

Chapter 18

Nosocomial Infections



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Key Points

- Nosocomial infections, also termed as “healthcare associated infections”, are infections acquired in health-care facilities. For patients, the infections should not be present or incubating at admission.
- Nosocomial infections can be categorized as endogenous infections and exogenous infections according to types of reservoirs. There are two types of exogenous infections: iatrogenic infections and cross infections.
- The epidemic process of nosocomial infections is usually described with 3 terms: (1) Source of infection; (2) Route of transmission; and (3) Susceptible population.
- Nosocomial infections are related to both patient factors, such as immunocompromise, and medical procedures that is implemented by health professionals at hospitals. It is the responsibility of all health professionals to reduce nosocomial infections.

18.1 Introduction

Nosocomial infections constitute a serious threat to the global health. Acquiring infections in health-care settings adds to the patient’s functional disability and emotional stress and in turn affect the patient’s quality of life. Furthermore, nosocomial infections can lead to excessive mortality among hospitalized patients. More than that, nosocomial infections may be disseminated from health-care settings to the general public if not appropriately controlled, and threaten the health of total population.

Nosocomial infections may lead to considerable economic costs. The increased consumption of drugs, the use of additional laboratory and other diagnostic

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procedures, and the need for isolation contribute significantly to the direct costs. The increased length of hospital stay also increases the indirect costs due to work hours lost. Nosocomial infections constitute an economic burden both for the individual patients and for the public health.

18.2 Definition and Diagnostic Standards

Nosocomial infections, also termed as “health-care-associated infections,” are infections acquired in health-care facilities, usually during hospital care after admission. To be considered to be nosocomial, the infections cannot be present or incubating at admission. Those infections acquired in the hospital but appearing after discharge, and the occupational infections among staff of the hospital are also considered to be nosocomial.

According to the “Diagnostic Standard for Nosocomial Infections’ issued by the National Health Planning Commission (formerly Ministry of Health of China), the following infections are considered to be nosocomial:

1. For those infections without a clearly defined incubation period, occurrence of infection beyond 48 h since admission; for those infections with a clearly defined incubation period, occurrence of infection beyond the average length of incubation period since admission;
2. The infection is directly related to the last hospital stay;
3. Appearance of new infection in sites other than the original ones (except for metastatic lesions caused by pyemia) or isolation of new pathogens in addition to the known pathogens during hospital stay (excluding the possibility of pollution or previous coexistence of infections);
4. Neonatal infections acquired during or after delivery;
5. Latent infections reactivated by diagnostic or therapeutic procedures, for example, herpes virus and *Mycobacterium tuberculosis*;
6. Infections acquired while working at the hospital as medical staff.

The following cases are not considered to be nosocomial:

1. Bacterial colonization without inflammation in open wounds of skin and mucous membrane;
2. Inflammations caused by trauma or non-biological factors;
3. Infection of the newborn through the placenta (onset of the disease within 48 h after birth), for example, herpes simplex virus, toxoplasmosis, or chicken pox;
4. Acute attack of the original chronic infections during hospital stays.

18.3 Nosocomial Infection Sites

There are many potential body sites for the occurrence of nosocomial infections. The following are the most frequent sites for nosocomial infections.

18.3.1 Surgical Sites

Surgical sites are subject to nosocomial infections. The infections are usually acquired during the surgical operation. The diagnosis is mainly based on clinical criteria: purulent discharge or spreading cellulitis around the wound or the insertion site of the drain. There are varieties of possible infecting microorganisms for surgical sites nosocomial infections, depending on location and aggressiveness of the surgery, patients' immunity status, and antibiotics use. The level of contamination during the surgical procedure is one of the most important risk factors for surgical site infections. Other risk factors for surgical site infections are the surgical procedures per se, the level of asepsis, as well as the virulence of the infecting microorganisms and concomitant infections at other body sites.

