MANUAL OF INFECTION CONTROL PROCEDURES

2nd Edition

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Principles of Infection Control

Hospitalized patients are more prone to develop infection as a result of surgery, invasive procedures and devices, immunosuppressive drugs, organ transplants etc. In addition, microorganisms flourish in health care setting and with breaks in infection control procedures and practices, along with patient's weakened defense mechanisms, help set the stage for nosocomial infections. Nosocomial infections lengthen patients' hospital stays and increase both morbidity and mortality. In addition, diagnosing and treating these infections puts intense pressure on the health services and health care budget.

Chain of infection

In order to control or prevent infection it is essential to understand that transmission of a pathogen resulting in colonization or infection requires the following six vital links (Fig. 1.1):

- 1. Causative agent
- 2. Infectious reservoir
- 3. Portal of exit from the reservoir
- 4. Mode of transmission
- 5. Portal of entry into the host
- 6. Susceptible host

Each link must be present for infection or colonization to proceed, and breaking any of the links can prevent the infection. The aim of isolation precautions is to interrupt these links.

1. Causative agent

The causative agent for infection is any microorganism capable of producing disease. Microorganisms responsible for infectious diseases include bacteria, viruses,



Figure 1.1 Figure showing chain of infection. An infection can occur only if the six components shown here are present. Removing any one link breaks the chain and prevents infection.



Figure 1.2 Endogenous or auto-infection where infection occurs from the patients' own colonizing microorganisms.

rickettsiae, fungi, and protozoa. Sometimes, microorganisms are part of patient's own body flora and can cause infection in the immunocompromised host. These infections are called *endogenous infections* (Fig. 1.2). Infections which are acquired from external sources are called *exogenous infections* (Fig. 1.3).



Figure 1.3 Exogenous or cross-infection where an infection occurs from an infected or colonized patient to other patients, health care workers and visitors or vice versa.

2. Reservoir of infection

The second link in the chain of infection is the reservoir, i.e. the environment or object in or on which a microorganism can survive and, in some cases, multiply. Inanimate objects, human beings, and animals can all serve as reservoirs, providing the essential requirements for a microorganism to survive at specific stages in its life cycle. *Pseudomonas* spp. survive and multiply in nebulizers and the hepatitis B virus (HBV) survives but does not multiply on the surface of haemodialysis machines.

Infectious reservoirs abound in health care settings, and may include everything from patients, visitors, and staff members to furniture, medical equipment, medications, food, water, and blood.

A human reservoir may be either a case or a carrier. A case is a patient with an acute clinical infection while a carrier is a person who is colonized with a specific pathogenic microorganism but shows no signs or symptoms of infection. A carrier may have a subclinical or asymptomatic infection, e.g. Hepatitis B virus.

Carriers fall into four categories: An *incubatory carrier* is one who has acquired the infection and has been incubating the illness but does not yet show symptoms. Incubation periods vary from one infectious disease to other (see page 114). A *convalescent carrier* is in the recovery stage of an illness but continues to shed the pathogenic microorganism for an indefinite period, e.g. a patient who has had a Salmonella infection commonly sheds the organism in his faeces even after symptoms disappear. An *intermittent carrier* occasionally sheds the pathogenic microorganism from time to time, e.g. some people are intermittent carriers of *Staphylococcus aureus*. A *chronic*



Figure 1.4 Summary of the modes by which various nosocomial infections are transmitted.

carrier always has the infectious organism in his system, e.g. chronic carriers of hepatitis B virus.

Carriers (especially when asymptomatic) may present a risk of transmission to susceptible patients in health care facilities because their illnesses go unrecognized and they and those around them are unlikely to take appropriate precautions against infection.

3. Portal of exit

The portal of exit is the path by which an infectious agent leaves its reservoir. Usually, this portal is the site where the microorganism grows. Common portals of exit associated with human reservoirs include the respiratory, genitourinary, and gastro-intestinal tracts, the skin and mucous membranes and the placenta (transmission from mother to fetus).

4. Mode of transmission

The microorganism can be acquired by inhalation (through respiratory tract), ingestion (through gastrointestinal tract), inoculation (through accidental sharp injury or bites), contact (during sexual intercourse) and transplacental transmission (microbes may cross placenta from the mother to fetus). It is important to remember that *some microorganisms use more than one transmission route* to get from the reservoir to a new host.

Of the six links in the chain of infection, the mode of transmission is the easiest link to break and is key to control of cross-infection in hospitals.

Contact transmission: Contact is the most common mode of transmission of infection in the health care settings. Contact transmission may be subdivided into direct contact, indirect contact, and contact with droplets that enter the environment.

Direct contact: Direct contact refers to person-to-person spread of microorganisms through actual physical contact. Microorganisms with a direct mode of transmission can be transferred during such patient care activities as bathing, dressing changes, and insertion of invasive devices if the hands or gloves of health care worker (HCW) are contaminated. Diseases that spread by direct contact include scabies and herpes simplex (if direct contact with infected oral lesions or secretions occurs). *Handwashing is the most effective way to prevent transmission by the contact route.*

Indirect contact: Indirect contact occurs when a susceptible person comes in contact with a contaminated object. In health care settings, virtually any item could be contaminated with certain microorganisms, e.g. endoscopes, respiratory equipment, etc. Thorough cleaning, disinfection, and sterilization are essential in the health care setting to prevent nosocomial infection acquired from contaminated items and equipment.

