

Chain of infection

One of the most widespread and frequent worries in hospitals and other healthcare facilities is the proliferation of infection. The spread of an infection within any community can be described as a *chain*. Pathogens are spread throughout a space as a result of the chain of infection. There are several interconnected steps that describe how pathogens travel. While this chain occurs in all types of settings, it is especially commonplace and important to understand in healthcare settings. Infection control and contact tracing are meant to break the chain, which prevents a pathogen from spreading.

Sterilization and other specific procedures completed by Central Sterile Supply Departments (CSSDs) are infection control methods fundamental in stopping the chain of infection. It is useful to explain the chain of infection in order to account for CSSD procedures and the reasons they exist. In understanding the chain of infection, the teams that work in the CSSDs are better able to protect patients, other healthcare professionals, and themselves from the spread of dangerous illness within healthcare settings.

Chain of infection is the sequence of events that lead to the spread of disease. It contains the fundamental components of communicable disease transmission. The chain of infection consists of six links, each connected to its adjoining links. They are:

1. The chain of infection begins with an infectious agent that makes its way into a reservoir host
2. The infectious agent then leaves the host at the portal of exit
3. The infectious agent travels through the air through one of several modes of transmission
4. The infectious agent lands on a portal of entry, such as the mucus membrane of the nose of a susceptible host
5. At the portal of entry, the infectious agent is able to reproduce
6. The susceptible host, who now has the infectious agent, becomes the reservoir host

In the first link of the chain is the pathogen itself. This pathogen is most often (but not always) a virus or bacterium. Some ways that we can stop the chain at this step include getting vaccinations and purifying

our water and food storage. Even simple things like staying home when we are sick will stop the infectious agent from spreading at this stage.

The first step in the chain of infection occurs when the reservoir host creates a suitable environment for the pathogen to grow in. The reservoir host can be a person, an animal, or even the soil or water. Infectious agents transmitted during healthcare derive primarily from human sources. Human reservoirs include patients, healthcare staff, household members, and other visitors. Such individuals may have active infections with symptoms, but they may also be in the asymptomatic, and/or in the incubation period of an infectious disease. They may even be transiently or chronically colonized with pathogenic microorganisms, particularly in the respiratory or gastrointestinal tract, as the bacteria residing in these areas are often the source of hospital-acquired infections, or HAIs.

To break this link, we can seek medical treatment, control non-human reservoir hosts like rodents and insects, and practice patient isolation. Unfortunately, it is also possible to be a carrier of disease without being sick, and there are three types of asymptomatic human reservoirs. Incubatory carriers are those who transmit pathogens before showing signs of illness as is the case with the flu. Convalescent carriers are those who have been sick but are now well while still being able to spread the disease. Chronic carriers are those who carry a pathogen long term while never showing any sign of the disease.

The next link in the chain of infection is the portal of exit, the launch pad of the reservoir host. The portal of exit generally occurs in areas that are wet such as mucous membranes, feces, blood, saliva, or urine. After a pathogen that has incubated in a reservoir host makes its way to a portal of exit, it is then expelled through a mode of transmission such as coughing or sneezing, so the chain of infection can be stopped at this step with simple precautions such as wearing a mask and covering the mouth when coughing.

Transmission

The next step, mode of transmission, is all about the transfer. The mode of transmission can happen through either direct or indirect contact. Direct contact is exactly what it sounds like, occurring when a new host touches the reservoir host to transmit the pathogen or receive the pathogen straight from the host. In HAIs specifically, direct transmission occurs when microorganisms are transferred from an infected person to another person, such as when blood or other blood-containing body fluids are

transmitted from a patient directly to a caregiver's body through contact with mucous membrane or breaks in the skin.

Indirect transmission, on the other hand, involves the transfer of an infectious agent through a contaminated intermediate object. There are three modes of indirect transmission: airborne, vehicle-borne, or vector-borne.

- Airborne transmission occurs by dissemination of either airborne droplet nuclei or small particles in the breathable size range that contain infection agents that remain infective over time and distance. Microorganisms carried in this manner may be dispersed over long distances by air currents and inhaled by susceptible individuals who have not had face-to-face contact with or been in the same room with the infectious individual.
- Vehicle-borne transmission is the most common form of transportation. This type of transmission is what occurs when a pathogen comes in contact with a surface and is then transmitted via secondary contact with that surface. An example of this type of transmission would be the hands of healthcare staff touching an infected body site on one patient and then touching another patient without using proper hand hygiene.
- Vector-borne transmission occurs when pathogens are carried by a usually parasitic animal, in this context called a vector. Common vectors include mosquitoes, fleas, and ticks.

Portals of entry

The next step in the chain of infection involves the portal of entry, which is the point at which the pathogen enters the new host. This can happen in one of three ways: inhalation, ingestion, or penetration.

- Inhalation occurs when airborne pathogens are breathed in
- Ingestion occurs when the pathogen is swallowed
- Penetration covers most other forms of pathogen entrance into a new host, occurring whenever a pathogen comes into contact with the exposed interior of the body. Examples of penetration include contact with open wounds or surgical sites, indwelling catheters, and urinary catheters.

After the pathogen enters through the portal of entry, it begins to incubate in this new reservoir host, restarting the chain of infection over again.

