Chain of Infection

Part 1: Foundations in Infection Control Series

Arizona Advisory Council on Indian Health Care

Learning Objectives

- What is the Chain of Infection?
- Why Understanding How Pathogens Spread is Important?
- What are the Steps in the Chain of Infection?
- How Do Pathogens Spread?
- How Can You Break the Chain?
- Steps to Teach Community Members on Breaking the Chain of Infection in their Daily Lives

Disclaimer: This presentation contains images of wounds and ports of entry, such as eye orbitals and large cuts on hands. ***Viewing discretion is advised and it may not be suitable for children.***

How to Use This Training

- This training may be used as either an interactive lecture, or as a self-paced course.
- Materials within this PowerPoint have been written out with more details than a typical PowerPoint presentation. This has been done intentionally, so as to allow the learner the opportunity to read through it at a time that is convenient for them, while also providing enough detail to ensure all learning objectives are met.
- If there are any questions in regards to this presentation, please email Alison Lovell at alison.lovell@aacihc.az.gov

What is the Chain of Infection?

Outbreak Examples – Legionnaire's Disease (Bacteria)

Examples of Infectious Illness Outbreaks

On July 21, 1976, a three-day convention for the American Legion was held in Philadelphia, Pennsylvania at the Bellevue-Stratford Hotel. More than 2,000 Legionnaires, attended the conference.

At the end of the conference, everything seemed fine, until three days later, when a pattern began to develop.

- **July 27:** 61-year old Ray Brennan began to complain of feeling tired, had a fever, and experienced difficulty breathing. He later died at his home on the same day, with the cause of death being listed as an apparent heart attack.
- **July 30:** 60-year old Frank Aveni also dies of an apparent heart attack. Then 3 additional Legionnaires die of apparent heart attacks.
- **July 31:** A physician was treating 3 Legionnaires and requested additional testing.
- **By July 31/August 1:** 6 more Legionnaires had died, between the ages of 39 and 82.

All individuals complained of tiredness, chest pains, lung congestion, and fever, which went beyond the typical heart attack symptoms.

Not all men lived near one another, so the connection as not immediately noticed. However, an outbreak was occurring of a deadly bacterial illness.

Source: https://time.com/archive/6848299/the-philadelphia-killer/ and https://en.wikipedia.org/wiki/1976_Philadelphia_Legionnaires%27_disease_outbreak#cite_note-Killer-3

Outbreak Examples – Legionnaire's Disease (Bacteria)

Examples of Infectious Illness Outbreaks

The connection was not immediately obvious

- By the first weekend of August, a physician in Pennsylvania had had three of the Legionnaires as patients, and he identified that they had been at the Legionnaires convention in Philadelphia.
- Additionally, officials at the American Legion had started to receive notices regarding the sudden deaths of their members.
- Within1 week, 130 people had been hospitalized, and 25 had died.
- This was further compounded by individuals *not* associated with the convention becoming sick. A 47 year-old bus driver had ***not*** attended the convention. He had, however, driven the Keystone Cadet Junior Drum and Bugle Corps to Philadelphia for a parade the day before the convention closed.

In total, 182 individuals fell ill, with 29 people dying. Of these, 149 were Legionnaires, but 33 ***were not.***

The outbreak then mysteriously stopped.

In took until January of 1977 to discover the cause. It turned out, there was Legionella bacterium within the hotel's air conditioner (within the cooling tower) and depending upon the room someone was in, and what vent they walked past, they could have been exposed. It had spread through the building.

Source: https://time.com/archive/6848299/the-philadelphia-killer/

Outbreak Examples – Legionnaire's Disease (Bacteria)

Examples of Infectious Illness Outbreaks

It was aptly named Leigonnaire's Disease.

- Legionnaire's Disease is a bacterial infection that can cause fever, chills, coughing and shortness of breath. Additionally, symptoms include muscle aches, headaches, tiredness, loss of appetite and diarrhea. When severe it progresses to pneumonia and can damage the liver, kidneys, and heart.

Arizona Advisory Council on Indian Health Care

Source:
https://time.com/archive/6848299/the-philadelphia-killer/

Outbreak Examples – Stomach "Flu" (Norovirus)

Examples of Infectious Illness Outbreaks

The norovirus is *incredibly* easy to spread. Additionally, the public has a lot of misconceptions about it!

First, it is spread by the fecal-oral route, and since a large percentage of people either don't wash their hands, or fail to wash their hands thoroughly enough to rid their skin of all microscopic material when they use the bathroom (so their hands *look* clean, and the person *thinks* their hands are clean, even though they are not), it is easy for traces of someone carrying the norovirus to wind up on their hands and be transferred to other surfaces.

- Think pens, remote controls, door handles, light switches, toilet flush switches, soap dispenser pumps, sink faucets, toilet paper rolls, locks on public restroom doors, cupboard knobs, kitchen utensils, etc.

Second, for those thinking that this is an exaggeration? It turns out that people shed ***billions of virus particles in their stool and vomit when they have norovirus***. This includes those who are **not actively ill.** While the illness lasts 24-72 hours, they have found that people who have fully recovered can still spread the virus up to *two weeks* after recovery!!!!

- So that friend visiting you and using your bathroom, who had norovirus ("stomach flu") one whole week ago, but feels perfectly fine now? Make sure they are a good hand washer, and that you wear gloves to clean the bathroom afterwards, because they are, regrettably, a contamination risk.

Third, the virus is a ***lingerer.*** It has been found "alive" and well and capable of making us sick on objects *weeks* after it was deposited.

Arizona Advisory Council on Indian Health Care

This means the virus is incredibly easy to spread, and that well-meaning people spread it without realizing.

Outbreak Examples – Stomach "Flu" (Norovirus)

Examples of Infectious Illness Outbreaks

The Case for Cruising

Cruises provide us an excellent "experimental" environment to show how quickly viruses spread when people are in close-quarters.

- 2019, Royal Caribbean Cruise Line, *Explorer of the Seas*, ***626 people sick with Norovirus***
- February of 2010, Celebrity Cruises, *Mercury*, ***443 people sick with Norovirus***
- March of 2010, Celebrity Cruises, *Mercury,* ***419 people sick with Norovirus***
- January of 2010, Princess Cruises, *Crown Princess,* ***396 people sick with Norovirus***
- February of 2012, **Princess Cruises**, *Crown Princess,* ***363 people sick with Norovirus***
- **September 2013, Celebrity Cruise Lines**, 335 ***people sick with Norovirus***
- January 2010, **Fred Olsen Cruise Lines**, *Balmoral,* 310 ***people sick with Norovirus***
- March of 2013, **Princess Cruises**, *Ruby Princess,* **276** ***people sick with Norovirus***
- February of 2009, **Princess Cruises**, *Coral Princess,* 271 people sick (possibly ***both E.coli and Norovirus***
- **April of 2009, Carnival Cruise Line**, *Carnival Liberty, 265* ***people sick with Norovirus***
- **January of 2012, Royal Caribbean Cruise Line**, *Voyager of the Seas,* 259 ***people sick with Norovirus***
- December of 2012, **Cunard Line**, *Queen Mary 2,* 220 ***people sick with Norovirus***
- July of 2012, **Princess Cruises**, *Sun Princess, 216* ***people sick with Norovirus***

Outbreak Examples – Fungal Outbreak

Examples of Infectious Illness Outbreaks

Did you know there were drug-resistant fungi?

There sure is! Candida auris, or C. auris, is found in healthcare facilities (typically) and spreads ***rapidly.*** In fact it's a killer, killing up to 1/3rd of those who contract **and fall ill** with it.

- That last part, the "and fall ill" is key, because while lots of people have the fungus on their skin and throughout the body, unless they have a weakened immune system they typically don't get sick. But if they do get sick, 1/3rd of them can expect to succumb to the fungal infection.
- It survives very well on just about any surface: chairs, walls, cables, fabrics like bedding and towels, hands, etc.
- Even bleaching and UV light don't always kill it 100%.

