should be fast acting, non-toxic, unaltered by environmental factors, odorless, economical, user-friendly, and fast drying; and should have appropriate viscosity.

What characteristics should alcohol-based solutions have?

- Alcohol-based solutions for topical use to disinfect the hands (with alcohol concentrations of 60% to 95%) have an immediate antimicrobial effect when

they come in contact with a bacterium because they denature the bacterial proteins. Their bactericidal effect is 3.2 to 5.8 $\log_{10}$ CFUs in 10 seconds (Table 4).

Table 4. Characteristics of the main hand hygiene products

Characteristic	Soap without antiseptic	Antiseptic soap	Alcohol solutions
Eliminates organic matter	Yes	Yes	No
Eliminates bacteria (in vivo)	Good	Good	Very good
Estimated length of the procedure	1 to 2 minutes	1 to 2 minutes	30 seconds
Cost	Very low	Low	Very low
Site where performed	Sink	Sink	Anywhere
Requires towel to dry hands	Yes	Yes	No
Requires an installation	Yes	Yes	No
Effects on the skin	Very rare	Rare	Very rare
Flammable	No	No	Yes
Meets at least 40% of hand hygiene requirements	Rarely	Rarely	Possibly

Adapted from: Widmer AF. Replace hand washing with use of a waterless alcohol hand rub? Clin Infect Dis. 2000;31(1):136-43.

- Alcohol-based solutions do not clean. Thus, the hands should be free of visible dirt. When they are visibly soiled, they should be washed and dried before applying the alcohol solution. For this reason, the two procedures, hand washing and application of an alcohol-based solution, are complementary; one does not take the place of the other.

- There are many available products, usually in the form of a gel or hydroalcoholic foaming solution, and their alcohol concentration ranges from 60% to 95%. The gel or foam solutions can be flammable, so it is important not to expose the hands to fire or sparks until they are fully dry. The characteristics that affect acceptance by users are scent, drying time, residual viscosity, and drying effect on the skin. The last-mentioned effect is not very common because emollients are added in the commercially available solutions.

What factors should be considered with regard to availability of and access to these solutions?

- Alcohol-based solutions should be placed near where a patient is being treated, preferably beside the patient's bed or where medication is being prepared. Installing wall-mounted dispensers far from the treatment area, such as near a sink, in a hall, or at the entrance to a room, makes them less likely to be used, since personnel have to go out of their way to access them. Thus, one of the main advantages of using the method—namely, the short procedure time—is lost. Placing them far away also sends unclear messages that could lead to incorrect procedures. For example,

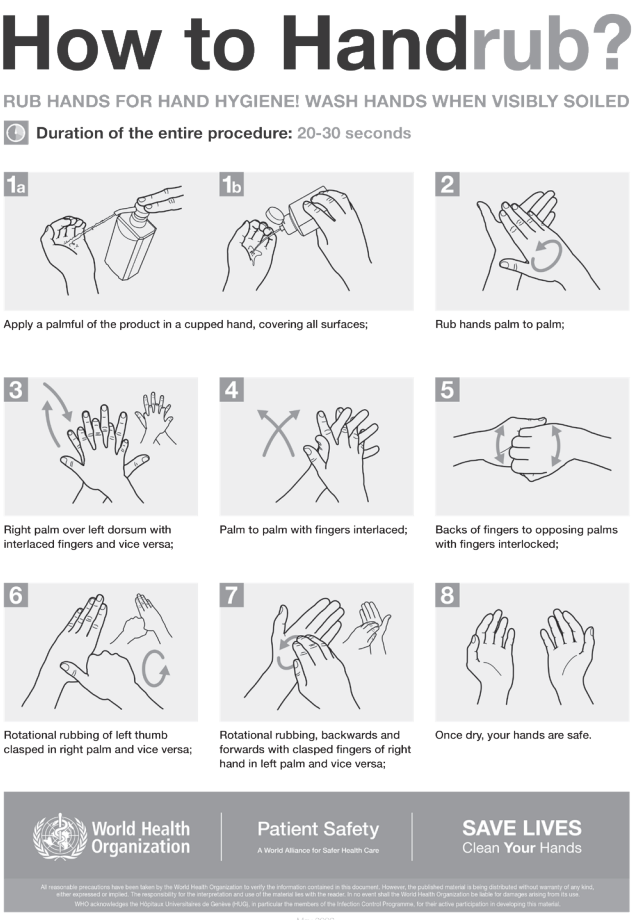
placing the alcohol-based solution near a washstand might suggest the need to disinfect the hands with the solution immediately after washing with soap and water.

- Alcohol-based solutions come in small sizes for individual use and larger containers with a pump. If possible, they should not be refilled. If they are going to be refilled, the container will have to be cleaned to eliminate any residue and then dried. A container that still has solution in it should never be refilled.
- A solution's validity period will vary depending on the manufacturer and the product. Therefore, the expiration date should be checked in each case.

What scrubbing/rubbing technique should be used with alcohol-based solutions?

- If the hands have visible dirt or have been in direct contact with body fluids, it will first be necessary to wash them with soap and water and dry them.
- Once the hands are dry and have no visible dirt, a squirt of the solution approximately 1 milliliter thick (a sufficient amount to spread over the entire hand) is placed in the palm and then rubbed until all of the surfaces of the hands (palms, fingers, backs) are in contact with the solution. Continue to rub until it dries (Figure 5).

Figure 5. Hand hygiene using an alcohol-based solution



Source: World Health Organization. Available from: http://www.who.int/gpsc/5may/How_To_HandRub_Poster.pdf.

Hand washing and the application of alcohol-based solutions are independent forms of hand hygiene, each with its advantages and disadvantages. They are not always interchangeable (Table 5). Both options are essential and should

always be available to improve adherence to an institution's practices.

Table 5. Advantages and disadvantages of alcohol-based solutions as compared with hand washing with soap and water

Advantages	Disadvantages
• Faster • User does not have to go to a sink • Does not require a special installation • Germicidal effect	• Effectiveness questioned[a] because a large amount of dirt/organic matter is still visible[b,c] • Can be less effective against specific microorganisms such as *Clostridium difficile* spores[d,e,f,g] • Potentially flammable, although this has been observed only on very rare occasions.

a. Studies under simulated conditions suggest that the microbicidal effect of alcohol-based solutions is not influenced by the presence of dirt and organic matter on the hands.

b. Pickering AJ, Davis J, Boehm AB. Efficacy of alcohol-based hand sanitizer on hands soiled with dirt and cooking oil. J Water Health. 2011;9(3):429-33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21976190.

c. Kawagoe J, et al. Bacterial reduction of alcohol-based liquid and gel products on hands soiled with blood. Am J Infect Control. 2011:39(9):785-7. Available from: http://dx.doi.org/10.1016/j.ajic.2010.12.018.

d. Oughton MT, et al. Hand hygiene with soap and water is superior to alcohol rub and antiseptic wipes for removal of *Clostridium difficile*. Infect Cont Hosp Epidemiol. 2009;30(10):939-44. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19715426.

e. Jabbar U, et al. Effectiveness of alcohol-based hand rubs for removal of *Clostridium difficile* spores from hands. Infect Cont

Hosp Epidemiol. 2010;31(6):565-70. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20429659.

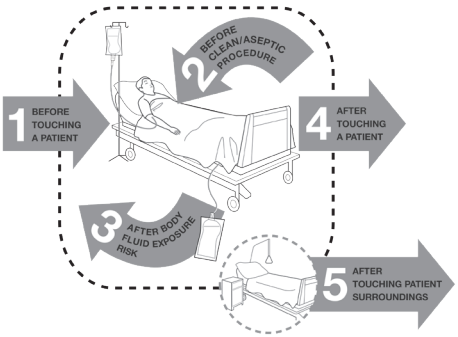
f. Boyce JM, et al. Lack of association between the increased incidence of *Clostridium difficile*-associated disease and the increasing use of alcohol-based hand rubs. Infect Cont Hosp Epidemiol. 2006;27(5):479-83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16671029.

g. No association has been found between increased use of alcohol-based solutions for hand hygiene and increased incidence of diarrheal disease from *Clostridium difficile*. If avoiding the use of alcohol-based solutions reduces overall adherence to hand hygiene, this negative impact should be taken into account in the final decision.

When should hand hygiene be done?

Just as important as good technique is performing hand hygiene at the proper time—namely, when the likelihood of contamination and carrying infectious agents to a portal of entry on a susceptible host is highest. Several situations, or "moments," have been identified as important times to disinfect the hands. The World Health Organization (WHO) promotes five widely recognized key moments for hand hygiene (Figure 6).

Figure 6. Five moments for hand hygiene recommended by the World Health Organization



What is known about conditions that affect adherence to hand hygiene?

- Studies conducted in intensive care units have shown that, in general, the level of hand-washing adherence is about 40%. Compliance varies with the individual health worker and the workload. Nursing personnel show greater compliance than other health team members. Higher workloads reduce compliance [2].
- Incorporation of alcohol-based solutions has been shown to increase hand hygiene adherence by nearly 55%. According to one study, the use of alcohol-based solutions increased over time from 5% to 22% without reductions in hand washing [31].
- Hugonnet et al. [31] observed a preference for alcohol-based solutions over hand washing with soap and water. The preference was related to the following factors: being a physician, performing high-risk procedures (e.g., touching blood vessels, changing from one site of activity to another on the same patient), and having to perform many procedures per hour.

What strategies can help to encourage hand hygiene?

A number of different strategies have been investigated to improve compliance with and adherence to hand hygiene, as well as sustainability over time. Two important strategies are (1) education of personnel and (2) education of patients, family members, and visitors.

1. **EDUCATION OF PERSONNEL** One successful experience [32] started with a brief training session that included

handing out alcohol-based solutions for individual use. Following the training, one of two additional interventions that had yielded good results in the past was added to the program. The two interventions will be called the "Geneva intervention" and the "Washington intervention," after the locations where they were conducted the first time. The interventions are described in Table 6.

Table 6. Training strategies to improve hand hygiene adherence

Geneva Intervention[a]	Washington Intervention[b]
Components: 1. Use of color posters (30 × 42 cm) on hand hygiene in treatment rooms, as well as in places where personnel pass when they are in transit, with messages on (1) the purpose of hand hygiene, (2) when it should be done, and (3) the recommended technique. 2. A brief staff training session on the use of alcohol-based solutions. 3. Distribution of individual bottles of alcohol-based solution. 4. Supervision of compliance via external observation, with immediate individual feedback on the findings without punitive consequences.	Components: 1. Participation of personnel in the facility where improved compliance is desired 2. Also, in the same workplace, participation of the clinical team in looking for and proposing ways to improve and organize hand hygiene, depending on the duties of the personnel and the circumstances in the facility; based on local experience.

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Geneva Intervention[a]	Washington Intervention[b]
This intervention was associated with a 56% increase in the use of alcohol-based solutions, particularly in infectious patient rooms. However, the same improvement was not observed in internal medicine areas.	This intervention was associated with a 48% increase in the use of alcohol-based solutions that was sustained until a subsequent evaluation two years later.

a. Larson EL, et al. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. Behav Med. 2000;26(1):14-22.

b. Pittet D, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene: Infection Control Programme. Lancet. 2000;356(9238):1307-12.

A systematic review of the literature found greater adherence to hand hygiene programs that included multimode interventions along at least five simultaneous intervention components (Table 7).

