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The Chain of Infection (264)

Authors: Nancy Evans, BS; Lauren Robertson, BA, MPT

Contact hours: 1

Price: $10

Course Summary

The very nature of healthcare settings makes them vulnerable to the spread of infections because they serve patients who are ill and are therefore susceptible hosts. Patients with altered immunity such as people with cancer or HIV/AIDS are at high risk for infection. Surgical patients are at risk because any incision creates a new portal of entry for pathogens. Elderly patients may have weakened immunity simply because of their age. Healthcare workers are themselves at risk of infection because of their close daily contact with patients who may harbor pathogens. Thus, infection control (and breaking the chain of infection) is a primary component of safe, effective patient care.

Target Audience

Nurses, nurse practitioners, advanced practice nurses, physical therapists, physical therapy assistants, occupational therapists and occupational therapy assistants*.

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Learning Objectives

Upon conclusion of this course, the learner will be able to:

1. Describe the 6 components of the chain of infection.
2. Discuss 3 host factors that affect the spread of infection.
3. Describe 5 common prevention strategies used to break the chain of infection.

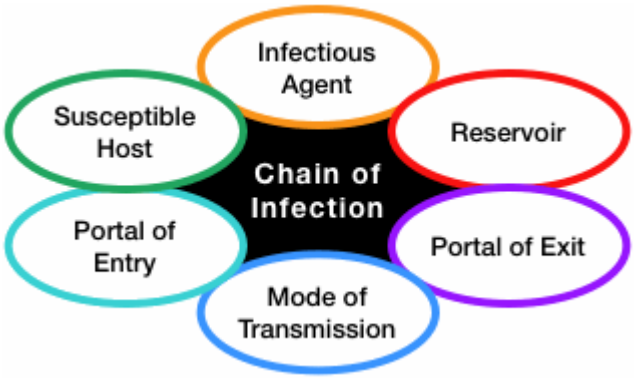
1. Examining the Chain

The very nature of healthcare settings makes them vulnerable to the spread of infections because they serve patients who are ill and are therefore susceptible hosts. Patients with altered immunity such as people with cancer or HIV/AIDS are at high risk for infection. Surgical patients are at risk because any incision creates a new portal of entry for pathogens. Elderly patients may have weakened immunity simply because of their age. Healthcare workers are themselves at risk of infection because of their close daily contact with patients who may harbor pathogens. Thus, infection control is a primary component of safe, effective patient care.

The spread of infection is best described as a chain with six links:

1. Pathogens or infectious agents
2. The reservoir (the normal location of the pathogen)
3. A portal of exit from the reservoir
4. A method of transmission
5. A portal of entry into a host
6. A susceptible host

The Chain of Infection



Infection control measures are designed to break the links and thereby keep the infection from spreading.

1.1 Pathogens and Infectious Agents

The presence of bacteria in and on the human body is normal; these bacteria are called resident flora. For example, the large intestine is colonized with *Escherichia coli*. However, when *E.coli* (**infectious agent**) exits the gastrointestinal tract (**reservoir**) through the anus (**portal of exit**), it can spread to the urinary tract by indirect contact (**mode of transmission** in women—wiping from back to front) and cause a urinary tract infection (UTI). The urethra is the **portal of entry**. A simple way for a woman (**susceptible host**) to break the chain of infection is to wipe from front to back. Teaching patients this simple technique can help prevent urinary tract infections in the future.

Pathogens include not only bacteria but also viruses, fungi, and parasites. The virulence of these pathogens depends on their number, their potency, their ability to enter and survive in the body, and the susceptibility of the host. For example, the smallpox virus is particularly virulent, infecting almost all people exposed. In contrast, the tuberculosis bacillus infects only a small number of people, usually people with weakened immune function, or those who are undernourished and living in crowded conditions.

An illustration of a bacillis. Bacillus can refer to any rod-shaped bacterium, or can be more specific to Bacillus, which is a gram-positive and rod-shaped genus. Source: 3DScience.com. Used with permission.

Viruses are intracellular parasites; that is, they can only reproduce inside a living cell. Viruses such as HIV/AIDS, and Hepatitis B and C have the ability to enter and survive in the body for years before symptoms of disease occur. Other viruses, such as the influenza and SARS viruses, quickly announce their presence through characteristic symptoms.

Fungal infections are prevalent throughout the world but only a few cause disease in humans, and most commonly affect the skin, nails, and subcutaneous tissue. However, fungi such as *Pneumocystis carinii* can be life-threatening to the person with HIV/AIDS.