18.3.2 Respiratory System

Patients with several diseases are at high risk of nosocomial pneumonia while hospitalized. The most frequently reported nosocomial pneumonia is among patients on ventilators. Monitoring of clinical manifestation and using radiological imaging support the diagnosis of pneumonia. Specimen investigation can improve specificity for the diagnosis. Infecting microorganisms may be either endogenous, for example, from nose, throat, or stomach, or exogenous, for example, from contaminated equipment. Patients with decreased level of consciousness are also at higher risk for nosocomial pneumonia. Children are susceptible to viral bronchiolitis, while the elderly are vulnerable to influenza and secondary bacterial pneumonia.

18.3.3 Bacteremia

The incidence of nosocomial bacteremia is low, but its case fatality rate is high – over 50% for some microorganisms. When infection occurs at the entry site of the device, it may be visible. If bacteremia is caused by the microorganisms colonizing the device within the vessel, it may be invisible. In the case of catheterization, the length of catheter, level of asepsis for the insertion procedures, and duration of catheter care are important factors influencing the risk of nosocomial bacteremia.

18.3.4 Urinary Tract

Urinary infections are the most frequently reported nosocomial infections. Compared with nosocomial infections in surgical sites, pneumonia or bacteremia, urinary infections cause less morbidity but occasionally lead to bacteremia and death. Urinary infections can be diagnosed through quantitative urine culture ($>10^5/\text{mL}$). The microorganisms responsible may be acquired from the patient's gut flora or from the health-care facilities.

18.4 Microorganisms

The infecting microorganisms in nosocomial infections may be bacteria, virus, parasites, or fungi, dependent on the patient populations, medical and surgical interventions, implemented nosocomial infection control programs, and health-care settings.

18.4.1 Normal Microorganisms in Nosocomial Infections

18.4.1.1 Bacteria

Bacteria are among the most frequently reported pathogens in nosocomial infections. These can be commensal bacteria. Infection occurs when immunity of the host is compromised. These can also be pathogenic bacteria, which lead to nosocomial infections when introduced regardless of the immunity status of the host. Staphylococci, pseudomonads, and *Escherichia coli* are the three pathogens of great concern for nosocomial infections.

18.4.1.2 Viruses

Many viruses can cause nosocomial infections. For example, the hepatitis B virus can be transmitted through invasive medical procedures, for example, transfusions, dialysis, and injections. Enteroviruses may be transmitted by the fecal-oral route. SARS-CoV-2 may be transmitted by respiratory droplet and aerosol.

18.4.1.3 Parasites and Fungi

Some fungi and parasites may cause infections among hospitalized patients with compromised immunity or undergoing extended antibiotic treatment. Risks of fungi infection increase for hospitalized patients when renovating aging hospitals. The

infecting pathogens can be *Aspergillus* spp., *Candida albicans*, or *Cryptococcus neoformans*.

18.4.2 Antimicrobial Resistance and Nosocomial Infections

Due to the inappropriate and uncontrolled use of antimicrobial agents, varieties of microorganisms, including bacteria, viruses, fungi, and parasites that can cause infections in humans, animals, or plants, no longer respond to antimicrobial agents that used to be effective. Antimicrobial resistance constitutes a global concern and is especially a problem for nosocomial infections. In health-care settings, resistant microorganisms have larger capability to spread. Patients undergoing surgery, cancer chemotherapy, and transplantation are at high risk of infections with resistant microorganisms. Genetic mutations of the antimicrobial-resistant microorganisms are thus more likely to spread between hospitalized patients in health-care settings. Restriction on antimicrobial consumption plays a role in the control of nosocomial infections.

18.5 Categories of Nosocomial Infections

Nosocomial infection can be categorized as endogenous infection and exogenous infection according to types of reservoirs.

18.5.1 Endogenous Infections

Endogenous infections occur when microorganisms that cause nosocomial infections are already present within the body. For example, a patient undergoing chemotherapy has a compromised immunity and the dormant tuberculosis becomes reactivated and infects the patient.

18.5.2 Exogenous Infections

Microorganisms that cause nosocomial infections are transmitted from outside the patient. There are two types of exogenous infections.