Outbreak

- Between 2019 and 2020, the number of infections (people who were actually sick with this) increased by 756 (59%), and then from 2020 to 2021 it increased by an additionally 1,471 cases (95% increase).
- That's not all that increased. The incidence of people not infected/sick with the fungus, but who were carriers for it (colonized) also increased! Between 2019 and 2020, it increased by 21%, and between 2020 and 2021 we increased from 1,310 cases to 4,041 cases.

Chain of Infection

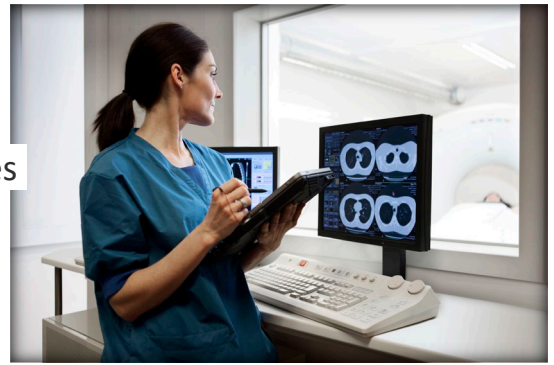
So What Exactly *is* the Chain of Infection that Causes These Outbreaks?

Did you ever wonder how illnesses spread?

- The spread of an infection within a community is often described as a “chain”. The chain is made up of the different, interconnected steps that describe how pathogens move between the environment and different organisms to cause illness.

The chain of infection is one of the first things researchers, epidemiologists and public health professionals try to learn about new illnesses. They try to understand how it exits the body and how it can be contracted. They then use contact tracing to track how fast it is spreading and to confirm *how* it is spreading. This allows them to issue scientific advice on how to take protective measures that are meant to break the chain, thereby preventing the pathogen from spreading.

By understanding how pathogens move and are contracted, healthcare professionals can then use proper infection control measures to stop the pathogen in its tracks.

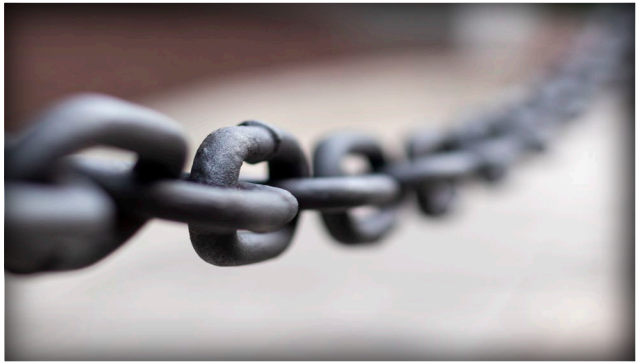


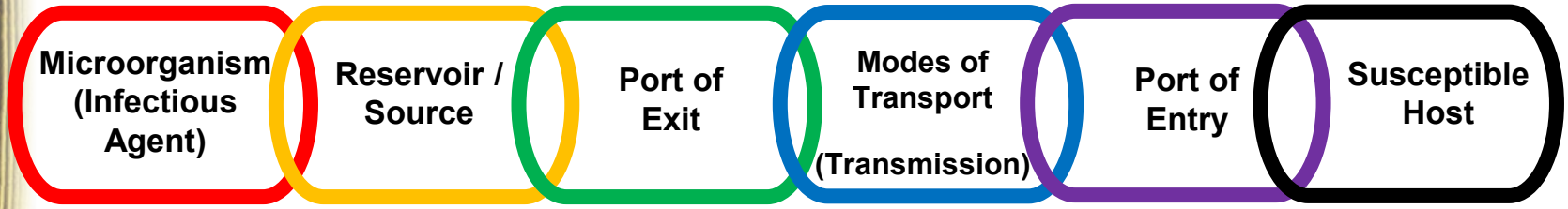
Community members can use this understanding to keep themselves safe when there are outbreaks of infectious disease in their community. However, they must understand *how* each illness is spread, as it often differs based on the illness.

Chain of Infection

There are 6 Links in the Chain of Infection

1. Microorganism (Infectious Agent)
2. Reservoir / Source (where the pathogen “lives”)
3. Port of Exit (from the reservoir/source)
4. Mode of Transport (how it is transmitted)
5. Port of Entry (how it gets into the host)
6. Susceptible Host





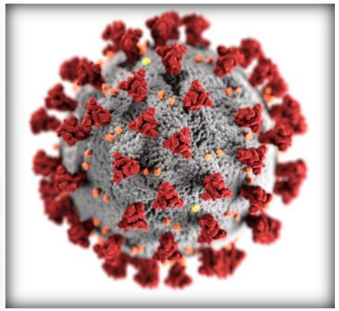
Arizona Advisory Council on Indian Health Care

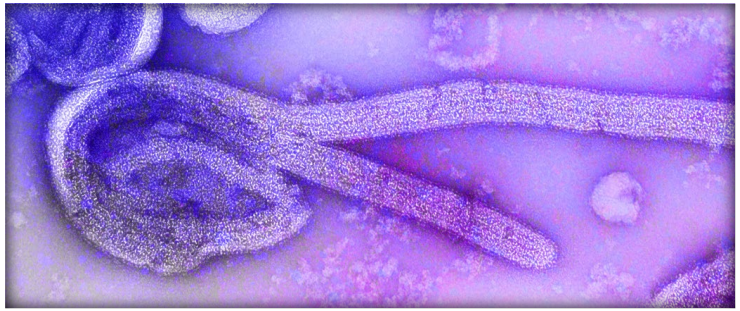
The Importance of Understanding How Pathogens Spread

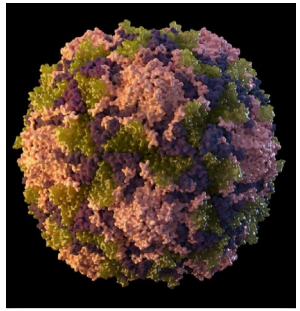
Why is Stopping the Spread of Pathogens Important?

Often we hear people say, “Germs are good for me. They help build my immune system!”

- **Yes,** to an extent that can be correct. It becomes a problem though, when we contract a “germ” (pathogen) that:
  - Can cause serious illness (i.e. being put on a ventilator, long-term disability or death), *or*
  - Can cause long-term damage to organs in our bodies, *or*
  - Cause autoimmune conditions to develop (i.e. autoimmune disorders may develop that are permanent, due to our body being “ramped up for too long” while fighting off another infection), *or*
  - Can mutate rapidly into something else.







Why is Stopping the Spread of Pathogens Important?

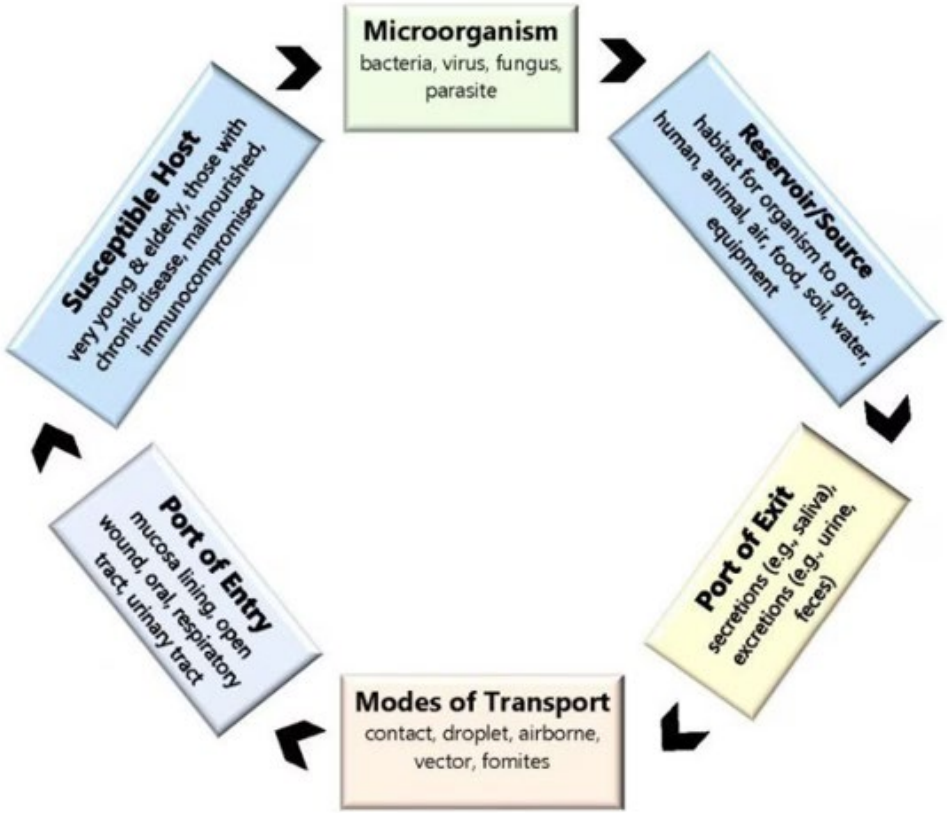
Assuming the right environmental conditions, such as temperature, pH, and availability of energy and nutrients for the pathogen to use as it replicates….