Parasites are organisms that infect and cause disease in animals. Protozoa, arthropods, and helminths are all parasites. Protozoa are single-celled organisms transmitted via direct or indirect contact or an arthropod vector (an infected carrier). Arthropods include scabies (mites), lice, and fleas, which generally infest skin, causing inflammation and itching. Infestation occurs by direct contact with the arthropod or its eggs. Helminths include roundworms, tapeworms, and flukes. They infect humans principally through ingestion of fertilized eggs or when the larvae penetrate the skin or mucous membranes.

Giardia (protozoa parasite)

Protozoa parasites: giardia trophozoites in a variety of positions. Giardia stick closely to the lining of the small intestine in the hosts they infect and cause mild to severe diarrhea. Source: 3DScience.com. Used with permission.

1.2 Reservoirs

A reservoir is any person, animal, arthropod, plant, soil or substance (or combination of these) in which an infectious agent normally lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host.

Animate reservoirs include people, insects, birds, and other animals. Inanimate reservoirs include soil, water, food, feces, intravenous fluid and equipment.

Humans are the most common reservoirs of pathogens that can infect themselves (see *E. coli* example above) and others. The following table summarizes the human reservoirs and methods of transmission of common infectious agents.

Human Reservoirs and Transmission of Infectious Agents

Reservoir	Transmission vehicle	Infectious agent
Blood	Blood, needle stick, other contaminated equipment	Hepatitis B and C; HIV/AIDS, Staphylococcus aureus, S. epidermidis
Tissue	Drainage from a wound or incision	S. aureus, E. coli, Proteus species
Respiratory tract	Airborne droplets from sneezing or coughing	Influenza viruses, SARS, Klebsiella species, *S. aureus*
Gastrointestinal tract	Vomitus, feces, bile, saliva	Hepatitis A virus, Shigella species, Salmonella species
Urinary tract	Urine	E. coli enterococci, Pseudomonas aeruginosa
Reproductive tract and genitalia	Urine and semen	Neisseria gonorrhoeae, Treponema pallidum, Herpes simplex virus type 2, Hepatitis B virus

1.3 Exit Portals

Portals of exit from the human reservoir include:

Blood

- Open wound, needle puncture site
- Any break in intact skin or mucous membranes

Respiratory tract

- Nose and mouth—sneezing, coughing, breathing or talking
- Endotracheal tubes, tracheostomies

Gastrointestinal tract

- Mouth—saliva, vomitus
- Anus/ostomies: feces/diarrhea
- Nasogastric tubes and other drainage tubes

Urinary tract

- Urethral meatus
- Urinary diversion ostomies

1.4 Modes of Transmission

Once a pathogen has exited the reservoir, it needs a mode of transmission to the host through a receptive portal of entry. Transmission can be by direct or indirect contact or through airborne transmission.

Direct contact is person-to-person transmission of pathogens through touching, biting, kissing or sexual intercourse. Spread of airborne droplets is also a form of direct contact but only if the host is within 3 feet of the reservoir. Sneezing, coughing, spitting, talking or singing can transmit droplets into the eyes, nose, or mouth of the host.

Indirect contact includes both vehicle-borne and vector borne contact. A vehicle is an inanimate go-between, an intermediary between the portal of exit from the reservoir and the portal of entry to the host. Inanimate objects such as cooking or eating utensils, handkerchiefs and tissues, soiled laundry, doorknobs and handles, surgical instruments and dressings, are common vehicles that can transmit infection. Blood, serum, plasma, water, food, and milk also serve as vehicles. For example, food can be contaminated by *E.coli* if food handlers do not practice appropriate handwashing techniques after using the bathroom. If the food is eaten by a susceptible host, such as a young child or a person with HIV/AIDS, the resulting infection can be life-threatening.

Vector-borne contact is transmission by an animate intermediary, an animal, insect or parasite that transports the pathogen from reservoir to host. Transmission takes place when the vector injects salivary fluid by biting the host, or deposits feces or eggs in a break in the skin. Mosquitoes are vectors for malaria and West Nile virus. Rodents can be vectors for hanta virus.

Airborne transmission occurs when the environmental pathogens (Legionella spp.) or residue of evaporated droplets from an infected person (e.g., *Mycobacterium tuberculosis*) remains in the air long enough to be transmitted to the respiratory tract of a susceptible host.

1.5 Portals of Entry

Infectious agents get into the body through various portals of entry, including the mucous membranes, non-intact skin, and the respiratory, gastrointestinal and genitourinary tracts. Pathogens often enter the body of the host through the same route they exited the reservoir, e.g., airborne pathogens from one person's sneeze can enter through the nose of another person.

