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Introduction

The principles and practices aimed at prevention and control of hospital-acquired infections are directed at various links in the chain of transmission. They include the following: (1) to contain or eliminate the reservoirs of agents and/or to curtail the persistence of agents in a specific setting, (2) to protect the host against disease caused by microorganisms, and (3) to interrupt the transmission of infection. Interventions to modify environmental reservoirs are aimed at interrupting the transmission for these inanimate environmental sources. The barriers, e.g., masks, were used to keep the smells and “contagion” away even before the germ theory of disease was conceived. The appropriate barriers now include gloves, gowns, and eye protection for blood/body fluid-borne infections and high-filtration masks for infections transmitted by droplet nuclei. The most important and effective nosocomial infection control intervention remains the routine washing of hands before, between, and

after patient contact in healthcare settings. This chapter focuses on the interruption of transmission of infectious agents in the hospital setting by Standard Precautions recommended for all patients and “isolation” of patients using precautions based on known methods of transmission.

Historically, hospital construction before 1850 featured open wards where cross infection was common and mortality rates were high in urban hospitals [1]. Based on the observations during the Crimean war, Florence Nightingale advocated small pavilion – type wards joined by open-air corridors [2]. She also emphasized the importance of asepsis and a clean environment. The germ theory of disease was accepted in the US hospitals in late 1800s leading to decrease in overcrowding and increase in antisepsis. Individual and group isolation was used by “communicable disease” hospitals as early as 1989 [3]. General hospitals began to isolate patients with communicable diseases in individual rooms with the use of separate utensils and disinfectant by the turn of the century [4]. The theory of communicability by contact rather than airborne spread for most diseases was promoted in France [5]. This allowed patients with communicable diseases to be housed in general wards with separation by wire screens. In addition to separating the patient from others, the barrier served as a reminder for hospital staff to wear gowns and wash hands. This is how the trend of caring for patient with communicable disease in the general hospitals rather than isolation/fever hospitals started in the United States. In the early twentieth century, it was demonstrated that fumi-

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gation had no effect on the secondary cases emphasizing the role of persons rather than things as spreaders of disease [6, 7]. The concept of cohorting, allowing patients with communicable diseases to be housed in the same room as other patients, was first applied in the Providence City Hospital [5]. The barrier techniques needed for each patient were put on a card placed on the patient's bed. The development of infection control programs in the US hospitals was prompted by the emergence of *Staphylococcus aureus* as a hospital pathogen in the late 1950s. The first edition of American Hospital Association's manual in 1968 presented a simple barrier precautions scheme for patients with communicable diseases and listed the need for gloves, gowns, masks, and visitor screening [7]. The CDC, while conducting nosocomial outbreak investigations in the 1960s, recognized the need for standardized policies for isolating hospitalized patients with communicable diseases [8]. The first CDC isolation recommendations were published in 1970 [9]. This manual listed seven categories of isolation: strict isolation, respiratory isolation, enteric precautions, wound and skin precautions, discharge precautions, blood precautions, and protective isolation. Many of the practices described in the manual are applicable to any hospitalized patient. Application of poor techniques when handling uninfected patients can only result in sense of false security. Updates to the CDC manual were made in 1975 and 1978. In 1983, substantial changes were made to the recommendations including the use of the word "guidelines." The CDC series Guidelines for the Prevention and Control of Nosocomial Infections that has followed is now the state of the art in infection control practices. These guidelines have accepted and customized for medical management of bioterrorism threats [10].

Standard Precautions

In 1985, the Centers for Disease Control and Prevention (CDC) introduced Universal Precautions (UP) to hospitals for the protection of healthcare personnel as a response to the emergence of HIV/AIDS. Another initiative,

Body Substance Isolation, soon followed. The CDC recognized there was confusion created by Universal Precautions and Body Substance Isolation, so in 1996, they published new guidelines with a two-tiered method, Standard Precautions and Transmission-based Precautions. The CDC, in cooperation with the Healthcare Infection Control Practices Advisory Committee (HICPAC), established Standard Precautions to address the prevention of the spread of infectious agents in healthcare settings and are the result of combining the key components from Universal Precautions and Body Substance Isolation along with the understanding that all blood and body fluids, except sweat, are potentially infectious, and inanimate objects are potentially contaminated with infectious agents, therefore are capable of being reservoirs in the chain of transmission of infectious agents [11, 12]. Does the term, "Standard," downplay the role and significance of these precautions? Absolutely not, the message is that this is the expected way to prevent the spread of disease and applies to every encounter between patients and healthcare providers.