Table 7. Components of multimode interventions and description

Intervention component	Description
Structure	Ensuring and supervising adequate access to water with adjustable temperature, soap (with or without antiseptic), and alcohol-based solutions for hand hygiene. "Adequate access" refers to availability of the requirements described in the previous paragraphs, proximity to the area where patients are being treated, and sufficient resources to ensure continuity. It will be necessary to remove physical and process-related obstacles that might hinder access to installations.

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Intervention component	Description
Education and training	Actively and regularly disseminating information to health workers on the importance of hand hygiene and proper technique. The health team's hand hygiene practice should be strengthened by presenting the evidence for endorsing it and by scheduling repeated individual or group training programs. This activity can be held either at the workplace or elsewhere (face-to-face or through distance learning). Conducting it in the workplace provides the opportunity to assess the presence of barriers on site; preferences for certain soaps, drying methods, and alcohol-based solutions; and whether there is convenient access to installations for performing hand hygiene. It can facilitate adaptation to the real situation and the preferences of personnel. On-site training also encourages personnel to develop the necessary skills.
Feedback	Monitoring adherence to the practice and providing regular feedback to the people on the health team. Feedback can be provided through field and supervisory visits to directly observe compliance with hand hygiene (when to perform it and the technique) as part of a program that encompasses all areas of patient care. Emphasis should be placed on high-risk areas (emergency room, intensive care unit, neonatology unit), direct or indirect supervision of indicators of compliance and correct times for hand hygiene (use of soap or alcohol-based solutions in the different areas), and the application of technology.[a,b] Various systems can be used, such as counting the number of times the alcohol or soap was dispensed, electronic monitoring with a camera, or immediate feedback.

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Intervention component	Description
Reminders in the workplace	Disseminating messages in the workplace that emphasize the importance of hand hygiene and correct practice, using graphics, posters, auditory material, e-mail, and other methods. In one study, an attempt was made to involve patients in the methods mentioned through reminders to health workers of when they should use hand hygiene[c]; but however, there is no evidence on the impact of this intervention.
Climate of institutional safety	Enlisting management teams in promoting institutional engagement in the prioritization of hand hygiene as a strategy for the prevention and control of HAIs.

Adapted from: Luangasanatip N, et al. Comparative efficacy of interventions to promote hand hygiene in hospital: systematic review and network meta-analysis. BMJ. 2015;351:h3728. Available from: http://www.bmj.com/lookup/doi/10.1136/bmj.h3728.

a. Srigley JA, et al. Hand hygiene monitoring technology: a systematic review of efficacy. J Hosp Infect. 2015;89(1):51-60. Available from: http://linkinghub.elsevier.com/retrieve/pii/S019567011400320X.

b. Ward M, et al. Automated and electronically assisted hand hygiene monitoring systems: a systematic review. Am J Infect Control. 2014;42(5):472-8. Available from: http://dx.doi.org/10.1016/j.ajic.2014.01.002.

c. Davis R, et al. Systematic review of the effectiveness of strategies to encourage patients to remind healthcare professionals about their hand hygiene. J Hosp Infect. 2015;89(3):141-2. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0195670114003752.

The five intervention components described above had better results when three additional components were included:

- Targets. Progressive hand hygiene adherence targets were established for both the health team as a whole and the individual health workers.
- Accountability. Strategies were included for sharing the individual and group results and their consequences with the health workers.
- Incentives and rewards. These were granted based on the achievement of expected results. They were economic or in some other form.

Table 8. Assessment of results using multimodal strategies

Strategy	Odds ratio (confidence interval = 95%) for achievement of hand hygiene
No strategy or the customary practice	1.0
One intervention component	4.30 (0.43 to 46.57)
Five intervention components	6.51 (1.58 to 31.91)
Five intervention components + one supplementary component	11.83 (2.67 to 53.79)

Adapted from: Luangasanatip N, et al. Comparative efficacy of interventions to promote hand hygiene in hospital: systematic review and network meta-analysis. BMJ. 2015;351:h3728. Available from: http://www.bmj.com/lookup/doi/10.1136/bmj.h3728.

2. **EDUCATION OF PATIENTS, FAMILY MEMBERS, AND VISITORS.** Three different perspectives have been used in assessing strategies for educating and engaging patients, family members, and visitors in hand hygiene:
   - Participants are made responsible for reminding members of the health team when their hands should be disinfected in the workplace, either as the

only strategy or as part of a multimodal strategy. A systematic review of the literature [34] found that this approach had favorable results when measured according to patients' intention to remind health workers that it was time to use hand hygiene. This was especially true when patients were involved in designing the strategy, as well as when health workers actively promoted the practice among patients. However, the impact of this intervention on hand hygiene adherence is unknown.

- As part of the strategy for assessing the timeliness of health workers' hand hygiene, rather than immediate direct feedback being provided, special forms are designed for patients to report the information to the officials responsible for controlling HAIs in hospitals. Although the impact of this intervention is unknown, it has been seen to facilitate patient and visitor involvement, since it avoids the discomfort and perception of insecurity that some patients might feel if they have to face health workers directly, especially physicians [35].
- Patients and their companions are seen not only as reservoirs in the chain of transmission but also as vehicles of transmission of infectious agents. Although transmission of HAIs through the hands of patients and their companions tends to be considered less important than transmission through the hands of health workers, some studies have shown low levels of adherence to hand hygiene by patients and their family members and visitors, which represents a potential risk for transmission [36, 37, 38]. Studies on strategies for improving hand hygiene in patients and their companions are still inconclusive, as is

evidence of the impact of these practices on HAIs, but there is agreement on the need for both health workers and health institutions to provide the means for hand hygiene to patients and their companions [39, 40, 41, 42].

Summary

Compliance with and adherence to hand hygiene practices are affected by a number of factors. The following conditions contribute to success:

1. Supplies are well stocked and installations are in working order, easily accessible, and located near the sites where patients receive care.
2. Training has been provided and personnel know how to disinfect their hands and how to use the products and installations. They also know the moments when this practice is required (see the WHO five moments described above).
3. Compliance is assessed regularly to identify the factors that may hinder or favor it.
4. Successful experiences have been adopted and adapted, and their impact has been assessed in the local setting.
5. The characteristics of the supplies and installations have been examined with a view to improving acceptance by personnel.
6. Multimodal strategies have been incorporated to promote hand washing and the use of alcohol-based solutions as supplementary measures in addition to

the standard precautions for infection control, not as isolated measures.

7. Personnel participate in decisions to improve compliance with hand hygiene insofar as possible, taking into account their duties, their adaptation to the working environment, and the available products and installations.

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B. Personal protective equipment (PPE)

What is personal protective equipment?

A group of items that can be used separately or in combination, personal protective equipment is intended to form a barrier that prevents contact between health workers and a patient, object, or environment in order to prevent the transmission of infectious agents while providing care. It is called personal protective equipment because it can keep health workers from becoming infected or passing on microorganisms from infected patients by protecting their various portals of entry (mucous membranes, airway, skin) from direct contact. It is important to distinguish the items used to protect personnel from the practices followed to prevent infections in patients or transmission between patients.

PPE should be used in combination with other control and prevention strategies. The decision to use it depends on the mode of transmission of the infection, which will determine, for example, whether only standard precautions apply or if isolation from contact with droplets or aerosols is required.

The recommendations on using this equipment are based on the opinions of experts, transmission mechanisms, the known portals of entry, perception of risk, severity of the disease, and other considerations. So far, no experimental studies have provided concrete information on its impact in specific circumstances [1, 2]. Assessing its effectiveness has been difficult because most of the studies have looked at combinations of different types of PPE or different types of PPE in combination with other standard precautions. These

combinations make it impossible to interpret the individual effect of each item, particularly with regard to the use of masks, eyeglasses, or face shields [3, 4, 5].

What general points should be considered in selecting PPE for an institution?

Each PPE item may come in a variety of designs, be made of different materials, or have different properties. In selecting PPE items, the following two points should be considered: (1) previous knowledge about the item among personnel and their familiarity with its use and (2) compliance with national regulations or codes that impose minimum requirements in the technical specifications of the equipment—for example, certification of the manufacturing process, impermeability, or impenetrability with respect to certain pathogens [6, 7, 8].

What are the different PPE items/components?

The main components of PPE—in other words, the items most frequently used—are gloves, gowns, and waterproof aprons; eye protection (glasses, goggles, face shields); and devices to protect the mucous membranes of the mouth (masks, face shields) (Table 9).

Table 9. Types of personal protective equipment

Item	Generic item illustration
Gowns	
Safety eyewear: glasses, wrap-arounds, goggles	
Face protectors, face shields	
Respirators	
Masks	
Gloves	

(cont. next page)

Item	Generic item illustration
Waterproof aprons	

- **GLOVES.** One of the main PPE components, gloves are intended to prevent contact of the skin on the hands with contaminated sources such as the skin of patients colonized or infected with multiresistant microorganisms, blood, or body fluids and to avoid colonization of the hands by microbial flora from patients [9]. They may differ in the following respects: sterility (sterile or non-sterile), the material they are made of (latex, nitrile, vinyl), size, and length (only to the wrist or covering the entire forearm).

What criteria need to be considered in selecting gloves?

- Sterility: The decision will depend on the type of procedure for which the gloves are to be used. If the procedure involves an aseptic technique, they should always be sterile. Only non-sterile or clean gloves are needed for routine patient care procedures.
- Impermeability
- Type of material
- Flexibility or rigidity of the material
- Risk of triggering allergies (hypoallergenic material)
- Adjustability of length to cover wrist or forearm
- Size

How does the risk for HAI transmission affect the composition of the gloves?

There is no available evidence linking the risk for HAIs with any specific material (latex versus other materials). Studies conducted under laboratory conditions have found that vinyl has less of a barrier effect than nitrile or latex, which means that it has a smaller protective effect in the event of percutaneous exposure [9, 10]. At the same time, a clinical study that compared different types of gloves used in operating rooms/suites and examined the risk of exposure to sharp instruments in surgical procedures lasting longer than six hours found that gloves made of nitrile and neoprene were more likely to develop defects or visible breaks than those made of latex [11]. However, this clinical study did not find that any of the gloves had a lesser protective effect against percutaneous exposure [12].

The use of double-layer gloves is evaluated in terms of preventing infection of the surgical wound and use in the operating room/suite, but that topic is beyond the scope of the present document.

RECOMMENDATIONS

- When use of long-sleeve gowns is indicated, place gloves on top of the cuff of the gown.
- Always change gloves between patients.
- Use gloves only when necessary; excessive use can cause certain types of dermatitis and increase sensitivity to latex.
- Perform hand hygiene immediately before and, even more important, after using gloves. Under no circumstance should glove use replace hand hygiene.

- It may be necessary to change gloves while caring for the same patient when different activities are required and the gloves become contaminated.
- Change gloves whenever they develop breaks or tears.

What precautions should be taken when putting on and removing gloves?

Ongoing training and supervision are necessary to ensure that the correct procedure is followed in putting on and, especially, taking off gloves. Studies have shown that improper technique in removing gloves can lead to contamination of the hands and spread of fluids and microorganisms to the health worker's clothes, the environment, and people nearby, thus creating a potential mechanism for transmitting microorganisms capable of surviving in the environment [13]. The hands become contaminated when the gloves are removed, regardless of whether or not the gloves have any visible perforations [14]. Since it is impossible to ensure that gloves will remain uncontaminated while they are being used, and since there is a high likelihood that the health worker will not notice all perforations, breaks, or tears, hand hygiene after removing gloves must always be performed, even if the hands do not appear to be soiled; this is especially true if gloves are going to be used with the next patient [9, 15].