The skin normally serves as a barrier to infection. However, any break in the skin, intentional or unintentional, invites the entrance of pathogens. Percutaneous injury, surgical incision, vascular access, and use of invasive devices all afford a portal of entry.

1.6 Susceptible Host

The final link in the chain of infection is a susceptible host, someone at risk of infection. Infection does not occur automatically when the pathogen enters the body of a person whose immune system is functioning normally. When a virulent pathogen enters an immune-compromised person, however, infection is sure to follow.

Whether exposure to a pathogen results in infection depends on several factors related to the person exposed (the host), the pathogen (the agent), and the environment. Host factors that influence the outcome of an exposure include the presence or absence of natural barriers, the functional state of the immune system, and the presence or absence of an invasive device.

Natural barriers to infection (**host factors**) include:

- Intact skin and mucous membranes.
- Nasal cilia (small, hair-like projections) that filter inhaled air and trap microorganisms.
- Lung macrophages, large white blood cells that ingest microorganisms, other cells and foreign particles, in a process called phagocytosis.
- Acidic environment in the stomach, urine, and vaginal secretions.
- Tears that continually wash away pathogens and contain lysozyme, which destroys some types of bacteria.
- Saliva contains many several bacterial inhibitors including lysozyme, lactoferrin, and secretory IgA.

The immune system is a complex network of cells, tissues and organs that interact to defend the body against infections. Defense mechanisms can be nonspecific or specific and include the inflammatory response, humoral (circulating) immunity, and cell-mediated immunity.

The inflammatory response is a local, nonspecific immune response of the tissues to infection or injury. This response aims to destroy or dilute the injurious agent, prevent spread of the injury, and promote tissue repair. The five characteristics of an inflammatory process are:

- Pain
- Swelling
- Redness
- Heat
- Impaired function of the injured tissue, if severely injured

A person with normal immune system function is described as immunocompetent. Someone whose immune system is impaired by illness or age-related factors is said to be immune-compromised. For example, a person with HIV/AIDS is immune-compromised.

The very young and the very old are also at risk for compromised immune function. Infections are a major cause of death among newborns. Although babies receive certain temporary immunities from their mothers through the placenta and in breast milk, their immune systems are still developing, making them vulnerable to infection. Aging also compromises immune function, particularly in those who are hospitalized or in nursing homes. Nutritional status is a key factor in immune function.

People with chronic disease may also be immune-compromised. People with diabetes mellitus or peripheral vascular disease are at high risk for infection because of impaired circulation. Medications can also impair immunity. For example, cancer drugs, anti-inflammatory medications such as corticosteroids, and certain antibiotics can interfere with normal immune function.

Any surgical procedure carries the risk of infection because it penetrates the skin. Any procedure that involves lymph node removal, such as modified radical mastectomy (removal of the breast and axillary lymph nodes), carries a long-term risk of infection and lymphedema (swelling).

Diagnostic or therapeutic procedures that involve an invasive device such as a urinary catheter or a chest tube also increase the risk of infection. Caring for patients with these devices demands strict attention to infection control standards and continuous monitoring for any sign of infection or inflammation.

Environmental factors can also affect the outcome of an exposure, particularly in the case of immune compromised patients. Contamination of the environment can occur through inadequate handwashing, improper waste disposal, inappropriate handling of laundry, or inadequate cleaning and disinfection of patient articles and patient rooms. Water supplies may become contaminated by environmental pathogens such as *Aspergillus spp.* and *Legionella spp*., which then become airborne. Inadequate air exchange can allow pathogens such as Mycobacterium tuberculosis and varicella-zoster virus to contaminate air supplies. Appropriate environmental infection-control measures and engineering controls can effectively prevent these infections.

Contamination of equipment with blood or other body substances can occur during almost any caregiving procedure. Invasive procedures such as venipuncture, surgery, or insertion or removal of a catheter or other device carry a high risk of contaminating care providers and patients. Equipment can also become contaminated with airborne or waterborne pathogens. This can have life-threatening implications for seriously ill or immune-compromised patients, for example, those undergoing dialysis.

2. Prevention Strategies

Infection prevention means breaking the chain of infection or interrupting the infectious disease process. Infections are prevented by:

- Controlling the routes of transmission.
- Supporting and protecting the host.
- Training and educating healthcare workers in appropriate preventive procedures.

To protect themselves and patients from the transmission of bloodborne pathogens, healthcare workers should consider all patients to be potentially infected and act accordingly. This means following Standard and Universal Precautions with all patients.