Standard Precautions group together infection prevention practices consisting of the use of Personal Protective Equipment (PPE), such as gowns, gloves, masks, goggles or face shields, and the performance of hand hygiene, washing hands with soap and water, especially when they are visibly soiled, or using an alcohol-based hand sanitizer. The basic premise for these practices is the need to anticipate a potential source of exposure, and take precautions by donning the appropriate barrier that will provide protection. For example, gloves should be worn when contact with blood, body fluid, or contaminated surfaces are likely. When the risk of being splashed by a potentially infectious substance exists, a mask and eye protection should be worn. A gown may be worn to protect clothing as well. Care should be taken when handling soiled linen and patient care equipment to reduce contamination of the environment with infectious agents.

Standard Precautions have been found to be an effective means of preventing the transmission of infectious agents in all healthcare settings. The Centers for Disease Control and Prevention

recommend that Standard Precautions be implemented for all patient encounters, whether the risk of transmitting an infectious agent is suspected or has been confirmed; all patients are to be thought of as potentially able to transmit.

Another component of Standard Precautions is the potential contamination of items in the patient's environment and appropriate measures to reduce the risk from inanimate sources. When handling or having direct contact with patient care equipment or other items in a patient's environment that potentially have been exposed to infectious agents, gloves should be worn followed by performing hand hygiene after removing gloves. When it is not practical to dedicate equipment to individual patients, proper cleaning and disinfecting or sterilizing is recommended before use on another patient.

Standard Precautions were originally established to protect healthcare personnel by reducing their risk of exposure to infectious agents. But in recent years, the importance of the protection of the patient has been recognized. The need for changes and reinforcement of proper infection control practices, as part of the practice of Standard Precautions, was identified as the result of outbreak investigations. From those investigations came the recommendations for Respiratory Etiquette/Cough Etiquette, Safe Injection Practices, and donning a mask during lumbar puncture procedures.

Respiratory Etiquette/Cough Etiquette is a practice that was implemented to reduce the spread of respiratory illnesses. During the SARS outbreak in 2003, emergency departments needed a way to control transmission of the disease, and putting a mask on a patient who has symptoms of a respiratory illness such as cough, increased production of respiratory secretions, and fever at the first stage of encounter in a healthcare facility has been shown to be effective. Healthcare facilities are expected to have masks, tissues, a waste receptacle, and hand hygiene products available with signage to explain their use at points of entry into the facility and in waiting areas.

Patients should be taught to use a tissue to cover their cough or sneeze, discard the tissue in a wastebasket, and wash their hands to reduce the risk of spreading infection.

The need to address injection practices was recognized in response to hepatitis B and C outbreak investigations that were caused by the use of poor technique during the administration of medications by injection. Used needles reinserted into a multidose vial or bag of saline and administration of intravenous injections to multiple patients using a single needle/syringe were two of the major breaks in infection control practices that were found to have led to the outbreaks. The need to educate healthcare personnel resulted in the establishment of "The One & Only Campaign," meaning one needle, one syringe, and only one time use for one patient. Safe Injection Practices dictate that used needles never be recapped, removed from disposable syringes, bent, broken or manipulated by hand, and are disposed of in puncture-resistant containers to prevent sharps injuries.

Wearing a mask to protect the patient has become a part of performing a lumbar puncture procedure after several patients were found to have acquired meningitis following a myelogram.

The expectation is that a mask will be worn whenever a catheter is placed or an injection administered into the spinal or epidural space.

Transmission-Based Precautions

In addition to Standard Precautions, Transmission-based Precautions are implemented when more restrictive measures are needed to decrease the risk of the spread of infection. The precautions taken to contain the known or suspected infectious agents are determined by their mode of transmission. A patient suspected of having, known to have, or in the case of Multidrug-Resistant Organisms, when a patient has a history of infection or colonization and there is a risk of transmission to others, the need to isolate the patient is important for the protection of others. There are three types of Transmission-based Precautions: Contact, Droplet, and Airborne. Contact Precautions are implemented when acquisition of a pathogen can occur by touching or coming in direct contact with a patient or the articles in the patient's environment. Illnesses spread by respiratory

droplets are prevented from transmission by Droplet Precautions. These infectious agents can be spread by being expelled in respiratory secretions during coughing, sneezing, or talking, but because the particles are large, they drop to the ground within 3–6 ft of the patient and do not pose a threat for those at a greater distance. There are some respiratory illnesses that require Airborne Precautions. Airborne Precautions require a room with special air handling capability. Negative pressure is established in the room, so that the particles, known to remain floating in the air for extended periods of time, can be ventilated to the outside or forced through an HEPA filtration system before the air is returned to circulate in the facility.