- Bacteria can easily double in number every 30 minutes through a process called binary fission (they reproduce asexually and 'split' into two, effectively doubling their numbers with each and every replication cycle). Some bacteria can do this within 10 minutes.
- Viruses cannot reproduce or replicate the same way as bacteria. They first must infiltrate a cell, and then they hijack our cells manufacturing centers (organelles like mitochondria), using them to make new component parts of themselves (proteins to make up their protective capsid layer, and replicating the DNA or RNA that is their genetic material). These component parts then get assembled into new viruses. So they don't "split" the same way bacteria do.
- As these component parts are first made, there is a lag period. The lag period is different for every virus.
- However, once the lag period is done, all the component parts of a virus are made and the cells' manufacturing centers are in full gear, creating thousands of new copies of the virus within a relatively short time frame. Time scale varies, but it can be between 8 hours for things like the poliovirus, to 72 hours for things like cytomegaloviruses (herpes and chickenpox).

This is why reducing the spread of COVID, the Flu, and other viruses is so important! Each new person infected, even if they only get a 'little' sick, is not just ONE opportunity, but potentially millions of new opportunities for the original virus to mutate into something far worse.

What are the Steps in the Chain of Infection?

Chain of Infection

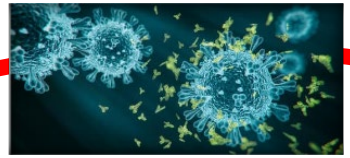


Arizona Advisory Council on Indian Health Care

Source: https://www.cdc.gov/niosh/learning/safetyculturehc/module-2/3.html

Chain of Infection

Microorganism



Reservoirs/Sources

Port of Exit

Modes of Transport

Susceptible Host

Port of Entry

Arizona Advisory Council on Indian Health Care

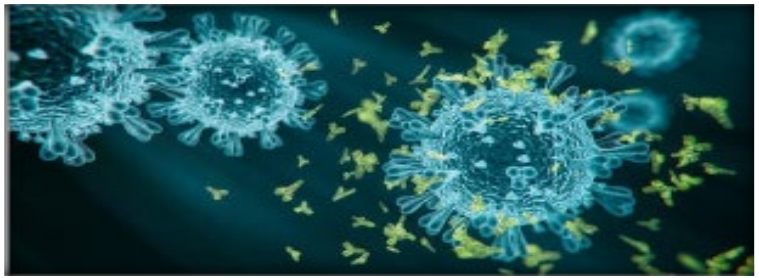
Step 1: Microorganism

Pathogen: An infectious microorganism (also called an infectious agent), such as viruses, bacteria, fungi, parasites, and even prions that are capable of spreading and causing disease.

The virulence of these will depend upon a variety of factors, such as their ability to multiple quickly, their robustness in surviving both outside of within their host organism, and the vulnerability and susceptibility of their target host.

Examples:

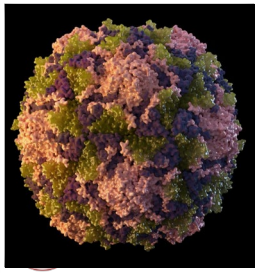
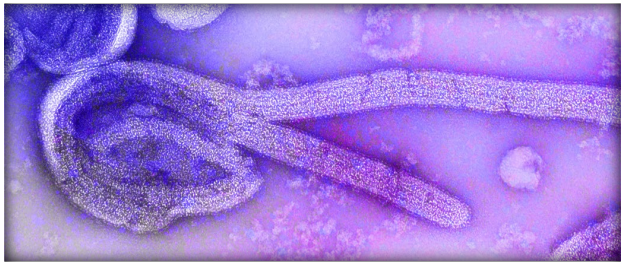
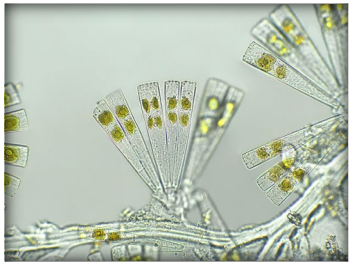
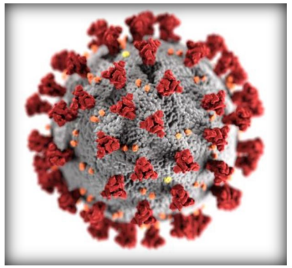
- Smallpox is *extremely* virulent, and nearly all individuals who are infected will become exposed (unless vaccinated).
- Tuberculosis bacillus (TB) is not very virulent, which surprises many people. It actually only causes an infection of concern within a small number of those exposed. Healthy people can wind up becoming reservoirs (carrying it). This is why TB testing is a requirement for even healthy healthcare workers – it's possible to be a carrier and be totally unaware.



Step 1: Microorganism

Types of Pathogens

Pathogen (Microorganism) Type	Examples
Virus	Influenza, COVID, Shingles, Hepatitis, Herpes, MERS, Smallpox, Ebola, and Marbur
Bacteria	Clostridium tetani, the causative agent of tetanus, Leptospirosis, Legionella pneumophila (Legionnaire's Disease), Lyme Disease
Fungi	Valley Fever (Coccidioides), Candidiasis and Aspergillosis
Parasite	Malaria, Giardia and Toxoplasmosis
Prion	Creutzfeldt-Jakob disease (CJD)

Step 2: Reservoirs/Sources

Reservoir: The organism(s), where a pathogen typically lives.

- The pathogen, whether it is viral, bacterial, fungal or parasitic, survives within the reservoir organism.
- The pathogen typically can reproduce itself within the reservoir organism, so it is ready to be transmitted to a susceptible host in stage 6.
- The reservoir organism can be an animal (including humans), plant, arthropod, or soil (i.e. reservoir for valley fever).
- Reservoir organisms are divided into animate and inanimate classifications.

Reservoirs/Sources

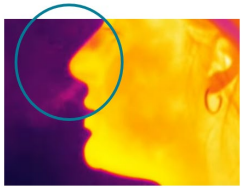
Animate Examples	Inanimate Examples
Humans, insects, waterfowl, bats, mice, etc.	Soil, food and water, bodily fluids (blood, saliva, urine, and fecal material), and equipment.
White Footed Mouse – Reservoir for Lyme Disease Humans – Reservoir for Malaria Humans – Reservoir for Cholera Humans – SARS-CoV-2 Bats - SARS-CoV-2 Camels – MERS Bats and Armadillos – Potential reservoirs for Valley Fever (Coccidioides)	Soil – Reservoir for Valley Fever (Coccidioides) Soil – Reservoir for Clostridium tetani, the causative agent of tetanus Water – Reservoir for Cholera Water – Reservoir for Legionella pneumophila (Legionnaire's Disease)

Step 3: Port of Exit

Ports of Exit

Ports of Exit are how pathogens/microorganisms exit their reservoir.

- For a human reservoir, the portal of exit can include things like:
- Respiratory secretions when we breathe, talk, sneeze or cough (i.e. Influenza)
- Saliva when we kiss someone (i.e. Epstein Barr)
- Blood, from paper cuts, menstrual cycles, intravenous use of drugs, or more severe injuries (i.e. Hepatitis B and HIV)
- Urine (i.e. Leptospirosis)
- Fecal material (i.e. Norovirus)
- Sexual secretions (i.e. HIV)
- Sweat (i.e Ebola)



Step 4: Modes of Transport

Transmission Routes

- Airborne (Aerosol)
- Direct, physical contact
- Fomites (non-living objects contaminated with a virus)
- Food, which can be contaminated at any point along the food chain.
- Animal Transmission

Step 4: Modes of Transport

Airborne (Aerosol) Route

Viruses and bacteria can become airborne as we breathe, with the particles hitching rides on our saliva droplets.