Preventing the spread of infectious organisms other than bloodborne pathogens includes:

- Early identification of the infectious organism.
- Prompt isolation of the patient.
- Initiation of appropriate treatment.

Routine use of Standard Precautions for all patients suspected of being infectious will reduce the risk of transmission even before a definitive diagnosis can be made and specific precautions based on that diagnosis can be implemented. Patients suspected of having a condition requiring Airborne, Droplet, or Contact Precautions require the use of enhanced precautions while the diagnostic process continues.

When an emergency nurse in Leesburg, Virginia encountered an elderly Chinese patient with atypical pneumonia who had just returned from a trip to China, she immediately placed her in a negative air-flow room and had the staff initiate isolation procedures. She then notified the county health department, who in turn alerted the CDC. Only later did the nurse learn that her quick thinking may have saved many lives.

The elderly Chinese woman was the first U.S. case of severe acute respiratory syndrome (SARS)—documented more than a month before the World Health Organization declared SARS a "worldwide health threat" (Fenwick, 2003).

SARS Coronavirus

The SARS coronavirus mutated to produce the novel COVID-19, which was first discovered in China in 2019. Source: Shutterstock.com.

Certain syndromes and conditions such as SARS carry a sufficiently high risk to warrant Airborne, Droplet, or Contact precautions. For a listing of some of those conditions and the recommendations beyond Standard Precautions, see "Type and Duration of Precautions Needed for Selected Infections and Conditions". (Available here).

Specific information about the SARS virus is available here.

Controlling the routes of transmission includes:

- Hand hygiene
- Use of appropriate barriers
- Sterilization or disinfection of patient care equipment
- Isolation or cohorting individuals with communicable diseases and conditions
- Environmental control measures
- Engineering control measures
- Work practice controls

2.1 Social Distancing

Social distancing is a preventive measure recommended by public health experts to slow the spread of COVID-19. It is advised that people stay at home as much as possible, going out only for critical needs like groceries and medicines, or to exercise and enjoy the outdoors. Other recommendations include avoiding gatherings of more than 10 people, no handshakes, regular handwashing, and, when encountering someone outside of your immediate household, remaining at least 6 feet apart (i.e., **social distancing**) (NIH Director's Blog, March 19, 2020).

Social distancing remains one of our best weapons to slow the silent spread of coronavirus and flatten the curve of the COVID-19 pandemic. This gives our healthcare professionals, hospitals, and other institutions valuable time to prepare, protect themselves, and aid the many people whose lives may be on the line from the 2020 coronavirus pandemic (NIH Director's Blog, March 19, 2020).

2.2 Hand Hygiene

Hand hygiene includes handwashing, antiseptic handwash, antiseptic hand rub, or surgical hand antisepsis. Appropriate hand hygiene is essential to preventing transmission of infection. According to the CDC, handwashing is the single most important measure to reduce the risks of transmitting organisms from one person to another or from site to another on the same patient.

Washing hands as promptly and thoroughly as possible between patient contacts and after contact with body substances, and equipment or articles contaminated by them is a key component of infection control and isolation precautions. Thorough drying of hands is also important as more organisms are transferred by wet hands than from hands that are thoroughly dried.

A wide selection of hand hygiene agents is available to promote safe patient care, including antimicrobial soaps/detergents, rubs, scrubs, and waterless antiseptic agents. According to the CDC (2007, 2019), alcohol-based products are more effective for standard handwashing or hand antisepsis than plain soap or antimicrobial soaps. Recent studies have shown that alcohol-based rinses or gels containing emollients cause substantially less skin irritation and dryness than soaps or antimicrobial detergents.

Factors that influence handwashing efficacy include not only the product used but the frequency and length of time hands are washed. CDC recommends a minimum of 15 seconds and longer if possible; however, research studies show that most healthcare workers wash for less than 10 seconds. Easy access to hand-hygiene supplies, whether sink, soap, medicated detergent, or alcohol-based hand-rub solution, is essential to appropriate hand hygiene.

Hand hygiene also includes attention to fingernails, which can harbor pathogens. Nails should be unpolished and less than ¼ inch long. Chipped nail polish, long nails, artificial fingernails or nail extenders may tear gloves and can harbor pathogens, even after careful handwashing or the use of surgical scrubs.

2.3 Barriers

Use of appropriate barriers or personal protective equipment (PPE), such as gloves, gowns, face shields, head covers, masks, also reduces transmission of pathogens. Gloves are the first line of PPE, and can prevent transmission of pathogens and heavy contamination of hands during patient care. However, wearing gloves cannot completely guard against acquiring viral infections, particularly HBV and herpes simplex virus.