Iatrogenic infections: The infections are caused by the contamination of medical instruments, equipment, supplies, and sanitary materials used in health care or by the poor sterilization, for example, microorganisms in water, damp environment, and contaminated devices.

Cross infections: Microorganisms are transmitted between patients, member of staff, or visitors through direct or indirect contact.

18.6 Epidemic Process of Nosocomial Infection

The epidemic process refers to the development and spread of nosocomial infections within the health facilities. The three terms frequently used to describe the epidemic process for infectious diseases, that is, source of infection, route of transmission, and susceptible population, are used here to describe the epidemic process of nosocomial infections. In view of the significant difference in epidemic process between endogenous infection and exogenous infection, the following details pertain primarily to the latter.

18.6.1 Source of Infection

Source of infection refers to the natural habitat of microorganisms which may cause nosocomial infection. Patients are one of the most important sources of nosocomial infections. Other important sources of nosocomial infection may be carriers, wet environment, mouse, arthropods, mosquito, and others. For more details, refer to Chap. 11.

18.6.2 Route of Transmission

Route of transmission refers to the spread of infecting microorganisms directly or through the environment to another person. The important routes of transmission for nosocomial infections may be direct contact, transfusion or infusion of other medical products, intramuscular injection or other invasive medical procedures, airborne transmission, waterborne transmission, arthropod-borne transmission, vertical transmission, and others. For more details, refer to Chap. 11.

18.6.3 Susceptible Population

The susceptibility varies for patients according to their age, gender, immunity, as well as medical procedures they are undergoing. Patients with compromised immunity are among the most susceptible populations. For more details, refer to Chap. 11.

18.7 Prevention of Nosocomial Infections

The risk of nosocomial infections is affected by both patient factors, such as immunity status, and health-care settings and medical procedures that elevate the likelihood of infection. It is the duty of all health professionals to prevent nosocomial infections.

18.7.1 Preventing Human-to-Human Transmission

18.7.1.1 Hand Decontamination

Maintaining hand hygiene is important for reducing nosocomial infections. For handwashing in hospitals, it requires running water, soap, and drying facilities. For hand disinfection, proper antiseptic is required. The procedures of handwashing/disinfection vary for medical procedures that patients will receive or have undergone.

Adherence to hand decontamination is frequently suboptimal. There may be a variety of reasons, including high frequency of patient contact, allergies to hand decontamination products, low perceived risk of infection, low awareness of hand decontamination procedures, lack of time required to complete the hand decontamination procedures, and lack of accessible equipment. The facilities must have policies to evaluate and manage this problem.

18.7.1.2 Clothing

An outfit, usually a white coat, is needed for staff. In special areas, uniform trousers and gown are required. An outfit must be changed in the case of being exposed to blood or other body fluid. In aseptic units and operating rooms, dedicated shoes should be used as well as caps or hoods that can cover the hair.

18.7.1.3 Masks

In operating room, staff wear masks to protect patients. When caring for immune-compromised patients, staff must wear masks. For infections which can be transmitted by the air, patients must wear masks when not isolated. When approaching patients with airborne infections, staff must wear masks to avoid being infected.

18.7.1.4 Gloves

Staff must wear sterile gloves in surgery or other invasive procedures. To protect the immune-compromised patients, staff must wear sterile gloves. Whenever hands are

likely to be contaminated, non-sterile gloves should be worn before patient contacts. When caring for patients with infections that can be transmitted by direct contact or respiratory droplets, non-sterile gloves should be worn to protect the staff. Wash hands with running water after removing or changing gloves.

18.7.1.5 Safe Injection and Other Skin-Piercing Practice

Injection or other skin-piercing procedures increases the risk of infection transmission between patients. It is required to use sterile needle and syringe, prevent contamination of medications, and eliminate unnecessary injections.

18.7.2 Preventing Transmission from Environment

The hospital environment can be classified into five types of zones according to the possibility of contamination, required level of asepsis, and risk of infection:

Zone A: It is clean areas without patient contact, for example, administrative office and library;

Zone B: It is areas possibly contaminated by microorganisms, for example, passageway and lab;

Zone C: It is areas with patient contact and microbial contamination, for example patients' room and bathroom;

Zone D: It is passageways for clinicians and patients in the designated zone for the diagnosis of infectious respiratory diseases. The entrance of clinicians' passageway connects to clean zones, while the entrance of patients' passageway connects to contaminated zones.