It is not recommended that gloves be sterilized and reused because it is difficult to ensure that they are not contaminated and the cost-benefit ratio is insignificant.

- GOWNS AND APRONS. A gown is an item of apparel, usually made of textile (disposable or reusable), plastic, or paper, that covers the body from the neck to the knees and the arms down to the wrists. It has an

opening and closing mechanism, usually located in the back. Some gowns have short sleeves and some open and close in the front. Their purpose is to keep the health worker's regular clothes from becoming contaminated or soiled during procedures that might create blood spatters, secretions, or excretions. Their use is also indicated when the procedure to be performed could place most of the health worker's clothing in contact with patients carrying specific microorganisms or with surfaces near patients.

On the other hand, an apron is made of waterproof material and covers the front of the body from the neck to the knees but not the arms. It should be used only as a second, waterproof barrier on top of the gown during procedures that generate a large volume of blood or body fluids.

Types of gowns

- Gowns made of cotton or linen. Since they are permeable, they should be used only when a low volume of patient secretions, blood, or body fluids is expected.
- Gowns made of plastic. They are usually waterproof, although some do not meet this requirement. If personnel expect to be exposed to a high volume of fluids, waterproof aprons should be used.
- Sterile gowns. These are intended for use when aseptic techniques are followed during invasive procedures. For other procedures, non-sterile gowns should be used.

How does risk for HAI transmission affect the composition of gowns?

In studies that have assessed the risk of operative wound infections, no differences have been found between reusable sterile gowns made of washable cotton or linen and sterile gowns made of plastic [16, 17]. To this point, when gowns are used to protect personnel from exposure to pathogens in blood and body fluids or to prevent cross-transmission between patients via health workers, the effect of the gowning material has not been determined. Most of the available research is in the form of laboratory studies, and the results vary depending on the material, the length of time it was used, and the pressure applied to test its permeability. Furthermore, a number of authors consider literature reviews conducted before 2000 [18] as no longer being valid because there have been so many recent changes in technology and manufacturing standards and regulations.

The following factors should be considered in decisions regarding whether to select disposable or waterproof apparel: (1) cost (reusable gowns for use by each individual patient and the cost of laundering them), (2) demonstrated impermeability of the specific material used, (3) user comfort (disposable materials tend to be less comfortable because of body temperature), (4) design, and (5) risk and impact of exposure to microorganisms [19, 20].

With regard to design, the choice of sleeve length—whether short sleeves or long sleeves with elastic cuffs—will depend on the risk of exposure. Usually, if the possibility of body fluid spattering or spilling is high, long sleeves will need to be used to keep fluids from landing on uncovered skin.

Types of waterproof aprons

- Disposable versus reusable
- Rigid or flexible material

Special attention should be paid to how the garment fastens. It should be easy to put on and, more importantly, to take off so that the user does not come in contact with fluids when it is being removed. In the case of reusable aprons, consideration should be given to how they are cleaned and disinfected.

- **PROTECTION OF THE FACIAL MUCOUS MEMBRANES (MOUTH, NOSE, AND CONJUNCTIVA)**. The conjunctiva and the mucous membranes of the nose and mouth are portals of entry for infectious agents. In certain circumstances, it is essential to protect them. In these cases, the barriers are mainly used to protect health workers during dental care or to provide isolation from contagion by aerosols, droplets, or any other risk of contact with body fluids coming directly or indirectly from a patient. The mucous membranes in the nose and mouth can be effectively protected from contact with body fluids or droplets and aerosols by using a variety of protective elements alone or in combination. Specific indications are given in Chapter IV (additional precautions based on mode of transmission).

Types of mouth and nose protectors

- Masks. These are non-occlusive devices that cover the health worker's nose and mouth with the aim of reducing the likelihood of contact between the mucous membranes in these areas and the potentially infectious body fluids of another person. Masks come in a

variety of designs: for example, some are pleated and unfold over the mouth, while others are preformed. The most appropriate type should be selected based on the purpose and the comfort of the user. Masks that are not preformed moisten more easily and lend themselves to contact with the user's mucous membranes. Although its impact has not been evaluated, this effect should be considered.

- Respirators with particle filters. These devices also cover the mouth and the nose, but unlike a mask, they filter the air, thus reducing inhalation of particles and protecting personnel from airborne pathogens. In order to achieve their purpose, they have to create an occlusive seal around the nose and the mouth. They can act as filters for air that is breathed in (with or without valves to facilitate breathing in and out) or as artificial providers of clean air for a person who is isolated from the outside, as in autonomous systems [21].

What is a type N95 or FFP2 respirator?

Respirators with filters come in different types (R95, N99, N95), based on a combination of two characteristics [21, 22]:

- Efficiency in filtering particles measuring as small as 0.1 to 0.3 μm (designated "95" if they remove 95% of such particles, "99" if they remove 99%, or "100" if they remove all particles).
- Degree of oil resistance (series N is nonresistant, series R is resistant, and series P is oil-proof).

The initials FFP in the designation of some respirators stand for *filtering facepiece* and refer to their ability to filter particles. In the health field, the most commonly used filter is the FFP2, which can filter 94% of particles measuring as small as 0.4 μm in diameter and is resistant to both oil-based and dry aerosols.

Are respirators as easy to use as masks?

All personnel should be familiar with and trained in the correct placement and removal of both masks and respirators and should be able to distinguish between the two devices. In order for the filter on a respirator to function properly, air has to pass through it. This is important, because if occlusion around the face is not complete, the filter will not be effective.

Training in the use of respirators should include ensuring that personnel are able to perform the following:

- *Adjustment test.* The purpose is to find out if air is leaking or the respirator is not filtering properly. This test must be performed in order to select the most appropriate type and size of respirator for the individual being fitted. A person should use only the specific respirator that successfully passed the adjustment test. International organizations suggest that the test be performed at least once a year, whenever a new type of respirator is introduced in a health facility, and whenever a physical change in the user might alter the balance between his or her face and the type and size of the respirator. There are several types of adjustment tests, usually divided into two broad categories [23]:
  - *Qualitative tests* (Figure 7). Following one of several standardized protocols, the tester exposes the user

wearing the respirator to aerosols with characteristic scents to determine whether he or she can smell them. If the scent can be detected, it means that the respirator is not properly adjusted on the user's face and needs to be switched to a different size or more appropriate model.

- *Quantitative tests*. The device's effectiveness is evaluated with special equipment that measures the number of particles inside and outside the respirator when it is in use.

Figure 7. Qualitative adjustment test

Source: OSHA et al. Hospital respiratory protection program toolkit: resources for respirator program administrators. May 2015.

- Seal check. The seal should be checked before each use of the respirator to ensure that it is working correctly before it touches the patient. If this is not done, there is no assurance that the respirator is properly filtering the inhaled air and therefore has the protective effect equivalent to that of a mask (Figure 8).

Figure 8. Sequence of the seal check before each use

1. Cup the respirator in your hand with the nosepiece at your fingertips allowing the headbands to hand 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.
   a) 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.
   b) 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.

Source: WHO. Available from : http://www.who.int/csr/resources/publications/SEALCHECK_EN_A2s.pdf?ua=1.

Masks and respirators are often used to prevent and control infections due to respiratory viruses and other droplet-transmitted agents that favor the nose or mouth as the portal of entry. There are no differences between masks and respirators in degree of protection against these agents. Respirators are associated with higher costs, user inconvenience,

and irritation of the skin on the face and neck [3,4]. Their use is indicated to prevent the transmission of infections caused by airborne microorganisms such as *Mycobacterium tuberculosis*.

How long can respirators be used without interruption? Can they be reused?

- Long-term use of respirators. A respirator can be used continuously for up to about eight hours (the length of time may vary depending on the manufacturer's specifications), as long as users do not touch its surface with their hands and seal checks are performed repeatedly to make sure it is working properly. Additional protective measures (face shields) should also be used if it is expected that exposure to droplets will be high. Respirators should be discarded after use in the following circumstances: when they have been worn during a procedure highly likely to generate aerosols, when they are visibly contaminated with any body fluid, when the seal check is unsatisfactory, or when the user experiences a significant increase in resistance to respiratory effort.
- Reuse of respirators. There is no consensus on the effectiveness of respirators in real conditions, nor are there any studies on the subject in the literature. Some authors, based on the results of a study conducted under controlled laboratory conditions [24],[b] suggest that if the same person reuses a respirator, it should not be used more than five times. After that, its filtration efficiency will decline significantly [25].

b. A total of 17 subjects participated in 20 sequences of placing and removing the respirator with seal checks each time. The study attempted to simulate a 10-hour shift with intermittent use of the respirator for one hour and pauses without the respirator between each one-hour period.

Types of eye protection

- Safety glasses or goggles. Unlike optical glasses (regular eyeglasses), safety glasses prevent aerosols, spatters, and droplets from coming in contact with the conjunctival mucous membranes. Regular glasses cannot be used for this purpose because they do not have barriers to protect the conjunctival mucous membranes. If a health worker needs to use medically prescribed glasses, there are goggles that can be adapted to accommodate them. It is important for them to be adjusted on the sides, under the eyes, and in the front. Also, the work area should have an indirect ventilation system to prevent the safety glasses from clouding up and hindering the user's vision.
- Face screens or shields. Unlike glasses, these types of equipment cover the entire face, from the forehead to the chin, and the frontal and parietal area of the skull. They do not require additional eye protection or a mask to guard against droplet-transmissible agents. They have an adjustable fastening arrangement in the front that also blocks spatters. When they are used to prevent the transmission of infectious agents via droplets, they allow the user to speak to other health workers more clearly than with the usual mask.

What characteristics should eye protection (safety glasses, goggles, face shields) have beyond serving as a barrier?

- It should not tarnish.
- It should be easy to adjust around the nose and over the forehead.
- It should be made of hypoallergenic material.

- It should have a fastening system or an adjustable means of holding it in place.
- It should be washable.
- It should allow for use over optical glasses.

Other PPE: boots, jumpsuits, hoods

Other items that may be regarded as components of PPE are headgear, jumpsuits, coveralls, arrangements for covering the neck, hoods, and shoe covers. There are no studies showing that these products provide effective protection against infectious agents during the provision of healthcare. Rather, they are used to avoid soiling regular clothes or shoes.

WHAT TYPE OF PPE SHOULD BE USED?

The type of equipment to be used and its specifications will mainly depend on the risk of exposure and user convenience.

1. Criteria for estimating the risk of exposure:
   - The type of procedure to be performed or care to be administered. It is important to foresee the duration of contact with the patient and the degree of exposure to specific situations that involve a high risk of contamination, generation of aerosols, or contact with or handling of sharps.
   - Any suspected presence of etiologic agents or infections to be avoided. Knowledge of the natural history of the disease, as well as the mode of transmission of the agent, will dictate the combination of PPE elements to be used and for how long.
2. User convenience. Health facilities should keep on hand the types and sizes of PPE that may be required

by the individual health workers, taking into account their physical frame and any special conditions (for example, personnel or patient allergy to latex, climate). While using more than the minimum required PPE elements may give the impression of greater safety, it can hinder health workers' performance and even expose them to greater risks during patient care while not providing additional protection [26]. There should be a balance between the desired protective effect and the risks and drawbacks of incorporating too many elements.