Wearing gloves does not replace the need for handwashing because gloves may have small, unnoticeable defects or may tear during use, and hands can become contaminated during glove removal. Hands should always be washed after glove removal particularly if hands are visibly soiled or if the glove has torn. In the absence of visible hand contamination, hand hygiene with alcohol hand rubs is appropriate after glove removal (APIC, 2016).

Gloves should also be changed any time the healthcare worker switches from contaminated to clean tasks, even with the same patient. Disposable gloves should **never** be washed or decontaminated after use. Sterilization or disinfection of patient-care equipment is fundamental to preventing transmission of pathogens.

Do's & Don'ts

DO'S AND DON'TS FOR WEARING GLOVES IN THE HEALTHCARE ENVIRONMENT

Types of gloves encountered in the healthcare setting

STERILE GLOVES

Indicated for performing any sterile procedure including but not limited to vaginal delivery, invasive radiological procedure, central vascular device dressing change, and accessing implanted central venous access ports.

NON-STERILE GLOVES

(e.g., nitrile, latex, medical vinyl)
Indicated in situations when there is potential for contact with infectious material ***(e.g., blood, other body fluids, microorganisms).***

NON-MEDICAL GLOVES

(e.g., vinyl)
May be used for food handling and some housekeeping procedures ***(e.g., cleaning and disinfection).***

UTILITY GLOVES

(e.g., facility, maintenance, central sterile processing)
Used for manual cleaning of instruments and decontamination with harsh chemicals.

Do	Don't
✓ **DO** wear gloves to reduce the risk of contamination or exposure to blood, other body fluids, hazardous materials, and transmission of infection.	✗ **DON'T** re-use or wash gloves (except for utility gloves after being properly cleaned).
✓ **DO** clean hands before putting on gloves for a sterile procedure (e.g., insertion of catheter or other invasive device).	✗ **DON'T** substitute glove use for hand hygiene.
✓ **DO** clean hands after removing gloves.	✗ **DON'T** use non-approved hand lotions.
✓ **DO** clean hands and change gloves between each task (e.g., after contact with a contaminated surface or environment).	✗ **DON'T** use gloves if they are damaged or visibly soiled.
✓ **DO** make sure that gloves fit you properly before performing any tasks.	✗ **DON'T** touch your face when wearing gloves.
✓ **DO** ensure the correct type of glove is available if you have skin sensitivity or allergy issues.	✗ **DON'T** wear the same pair of gloves from one patient to another.
✓ **DO** wear gloves in hemodialysis settings for any contact with the patient or the patient's equipment.	✗ **DON'T** wear gloves in the hall; consult your facility's policy for exceptions.
✓ **DO** follow your facility's policy on glove use and remember to consult CDC* and WHO* hand hygiene guidance.	✗ **DON'T** forget to remove and dispose of gloves properly.

APIC

Source: Association for Professionals in Infection Control and Epidemiology. Used with permission.

2.4 Sterilization

Sterilization or disinfection of patient care equipment is fundamental to preventing transmission of pathogens. In general, reusable medical devices or patient-care equipment that enters normally sterile tissue or the vascular system or through which blood flows should be sterilized before each use. Sterilization means the use of a physical or chemical procedure to destroy all microbial life, including highly resistant bacterial endospores.

The major sterilizing agents used in hospitals are:

- Moist heat by steam autoclaving
- Ethylene oxide gas
- Dry heat

However, there are a variety of chemical germicides that have been used to reprocess reusable heat-sensitive medical devices and appear to be effective when used according to manufacturer's instructions. These chemicals are rarely used for sterilization but appear to be effective for high-level disinfection of medical devices that come into contact with mucous membranes during use, such as flexible fiberoptic endoscopes (CDC, 2007, 2019).

2.5 Isolating and Cohorting

[Material in this section is taken from CDC, 2007, 2019, unless otherwise cited.]

Isolating or cohorting patients with communicable disease is essential to prevent outbreaks among patients and healthcare providers. **Isolation** means placing the infected patient in a private room to prevent direct or indirect contact transmission of microorganisms and taking other isolation precautions as appropriate.

Isolation precautions have disadvantages to the hospital, patients, personnel and visitors: specialized equipment and environmental controls increase the cost of care, are inconvenient to healthcare workers, and force solitude for patients. However, these disadvantages must be weighed against the hospital's mission to prevent the spread of serious infection in the hospital.

Isolation is particularly important when the patient has poor hygiene habits, contaminates the environment, or cannot assist in maintaining infection control procedures to limit transmission of microorganisms; this includes infants, children and patients with altered mental status. Whenever possible, the private room should have handwashing and toilet facilities.