Statistics from the American Institute of Physics:

- A single breath will release between 50 and 5,000 saliva droplets.
- Within ***90 seconds*** of breathing without a mask, saliva droplets will travel ***over 7 feet***.
- When breathing **with** a non-medical face mask, within 90 seconds saliva particles travel ***only 2 feet***.
- A single cough will release ***3,000 droplets at up to 50 mph***! A sneeze moves even faster and can travel ***up to 200 mph***! **These travel across a room in *seconds.***

Arizona Advisory Council on Indian Health Care

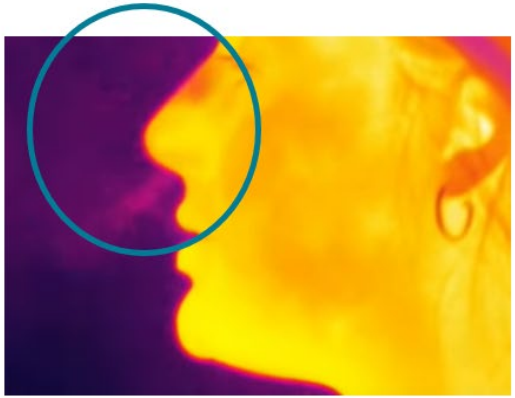
Sources: American Institute of Physics and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7462404/#:~:text=The%20slogan%20%E2%80%9CCoughs%20and%20Sneezes,40%2C000%20(1%E2%80%933).

Step 4: Modes of Transport

Airborne (Aerosol) Route

- Using a study of SARS-CoV-2 virus as an example, if there are two individuals….
  - Individual #1: Person with a high viral load (a large amount of virus circulating in their body, which correlates to being more symptomatic with the illness in question)
  - Individual #2: A Healthy Person
  - Distance Separated: 1 meter (3.28 feet)

More than 65% of saliva droplets, carrying the pathogen (SARS-CoV-2 virus in this example) land on Individual #2, exposing them to the virus.



Arizona Advisory Council on Indian Health Care

Source: https://www.iop.org/explore-physics/physics-around-you/staying-safe-coronavirus/masks-distancing

Step 4: Modes of Transport

Direct, Physical Contact

There are a LOT of ways, via direct physical contact, that can result in viral transmission from one person to another, or from one animal to a person. These include things like:

- Shaking hands at the office
  - **Fun Fact:** Studies have shown that fist bumping actually is less likely to transfer pathogens from one person to another, which is why you'll see a lot of EMS professionals fist bump rather than handshake!
    - The American Journal of Infection Control found that fist bumps transferred ***10X fewer pathogens*** than handshakes!
    - A study by Aberystwyth University found fist bumps transferred 90% fewer pathogens than handshakes!
    - That same study by Aberystwyth University found that high fives transferred 50% fewer pathogens than handshakes!
- Hugging or kissing
- Sexual intercourse or other sexual activities
- Getting exposed, particularly in a healthcare setting, to bodily fluids through splashing, coughing, or needle sticks
- Snuggling on a couch watching a movie
- Puppy paw high fiving your favorite pet after it has "done its business" outside
- Using the same straw to sample your friend or family member's most *excellent* coffee

Step 4: Modes of Transport

Direct, Physical Contact

Direct contact can also transmit viruses.

- Everyday activities like shaking hands and hugging can put us into contact with another person's bodily fluids, like saliva, urine, sweat, or even blood for those of us who work in a healthcare setting.

This is due to a variety of factors, like:

- Forgetting to wash hands after using the restroom, which 42% of pre-pandemic survey respondents admitted to *not* doing regularly.
- During the pandemic and post-pandemic, the number of individuals self-reporting adherence to handwashing increased, but it is still not 100%.
- Observational studies have shown, repeatedly, that the majority of people (between 80% and 92%) fail to wash their hands correctly, meaning pathogens will be left behind on their hands. This *included* healthcare workers.
- Post pandemic, many respondents still admitted to not washing their hands or using hand sanitizer, after blowing their nose (25% of survey respondents admitted to this)

Step 4: Modes of Transport

Fomite Transmission Routes

Fomites are non-living objects contaminated with a virus. These can become contaminated in a LOT of different ways. Some examples include:

- A person sneezes while using a computer desk, and their aerosolized saliva droplets spray the computer monitor, then fall to land on the desk, keyboard, and mouse. Then the next person uses the desk and comes into contact with any viral particles they sneezed out, simply by touching the keyboard, desk or mouse.
- A person uses a public restroom and touches the bathroom stall handle to unlock it, so they can get out. However, every other person who has used the restroom has also done this. This can put them into contact with viral particles from the urine of other individuals.
- Cutting yourself on barbed wire and coming into contact with tetanus (not a virus) or with a viral particle left behind by a bird that had landed and rested on the wire.

Step 4: Modes of Transport

Food and Water Routes

Food, which can be contaminated at any point along the food chain.

- Microbes need nutrients for growth and they like to consume the same foods as humans.
- Cabbage is a great example!
- Picture this…you're a farmer. You grow cabbage. Your see all kinds of cute little wormie things on the cabbage you are growing and think nothing of it.

The Adorable Inch Worm in Question

This little interloper actually carries a virus, and sheds the virus all over the leaves!

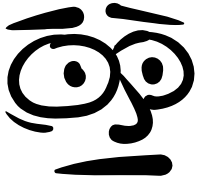
- The cabbage then gets harvested, rinsed off, and is sent to market. Unbeknownst to you, the farmer, even after a light rinsing of the leaves, each 'serving' still has 10 to power of 8 (100,000,000) virus particles on it from the adorable little inchworm!
- Next, people purchase and then *eat* the cabbage! They inadvertently consume the virus particles as well! Even if they wash it again, some still remains!
- Fortunately, this doesn't hurt us as we lack the right receptors to get infected by this particular virus, but virus particles from this are frequently found in human fecal samples!

Step 4: Modes of Transport

Vector-Borne Transmission

Sometimes a vector, which is another living organism, will carry a virus or other disease-causing pathogen. That vector does not always suffer ill-effects and may live perfectly happily and healthily with the disease-causing pathogen.

- However, when the organism comes into contact with a person, it can transfer the pathogen to the human (or to another host) that *will* become infected with the disease.
- These organisms are called “Reservoirs”. They keep the virus within them, and don’t get sick. They act as a mobile viral sharing station!
  - Good examples include mosquitoes (for transmitting malaria or west nile virus), fleas (yersnia pestis, AKA the bubonic plague), ticks (lyme disease, rocky mountain fever), bats (rabies), waterfowl and poultry (bird flu/influenza), and many more.
- Sometimes the vector (animal) carrying the pathogen also gets sick. You see this in rabies when it infects a racoon, fox, coyote, dog, etc.

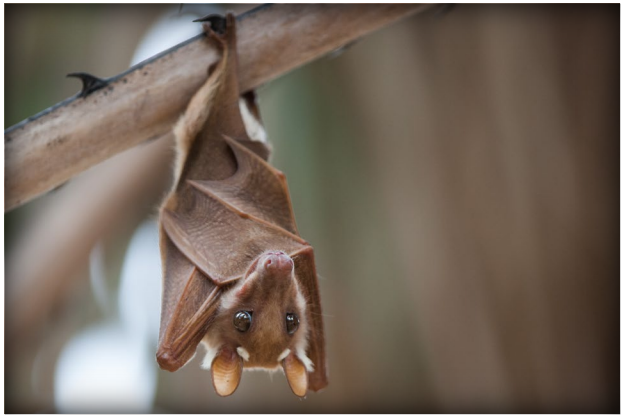


Step 4: Modes of Transport

Vector-Borne Transmission

Key Terms to Know about Vector Borne Transmissions:

- **Reservoir Host** are animals that 'house' an infectious pathogen, like a virus, bacteria, fungus, or parasite. They frequently do not have any adverse effects from housing the infectious organism, although sometimes (like in the case of rabies) they do. These reservoir hosts transmit infections to humans when the infectious agent is able to infect human cells.
- **Zoonoses (Zoonotic Diseases)** are infectious diseases that are transmitted between animals and humans. There are currently well over 200 known zoonotic diseases, and these include viruses, bacteria, fungal infections, and parasitic infections.
- **Arboviruses** are infectious diseases transmitted by arthropods, like mosquitoes and ticks. These tend to be more common during warmer months when people are outdoors more.