In the regular care of any patient, the use of gloves should be considered when touching body parts that may be contaminated. If spatters of secretions, stool, or blood are expected, facial protection and use of a gown or apron should be added. When precautions are being taken with a patient based on mode of transmission, the personal protective equipment should be selected according to the type of isolation indicated.

HOW IS PPE USED IN AN INSTITUTION?

1. The PPE elements should be available whenever they are needed. To maintain an adequate supply, it will be necessary to calculate the required stock levels in the sizes used by the health team that will be providing the care. For this purpose, the following steps are recommended: (1) determine how many care procedures the patient will require over a given period of time (in the case of disposable PPE, allow for one garment or device per patient procedure for each health worker; in the case of reusable gowns, estimate one gown per patient of the type regularly used by the health worker, or one gown per patient and one per type of

health worker, and recommend that they be changed and laundered daily); (2) estimate how many care procedures (for example, checking vital signs, caring for the patient's comfort) can be provided by a single health worker in a given time period; and (3) identify the physical characteristics and medical background of the personnel who will be providing care. It is important to estimate the sizes of PPE to be used and the particular materials if there are health workers with allergies, especially allergies to latex.

2. Train the personnel who will be using the PPE on:
   - The elements that encompass PPE
   - When and where it should be put on and removed
   - Possible need for assistance and supervision in putting on and removing the equipment
   - Correct donning sequence
   - Correct sequence of removal
   - Times for hand hygiene, especially during the sequence of removing the PPE
   - Where to dispose of the PPE
   - What to do if the sequence of removal fails or if there is exposure to body fluids during use
3. Observe whether personnel are using the PPE correctly, ensuring that:
   - They are not wearing the PPE outside the patient care area
   - The fasteners and ties are properly adjusted
   - The PPE covers the surfaces for which it was designed—for example, masks are secure and cover both the nose and mouth

- The PPE is the correct size and appropriate for the risk in question
- Health workers do not touch their face or eyes with gloved hands while they are providing care

WHAT CONDITIONS CAN AFFECT ADHERENCE TO PPE USE?

No single strategy has proven to be effective in achieving sustained adherence and correct PPE use over time. The various studies that have evaluated interventions were based on structured face-to-face training or distance learning using computer-based media or the Internet, either alone or coupled with simulations [27], skill assessments by trained peers, practical training, or video support [28]. These strategies have demonstrated only short-term results, followed by a reduction in adherence down to levels similar to those before the intervention. Although one reason for noncompliance is not knowing what should be done or how to do it, other reasons for gradually reduced adherence include excessive workload, insufficient time, low perception of risk, and location of the PPE more than 3 meters from the entrance to the patient's room [29, 30]. All of these factors should be considered when planning an intervention.

The use of respirators should be evaluated frequently because misuse is common. The reasons for misuse cited most often are the inconvenience of adjusting the straps, pressure on the face, difficulty breathing, and itching in the area under pressure [25].

Studies of perceived risk have found differences in perceptions and willingness to use PPE depending on the type of health professional [31]. The differences are most pronounced when it comes to the specific interventions that

the professionals perform and their functions may be better than training activities or mass education. Given that these activities have only a brief effect on adherence and proper PPE use over time, it is essential to have regular ongoing training programs, especially on the complex sequence of removing the apparel and the risks of exposure to especially serious diseases [32]. These situations are more apparent when precautions are based on modes of transmission, which requires knowing or suspecting that the disease is present. Some authors have suggested that it would be useful to have reminders posted in places where PPE is removed, with trained professionals supervising the donning and doffing processes [33], while others suggest focusing on the supervision of PPE handling only for specific high-risk stages, such as removal of the gown or apron [34]. With any of these strategies, they are likely to be more successful if they have support from the institution and the management team, as well as the officials directly in charge of the personnel involved [32].

WHAT PRINCIPLES APPLY TO THE PPE DONNING AND DOFFING SEQUENCE?

Using PPE protects the health team, but missteps during its use and, especially, its removal can lead to the transmission of microorganisms.

There are several different sequences for donning and doffing PPE (see http://www.who.int/csr/resources/publications/PPE_EN_A1sl.pdf?ua=1), but once one of them has been adopted, the following general principles should always be observed:

- The steps involved in donning PPE should follow a given order. This sequence ensures that the item will

be properly used and remain in place during performance of clinical activities. It will also facilitate later removal under safe, controlled conditions.

- Since the front of the PPE garment and the arms and hands are the parts that will have the most contact with patients, they are the parts most likely to be contaminated when the garment is removed.
- Because the user's face has the most portals of entry (conjunctival, nasal, and oral mucous membranes), it is considered the area at greatest risk. Therefore, when the PPE is being removed, care should be taken to ensure that the face is protected at all times and has no contact with contaminated items. The last step in removing the PPE will be the facial components, which should be taken off after all of the other parts have been removed and the hands have been disinfected.
- Practice in donning and doffing PPE should be an ongoing activity for personnel who are expected to use it. The personnel should know the sequence of steps, which should be planned and supervised. Training should be done using models of the locally available equipment so that personnel will be familiar with specific characteristics such as fastening systems, adjustment procedures, and the resistance and flexibility of the material. Personnel should be trained on the basis of the role they play, either individually or in small groups. Feedback based on observations during regular in service use can be more useful than mass activities. While no one method is infallible, systematically practicing and executing the steps under supervision has been associated with the least likelihood of self-contamination and contamination of the environment [13, 35].

Summary

- Make sure an adequate stock of PPE is on hand.
- Involve personnel in the selection of PPE.
- Avoid variability in the types of materials and models to be used in the institution so that training can be more standardized.
- Use the items available in the institution to train personnel in the correct placement, use, and removal of PPE.
- Enlist leaders to set an example with respect to PPE use.
- Check for compliance with or inappropriate use of PPE.
- Dispose of items safely.
- Train personnel in risk assessment and indications for the use of PPE.

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C. Prevention of sharps accidents

Why is prevention of accidents involving sharp instruments part of standard precaution?

Clinical practice involves risks for health workers, including exposure to blood and other body fluids from patients through spatters on mucous membranes or breaks in the skin or through percutaneous injuries such as pricks or cuts from needles or other sharps. The risk of infection occurs because some patients are asymptomatic carriers of infectious agents that can be transmitted by blood, such as HIV, hepatitis B virus (HBV), and hepatitis C virus (HCV). Given the possible asymptomatic nature of these infections, protective measures need to be taken in the presence of all patients, regardless of whether or not they are known carriers. For this reason, the measures are called standard precautions. Exposure to spatters is prevented by the use of barriers or personal protective equipment. This chapter will deal with the subject of punctures and cuts.

What are the factors that place health workers at risk for infection from punctures and cuts?

The risk of health workers becoming infected depends on the prevalence of infections in their patients, the nature and frequency of exposure, and their own immune status. Furthermore, both the nature and frequency of exposure are strongly associated with the type of care being provided (Table 10).

Table 10. Frequency of occupational exposure to material potentially infected with HIV, hepatitis B virus, and hepatitis C virus in procedures observed and procedures with accidents

Type of care	Procedures observed (n)	Procedures observed with exposure to fluids (%)	Procedures observed with accidents due to sharps (with or without exposure) (%)
Surgery	206 – 1382	6.4%-50.4%	1.3%-15.4%
Obstetrics-gynecology	230	32.2%	1.7%
Diagnostic imaging with invasive procedures	501	3.0%	0.6%
Emergency room	9,763	3.9%	0.1%
Dentistry	16,340	Not reported	0.1%

Adapted from: Beltrami EM, et al. Risk and management of blood-borne infections in health care workers. Clin Microbiol Rev. 2000;13(3):385-407. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=88939&tool=pmcentrez&rendertype=abstractt.

In studies of infections among health workers following percutaneous exposure to the three agents mentioned above, the following transmission risks have been identified, expressed in number of infections for every 100 pricks or cuts with instruments contaminated with blood containing the pathogen: HIV infection, 0.3% (95% confidence interval = 0.2%-0.5%); infection with HBV, <6% if the patient source was negative for HBeAg antigen and ≥30% if the patient was positive for HBeAg antigen; and HCV infection, 1.8% (0%-7%) [1].

What types of objects or materials pose a risk of exposure?

Sharps include any of the various objects with a sharp edge or pointed tip used in clinical care that can cut or penetrate the skin or the mucous membranes. Examples are solid needles such as those used in suturing, hollow injection needles, scalp vein-type intravascular cannulas, scalpel blades, scissors, biopsy forceps, glass ampoules containing infective material (blood, fluid from a sterile cavity, or any fluid with visible blood), and dental instruments, including high-speed hand instruments and drills.

Who is exposed?

Any person who has been in contact with a sharp instrument contaminated with blood or other fluid from a normally sterile cavity of the body is considered to have been exposed. Several factors affect the risk for a sharps accident, including the type of procedure and instruments employed, use of gloves, skill and training in the practice, knowledge of occupational and infection control measures, procedure followed in handling needles and syringes, health worker fatigue and workload, illumination, pressure of working conditions, and perception of risk.

The epidemiology of percutaneous exposures depends on a variety of factors, including the type of procedure performed and the objects used in the facility, the frequency of the procedures, and application of the established prevention measures. The practices that are most often associated with pricks and cuts are recapping of previously used needles and unsafe collection and disposal of sharps. Thus,

the health workers who tend to be most exposed are those working in surgical areas, emergency rooms, sample collection sites, and laboratories, as well as any personnel who handle objects contaminated with blood during tasks other than healthcare [2].

All personnel working in a health facility are exposed to accidents with sharps, but there are situations in which the risk is greater:

- Before a procedure, when laying out the scalpel blade or loading a syringe, although this type of exposure does not involve a risk of infection since the material is not contaminated with blood or fluids
- During a surgical procedure, when transferring a blood-contaminated sharp (scalpel, trephine, guide, etc.) from one hand to the other
- Immediately after performing a procedure, during recapping of needles
- During and after disposal of sharps, by:
  - Perforating the waste receptacle designated for disposal of sharps when the container is not moisture-proof or resistant to punctures or perforations
  - Allowing a receptacle to overflow so that sharps are exposed
  - Using receptacles without a protective cover

How can sharps accidents be avoided?

Many measures to prevent sharps accidents are based on before-and-after studies, opinions of specialists, statistical models, and perceptions of risk. There are few well-designed

controlled clinical trials with an adequate sample size because these matters are regulated by national standards in a number of countries. Also, it is difficult to measure the impact if the interventions are being practiced by an entire group. Furthermore, various methods are used to assess the results, which are usually based on incident reports filed by the affected health workers.

The best way to prevent injection-related sharps accidents is to avoid any unnecessary injections. The clinical team should look into the availability of effective oral or non-injectable parenteral therapies and standardize their administration locally. Still, it is not enough to standardize the criteria and institutionalize them in writing; they will need to be disseminated and integrated into the practice of the clinical personnel responsible for applying them. Compliance should be supervised by trained staff. Finally, the results from compliance assessments should be shared regularly and systematically with the pertinent units and clinical professionals [3].

Once the indications for use of sharps have been evaluated and accepted, the following measures should be taken to reduce the risk of accidents of this kind:[c]

- Use of gloves
- Safe handling of instruments
- Separation and safe disposal of used sharps
- Use of devices with an active and passive safety mechanism

c. When sharps are used in invasive procedures, attention should be given to preventing infections. The measures should include, at the very least, hand hygiene before and after the procedure, use of sterile gloves, application of an antiseptic to any puncture site, and application of a sterile covering on the site where a permanent catheter is inserted.