If a private room is not available, an infected patient is **cohorted**, that is, placed with another patient infected by the same microorganism, provided that neither is infected with other potentially transmissible microorganisms. This can be helpful during outbreaks or when there is a shortage of private rooms.

When a private room is not available and cohorting is not achievable or recommended, the healthcare worker should consult an infection control professional before patient placement. If it is necessary for an infected patient to share a room with a non-infected patient, it is important that patients, personnel, and visitors take precautions to prevent the spread of infection and that roommates are selected carefully.

If a patient is suspected of infection with an airborne pathogen, such as the SARS virus, a private room with appropriate air handling and ventilation is critical to reducing the risk of transmission to susceptible patients and other others in the hospital. Some hospitals use an isolation room with an anteroom as an extra measure of precaution. Standard precautions should be followed with all patients, regardless of infection status.

3. Controls

3.1 Environmental Controls

Environmental control measures also help prevent the transmission of infection. These measures include (CDC, 2007, 2019):

- Environmental cleaning (housekeeping)
- Appropriate ventilation
- Waste management
- Linens (textiles) and laundry management

3.1.1 Environmental Cleaning (Housekeeping)

Appropriate housekeeping and sanitation practices are essential to reduce the spread of infection, particularly in high-risk areas such as nurseries, operating rooms and intensive care units. The CDC guidelines include the following recommendations:

- Keep housekeeping surfaces (e.g., floors, walls, tabletops) visibly clean on a regular basis and clean up spills promptly.
- Do not use disinfectant sprays in patient-care areas.
- Avoid large-surface cleaning methods that produce mists or aerosols, or disperse dust in patient care areas.
- Follow proper procedures for effective uses of mops, cloths and solutions.

3.1.2 Appropriate Ventilation

- Filter incoming air using central or point-of-use high efficiency particulate (HEPA) filters capable of removing 99.97% of particles ≥0.3 µm in diameter.
- Direct room airflow with the air supply on one side of the room that moves air across the patient bed and out through an exhaust on the opposite side of the room.
- Ensure positive air pressure in room relative to the corridor (pressure differential of ≥12.5 Pa to ≥2.5 [0.01-in water gauge]).
- Monitor air pressure daily with visual indicators (e.g., smoke tubes, flutter strips).
- Ensure well-sealed rooms that prevent infiltration of outside air.
- Ensure at least 12 air changes per hour.

3.1.3 Waste Management

There are two categories of hospital waste: regulated medical waste and unregulated waste. According to the CDC, most hospital waste is no more infective than ordinary residential waste, nor is there evidence that current hospital waste management practices have caused disease in the community.

Regulated medical waste ("red bag" waste) demands special precautions in handling and disposal. Regulated medical waste includes:

- Microbiology laboratory waste
- Pathology and anatomy waste
- Bulk blood or blood products
- Sharp items such as used needles or scalpel blades. (CDC, 2007, 2019)

These items require special handling, transport and storage procedures.

CDC recommends the following guidelines:

- Personnel responsible for waste management need appropriate training in handling and disposal methods in accordance with hospital policy.
- Waste generated in isolation areas should be handled using the same methods used for regulated waste from other patient-care areas.
- Disposable syringes with needles, including sterile sharps that are being discarded, scalpel blades, and other sharp items should be disposed of in puncture resistant containers located as close as practical to the point of use.
- Do not bend, recap, or break used syringe needles before discarding them into a container.
- Sanitary sewers may be used for safe disposal of blood, suctioned fluids, ground tissues, excretions, and secretions, provided that local sewage discharge requirements are met and that the state has declared this to be an acceptable method of disposal.
- Store regulated medical wastes awaiting treatment in a properly ventilated area inaccessible to vertebrate pests. Use waste containers that prevent development of noxious odors. (CDC, 2007, 2019)

If treatment options are not available at the site where the waste is generated, transport regulated medical waste in closed, impervious containers to the on-site treatment location or to another facility for treatment as appropriate.

Regulated medical waste must be treated by a method (steam sterilization, incineration, interment, or an alternate treatment technology) approved by the appropriate authority (such as the state, Veterans Administration, or Indian Health Service) before disposal in a sanitary land fill (CDC, 2007, 2019).