Step 4: Modes of Transport

There is Overlap Between Exposure Routes

Have you ever heard of “Toilet Plume”?

- This happens in public restrooms, when toilets get flushed on high power. It sends a cloud of aerosolized, microscopic particles into the air when the toilet is flushed. These aerosolized particles behave the same way that aerosolized particles do when we breathe, speak, sneeze or cough!
- This plume (and the aerosolized particles) travel up into the air, typically around six feet (can vary based on if there is air circulation) and can land on surfaces like the toilet paper, toilet seat, the flush handle, floors, sinks, sink handles, and even the soap dispenser pump!
- The plumes carry not just water, but microscopic bits of urine, fecal material, and of course, viruses!
- This is especially true when someone has diarrhea.

This is an overlap of direct contact and aerosolization. You could either breathe it in, or you could touch a surface the particles landed on.

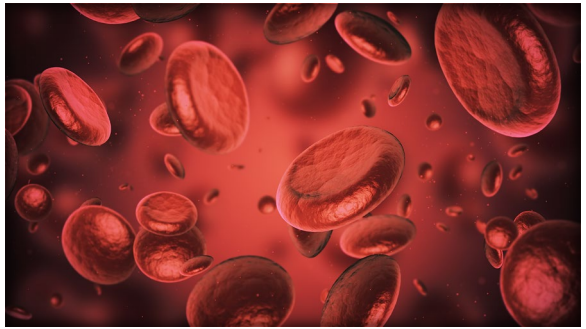
Step 4: Modes of Transport

There is Overlap Between Exposure Routes

Rare Cases of Suspected Ebola Transmission via the Air!

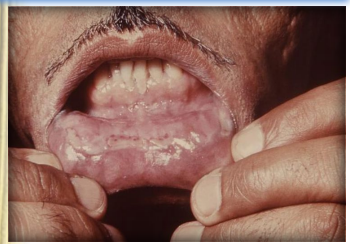
- It's well-known that ebola is a very virulent virus that causes severe illness, and that it is spread by coming into direct contact with bodily fluids, like sweat, urine, feces, blood, or even through sexual intercourse.
- However, there has been acknowledgment that a small fraction of Ebola cases in hospitals in Africa may have been the result of exposure to small droplets or aerosols containing the virus. This can happen if an IV is ripped out, causing blood to flick into the air, or if a catheter is ripped out by the patient, sending urine into the air.

This is an overlap of direct contact and aerosolization. You could either breathe it in, or you could touch the bodily fluids directly.

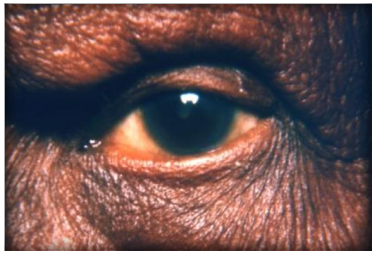


Step 5: Port of Entry Examples on the Human Body

Any mucus membrane, including those of the eye, nose, mouth and lips, gastrointestinal tract (including the anus), and genitourinary parts (including sexual organs) can serve as a port of entry.



Cuts (yes, even paper cuts), abrasions, lacerations, cold sores, and *any* type of small, open wound can create a "port of entry".



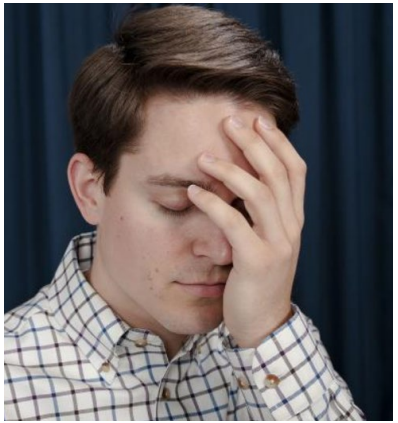
The mucosa of your eye is a great route for pathogens to enter your body. Rubbing your eyes, putting in contact lens, putting on makeup like mascara or eyeliner, and even just walking around without eye protection can result in pathogens landing (or being introduced directly to) the mucosa of your eye.

Acne can result in skin lesions and openings on the face, neck, back and chest that provide easy entry for pathogens. If open acne sores are not covered, infectious pathogens that are carried in the air can land on them, or accidentally touch, can result in the disease-causing pathogen entering your body.

Arizona Advisory Council on Indian Health Care

Source: CDC Public Image Library. Image # 19224 Photo credit, CDC/ Dr. Andre J. Lebrun; 1969, J. Justin Older, MD; Image # 1573, CDC Dr. Herman, 1964; Image # 12570, 1964, CDC/ Dr. J. Lieberman; Dr. Freideen Farzin, Univ. of Tehran; Image #20485, 1965, CDC Glen Lambert

Step 5: Port of Entry – Example of Accidental Exposure



It's easy to accidentally introduce pathogens into your mucus membranes, and we aren't even the only species guilty of it!

It is estimated that we touch the T-zone of our faces (eyes, nose, mouth, and chin – areas near our mucus membranes that are likely to result in transfer of pathogens that were on our hand into our bodies), around 68.7 times, ***per hour.***

- This was per a systemic review, average out findings from other studies measuring how often the T-zone was touched.
- Even during the height of the pandemic, in university environments where campaigns to keep individuals self-aware of their T-zone were prominent, students were found to touch their T-zone 23 times per hour.

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7350942/ **/ Sources CDC Public Image Library. Image #** 21779 Photo credit, CDC/ National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) and Lauren Bishop; Image #21765 and https://www.discovermagazine.com/the-sciences/digging-into-nose-picking-and-why-we-are-guilty-of-it

Step 6: Susceptible Host

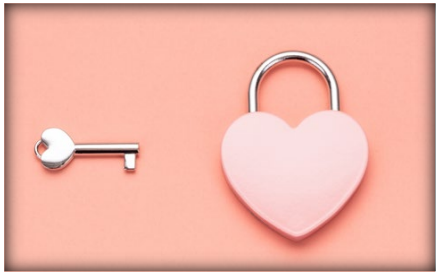
There's More to the Chain of Infection though…

It's not enough for a virus, bacterium, or parasite to just ***find*** their way inside of an organism through a 'port of entry'.

A pathogen must also find its way into a *susceptible host*.

A susceptible host is not as straightforward as it sounds. It actually depends on several factors, including individualistic factors of the exposed organism (the host), the pathogen's properties (the virus, bacteria, fungi, or parasite), and the environment (external and internal to the host.)

Animal Mechanism for Viruses



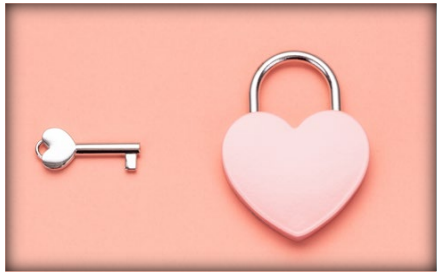
1. **Animal Cells:** First, not all viruses or bacterial infections can infect all animals.
   - For instance, animal cells have a cellular member made up of glycoproteins and glycolipids. In order for a virus to cause active infection within an animal, the virus must get inside the person's cells. This requires the virus (usually proteins on the capsid or envelope of the virus) to bind to the cellular membrane of the animal cell. Think of it like a 'lock and key' model.
   - Since each animal cell type, even different tissues within the same person, may have different proteins on their cellular membrane surface, this can be tricky for a virus to find the right cell type, with the right proteins, that it has a key to.
   - Once it finds the right cell type and receptor to get into the cell, it then begins to replicate within the host organism cell.
   - Different animals, have different receptors on their cells. This is actually how some animals can host viruses, without actually getting sick from them – their cells lack the receptors to allow the virus into them.