Whatever measures are adopted, they should be accompanied by a strategy of regular staff training that includes behavior modification. It is recommended that facilities adopt modalities that can be replicated through practice in the field, use locally available supplies and equipment, and rehearse the procedures that involve sharps in areas where they are usually performed [4, 5].

What does safe handling of sharps entail?

The main strategies are designed to avoid the practices that entail the greatest risk. Best practices that should be promoted with the health team include:

- Using assistants for procedures that involve changing syringes or performing certain maneuvers (e.g., drawing a sample to test for arterial blood gases), when patients are agitated, or when patients are young children
- Not recapping previously used needles
- Not handling or disassembling a sharp directly with the fingers; if necessary, use tweezers
- Ensuring at all times that the tip or edge of the sharp is pointing away from the body of the user and the assistant
- Avoiding the transfer of unprotected sharps from the place where they were used to the disposal site (disposal receptacles should be located immediately next to the site where the procedure was performed)
- Using a tray to receive and deliver sharps, such as scalpels, and avoiding hand-to-hand transfer between health workers

- Communicating verbally when a sharp object is handed from one person to another.

Also, technologies have been evaluated to prevent or minimize human error in clinical practice. These approaches involve behavioral changes—for example, the use of retractable needles to prevent accidental punctures. Opinions differ on the impact of incorporating those technologies and their cost-effectiveness [6]. However, in specific practices, such as surgical care, studies have consistently demonstrated the effectiveness of blunt-tip suture needles (as opposed to sharp-tip needles) and double-layer gloves in preventing percutaneous exposures [7, 8]. Regardless of these results, before any of these devices are introduced into clinical practice, health workers should be trained in their use and become familiar with them.

How should sharps be discarded?

Once the procedure involving the use of a sharp has been performed, the sharp should be disposed of immediately and safely in a special container for sharps waste. These containers should be waterproof and resistant to punctures and cuts. They should also be properly labeled (for example, with the biohazard symbol) and used only for sharps. Finally, they should be sealed with a cover.

The following conditions for managing containers facilitate adherence and increase safety in handling them:

- They should be placed near the site where the procedure is carried out and at a height that makes it possible to see the opening when a sharp is inserted. They should never be left on the floor or within reach of children.

- They should not be filled above three-fourths of their capacity; when they reach that level, they should be replaced with an empty container [World Health Organization, 2010].
- No disinfectant (chlorine or other) should be used on the receptacle; it will have no effect because chlorine is inactive on organic matter. Furthermore, if hospital waste is burned, exposure of the hypochlorite to heat can generate toxic gases.

What measures other than the standard precautions can be used?

There are other measures for preventing infections, not listed in the standard precautions, that will help to improve the safety of health workers. They include the introduction of protocols for vaccinating personnel against HBV and strategies to ensure compliance; management of postexposure to HBV and HIV; and the use of notification systems and exposure analysis to determine what caused the accidents and how they can be prevented with institutional measures.

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D. Management of the environment

Why is management of the environment included in the standard precautions?

Patients are the main reservoir of the microorganisms that cause HAIs. Infection can be transmitted from patients through various mechanisms, including autoinfection, carrying an infectious agent from one part of the body to another (for example, from the intestine to the urinary tract), and cross-transmission between patients via the hands of health workers following contact with these agents. It is estimated that 20% to 40% of infections are attributable to cross-transmission.

Does the environment contribute to all HAIs?

HAIs tend to be contracted through direct contact with an infected patient; however, it has been found that the environment plays a role in the chain of transmission. The following characteristics of infectious agents can contribute to environmental transmission:

- Ability to survive on environmental surfaces for prolonged periods, either in a vegetative state or as spores
- Ability to maintain virulence following exposure to the environment
- Ability to colonize patients without symptoms
- Ability to temporarily contaminate the hands of health workers
- Ability to cause an infection with a low dose.

Although several microorganisms have all of these characteristics, the fact that one is found in the environment does not necessarily mean it can transmit an infection. For an infection to be transmitted, all components in the chain of transmission have to be present. Thus, merely identifying an agent within a patient's environment is not sufficient to assume that it was a cause of disease [1]. The theory that contaminated surfaces contribute to the chain of transmission has been corroborated only for a small number of infectious agents (Table 11):

Table 11. Studies on the role of the environment in transmission of healthcare-associated infectious agents

Type of study / Infectious agent	Mathematical transmission[a]	Microbiological studies[b]	Epidemiological studies[c]	Intervention studies[d]	Outbreak studies[e]
Clostridium difficile	×	×	×	×	×
Acinetobacter spp.		×	×	×	×
Vancomycin-resistant Enterococcus spp.		×	×	×	×
Pseudomonas aeruginosa			×	×	×
Methicillin-resistant Staphylococcus aureus		×	×	×	×
Norovirus	×				×
Multiresistant Gram-negative bacilli				×	×

Adapted from: Otter JA, et al. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and

an overview of strategies to address contaminated surfaces in hospital settings. Am J Infect Control. 2013;41(suppl):S6-11.

a. Direct evidence studies in which the number of patients expected to be infected by the particular microorganism is estimated using mathematical models based on the agent's known mechanism of transmission and then compared with the number of cases actually observed. If there are more cases in reality, consideration is given to possible factors or conditions that might alter the agent's known mechanism of transmission—in other words, the presence of other mechanisms of transmission.

b. Studies using various microbiological or biochemical techniques in which a microorganism has been consistently identified in the environment.

c. Case-control studies and cohort studies.

d. Studies that look at the incidence of an infection over a given period, after which an intervention is introduced to control or reduce the incidence of the infection; the incidence is then measured in the intervention group (also known as quasi-experimental studies).

e. Studies of outbreaks and other epidemiological investigations, which contribute better evidence on the role of the environment in the transmission of infectious agents.

When infections are endemic, few HAIs are associated with contamination of equipment, surfaces, waste products, or patient clothing. The association has been observed more often in outbreaks. In the following list of proposed interventions and recommendations, some are based not on epidemiological research or clinical trials of acceptable size and design, but rather, on basic hygiene measures, common sense, cultural considerations, and the consensus of experts.

What does "environment" comprise in the context of HAIs?

- **FOMITES AND INSTRUMENTS.** Inanimate items that should be cleaned and disinfected or sterilized, depending on what they are going to be used for. This topic has been addressed in other manuals that specifically cover cleaning, disinfection, and sterilization of medical articles [2].
- **SURFACES AND EQUIPMENT.** All surfaces and accessories in the patient's environment that are used temporarily or on an ongoing basis during care, including fixed or mobile non-disposable items (furniture, equipment, etc.).
- **WASTE.** All discarded materials or objects used in patient care or in the patient environment that are to be removed from the health institution, usually classified as solid or liquid waste or biological or medical waste.
- **CLOTHING AND BEDDING.** All textile items used by the patient, including bed linens, towels, hospital gowns, and pajamas.

How should the environment be managed?

Some studies have shown a correlation between proper management of contaminated surfaces, based on cleaning or disinfection, and reductions in the risk of HAI cross-transmission and outbreaks associated with certain infectious agents, including methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, extended-spectrum β-lactamase-producing Enterobacteriaceae (ESBL), *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and multiresistant *Acinetobacter baumannii*, norovirus, and *Clostridium difficile*

[1, 3, 4, 5, 6]. However, not all microorganisms respond similarly to all methods and types of cleaning and disinfection. For example, isolates of norovirus and *Clostridium difficile* have shown greater resistance to common cleaning and disinfection processes. Therefore, the cleaning and disinfection program should be adapted to the properties of the microorganisms in question and to the risks associated with HAI-related equipment, surfaces, and clothing [3].

Environmental elements should be classified based on an HAI risk analysis that takes the following criteria into account [7]:

- Degree of patient exposure. A distinction should be made between equipment or surfaces in direct contact with the patient and those in which there is only minimal contact.
- Properties of the microorganisms involved or potentially involved in the infection, based on the patient's risk profile. These properties should include survival time on surfaces, resistance to disinfectants, infective dose, and pathogenicity.

This characterization should be different for each unit and for each type of patient. For example, because of their risk profile, patients in intensive care units, on dialysis, or who have received transplants are at greater risk for multiresistant bacterial infections than those in less complex medical-surgical units or situations [8, 9, 10, 11].

Aren't cleaning and disinfection the same thing?

Although cleaning and disinfection are often confused, they are not the same thing. Cleaning removes dirt deposited on

inanimate surfaces by mechanical (friction), physical (temperature), or chemical means for a certain length of time [12]. Disinfection, on the other hand, is a physical or chemical process in which vegetative microorganisms are removed from inanimate objects but without the assurance that bacterial spores have been removed. In this document, disinfection refers to the use of chemical agents known as intermediate-level disinfectants (phenols, sodium hypochlorite) that remove vegetative bacteria and some bacterial spores, as well as the use of chemical agents known as low-level disinfectants (quaternary ammonium compounds) that remove vegetative bacteria, fungi, and some viruses for a short time (less than 10 minutes) [2].

Cleaning and disinfection of low-risk surfaces

In cleaning and disinfection, low-risk surfaces and equipment are those that will not come in contact with mucous membranes or breaks in the skin.

Multidisciplinary working teams composed of personnel from the departments involved in cleaning and selecting the disinfectant products for purchase should participate in formulating the programs for cleaning and disinfecting low-risk clinical surfaces and equipment. These teams should include administrative, nursing, and pharmacy personnel and those responsible for HAI control, supplies, and cleaning. The programs should have:

1. Clearly defined duties and responsibilities for each of the different types of personnel involved in the cleaning and disinfection activities.
2. Criteria for classifying the surfaces that will be subject to intervention.

3. A list of the steps that need to be taken and their frequency. This may vary depending on the type of activity. For example:
   - A surface that has only been in brief contact with a patient or personnel (low-touch surface) requires daily cleaning (wiped with a moist rag or towel with or without detergent); additional cleaning and subsequent disinfection would be done only in the presence of body fluids, organic matter or when the patient is discharged.
   - A surface in an environment that has been involved in the chain of transmission of microorganisms from a patient (high-touch surface) requires cleaning and subsequent disinfection.
   - It is always necessary to remove organic matter mechanically with water and detergent before applying any type of disinfectant. When the use of disinfectants is being considered after the use of detergents, it is necessary to be aware of combinations of products that can generate chemical reactions or gases that are toxic for humans (for example, an ammonium combined with hypochlorite). In such cases, the detergent should not be used and time should be allowed for the surface to dry before applying a disinfectant product.
   - The process of selecting the products and supplies needed for cleaning and disinfection should include a review of those approved under national regulations and by the health facility. The manufacturer's directions should be observed when preparing and using the product. The following characteristics are usually evaluated when selecting a disinfectant:

broad spectrum activity; brief latency time between application and effect; compatibility with the surface on which it will be applied, other chemicals that might be used, and the environment; low toxicity for humans; minimal allergenic effect; low volatility; tolerable scent and acceptability by users and others in the environment; ease of preparation, handling, using, and storage; and low cost. Examples of products for surface disinfection are as follows:

- Chlorine solutions (1,000-5,000 parts per million). See the chlorine dilution formula at the end of this chapter.
- Alcohol (70%).
- Quaternary ammonium solutions. Different solutions have different degrees of activity (see specific manual on the subject).
- If contamination with *Clostridium difficile* spores is suspected, 0.05% chlorine solutions are preferred. Hydrogen peroxide-based disinfectants have also been shown to be effective against *C. difficile*.
- For information on other disinfectants for use against HAIs, a good resource in Spanish is the document *Limpieza y desinfección de superficies hospitalarias* [Cleaning and Disinfection of Hospital Surfaces], prepared by the National Health Surveillance Agency of Brazil with support from the Pan American Health Organization (PAHO) [12].