Droplet transmission: Droplet transmission results from contact with contaminated respiratory secretions. A person with a droplet-spread infection coughs, sneezes, or talks, releasing infected secretions that spread through the air to the oral or nasal mucous membranes of a person nearby. Microbes in droplet nuclei (mucus droplets) can travel up to about 3 ft (1 m). Droplet transmission differs from airborne transmission in that the droplets don't remain suspended in the air but settle on surfaces. Examples of diseases spread by droplets include influenza, whooping cough, etc.

Airborne transmission: Airborne transmission occurs when fine microbial particles or dust particles containing pathogens remain suspended in the air for a prolonged period, and then are spread widely by air currents and inhaled. The tiny particles remain suspended in the air for several hours and may cause infection when a susceptible person inhales them. Examples of diseases spread by the airborne include pulmonary tuberculosis, varicella, and measles.

5. Portal of entry

The portal of entry is the path by which an infectious agent invades a susceptible host. Usually, this path is the same as the portal of exit. For example, the portal of entry for tuberculosis and diphtheria is through the respiratory tract, hepatitis B and Human Immunodeficiency Virus enter through the bloodstream or body fluids and Salmonella enters through the gastrointestinal tract. In addition, each invasive device, e.g. intravenous line, creates an additional portal of entry into a patient's body thus increasing the chance of developing an infection.

6. Susceptible host

The final link in the chain of infection is the susceptible host. The human body has many defense mechanisms for resisting the entry and multiplication of pathogens. When these mechanisms function normally, infection does not occur. However, in immunocompromised patients, where the body defenses are weakened, infectious agents are more likely to invade the body and cause an infectious disease. In addition, the very young and the very old are at higher risk for infection because in the very young the immune system does not fully develop until about age 6 months, while old age is associated with declining immune system function as well as with chronic diseases that weaken host defenses.

Body's defense mechanisms

The body's defense mechanisms fall into two general categories:

First line of defense: External and mechanical barriers such as the skin, other body organs, and secretions serve as the body's first line of defense. Intact skin, mucous membranes, certain chemical substances, specialized structures such as cilia, and normal flora can stop pathogens from establishing themselves in the body. The gag and cough reflexes and gastrointestinal tract peristalsis work to remove pathogens before they can establish a foothold. Chemical substances that help prevent infection or inhibit microbial growth include secretions such as saliva, perspiration, and gastrointestinal and vaginal secretions as well as interferon (a naturally occurring glycoprotein with antiviral properties). Normal microbial flora controls the growth of potential pathogens through a mechanism called microbial antagonism. In this mechanism, they use nutrients that pathogens need for growth, compete with pathogens for sites on tissue receptors and secrete naturally occurring antibiotics to kill the pathogens. When microbial antagonism is disturbed, such as by prolonged antibiotic therapy, an infection may develop; for example, antibiotic therapy may destroy the normal flora of the mouth, leading to overgrowth of *Candida albicans* and consequent thrush.

Second line of defense: If a microorganism gets past the first line of defense by entering the body through a break in the skin, white blood cells and the inflammatory response come into play. Because these components respond to any type of injury, their response is termed non-specific. The main function of the inflammatory response is to bring phagocytic cells (neutrophils and monocytes) to the inflamed area to destroy microorganisms.

If a pathogen gets past non-specific defenses, it confronts specific immune responses, cell-mediated immunity or humoral immunity. Cell-mediated immunity involves T cells. Some T cells synthesize and secrete lymphokines. Others become killer (cyto-toxic) cells, setting out to track down infected body cells. Once the infection is under control, suppresser T cells bring the immune response to a close. Humoral immunity, mediated by antibodies, involves the action of B lymphocytes in conjunction with helper T cells. Antibodies produced in response to the infectious agent help fight the infection. In response to the effects of suppressor T cell activity antibody production then wanes. Impaired host defenses make patients more susceptible to infection. Conditions that may weaken a person's defenses include malnutrition, extremes of age, inherited and acquired immune deficiencies, chronic disease, immunosuppressive therapy, surgery and inadequate immunization.



Figure 1.5 Five pillars of infection control. Surveillance and audit are essential tools to monitor the effectiveness of the programme.

Strategies to control health care associated infection

Strategies to control and prevent nosocomial infection fall into three main categories:

• Control or elimination of infectious agents

- Control of transmission
- Reservoir control

Control or elimination of the infectious agent: This is achieved by placing patients with suspected or proven infectious diseases under source isolation and applying barrier precautions. Infectious agents can be controlled or eliminated by effective disinfection and sterilization of items and equipments and thorough cleaning of the environment. This helps reduce the bioburden of microorganisms in health care facilities.

Control of transmission: This can be effectively achieved by handwashing, aseptic techniques and control of the health care environment. Proper handwashing has been shown to be effective in preventing the spread of infection. Basic aseptic technique must be practiced for sterile procedures e.g. insertion of intravenous lines and urinary catheters. Effective decontamination and control of the environment (e.g. mechanical ventilation) is essential to control transmission of microorganisms.

Reservoir control: Almost any piece of equipment used in health care facilities may harbour microorganisms and therefore act as a reservoir (e.g. respiratory therapy equipment and ventilator circuits, bedpans, urinals, bed linen etc). Interventions directed at controlling or destroying infectious reservoirs in health care facilities include using either disposable equipment or decontaminating equipment as soon as possible after use. In addition, both patients and health care workers may also act as reservoirs of infection. Identifying and treating these individuals will reduce the reservoirs and help prevent cross-infection.

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