Step 6: Susceptible Host

1. **Animal Cells:** First, not all pathogens can infect all animals.

- **A Special Note on Viruses:**
  - For the case of viruses, animal cells have a cellular member made up of glycoproteins and glycolipids. In order for a virus to cause active infection within an animal, the virus must get inside the person's cells. This requires the virus (usually proteins on the capsid or envelope of the virus) to bind to the cellular membrane of the animal cell.
  - Think of it like a 'lock and key' model.
  - Since each animal cell type, even different tissues within the same person, may have different proteins on their cellular membrane surface, this can be tricky for a virus to find the right cell type, with the right proteins, that it has a key to.
  - Once it finds the right cell type and receptor to get into the cell, it then begins to replicate within the host organism cell.
  - Different animals, have different receptors on their cells. This is actually how some animals can host viruses, without actually getting sick from them – their cells lack the receptors to allow the virus into them.

Animal Mechanism for Viruses



Step 6: Susceptible Host

1. Animal Cells and Viruses (continued…)

Finding the Right Receptor

- Viruses often do not have the 'key' of the 'lock and key' for *all* cell types.
- This means they CANNOT punch their way through just *any* cellular membrane.
- It has to be a cellular membrane that has a protein its "key" can "lock onto."

How Do Viruses Find the Right Cell Type, with the Right Proteins on it?

It starts off….by **RANDOM CHANCE!**

Once a virus is in a person's body, it literally bumps around until it encounters a cell that it can bind to. This happens through random collisions and electrostatic forces.

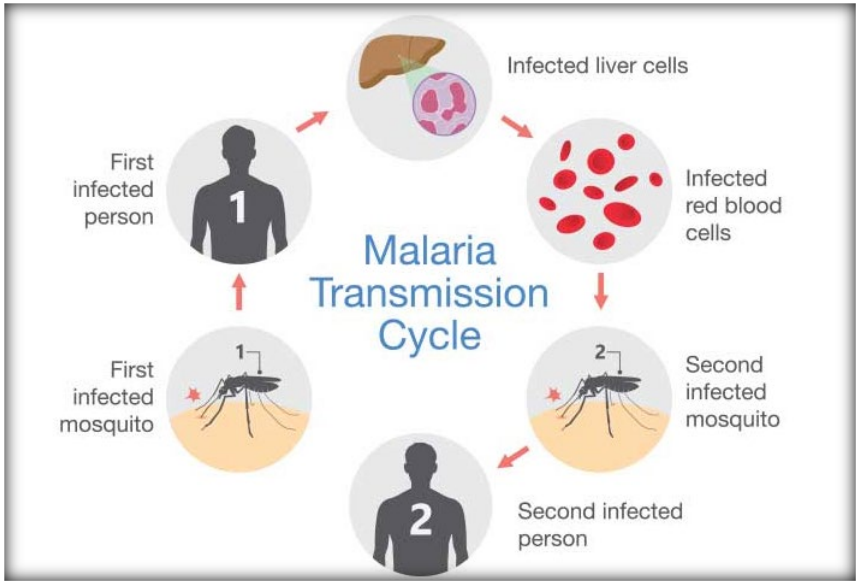
- This is the equivalent of being blindfolded, dropped off at an apartment complex and given a key to 'one apartment'.
- You are then given the task of running around the entire complex, to try and find the right door that the key fits into.
- You have to do this with limited time though! If you take too long, then you (the virus) breaks down. When this happens with a viral infection, no illness occurs.
- And remember…this is done blindly, because viruses are not really alive, and are not capable of doing this with sentient thought.

Step 6: Susceptible Host

1. **Animal Cells:** First, not all pathogens can infect all animals.

- **A Special Note on Parasites:**
  - Parasitic infections actually vary *greatly* and are beyond the scope of this course. However, know that complex ecological, sociological, and biochemical processes come into play for usually more than one organism, affecting how and when a susceptible host is encountered.

Malaria Chain of Infection



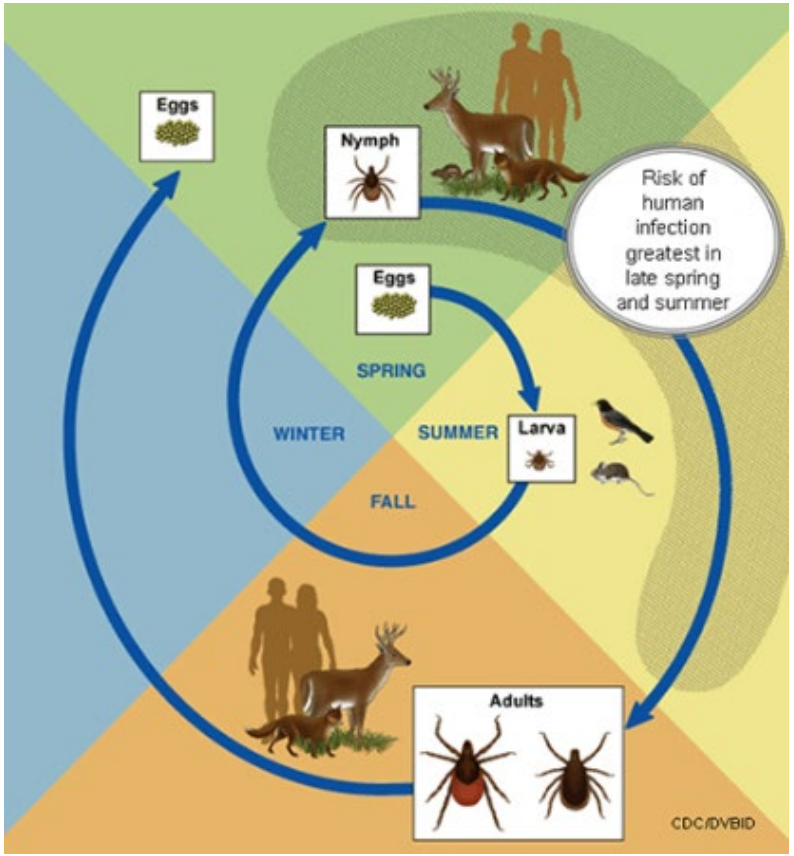
Arizona Advisory Council on Indian Health Care

Step 6: Susceptible Host

1. **Animal Cells:** First, not all pathogens can infect all animals.

- **A Special Note on Bacteria:**
  - Bacterial infections, like all other pathogens, can be introduced in a variety of ways. This is also beyond the scope of this course.
  - However, know that bacteria can be picked up through surface contact, via airborne transmission, and even through vectors, like tick bites.
  - Lyme disease (*Borrelia burgdorferi*) is a great example of a bacterial, vector-borne. It is transmitted by a tick bite.

Lyme Disease Chain of Infection



Arizona Advisory Council on Indian Health Care

Source: https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/LymeDisease/LymeDisease_print.html

Step 6: Susceptible Host

2. **Plant Cells:** For plant cells, if a virus is involved, the plant cell must have physical damage to it. Viruses cannot simply infiltrate a plant's cellular wall via a lock and key mechanism (not usually) the way they do with animal cells.

- Plant cells involve infiltration via mechanical damage to the cellular wall.
- Without a virus coming across a plant that already has damage (i.e. like an aphid chewing on it) it can enter into the plant, but not be able to replicate.

Plant Mechanism for Viruses

3. **Bacteria and Fungi:** Bacterial and Fungal infections rely upon other factors, but they still must encounter a host environment that is 'friendly' towards their replication.

Source: CDC Public Image Library. Image # 17655 CDC//Dr. Lucille K. Georg /1969

Step 6: Susceptible Host

4. Immune System Evasion Time!

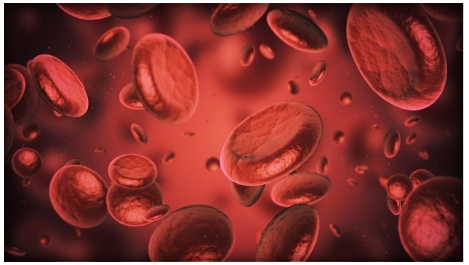
Assuming all other criteria are met, which include:

(1) Finding a host with the right type of cells to attach to (for viruses), *and*

(2) An internal host environment that is favorable for allowing replication of the pathogen the *chance* to occur (i.e. correct pH balance, temperature, available nutrients, etc.