4. Methods of applying detergents and disinfectants. Consideration should always be given to the safety of the person doing the cleaning, especially with regard

to exposure to chemical agents that can have a negative effect on health. Cleaning should always precede disinfection.

5. Education and training of the personnel who will be performing each of the cleaning activities, whether followed by disinfection or not. These workers may be in contact with isolation rooms, which means that they should be familiar with pertinent measures, apply these and receive support when they are performing their duties.
6. Regular supervision of cleaning activities and periodic feedback on the results.

What is the best way to supervise the cleaning process?

There is no evidence that one method is superior to others, which means that it will be necessary to assess the advantages and disadvantages of each method and choose the ones that are most sustainable over time (Table 12).

Table 12. Methods of supervising the cleaning and disinfection processes: advantages and disadvantages

Method	Advantages	Disadvantages
Visual inspection	Simple Low cost Immediate results	Not very objective (depends on the observer)

(cont. next page)

Method	Advantages	Disadvantages
Aerobic colony count	Simple Capable of identifying pathogens	Expensive Requires microbiology laboratory Results not available until 48 hours after evaluation Sampling technique not standardized Results difficult to interpret
Fluorescent markers	Low cost Minimal equipment required Immediate results	Requires ultraviolet lamps and time to mark surfaces before cleaning Results difficult to interpret Effectiveness depends on person performing the test
Bioluminescence	Immediate and quantifiable results	More expensive Requires a luminometer and swabs to take samples

Adapted from: Havill NL. Best practices in disinfection of noncritical surfaces in the health care setting: creating a bundle for success. Am J Infect Control. 2013;41(suppl 5):S26-30. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23622744.

Is handling of patient clothing often associated with HAIs?

Infections associated with handling patient clothing in health facility laundries are uncommon, especially considering the high volume of items that circulate and are laundered. Some outbreaks have been reported, mainly among

laundry personnel. The species identified were *Sarcoptes scabiei*, *Salmonella typhimurium*, *Salmonella hadar*, *Microsporum canis*, *Rhizopus delemar*, hepatitis A virus, and Q fever. Apparel contaminated with body fluids may contain bacterial loads of up to 10^8 CFU per 1 cm^2 of fabric. However, the control measures that have been adopted for handling and processing them have succeeded in reducing the risk of transmitting infection [13, 14, 15]. That said, there is still potential for health workers to be cut and punctured by sharp objects inside their garments, which is another reason for emphasizing the importance of safe handling and disposal of sharps.

What steps should be considered in the management of laundry to prevent HAIs?

The recommendations here are similar to those for cleaning and disinfection, including the need to prepare and disseminate institutional protocols that cover transportation and laundering, among other processes. In addition, there are certain specific recommendations for this phase of the process [16, 17]:

- After wearing clinical garments:
  - Do not shake them.
  - Put them immediately in closed, clearly marked containers that will be used to remove them from the patient area. These garments should never be temporarily laid on furniture or other surfaces in the patient area.
  - Place clothing with blood or other body fluids in waterproof and leak-proof containers (for example, closed bags).

- When taking soiled clothing or linen to the laundry after it has been removed from the clinical service:
  - Ensure that there is no direct contact between patient clothing or linen and the body of the health worker who is transporting it. If possible, transport it in closed containers.
  - Do not shake it.
  - Remove any solid organic matter (for example, stool) before placing items in containers for soiled clothes.
  - There is no need to separate clothing and linen from infected and uninfected patients because it has not been shown that the former contain more microorganisms than the latter [18]. This practice may vary depending on the institution.
- When items are being separated in the laundry [19].
  - The institution should determine the point in the laundry process at which the clothing and linen will be separated and classified by type of item or fabric. This classification is intended to reduce the risk of workers being exposed to contaminated clothes or linen or any sharps that may be present. It is also important to protect the laundry and washing machines from exposure to potentially harmful materials (needles, scalpels, solid objects with sharp surfaces, etc).
  - Personnel should wear gloves that are thick enough to reduce the risk of percutaneous exposure.
- When the clothing and linen are being washed [20, 21, 22, 23]:
  - Wash by machine, not by hand.

- Use hot water (≥70° C). Do not dry clean.
- Remove dirt and organic matter mechanically.
- Use detergent for clothes and linen.
- Wash for at least 20 minutes.
- If any of the above requirements are not met, it is recommended that the process be repeated.
- It is usually recommended that all items be dried and pressed at >150° C, but it may be necessary to alter the temperature based on the manufacturer's instructions for the particular fabric.

- During transportation and storage:
  - Transport clean clothes and linen from outside laundries in packages well protected by fabric covers to prevent contamination with dirt or dust in the course of loading and unloading.
  - Store gowns and linen for clinical use in a dry and dirt- and dust-free area (for example, in closed cabinets).

Personnel should wear PPE at all times, depending on the assessment of risk of exposure. Usually, a gown, apron, and thick gloves are required when handling soiled clothing. Masks and eyeglasses can be used if the items are to be shaken or handled in large quantities.

Waste

DOES THE WASTE IN HEALTH FACILITIES CARRY A GREATER RISK FOR HAIs?

It has been estimated that between 20% and 40% of the waste generated by health facilities poses a risk similar to

that of domestic waste, with similar characteristics in terms of types of microorganisms. Some studies have found that waste from isolation units has a lower microbial burden than that from ordinary healthcare units [24]. Some authors suggest that no more than 3% of the total volume of clinical waste has infectious potential [25] and that the perception of risk is greater than the real risk in the case of HBV, HCV, and HIV infections [26]. Other studies have failed to find a higher prevalence of HBV infection among hospital waste management personnel than among those who handle community waste [27, 28]. Thus, there is no evidence that there is a greater infectious risk in handling hospital waste than there is in handling domestic waste.

How can hospital waste be managed to prevent HAIs?

With the exception of sharps waste, which requires special handling (and has already been discussed), there is no need to take additional measures to manage waste other than those for handling waste from infected patients. Body fluids (urine, blood, and stool) can be disposed of through the sewerage system, where they are quickly diluted, without having to apply an additional disinfectant.

When it is not possible to dispose of waste through the sewerage system, it should be handled only after assessing the risk of exposure for workers. All waste should be transported using protective measures for workers—that is, in bags made of strong waterproof material.

All countries have regulations on the management of hospital waste outside the health facility. These regulations should be followed, especially the ones on handling containers of

contaminated sharps and waste from pathology units and microbiology and clinical laboratories.

FORMULA FOR DILUTING SODIUM HYPOCHLORITE USING COMMERCIAL PRODUCTS

Some health establishments use commercial solutions to prepare chlorine dilutions at 1,000 parts per million (ppm) or 5,000 ppm. These dilutions can be challenging because the commercial solutions come in different concentrations. The following table shows examples of how to prepare the dilution based on different original concentrations. It is important to know that:

0.5% solution = 5,000 ppm
0.1% solution = 1,000 ppm

Formula for diluting sodium hypochlorite: **Total parts of water added = [% of concentrated original ÷ % of desired concentration] – 1**				
Examples				
Commercial solution	**Desired solution**	**Formula**	**Result**	**Preparation**
5.0% concentrated chlorine solution	Chlorine solution diluted to 0.5% (5,000 ppm)	[5.0% ÷ 0.5%] – 1	9	Add 9 parts water to 1 part commercial chlorine solution at 5.0%
5.0% concentrated chlorine solution	Chlorine solution diluted to 0.1% (1,000 ppm)	[5.0% ÷ 0.1%] – 1	49	Add 49 parts water to 1 part commercial chlorine solution at 5.0%

(cont. next page)

Formula for diluting sodium hypochlorite: Total parts of water added = [% of concentrated original ÷ % of desired concentration] – 1				
Examples				
Commercial solution	**Desired solution**	**Formula**	**Result**	**Preparation**
	Chlorine solution diluted to 0.1% (1,000 ppm)	[5.5% ÷ 0.1%] – 1	54	Add 54 parts water to 1 part commercial chlorine solution at 5.5%
6.0% concentrated chlorine solution	Chlorine solution diluted to 0.1% (1,000 ppm)	[6% ÷ 0.1%] – 1	59	Add 59 parts water to 1 part commercial chlorine solution at 6.0%
6.0% concentrated chlorine solution	Chlorine solution diluted to 0.1% (1,000 ppm)	[6% ÷ 0.5%] – 1	11	Add 11 parts water to 1 part commercial chlorine solution at 6.0%

It should be noted that the concentrations of some commercial chlorine solutions are different from the figures indicated on the label. For this reason, solutions with known concentrations are preferred.

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Additional precautions based on mode of transmission

IV

The standard precautions are not always sufficient to control the transmission of certain infectious agents; additional precautions may need to be taken to address specific cases. These additional precautions are described below, based on the agents' mode of transmission: by contact, droplets, air (droplet nuclei), and other means. This section also covers the subject of cohort isolation.

What is the difference between the standard precautions and the additional precautions based on mode of transmission?

Generally speaking, the additional precautions are complementary measures. Unlike the standard precautions, which are applied without needing to know the patient's infection or colonization status, they are applied only when the patient is known to have or suspected of having an infectious disease, especially if the disease would still be in the infectious period. They are also applied in some cases in which the patient is known to be colonized with an agent that is

resistant to the antimicrobial drugs of public health importance (see chapter on this subject).

Many of the additional precautions are based on opinions of experts, the transmission mechanism, the known portal of entry, the perception of risk, and the severity of the disease, among other considerations. Most controlled clinical trials and other evidence-based data have been concerned with specific pathologies and microorganisms, and the primary focus has been on infections with methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococcus* (VRE) [1]. In fact, the effectiveness of the additional precautions has been observed in the control of epidemic outbreaks due to a number of different infectious agents.

What is involved in applying the additional precautions based on mode of transmission?

In order to implement the additional precautions, it is necessary to:

1. Have definitions and protocols in place that are easily accessible to personnel in the health facility. They should indicate the type of additional precaution that will be needed for each known or suspected infectious disease or infectious agent of public health importance. This information will facilitate implementation of the measures when they are appropriate and promote a dialogue between health workers and the professionals who direct the clinical services.
2. Provide ongoing education and training for the personnel in charge of deciding on the application of additional precautions and those responsible for

implementing them. Local resources and other planned activities should be taken into account. Some authors recommend using summarized guidelines to facilitate the expeditious application of local protocols. Health workers should be familiar with these summaries and be able to access them easily. They should be available in several places—for example, on the back of ID cards or employee credential cards, in clinical files, on computer screen protectors, and so on [2].

3. Ensure that professionals who are in training and those who have not had specific training on the subject do not participate in the care of patients for whom precautions based on the mode of transmission are indicated.
4. Have programs for evaluating compliance with the measures and providing feedback to the personnel involved in applying them to avoid or correct possible missteps.
5. Establish strategies for avoiding anxiety, confusion, or rejection of the measure by patients or their family members, regardless of the precaution selected. For example, they should be informed of the reasons for the procedure, the time it may take, and any specific precautions that should be followed during family member visits [3].
6. Ensure that the standard precautions continue to be applied and remain unchanged when the additional measures are applied. The standard precautions should always be applied, including in areas where patients are undergoing triage to set priorities for their care and places where patients enter the facility before it is known whether or not they have an infectious clinical condition.