Contact Precautions, in Addition to Standard Precautions

Contact Precautions require that a gown and gloves be worn to protect the healthcare worker while performing patient care activities. It is recommended that the gown and gloves be put on prior to entering the room. This combination of PPE can also impact the safety of other patients that are being cared for by the same healthcare worker and may potentially be exposed to pathogens that can be transported to them on the caregiver's clothing. Hand hygiene is a key component of Contact Precautions. Hands should be washed with soap and water, or an alcohol-based hand sanitizer product used, prior to putting PPE on and after removing it.

Examples of Illnesses Requiring Contact Precautions

- When patient is known or suspected to have an illness transmitted by direct contact with the patient or by contact with articles in the patient's environment

All Multidrug-Resistant Organisms

Gastrointestinal, respiratory, skin, or wound infections or colonization with multidrug-resistant bacteria judged by the infection control program, based on current state, regional, or national recommendations, to be of special clinical and epidemiologic significance

Enteric infections with a low infectious dose or prolonged environmental survival, including:

For diapered or incontinent patients: enterohemorrhagic *Escherichia coli* O157:H7, *Shigella*, hepatitis A, or rotavirus

Respiratory syncytial virus, parainfluenza virus, or enteroviral infections in infants and young children

Skin infections that are highly contagious or that may occur on dry skin, including:

Diphtheria (cutaneous)

Herpes simplex virus (neonatal or disseminated)

Impetigo

Major (noncontained) abscesses, cellulitis, or decubiti

Pediculosis

Scabies

Staphylococcal furunculosis in infants and young children

Zoster (disseminated or in the immunocompromised host)†

Viral/hemorrhagic conjunctivitis

Viral hemorrhagic infections (Ebola, Lassa, or Marburg)

Interventions Used When Implementing Contact Precautions

- Patient and visitor education.
- Signage for patient's room.
- Availability of PPE (gowns and gloves).
- Gown and gloves worn on entry to room.
- Use dedicated or disposable equipment.
- Upon exiting, PPE is discarded inside the room.
- Hand hygiene: Hand washing with soap and water or an alcohol-based hand sanitizer.
- Limit transport of patient.
- Clean room daily, focusing on frequently touched surfaces.

Special Contact Precautions, in Addition to Standard Precautions

Special Contact Precautions may be necessary for patients infected with a spore-forming organism. *Clostridium difficile infection* (CDI),

Norovirus, or any organism that is resistant to the usual hospital cleaners and disinfectants require different means to reduce the risk of transmission of disease.

Interventions Used When Implementing Special Contact Precautions

- Hand washing with soap and water before and after contact with the patient, scrubbing to create slight friction to mechanically mobilize any organism that may be on the hands, and rinsing well to flush the organism off the skin.
- Meticulous cleaning of room with an EPA-approved, hospital grade cleaner, followed by disinfecting with a 1:10 bleach solution, especially frequently touched surfaces.
- Use dedicated or disposable equipment.

Respiratory or Droplet Precautions, in Addition to Standard Precautions

Droplet Precautions should be implemented when caring for a patient with a respiratory infection or when there is risk of exposure to respiratory secretions or contact with mucous membranes. Placing the patient in a private room is preferred, but when a single-patient room is not available, an assessment of risk to other patients should be done before placing an infectious patient with others. If it is necessary to place multiple patients in the same room, separating them by three or more feet and having a privacy curtain drawn between them is important. Teaching patients to practice Respiratory Etiquette can also help reduce the transmission of infectious agents.

Interventions Used When Implementing Droplet Precautions

- Hand hygiene.
- Private room preferred, but not required; patients with the same disease can be placed in the same room.
- Surgical/procedural mask is worn by care providers and put on before entering the room.

- Handle items contaminated with respiratory secretions with gloves.
- Use dedicated or disposable equipment.
- Upon exiting, PPE is discarded inside the room.
- Clean room daily, focusing on frequently touched surfaces.
- Patient should only leave room for essential test, and wear a surgical/procedural mask when out of their room.