There is now there is the matter of surpassing the host's immune system. Simply put, this means that the final link in the chain of infection is finding a **susceptible host.**

Immune System Evasion



The Immune System

- The immune system is complex and *very* good at its job. The pathogen must find a host that not only meets all other requirements, but that is also ***at risk of infection.***
- Infection does not occur automatically when the pathogen enters the body of a person, animal or plant whose immune system is functioning normally.
- However, if an immune system is sluggish (immunocompromised) or if the pathogen is particularly quick at replicating to high levels within the body/plant (creating a high pathogenic load), then symptomatic infection generally follows.

Step 6: Susceptible Host

Susceptible Host

Susceptible Hosts are organisms that are at risk. For people, this can mean healthcare workers, due to their high exposure, or individuals who are patients with weakened immune systems.

Immune System Issues

Immune systems can be weakened for a variety of reasons, such as the individual being:

- Very young or very old; *or*
- Immunocompromised due to a disease process; *or*
- Immunocompromised due to medications they are taking, like long-term steroid use; *or*
- Immunocompromised due to the treatments they are undergoing for other conditions, such as chemotherapy

Other factors that affect the immune system include things like:

- The presence of chronic diseases that impair the immune system (i.e. type II diabetes), *or*
- Alcohol use, *or*
- Nicotine use, *or*
- Sedentary lifestyles.

How Do Pathogens Spread?
Scenarios

Chain of Infection Scenario: Picture This….

Scenario 1

- There's an outbreak of infectious respiratory illness and you have health conditions that put you at **high risk of severe illness**. However, your car is running on empty. You spot an empty gas station and pull in, figuring this is okay. No other people are around after all.
- You pull up, get out of your car, slide your credit card into the pump, punch in your bank PIN, and then grab the gas pump to fill up.
- The little numbers tick up as the gallons fill your car. And then it happens….
  - Maybe you have an itch and unconsciously reach up to itch your nose.
  - Maybe the wind kicks up, and sends your hair blowing against your mouth, sticking there, so you reach up to swat it away.
  - Perhaps your glasses are slipping down your nose, and you reach up to adjust them.
- Regardless of **HOW** it happens, you have just touched your face near mucus membranes.
- Unbeknownst to you, the person using the pump before you, **a person you never saw and have never met**, had just coughed into their hand, touched the electronic keypad to enter in their own PIN, and also touched the gas pump. The problem is that this person was sick with a potentially deadly virus. For them, it was just a cold, but for you, it could be deadly.

Viruses can live on surfaces for many hours, capable of causing illness. So even though you never saw the other person, and you have been wearing a mask around other people diligently, you wind up sick anyway due to pumping your gas and then touching your face before cleaning your hands.

Chain of Infection Scenario: Picture This….

Scenario 2

You're a healthcare or public health worker out in the community. You go into someone's home, who is symptomatic for an airborne, respiratory illness. They are coughing, sneezing and sniffling.

You wear full PPE, wearing gloves, an N95 mask, and a face shield to protect the mucus membranes of your eyes.

You finish your visit, and go back out to your car, where you do the following:

1. Set your electronic tablet or clipboard down onto your car's hood (you had this to do your visit note)
2. You get out a disposal bag for your PPE
3. You remove your PPE carefully, making sure to take it off safely and to deposit it into the disposal bag
4. You then pick up your electronic tablet or clipboard with your bare hands, get into your car, and toss the garbage bag into the back seat
5. You re-read your visit note, set the electronic tablet or clipboard onto your car seat, start your car, then drive off

How did you potentially contaminate yourself?

Breaking the Chain of Infection

Breaking the Chain

For Healthcare Workers, Personal Protective Equipment, also known as "PPE", KEY!

PPE is specialized equipment or clothing (such as masks, gowns, and medical gloves) worn to minimize your exposure to infectious materials (such as viruses, bacteria and fungi).

- PPE is routinely worn by healthcare providers.
- PPE can also (and should be) worn by community members during certain situations, such as a pandemic.

What is Personal Protective Equipment (PPE)?

- **PPE acts as a barrier between infectious materials (pathogens, such as viral and bacterial contaminants), and your skin, mouth, nose, or eyes (mucous membranes)**.
- The barrier created by PPE has the ***potential*** to block transmission of contaminants from blood, body fluids, or respiratory secretions (i.e. aerosolized droplets that go into the air when we breathe, talk, cough or sneeze).
- PPE is **not a guarantee of safety.** However, PPE tips the odds in a person's favor, by lowering their risk of exposure to pathogens.
  - For example, in one study, gloves being worn by healthcare providers were found to be contaminated with MRSA 18-24% of the time, and with Vancomyocin Resistant Enterococci (VRE) 12-63% of the time after entering a patient's room, even when *not doing direct patient care.* These are two contagious, potentially deadly, antibiotic resistant infections.
  - However, upon removing the gloves, the hands of the healthcare workers were only contaminated ***beneath the gloves*** 3% of the time with MRSA, and 0-4% of the time with VRE.
  - Washing their hands afterwards and disinfecting with an alcohol-based hand sanitizer, removed the lingering MRSA and/or VRE, preventing the healthcare worker from becoming infected.

Source: *Snyder G et al., ICHE, 2008; Roghmann M et al., ICHE 2015; Grabsch E et al., ICHE, 2006; Zachary K et al., ICHE, 2001*

Types of Personal Protective Equipment (PPE)

During a pandemic, there are different types of PPE you may encounter.

- **Face Masks** – Cloth masks, surgical masks, KN95 masks, or N95 masks. These protect the mucous membranes of your nose and mouth.
- **Gloves** – Vinyl and Latex are available. These ***disposable*** and protect your hands. Gloves used for PPE are **NOT RESUSABLE.** You wear them once, then throw them away. This protects you from infectious materials getting into tiny cuts on your hands, and if any pathogens, such as COVID-19, get on your hands, allows for easy removal *from* your hands.
- **Face Shields** – These are worn over your face, and offer *some* protection for the mucous membranes of your face, mouth, nose and eyes. An N95 mask paired with a pair of googles is always better.
- **Gowns and Aprons** – These are disposable materials (typically) that can be thrown over the clothes you are wearing and protect your skin and clothing from contaminants.

Types of Personal Protective Equipment (PPE)

Masks

Wearing a cloth or surgical mask helps reduce the amount of saliva that becomes aerosolized as you breathe, talk, cough or sneeze. This helps protect others. A KN95 or N95 mask reduces the particulates you breathe in, helping to protect *you*.

Gloves

Gloves lower how much of an infectious material gets onto our hands. We often have many tiny cuts on our hands, and gloves also help prevent pathogens from getting into our bodies through these cuts.

Face Shields

If a patient or family member coughs directly in your face, the saliva droplets will hit the face shield, preventing the direct bodily fluids from getting into your mucus membranes directly.

Gowns and Aprons

Gowns and aprons can help keep bodily fluids off of you. For instance, if you have a cut on your arm and get splashed with saliva spray or vomit while caring for a family member, the fluid will not get into the cut if you are wearing a gown. If you are helping a sick member of your household to isolate, and have to go into the isolation area (i.e. a separate room of the home) to provide care for them, if you wear a gown, and remove the gown correctly before leaving the room, you will reduce the contaminants on your clothes, and reduce what you track into the rest of the home.

Arizona Advisory Council on Indian Health Care

Why is PPE Important?

- Pathogens (i.e. viruses, bacteria and fungi) capable of causing illness can survive outside the body, either lingering in the air or on surfaces, for different lengths of time.
- This means you can get sick from touching a surface that still has live virus on it, even if you never saw the person who was sick.
- You can also get sick breathing in air that has aerosolized respiratory droplets, carrying a pathogen on them.
- You can also pick up live virus when caring for a sick family member who is attempting to isolate in the same household as you.
- You can also pick up live virus when out and about in the community, working or doing your necessary daily life activities, such as going to the doctor, getting groceries, or even getting gas!