What needs to be known in order to decide if additional precautions are required?

- What is the patient's confirmed or suspected diagnosis?
- What is the infectious agent and its mode of transmission?
- What is the natural history of the disease? For what period of time is the agent infectious?
- What type of procedure will the patient be undergoing?
- What measures need to be taken to avoid transmission of the infectious agent (cross-transmission)? Is there any risk of contamination? Where should the patient be located? What type of PPE will need to be used?

CONTACT TRANSMISSION

This mode of transmission is the most common. It can occur in two forms:

- Direct contact, when microorganisms travel from the reservoir directly to the susceptible individual without any other elements involved in the transmission.
- Indirect contact, when the susceptible host comes into contact with the infective microorganism through an inanimate intermediary (clothing, fomites, surfaces in the room) or an animate one (via the hands of a health worker when in contact with another patient). The infectious agent must have the capacity to survive in the environment. Therefore, identifying an agent in the environment is not sufficient evidence

to account for transmission, since it does not necessarily mean that the microorganism has retained its infective capacity or that it has been involved in the chain of transmission. Some of the microorganisms that are transmitted this way include *Clostridium difficile*, *Acinetobacter* spp., *Enterococcus* spp. (including vancomycin-resistant strains), *Pseudomonas aeruginosa*, *Klebsiella* spp., *Staphylococcus aureus* (including methicillin-resistant strains), norovirus, respiratory syncytial virus, rotavirus, Gram-negative bacilli, and enterobacteria that are sensitive or resistant to antimicrobial drugs—for example, extended-spectrum β-lactamase- or carbapenemase-producing Enterobacteriaceae.

Where should a patient requiring contact precautions be located?

Given the potential for indirect transmission of infectious agents, the decision regarding where to locate the patient should always be based on an analysis of the risk of transmitting HAIs to other patients:

1. Place the patient in a separate room or a room with other patients who have the same diagnosis (the same agent and the same genotype). The latter option is especially useful when the facility has a large number of cases caused by the same infectious agent (for example, during outbreaks).
2. When no separate room is available, an exception can be made to place the patient in a room with other patients as long as the following conditions are met:
   - The patient can be placed in a shared room if the surrounding area is large enough to allow for the patient's

comfort and also for the space and supplies required by other patients (intravenous medication stand, footstool, etc.).

- Do not place a patient indicated for isolation in the same room with patients undergoing invasive procedures or immunocompromised patients who could suffer serious consequences.

What are the requirements for the room or hospital area to be occupied by a patient needing additional precautions?

The room should meet the same conditions as for the standard precautions. In other words, it should have the necessary arrangements for the use of PPE and hand hygiene, especially a sink with running water that can be adjusted for temperature, soap, disposable paper towels or a system for drying hands (requirements for hand hygiene), and an alcohol-based solution for hand disinfection at the point of care.

In addition,

- If precautions are being taken for enteric diseases and the patient is ambulatory, the patient should have a separate bathroom for his or her exclusive use or, if this is not possible, some other means of minimizing the risk of transmitting microorganisms through contact with stools (an individual or disposable bedpan, basin, or potty). If the patient has to share a bathroom, it should be cleaned and disinfected under supervision after every use.
- If PPE is to be used, there should be a place to keep it before entering the room or the patient's area and a receptacle where it can be discarded after caring for the patient and before leaving the room or unit.

- There should be a clear, visible sign at the entrance to the room or patient area warning that contact precautions are being taken and including the applicable instructions.

What measures should be taken during care for patients requiring contact precautions?

The use of barrier PPE elements should be considered if direct physical contact with the patient or indirect contact with potentially contaminated surfaces is expected. The PPE should be single-use equipment or only for use with the particular patient. It should be put on before entering the room or patient area and removed before leaving. At the very least, use of the following barrier elements should be considered:

- Single-use gloves. Waterproof, disposable, non-reusable gloves should be used, and hand hygiene should be performed both before putting them on and after removing them.
- Dedicated gown. It does not have to be disposable, but it must be used only to care for one specific patient. The same gown may be used by different members of the health team caring for the same patient. Experts suggest that it should be changed or laundered daily.

If there is a chance of spattering or contact with body fluids, the standard precautions should be applied: protect the facial mucous membranes and wear a waterproof apron over the gown.

When transferring a patient who requires these measures, any personnel who come in contact with the patient should follow the indications above and make certain that the supplies are disposable or properly cleaned and disinfected before reusing them.

DROPLET TRANSMISSION

In this form of transmission, particles measuring 5 to 100 μm (typically ≥20 μm) in diameter (droplets) are emitted from the respiratory tract of the infectious patient when he or she coughs, sneezes, or talks. When particles are very small, they remain airborne only for a few seconds (except for droplets <20 μm, which can stay in suspension for several minutes) and travel less than 1 meter. Examples of microorganisms or diseases that are transmitted in this way are diphtheria, whooping cough, meningococcal meningitis, influenza, adenoviruses, and coronaviruses (such as SARS coronavirus and MERS [Middle East respiratory syndrome] coronavirus).

What is the objective of precautions against droplet transmission?

The precautions are intended to prevent droplets transmitted by a patient from coming into contact with the conjunctival, nasal, or oral mucous membranes of a susceptible host (health worker or another patient) located less than 1 meter away. It should be remembered that the conjunctival membranes drain into the nasal cavity through the tear ducts, which means that they are a portal of entry for certain infectious agents, especially viruses.

Where should a patient requiring droplet precautions be located?

The decision regarding where to locate the patient should always be based on an analysis of the risk of transmitting HAIs to other patients. The options are:

1. Place the patient in a separate room or a room with other patients who have the same diagnosis, the same agent, and the same phenotype.

2. On an exceptional basis, when the facility has a large number of cases caused by the same agent (for example, during hospital outbreaks due to outbreaks in the community), the patient may share a room with other patients as long as the following conditions are met:
    - The patient can be placed in a shared room if there is at least 1 meter of surrounding area to allow for the patient's comfort and also for space and supplies required by other patients (intravenous medication stand, footstool, etc.).
    - Do not place a patient indicated for isolation in the same room with patients undergoing invasive procedures or immunocompromised patients who could suffer serious consequences.
3. This option is especially useful when the facility has a large number of cases caused by the same infectious agent (for example, during outbreaks).

What are the requirements for the room or hospital area to be occupied by a patient needing droplet precautions?

The room should meet the same conditions as for the standard precautions—in other words, it should have the necessary arrangements for the use of PPE and hand hygiene, especially a sink with running water that can be adjusted for temperature, soap, disposable paper towels or a system for drying hands (requirements for hand hygiene), and an alcohol-based solution for hand disinfection at the point of care. In addition:

- If PPE is to be used, there should be a place to keep it no farther than 1 meter from the patient's area and a receptacle where it can be left after caring for the patient and before leaving the room or unit.

- The room should have a door that closes, as well as good ventilation.
- There should be a clear, visible sign in the room or patient area warning that droplet precautions are being taken and including the applicable instructions.

What measures should be taken during care for patients requiring droplet precautions?

The decision to use PPE will depend on the expected distance from the patient. If it is less than 1 meter, guidelines are as follows [4]:

- Protect facial mucosa with a preformed surgical-type mask, preferably not pleated, in addition to (1) eyewear or (2) a face shield. If the face shield is long and extends below the chin, there is no need to use a mask. It is not necessary, or even advisable, to use both eyewear and a face shield at the same time because it would restrict the user's vision.
- Apply standard precautionary measures if there is risk of spattering or contact with body fluids, including:
  - A gown and, if necessary, an apron
  - Single-use gloves (disposable, non-reusable) to protect against exposure to droplets deposited on surfaces in the environment near the patient
  - Hand hygiene, performed both before putting on gloves and after removing them

During transfer, patients should wear a conventional or non-folding surgical mask to cover exhaled droplets.

AIRBORNE TRANSMISSION (VIA DROPLET NUCLEI)

This type of transmission takes place in the air through the dissemination of particulates measuring less than 5 μm in

diameter. When pushed by air currents, these particulates can remain airborne for prolonged periods and travel greater distances than droplets [5]. Therefore, they can be inhaled and enter the alveoli of individuals in the same room, even if they have not had direct contact with the infected patient.

Droplet nuclei may be generated directly by the patient when he or she coughs or sneezes (e.g., in the case of patients with tuberculosis) or by clinical procedures, including tracheal intubation, noninvasive positive-pressure ventilation, invasive high-frequency ventilation, airway aspiration, tracheotomy, respiratory kinesiotherapy, fogging, fiber-optic bronchoscopy, sputum induction, centrifugation of samples, and procedures using saws to cut tissues. Among these procedures, according to studies on transmission of the SARS coronavirus, the ones that pose the greatest risk are tracheal intubation, noninvasive ventilation, tracheotomy, and manual ventilation prior to intubation [6]. Examples of microorganisms transmitted by this means are the Mycobacterium tuberculosis bacillus (from bacilliferous patients) and the measles, chickenpox, and disseminated shingles viruses.

Where should a patient requiring airborne transmission precautions be located, and what are the pertinent requirements for the room or hospital area?

This decision should always be based on an analysis of the risk of transmitting HAIs to other patients. Options are as follows:

1. A separate room that allows for:
    - Restricted access.
    - Ventilation to the outside of the building, never toward areas where other patients are located. The

door should always be closed. The use of negative pressure has been recommended, if it is available, although it has not been shown to be more effective than a window that opens to the outside [7, 8].

- When the room does not have exterior ventilation or the climate does not make it possible to open the windows, air extraction systems that allow for at least 6 to 12 air changes per hour can be used. If the air is not vented to the outside and ends up reaching other patient areas or closed spaces, it should be treated with a system that uses HEPA (high-efficiency particulate air) filters [9].

2. A shared room. If necessary, the patient can be placed in a room with other patients who have the same diagnosis, the same agent, and the same genotype. If in doubt, especially in cases where the infectious agent can develop antimicrobial resistance (for example, *Mycobacterium tuberculosis*), always place the patient in a separate room.

3. The room should meet the same conditions as for the standard precautions—in other words, it should have the necessary arrangements for the use of PPE and hand hygiene, including a sink with running water that can be adjusted for temperature, soap, disposable paper towels or a system for drying hands (requirements for hand hygiene), and an alcohol-based solution for hand disinfection at the point of care. In addition:

   - There should be a place to keep the PPE outside the patient's area and a receptacle where it can be discarded after caring for the patient and before leaving the room or unit.

- There should be a clear, visible sign in the room or patient area warning that droplet nuclei precautions are being taken and including the applicable instructions.

What measures should be taken during care for patients who require airborne transmission precautions (infections transmitted via aerosols)?

Given the transmission mechanism, a health worker approaching a patient with this type of infection should use a type N95 or FFP2 high-efficiency respirator or equivalent before entering the room, touching the patient, or initiating a procedure that might generate aerosols [10].

The clinical personnel who provide care should be immunized before treating patients with vaccine-preventable diseases. The vaccination record should be documented in an official registry or on a personal vaccination card.

Moving the patient to other units should be restricted. If it is necessary, the accompanying personnel should follow the relevant indications. In addition, a surgical mask may be placed on the patient to cover exhaled droplets, subject to the patient's general status and ability to breathe with the mask in place.