3.1.4 Textile and Laundry Management

Textiles and laundry management also can affect transmission of infection. According to the CDC, except for soiled textiles from patients in isolation, the risk of actual disease transmission from soiled laundry is negligible. Thus common-sense hygienic practices for handling, processing and storage of textiles are recommended. These practices include:

- Minimal handling and agitation of soiled laundry to prevent gross microbial contamination of the air, surfaces, and healthcare workers.
- No sorting or rinsing textiles in the location of use.
- Bagging or placing soiled textiles in containers at the location where it was used.
- Labeling or color-coding bags or containers for contaminated waste.
- If laundry chutes are used:
    - Ensure that laundry bags are closed before tossing the filled bag into the chute.
    - Do not place loose items in the laundry chute.
- Textiles heavily contaminated with blood or other body fluids should be bagged and transported in a manner that will prevent leakage.
- Do not use dry cleaning for routine laundering in healthcare facilities.
- Clean textiles should be handled, transported, and stored by methods that will ensure their cleanliness. (CDC, 2007, 2019)

Note: OSHA guidelines state that employers are responsible for laundering workers' person protective garments or uniforms that are contaminated with blood or other infectious materials (OSHA, n.d.).

3.2 Engineering Controls

Engineering controls include equipment, devices or instruments that remove or isolate a hazard. Work practice controls are modifications in technique that reduce or eliminate the likelihood of exposure by altering the manner in which a task is performed (OSHA, n.d.).

3.3 Work Practice Controls

Support and protection of the host helps prevent the spread of infection, not only from healthcare worker to patient but from patient to healthcare worker.

Support and protection of the host includes:

- Vaccination is available to prevent certain conditions, such as Hepatitis B virus.
- Pre-and post-exposure prophylaxis measures.
- Protecting skin and immune system integrity of both patients and healthcare workers helps prevent transmission of pathogens.
- Training and education of healthcare workers in appropriate infection control practices and standards for their particular duties are the foundation of safe patient care. (OSHA, n.d.)

[Please continue to next page for course references]

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[Please continue to next page to start quiz]

5. Quiz: Chain of Infection (264)

1. The chain of infection includes which of the following?

a. Pathogen, host, epidemic and close contact with the infected person.
b. A virus, bacterium, pathogen, and reservoir.
c. Pathogen, reservoir, portal of exit from the reservoir, method of transmission, portal of entry and a susceptible host.
d. A reservoir, mode of transmission, poor infection control practices, and a poor immune system.

2. The virulence of a pathogen depends on which of the following factors?

a. Their potency, their ability to enter and survive in the body, and the susceptibility of the host.
b. Their ability to enter the body only.
c. Their potency only.
d. The number of people infected with the pathogen.

3. Examples of human reservoirs for infectious agents include:

a. Intact skin, hair, urinary tract and urine.
b. Blood, tissue, respiratory tract and genitalia.
c. Hepatitis B and C, urine, feces, and bile.
d. E. coli, blood, tissue, and semen.

4. Portals of exit from the human reservoir include:

a. Blood, urinary tract, GI tract and hepatitis C.
b. Intact skin, E. coli, GI tract and urinary tract.
c. Poor handwashing, S. aureus, blood and open wounds.
d. Nose and mouth, anus, break in intact skin.

5. A pathogen can be transmitted from one person to another through which of the following modes?

a. Person-to-person transmission of pathogens through touching, biting, kissing or sexual intercourse.
b. Cooking or eating utensils, handkerchiefs and tissues, soiled laundry, doorknobs and handles, surgical instruments, and dressings.
c. Blood, serum, plasma, water, food, and milk.
d. All of the above.

6. All of the following statements about portals of entry are true except:

a. Infectious agents get into the body through various portals of entry, including the mucous membranes, non-intact skin, and the respiratory, gastrointestinal, and genitourinary tracts.
b. Pathogens often enter the body of the host through the same route they exited the reservoir.
c. The skin does not normally serves as a barrier to infection.
d. Percutaneous injury, surgical incision, vascular access, and use of invasive devices all afford a portal of entry.

7. Which of the following biological and environmental factors increase the risk of infection?

a. A compromised immune system, invasive diagnostic or therapeutic procedures, and contaminated water supply.
b. A healthy immune system, exposure to a pathogen and contaminated equipment.
c. A compromised immune system, good air circulation, and invasive procedures.
d. Aging, lack of exercise, and excessive body fat.

8. All of the following practices are recommended to break the chain of infection or interrupt the infectious disease except:

a. Controlling the routes of transmission.
b. Strict isolation for anyone with any type of infection.
c. Supporting and protecting the host.
d. Training and educating healthcare workers in appropriate preventive procedures.

9. Preventing the spread of infectious organisms other than bloodborne pathogens includes which of the following procedures?

a. Early identification of the infectious organism.
b. Prompt isolation of the patient.
c. Initiation of appropriate treatment.
d. All of the above.