This is where PPE can come in!

Arizona Advisory Council on Indian Health Care

Example Timeframes: How Long Do Pathogens Live on Surfaces?

Surface Type → / Pathogen ↓	Hard, Nonporous Surfaces (i.e. countertops, doorknobs, stainless steel items, plastics, toilet handles, etc.)	Soft, Porous Surfaces (i.e. bedding, paper towels, etc)	Your Hands
COVID-19	8 days	No data yet available	21 hours
The Flu (Influenza A & B viruses)	24-48 hours	8-12 hours	15 minutes
RSV	Several hours	Several hours	30 minutes
The Common Cold	Up to 1 week, but they lose a great deal of virulence after 24 hours if exposed to UV light	Up to 1 week, but they lose a great deal of virulence after 24 hours if exposed to UV light	1 hour
M-pox	***More than 15 days***	***More than 15 days***	No data yet available. *However*, it can be inferred, based on the longevity of the orthopoxvirus on other surfaces, that it will survive until hands are cleaned.

Steps to Teach Community Members on Breaking the Chain of Infection in their Daily Lives

Why is PPE Important?

During a pandemic, or a surge in viral, bacterial, or fungal infections in your community, you can take the following precautions using PPE to protect yourself, your family, and your community.

The following slides contain ***examples*** of when you, as a Community Member or Health Care Worker out in the community, may wish to use PPE.

Arizona Advisory Council on Indian Health Care

Why is PPE Important?

Use Gloves when:

- **Caring for a Sick Household Member –** Many viruses live for hours to weeks on nonporous (hard) and porous (soft) surfaces. When caring for a sick household member and touching things they have touched or breathed/coughed on, you risk contamination of yourself. Wearing gloves adds a layer of protection. Additionally, when touching a household member when providing direct, hands on care, you are preventing any bodily fluids (i.e. sweat, saliva, etc.) that may contain a pathogen from getting on your hands directly.
- **Cleaning** potentially contaminated areas or high touchpoint areas (i.e. door handles, countertops, keyboards, light switches, etc.) at work or in the home
- **You have papercuts or other open wounds** on your fingers or hands, and you are doing daily activities such as pumping gas, that involve coming into direct contact with high-touchpoint areas.
  - **High-Touchpoint Areas** are **areas that have frequent contact with hands**, and are likely to have been contaminated with microorganisms that could then be picked up by others on their hands. For example, door handles, light switches, and shared equipment.

Why is PPE Important?

Use Masks When:

- **Caring for a Sick Household Member -** Not only does this help to protect you from catching their illness, but it also helps to protect them from any illness you may be an asymptomatic carrier for.
  - For example, it ***is very possible to catch both COVID-19 and the Flu at the same time.*** If you are caring for a family member who is sick with the Flu, and you were exposed to COVID-19 but *feel fine*, you may be an asymptomatic carrier. Wear a mask when caring for your family member so they don't catch COVID-19 from you, when their immune system is already busy fighting the flu.
- **In Public Spaces**, when there is a pandemic or when there has been an uptick or surge in the number of cases of infectious respiratory diseases, such as COVID-19, the Flu, or RSV, in your area.
- **You are sick!** If you have cold symptoms, test for COVID-19 using an At-Home Self Test. If you are negative, you may still have COVID-19 and be in an early stage of it, or you may have another illness that is contagious via respiratory secretions. If you **have to leave your home** then make sure to wear a mask, and follow CDC guidance.

Why is PPE Important?

Use Face Shields When:

- You are medically unable to tolerate a face covering.
- Your job is impeded by a mask, such as in the case of a School Speech Therapist.
- When you need to protect your eyes, nose, mouth and face from flying objects and liquids.
- **Face Shields are NOT replacements for masks.** Face shields can give the wearer a false sense of security, but they do NOT prevent the wearer from inhaling the respiratory droplets of other people, NOR do they prevent your own respiratory droplets from entering the air. Face shields would be the absolute, bare minimum in a respiratory outbreak, and are unlikely to work in terms of protection from airborne illness. They are *only truly useful* for preventing splashes to mucus membranes on the face, by adding a layer of protection.

Gowns and Aprons

- Typically, there is no need for community members to wear gowns or aprons.
- Gowns and Aprons are usually worn by healthcare professionals when caring for patients, or when working mass testing or vaccination clinics. The main circumstance in which a community member may find a gown or apron useful is when caring for a sick member of their household.
- **Caring for a Sick Household Member –** Ideally a sick household member will be set up in an area of the home for isolation. When caring for them and entering the isolation area of the home, you can don a gown or apron over the clothes that you are wearing. This will protect your skin and clothing from contaminants, such as respiratory secretions and other bodily fluids (i.e. vomit, urine, etc.).

Resources

Resources

Centers for Disease Control and Prevention (CDC) Resources:

- https://www.cdc.gov/niosh/learning/safetyculturehc/module-2/3.html
- https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/disinfecting-your-home.html

Chain of Infection

- https://www.nipcm.scot.nhs.uk/care-home-infection-prevention-and-control-manual-ch-ipcm/print?section=2820

Digging into Nose Picking and Why We Are Guilty of It

- https://www.discovermagazine.com/the-sciences/digging-into-nose-picking-and-why-we-are-guilty-of-it

How Frequently Do We Touch Facial T-Zone: A Systematic Review

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7350942/

Transmission of Methicillin-Resistant Staphylococcus aureus (MRSA) to Healthcare Worker Gowns and Gloves During Care of Nursing Home Residents

- Source: (Snyder G et al., ICHE, 2008; Roghmann M et al., ICHE 2015; Grabsch E et al., ICHE, 2006; Zachary K et al., ICHE, 2001)
- https://pubmed.ncbi.nlm.nih.gov/26008727/

MERS-CoV, SARS-CoV, SARS-CoV-2 Agent Information Sheet

- https://www.bu.edu/research/ethics-compliance/safety/rohp/agent-information-sheets/coronaviruses-agent-information-sheet/

Resources

Norovirus Links

- https://www.ama-assn.org/delivering-care/public-health/what-doctors-wish-patients-knew-about-contagious-norovirus
- https://healthland.time.com/2014/01/27/cruise-out-of-control-the-13-worst-norovirus-outbreaks-on-cruise-ships/
- https://www.michigan.gov/lara/-/media/Project/Websites/lara/bchs/Folder3/General_Noro_Fact_Sheet_173589_7.pdf

Legionnaire's Disease

- https://www.nbcnews.com/health/health-news/cdc-fungal-infection-candida-auris-alarming-spread-rcna75477
- https://en.wikipedia.org/wiki/1976_Philadelphia_Legionnaires%27_disease_outbreak

Lyme Disease

- https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/LymeDisease/LymeDisease_print.html

Ebola

- https://www.dhs.gov/science-and-technology/news/2021/04/20/feature-article-new-tech-makes-detecting-airborne-ebola-virus-possible

Malaria and Lyme disease - the largest vector-borne US epidemics in the last 100 years: success and failure of public health

- https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7069-6

Resources

Virologist

- https://my.clevelandclinic.org/health/articles/25116-virologist

Dr. Vincent Racaniello, Columbia University Virology Lecture Series: 2024

- https://www.youtube.com/watch?v=GEC36qO3dBU&list=PLGhmZX2NKiNktEViriylQ3haM_a_kAfbk

Coughs and Sneezes: Their Role in Transmission of Respiratory Viral Infections, Including SARS-CoV-2

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7462404/

Mask Wearing and Social Distaincing

- https://www.iop.org/explore-physics/physics-around-you/staying-safe-coronavirus/masks-distancing

1 in 4 Americans aren't washing their hands regularly

- https://www.livescience.com/hand-washing-covid-19-pandemic.html

Photo Credits

Images used in this presentation are from the following sources (stock and public domain images) or with the permission of:

- CDC Public Image Library
- Microsoft PowerPoint Stock Images
- Alison Lovell, NREMT
- Andrew Lovell, NREMT
- Kristine Rodriguez, MS CCC-SLP


Thank you for attending!