Zone E: It is buffer areas between clean and contaminated zones.

To minimize the microorganisms from environment, cleaning, disinfecting, and sterilizing must be used appropriately for each type of zone.

18.7.2.1 Routine Cleaning

Routine cleaning is scheduled to make the environment visibly clean. The frequency of routine cleaning and cleaning agents need to be specified for all types of reused equipment/devices used in the health-care settings and all areas in the hospital.

18.7.2.2 Disinfection of Equipment

The purpose of disinfection is to remove microorganisms without complete sterilization. The disinfectants must be nonvolatile, free from irritating smells, and not

harmful to equipment or persons. The disinfection procedures must kill or remove the targeted microorganisms.

18.7.2.3 Sterilization

Sterilization is to destruct all microorganisms on the medical devices. Sterilization is performed for those medical devices used to penetrate sterile body surface, as well as medications and parenteral fluids.

18.8 Surveillance of Nosocomial Infections

Surveillance is a program designed to monitor nosocomial infections in a continuous, systematic, and long-term manner. It plays an important role on identifying the early signs of local problems and the evaluation of the effectiveness of nosocomial infection control policy.

18.8.1 Objectives of Surveillance Programs

The ultimate aim of surveillance is to reduce the burden of nosocomial infections in the local area and alleviate the costs.

The specific objectives of a nosocomial infections surveillance program usually include the following:

1. To monitor trends in nosocomial infections, including incidence, prevalence, and distribution of nosocomial infections;
2. To evaluate the effectiveness of prevention programs, and to adjust the currently ongoing prevention programs accordingly;
3. To recognize sources of nosocomial infections, particularly in situations of an outbreak, and to take immediate actions to control transmission;
4. To find aspects for improvement in the local nosocomial infections control programs.

18.8.2 Implementation of Surveillance Programs

Surveillance programs can be implemented at the hospital level. Involving partners include the infection control practitioner, physician, nurse, lab staff, director, and administrator. Before implementing a surveillance program, the partners need to decide the following:

1. Which patients and units to be monitored;
2. What type of infections and relevant information to collect;
3. The time period of the surveillance and frequency of monitoring;
4. Data collection and information retrieve methods;
5. Methods for data management and analysis;
6. Methods for information dissemination and feedback collection;
7. Methods for maintaining confidentiality.

Besides at the hospital level, surveillance of nosocomial infections may also be implemented at the levels of local, regional, national, or international networks. On a confidential basis, hospitals may share data with other facilities in the local, national, or international network for the purpose of improving nosocomial infection control programs.

18.8.3 Evaluation of Surveillance Program

Evaluation of the surveillance programs is necessary. Maintaining contacts with the surveillance program staff can also help maintain their compliance with the guidance of the surveillance program. An evaluation usually includes the following:

18.8.3.1 Strategy Evaluation

Evaluate whether the surveillance program has the following quality: simplicity, flexibility, acceptance, sensitiveness, effectiveness, and efficiency.

Evaluation can be undertaken by means of field survey, focus group, or interview.

18.8.3.2 Feedback Evaluation

Feedback evaluation aims to address the following specific issues:

1. Is confidentiality respected during the implementation of the program? Is maintaining confidentiality compatible with data dissemination required for the purpose of infection control?
2. Are the results of the evaluation widely shared internally within the units and externally between facilities in the network?
3. Is the population under surveillance well representative of the target population?
4. Is risk adjustment/stratification appropriately used?
5. Is the length of the surveillance period sufficient to draw a conclusion?

18.8.3.3 Evaluation of Data Quality

The denominator and nominator used in calculating the incidence or prevalence of nosocomial infections need to be periodically evaluated in terms of exhaustiveness (missing patients), completeness (missing data), and correctness (data error).