10. According to the CDC, the single most important measure to reduce the risks of transmitting organisms from one person to another or from site to another on the same patient is:

a. Prompt and thorough reporting
b. Handwashing
c. Isolation of infected patients
d. Use of gloves

11. All of the following statements about isolation are true except:

a. Isolation is particularly important when the patient has poor hygiene habits or cannot assist in maintaining infection control procedures.
b. If a private room is not available, an infected patient is cohorted with another patient infected by the same microorganism.
c. The private room should not have handwashing and toilet facilities, which will serve to spread the infection.
d. If a patient is suspected of infection with an airborne pathogen, a private room with appropriate air handling and ventilation is critical.

12. In addition to standard precautions, environmental precautions also prevent the spread of infection. These include which of the following practices?

a. Appropriate housekeeping and sanitation practices particularly in high-risk areas such as nurseries, operating rooms and intensive care units.
b. Special precautions in handling and disposal of regulated medical waste ("red bag" waste).
c. Appropriate training in handling and disposal of waste management in accordance with hospital policy.
d. All of the above.

13. Support and protection of the host helps prevent the spread of infection. This can be accomplished in which of the following ways?

a. Protecting skin and immune system integrity of both patients and healthcare workers.
b. Keeping healthcare workers away from infected patients.
c. Using gloves, masks, gowns and isolation rooms with all infected patients.
d. Rotating the shifts of healthcare workers to minimize exposure to infectious disease.

[Please continue to next page for answer sheet]

Answer Sheet: Chain of Infection (264)

Name (Please print)_____

Date_____

Passing score is 80%

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____

[Continue to next page for course evaluation]

Course Evaluation: Chain of Infection (264)

Please use this scale for your course evaluation. Items with asterisks * are required.

1 = Strongly agree 2 = Agree 3 = Neutral 4 = Disagree 5 = Strongly disagree

*Upon completion of the course, I was able to:

1. Describe the 6 components of the chain of infection. 1 2 3 4 5
2. Discuss 3 host factors that affect the spread of infection. 1 2 3 4 5
3. Describe 5 common prevention strategies used to break the chain of infection. 1 2 3 4 5
4. Discuss Florida domestic violence legislation and reporting requirements for healthcare

*The author(s) are knowledgeable about the subject matter. 1 2 3 4 5

*The author(s) cited evidence that supported the material presented. 1 2 3 4 5

*Did this course contain discriminatory or prejudicial language? Yes No

*Was this course free of commercial bias and product promotion? Yes No

*As a result of what you have learned, will make any changes in your practice? Yes No

If you answered Yes above, what changes do you intend to make? If you answered No, please explain why.

*Do you intend to return to ATrain for your ongoing CE needs?

_____Yes, within the next 30 days. _____Yes, during my next renewal cycle.

_____Maybe, not sure. _____No, I only needed this one course.

*Would you recommend ATrain Education to a friend, co-worker, or colleague?

_____Yes, definitely. _____Possibly. _____No, not at this time.

*What is your overall satisfaction with this learning activity? 1 2 3 4 5

*Navigating the ATrain Education website was:

_____Easy. _____Somewhat easy. _____Not at all easy.

*How long did it take you to complete this course, posttest, and course evaluation?

_____60 minutes (or more) per contact hour _____59 minutes per contact hour

_____40-49 minutes per contact hour _____30-39 minutes per contact hour

_____Less than 30 minutes per contact hour

I heard about ATrain Education from:

_____Government or Department of Health website. _____State board or professional association.

_____Searching the Internet. _____A friend.

_____An advertisement. _____I am a returning customer.

_____My employer. _____Social Media

_____Other _____

Please let us know your age group to help us meet your professional needs:

_____18 to 30 _____31 to 45 _____46+

I completed this course on:

_____My own or a friend's computer. _____A computer at work.

_____A library computer. _____A tablet.

_____A cellphone. _____A paper copy of the course.

Please enter your comments or suggestions here:

[Continue to next page for registration and payment]

Registration and Payment: Chain of Infection (264)

Please answer all of the following questions (* required).

*Name: _____

*Email: _____

*Address: _____

*City and State: _____

*Zip: _____

*Country: _____

*Phone: _____

*Professional Credentials/Designations:

_____

*License Number and State: _____

Payment Options

You may pay by credit card, check or money order.

Fill out this section only if you are paying by credit card.

1 contact hour: $10

Credit card information

*Name: _____

Address (if different from above):

*City and State: _____

*Zip: _____

*Card type: Visa Master Card American Express Discover

*Card number: _____

*CVS#: _____ *Expiration date: _____