Patients with infections that have more than one mode of transmission

It has been documented that some diseases can be transmitted by more than one route. For example, chickenpox can be transmitted through both direct and indirect contact, droplets, and airborne nuclei. In such cases, all of the measures

described for each type of isolation should be instituted, giving preference to the strictest measure when there is more than one possibility.

Cohort isolation

The purpose of this type of isolation is to use resources cost-effectively, applying the same measures to a group of patients with the same infection caused by the same agent. Cohort isolation is often used as a control measure when the number of infected patients surpasses the institution's normal capacity (for example, during outbreaks or periods of hyperendemic disease), both to make optimal use of resources and to facilitate supervision of care. A multicenter study on this subject found more than a 40% reduction in compliance with standard precautions when a large number of patients required precautions against contact. Grouping them in a cohort made it easier to supervise care and provide feedback to the clinical team [11].

When is cohort isolation indicated?

It is used when a significant number of patients need to be isolated and they all have the same disease, caused by the same agent, and require the same types of precautions (contact, droplets, or airborne). Thus, cohort isolation may be used for contact, droplet, or airborne precautions. It can also be helpful in controlling outbreaks of highly communicable diseases or outbreaks that have been difficult to handle.

How is cohort isolation applied?

- Limit the cohort to confirmed cases of infection by the same infectious agent (agent, strain, or clone)

based on the best available information at the time the decision is made.

- Assign personnel to exclusive care of the cohort in order to avoid contact with other patients. No other patients should be seen by the personnel attending the cohort.
- Set aside a physical space for exclusive use by patients infected with the agent. It should include a nursing station, a storage area for supplies, and bathrooms.
- Close down the cohort isolation area when the last case has been discharged.

When can the indication for additional precautions based on modes of transmission be suspended?

The decision to suspend additional precautions based on the mode of transmission for one or more patients is complicated, and the supporting evidence is limited. Various criteria have been proposed depending on the epidemiological situation. They can be summarized as follows:

- If the infective period is known, the additional measures should be applied until the patient is no longer in a position to transmit the agent. Depending on the disease, this may be the number of days since the onset of symptoms (with influenza, for example, the measures should be applied for five days starting from the first appearance of symptoms), the number of days without symptoms (e.g., 48 hours without diarrhea in patients treated for diarrhea due to *Clostridium difficile*), or the number of days since the start of an effective treatment (for example, in patients with impetigo, treatment should be given for

24 hours before lifting the measures). In some cases, it may be based on laboratory results (e.g., negative sputum-smear microscopy in patients with tuberculosis).

- If the infective period of the disease being treated is unknown (for example, a pulmonary infection due to *Burkholderia cepacia* complex or another bacterium resistant to antimicrobial drugs), there is no established recommendation. Some authors suggest maintaining isolation until the patient is discharged [12], while others recommend isolating the patient until at least two carrier studies (detection tests), taken at different times, are negative [13]. There are no conclusive studies indicating the best way to proceed in these cases.

The decision to discontinue the additional precautions should be made locally, based on the best available information. The criterion used should be noted for the record so that the information is available for subsequent evaluations. When the additional precautions are suspended for a given patient, the standard precautions should still be followed.

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Precautions for preventing infections of public health importance due to resistant and multiresistant agents

V

Standard precautions and multiresistant agents

Although antimicrobial resistance poses a threat to public health, its health impact on HAIs and the effectiveness of the measures aimed at controlling their dissemination have been difficult to assess [1, 2, 3, 4, 5, 6, 7, 8, 9]. This is true especially because:

- There is no good definition of multiresistance (the best known and most commonly used definition was published in 2011) [10]. Information prior to that year does not include the same definition.
- The variables measured are not the same. For example, some studies measure infections only, others include colonizations, and still others add temporary transmission of infectious agents.

- It is difficult to identify the cause of harm in patients who are seriously ill and have been subjected to a number of risky procedures.

What are the main recommended measures?

While some of the measures for preventing and controlling HAIs are valid for any microorganism, others should be assessed in terms of the epidemic situation in the particular institution (ongoing state of endemic disease, epidemic outbreak, or endemic disease that has been difficult to combat) and the infectious agent involved. The following recommendations are based on expert opinions, evidence obtained from a few controlled clinical trials, quasi-experimental before-and-after studies, and nonexperimental studies (controlled case and cohort studies). They mainly refer to containment of the various types of HAIs due to methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, extended-spectrum β-lactamase-producing Enterobacteriaceae, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* that are resistant to more than one agent in three or more categories of antimicrobial drugs [11, 12, 13, 14, 15, 16]. It has been observed that some interventions shown to be effective for certain types of HAIs do not necessarily yield the same result for others.

The scarcity of available evidence, coupled with the recent spike in research on effective interventions in light of the importance of the problem, has resulted in highly dynamic information. As a result, some of the recommendations in Tables 13 and 14 may change in the near future. The measures

have been organized according to the epidemiological situation in which they are applied and whether the problem is periods of endemic disease, outbreaks, or hyperendemic disease.

Table 13. Measures for containing healthcare-associated infections during periods of endemic disease

Measure	Microorganisms against which the intervention has proven to be effective
Improved adherence to hand hygiene measures (structure and inputs, education, supervision and feedback).	MRSA, VRE, ESBL, and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*
Isolation from contact with patients colonized or infected with the microorganism according to local protocols. In *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and MRSA infections and colonizations, a separate room is preferred. There is no consensus in the literature on when to recommend suspending the measures and discharging the patient or on follow-up strategies such as periodic culturing of colonized and infected patients. The measures may be suspended when the patient produces two or more negative cultures for the agent previously detected.	MRSA, VRE, ESBL (except for *Escherichia coli*), and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*

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Measure	Microorganisms against which the intervention has proven to be effective
Systematic cleaning of nearby spaces and surfaces or those most likely to come in contact with the infected or colonized patient using low- and intermediate-level disinfectants.	ESBL and multiresistant ***Klebsiella pneumoniae***, ***Pseudomonas aeruginosa***, and ***Acinetobacter baumannii***
Designation of items such as thermometers and stethoscopes for exclusive individual use with infected or colonized patients. If this is not possible, disinfect these articles after use with each patient.	MRSA, VRE, and multiresistant ***Acinetobacter baumannii***
Education of health workers participating in the care and treatment of colonized or infected patients on transmission mechanisms and the importance of complying with the measures indicated, with regular feedback on their compliance.	MRSA, VRE, ESBL, and multiresistant ***Klebsiella pneumoniae***, ***Pseudomonas aeruginosa***, and ***Acinetobacter baumannii***
Implementation of strategies for readmission of colonized or infected patients, with locally defined time periods, indications for admission, and care based on contact precautions.	MRSA, VRE, ESBL, and ***Clostridium difficile***
Identification of colonized or infected patients when they are being transferred to another unit in the hospital or another institution.	MRSA, VRE, and ESBL
Note. MRSA = methicillin-resistant ***Staphylococcus aureus***; VRE = vancomycin-resistant ***Enterococcus***; ESBL = extended-spectrum β-lactamase-producing Enterobacteriaceae.	

Sources: Calfee DP, et al. Strategies to prevent methicillin-resistant *Staphylococcus aureus* transmission and infection in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(7):772-96. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24915205.

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Table 14 lists additional measures that can be implemented when the ones above are considered insufficient (after having confirmed compliance)—for example, when there is a steady increase in endemic infections, hyperendemic situations, or outbreaks of HAIs or in the case of establishments that have adopted policies for the eradication of certain infectious agents.

Table 14. Additional measures for containing healthcare-associated infections during periods of endemic disease

Measure	Microorganisms against which the intervention has proven to be effective
Implementation of active case-finding strategies to identify infected and colonized patients through detection cultures or other tests for the purpose with a view to isolating groups at risk, such as patients who are: • hospitalized in intensive care units • undergoing prolonged antimicrobial treatment • undergoing immunosuppressive treatment • diagnosed with hematologic cancers • being treated for extensive burns • using invasive devices (invasive mechanical ventilation, hemodialysis, central vascular catheters) • from establishments or units with hyperendemic diseases or outbreaks caused by multiresistant infectious agents • sharing a room with infected or colonized patients There are no controlled studies on this strategy. The schedule recommended by experts for conducting active case-finding should be consistent with the epidemiological context. For example, start detecting infections upon admission and measure the weekly prevalence to discover the period with the largest number of cases. Then, as the number of cases starts to fall, begin measuring the prevalence every two weeks and then monthly, bimonthly, and, finally, semiannually. The sampling sites that have been recommended are as follows: • MRSA: cultures of sites where there are breaks in the skin (wounds, cuts, punctures), cultures of nasal and throat swabs (also endotracheal, perigastrostomy, perineal, and perirectal swabs) • VRE: cultures or swabs of the rectal or perirectal area (or, in some cases, cultures of stool samples) • Multiresistant Gram-negative bacilli: cultures of rectal or perirectal swabs, sometimes in combination with swabs from endotracheal aspirate, expectoration, sputum, the nasal or pharyngeal areas, skin from the axillary or inguinal areas, or discharge from wounds	MRSA, VRE, ESBL, and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*

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Measure	Microorganisms against which the intervention has proven to be effective
Strengthening of supervision of the disinfection process at the highest level if there is suspicion that endoscopic procedures might be involved as a microorganism transmission mechanism.	ESBL and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*
Testing of health workers with detection cultures if there is suspicion that they might be involved in a microorganism transmission mechanism, either to interrupt the colonization process or to exclude them from providing patient care.	MRSA and ESBL
Implementation of mechanisms to alert clinical personnel when patients are found to have been carriers or were hospitalized in units with colonized/infected patients, in order to initiate isolation measures.	ESBL and multiresistant *Klebsiella pneumoniae* isolates
Isolation of cohorts.	MRSA, VRE, ESBL, and multiresistant *Klebsiella pneumoniae* isolates
Isolation in a separate room.	VRE, ESBL, and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*
Daily bathing of patients in intensive care units with chlorhexidine soap or chlorhexidine wipes/towelettes.	MRSA and VRE
In hospitals with culture detection programs, eradication of MRSA nasal transmission in nasal carrier patients with mupirocin and bathing of patients with chlorhexidine soap or chlorhexidine wipes. The use of mupirocin to eradicate MRSA in patients without previous screening has not been shown to have an impact.	MRSA
Implementation of intensified programs to supervise cleaning and disinfection, including supervision of the preparation of disinfectants, with feedback for personnel who perform the procedure. Non-critical articles should not be shared between patients unless they are in the same cohort.	ESBL and multiresistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*

Note. MRSA = methicillin-resistant ***Staphylococcus aureus***; VRE = vancomycin-resistant ***Enterococcus***; ESBL = extended-spectrum β-lactamase-producing Enterobacteriaceae.

Sources: Calfee DP, et al. Strategies to prevent methicillin-resistant *Staphylococcus aureus* transmission and infection in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(7):772-96. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24915205.

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The success of measures for dealing with an outbreak or hyperendemic disease depends on the level of compliance with measures applicable to any endemic disease. If reliable information on the effectiveness of a given measure is lacking, it is important to evaluate its success or failure whenever it is applied.

Is active supervision of those who prescribe antimicrobial drugs (guidance on the use of antibiotics) an effective measure?

Although guidance strategies have been considered effective in the prevention and containment of antimicrobial resistance, the studies that have evaluated them have been inconsistent in their results, and these strategies have always been included with other measures for controlling infections (as noted in Tables 13 and 14). Thus, when providing guidance, it should always be offered along with other measures and never as an isolated strategy [17, 18, 19, 20, 21, 22, 23, 24, 25, 26].

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