The most common pathogens that cause hospital-acquired infections are Staphylococcus, Pseudomonas, and E. coli. Some of the common nosocomial infections are urinary tract infections, respiratory pneumonia, surgical site wound infections, gastrointestinal infections, and skin infections. An infection is regarded as nosocomial if it is as a result of treatment in a hospital or hospital-like setting, but secondary to the patients' original condition and manifests 48 hours or more after hospital admission or within 30 days after discharge.

There are several reasons that it is more difficult to stop the chain of infection inside a healthcare facility. To begin with, hospitals by their nature naturally have higher quantities of pathogens present, making the chances that the chain of infection will be perpetuated much more likely. Furthermore, patients often have weakened immune systems. This makes them more susceptible as a host, as it is harder for them to keep pathogens from incubating once they cross through the portal of entry. Furthermore, many patients undergoing surgery have an easy access portal of entry at their surgical site.

Another challenge when stopping the spread of infection inside the hospital is that there are healthcare staff going from room to room, and if they are not careful this movement makes them an excellent mode of transmission – specifically, vehicle-borne transmission. It is essential that ALL hospital staff know at least the basics of universal precautions in order to prevent increased perpetuation of the chain of infection. ALL hospital staff means not only patient care staff but also cleaning, dietary, and CSSD staff.

Any healthcare staff who might ever need to go into a one patient's room and then into a different patient's room should be trained in these precautions. In addition to hospital staff visiting multiple patients, dangers arise as some areas like radiology, surgery, emergency rooms, and the various therapy areas all see multiple patients who can infect each other while there. They may also leave pathogens on surfaces that, if not cleaned by hospital staff, can be picked up by the next patient using that hospital facility.

Correlations

As the previous section showed, there are many ways that being unaware of the chain of infection can cause problems in a hospital, particularly when healthcare staff disregard the health and safety

procedures that might stop the chain. There have been many notable examples of when ignorance of the chain had harmful real-world effects, and these instances provide valuable demonstrations of why it is important to understand and consider the effects of the chain of infection.

The investigation of four large outbreaks of hepatitis among patients in ambulatory care facilities in the United States identifies a need to define and reinforce safe injection practices. The four outbreaks occurred in a private medical practice, a pain clinic, an endoscopy clinic, and a hematology clinic. The primary breaches in infection control practice that contributed to these outbreaks were reinsertion of used needles into a multiple dose vial and the use of a single needle to administer IV medication to multiple patients. These and other outbreaks of viral hepatitis could have been prevented by adherence to basic principles of aseptic technique for the preparation and administration of medications. This would have prevented the intermediate steps in the chain of infection that involve vehicle-borne transmission of pathogens from the portal of exit to the portal of entry.

Luckily, the chain of infection has been thoroughly considered in relation to future outbreaks, and changes have been made. Outbreaks related to unsafe injection practices indicate that some healthcare staff are unaware of, do not understand, or do not adhere to basic principles of infection control. Among the deficiencies identified in recent outbreaks were a lack of oversight of staff and failure to follow up on reported breaches in infection control practices in ambulatory settings. Therefore, to ensure that all healthcare staff understand and adhere to the recommended practices, principles of infection control and aseptic technique need to be reinforced in training programs and incorporated into institutional policies that are monitored for adherence.

Another case of unfortunate disregard for the chain of infection occurred in 2004 when the Centers for Disease Control and Prevention (CDC) investigated eight cases of post-myelography meningitis that were reported to the CDC. Equipment and products used during these procedures were excluded as probable causes of contamination, and procedural details available for seven of those cases determined that antiseptic skin preparations and sterile gloves had been used. However, none of the clinicians wore a face mask, giving rise to the speculation that droplet transmission was the most likely culprit.

Bacterial meningitis following myelogram and other spinal procedures has been previously reported. As a result, a question has been raised about whether face masks should be worn to prevent droplet

spread during spinal procedures. Again in this case, the chain of infection that allowed the growth of dangerous pathogens could have been stopped if transmission (this time airborne) of those pathogens had been prevented by knowledge of the chain of infection and proper use of that knowledge.

Face masks are effective in limiting the dispersal of oropharyngeal droplets and are recommended for the placement of central venous catheters. In October of 2005, the Healthcare Infection Control Practices Advisory Committee reviewed the evidence and concluded that there is sufficient experience to warrant the additional protection of a face mask for the individual placing a catheter or injecting material into the spinal or epidural space, codifying the proper use of knowledge of the chain of infection.

The chain of infection is the essential element of communicable disease transmission. The CSSD has the power to continue the chain of infection or prevent transmission. Breaking just one single link in the chain of infection prevents communicable disease, and it cannot be passed on to another individual.

Regardless of the method used to examine them, it is found that pathogens are a part of everyday life. Some pathogens are helpful, others are harmful. They are found in our air, soil, water, and in/on our bodies at all times. Many pathogens live in and on our bodies without causing harm and some even help us to stay healthy. Only a small fraction of pathogens is known to cause infection.

Infectious agents (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/survive in the body, and the susceptibility of the host. Viruses are intracellular parasites. What that means is, they can only reproduce inside a living cell.

None of the pathogens move themselves. In healthcare settings, they depend on people, the environment, and/or medical equipment to move them. That is the reason it is important for the teams who work in the CSSDs to understand about the chain of infection.

This continuing education course titled Understanding the Chain of Infection: Part 1 provided information about its basic components, the steps in its cycle, modes of transmission, portals of entry,

hospital-acquired infections, and case studies. Additional information can be found in the continuing education course titled Understanding the Chain of Infection: Part 2.