Examples of Illnesses Requiring Droplet Precautions

- When patient is known or suspected to have an illness transmitted by large particle droplets
Invasive *Haemophilus influenzae* type b disease, including meningitis, pneumonia, epiglottitis, and sepsis

Invasive *Neisseria meningitidis* disease, including meningitis, pneumonia, and sepsis

Other serious bacterial respiratory infections spread by droplet transmission, including:

Diphtheria (pharyngeal)

Mycoplasma pneumonia

Pertussis

Pneumonic plague

Streptococcal (group A) pharyngitis, pneumonia, or scarlet fever in infants and young children

Serious viral infections spread by droplet transmission, including:

Adenovirus

Influenza

Mumps Parvovirus B19

Rubella

Airborne Precautions, in Addition to Standard Precautions

A patient requiring Airborne Isolation Precautions should be placed in a room capable of supporting negative pressure airflow. The air should be vented outside or filtered before being circulated in the facility. The air pressure in the room should be tested daily while it is occupied with a confirmed or suspected infectious patient. All health-care providers wear an N-95 respirator on entry to the room. If a room capable of providing

negative pressure is not available, the patient may be placed in a single-patient room and wear a surgical/procedural mask as tolerated, until an Airborne Illness Isolation Room is available.

Interventions Used When Implementing Airborne Precautions

- Hand hygiene.
- Patient is placed in an Airborne Illness Isolation Room (AIIR)/Negative Pressure.
- Door remains closed.
- Limit transport of patient for essential tests only, and when necessary patient wears a surgical/procedural mask outside their room.
- Use dedicated or disposable equipment.
- Fit-tested N-95 level respirator is put on before entering room.
- Respirator is removed only after exiting room with the door closed.

Examples of Illnesses Requiring Airborne Precautions

- When a patient is known, or suspected, to have an illness transmitted by airborne droplet nuclei that can be suspended in the air and remains infectious for long distances
 - Measles
 - Varicella (including disseminated zoster)
 - Tuberculosis

Strict Isolation

Strict Isolation was introduced in 1970 as one of the seven categories of isolation precautions. It continued to be included as a category through the 1983 revision when the precautions became more disease-specific and was practiced until the guideline for Universal Precautions was published. Isolation practices at that time were simple and required little decision making by the healthcare team members. The isolation category for patients with infections transmissible by more than one route is a combination of above-described categories, e.g., a combination of contact and airborne precautions for varicella.

Quarantine

The practice of quarantine is used to prevent the potential spread of disease when it is suspected that a person who is currently well may have been exposed to a communicable disease. By law, a person can be held, separated from others, or confined to their home to wait out an illness's incubation period to determine if they become ill [13].

Examples of communicable diseases that are Quarantinable:

Cholera
 Diphtheria
 Infectious tuberculosis
 Plague
 Smallpox
 Yellow fever
 Viral hemorrhagic fevers
 SARS
 New types of influenza that have the potential to cause a pandemic

Summary

It is obvious that for a hospital to just say that they have and follow the CDC guidelines for prevention of transmission of infectious agents is rather bureaucratic and simplistic. The actual implementation is absolutely dependent on behavioral changes needed to support improvements in the areas of personal hygiene, specifically in the washing of hands between tasks in preparation of food, caring for children, and caring for the sick in the hospital and non-hospital settings. In the hospital setting, risks of transmission to other patients especially those with serious comorbidities and immunocompromising conditions are associated with morbidity, mortality, and cost. It is not uncommon to see healthcare workers using personal protective equipment inappropriately. For example, if a gown is not worn and tied properly, it actually be falling on top of the patient and other surfaces and become more likely to pick and transmit microorganisms. If it is not

disposed properly, flows out of containers, the organisms can be aerosolized and transmitted in more than one way. It is the responsibility of everyone not just a few infection preventionists in the hospital to understand the principles and implement the practices of infection prevention. The practices the healthcare providers believe which protect them and their families are more likely to be adhered to. In this regard, the significance of basic hand hygiene principles seems to be least valued and understood. On the other hand, they can be overzealous about isolation precautions in a given patient based on profiling and misconceptions leading to their isolation from care. Unfortunately, this collateral damage has not received much attention. It is fair to say that as healthcare providers of all types, we have not reached a balanced and fully understood level in infection prevention practices 45 years after they were first formalized. One of the major reasons is the fact that during formative medical school years, the teaching of basic and applied sciences like microbiology is de-emphasized, and getting into the glamorous realm of clinical medicine very early is encouraged at the cost of learning fundamentals.

Resource constrained settings cannot justify to deviate from the guidelines necessary to prevent HAI. The abovementioned measures have been spelled out in simple language to help implementation in letter and spirit.

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