Transmission (medicine)

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In medicine, public health, and biology, **transmission** is the passing of a pathogen causing communicable disease from an infected host individual or group to a particular individual or group, regardless of whether the other individual was previously infected.[1]

The term strictly refers to the transmission of microorganisms directly from one individual to another by one or more of the following means:

- droplet contact – coughing or sneezing on another individual
- direct physical contact – touching an infected individual, including sexual contact
- indirect physical contact – usually by touching soil contamination or a contaminated surface (fomite)
- airborne transmission – if the microorganism can remain in the air for long periods
- fecal-oral transmission – usually from unwashed hands, contaminated food or water sources due to lack of sanitation and hygiene, an important transmission route in pediatrics, veterinary medicine and developing countries.

Transmission can also be indirect, via another organism, either a vector (e.g. a mosquito or fly) or an intermediate host (e.g. tapeworm in pigs can be transmitted to humans who ingest improperly cooked pork). Indirect transmission could involve zoonoses or, more typically, larger pathogens like macroparasites with more complex life cycles. Transmissions can be autochthonous (i.e. between two individuals in the same place) or may involve travel of the microorganism or the affected hosts.

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Definition and related terms

An infectious disease agent can be transmitted in two ways: as horizontal disease agent transmission from one individual to another in the same generation (peers in the same age group).[2] by either direct contact (licking, touching, biting), or indirect contact air – cough or sneeze (vectors or fomites that allow the transmission of the agent causing the disease without physical contact).[3] or by vertical disease transmission, passing the agent causing the disease from parent to offspring, such as in prenatal or perinatal transmission.[4]

The term *infectivity* describes the ability of an organism to enter, survive and multiply in the host, while the *infectiousness* of a disease agent indicates the comparative ease with which the disease agent is transmitted to other hosts.[5] Transmission of pathogen can occur in various ways including physical contact, contaminated food, body fluids, objects, airborne inhalation, or through vector organisms.[6]

The point of the body where a pathogen enters is called the *locus*. In droplet, contact and other airborne transmission it may be the respiratory system, but it could also be the gastrointestinal tract.

Routes

Airborne

"Airborne transmission refers to infectious agents that are spread via droplet nuclei (residue from evaporated droplets) containing infective microorganisms. These organisms can survive outside the body and remain suspended in the air for long periods of time. They infect others via the upper and lower respiratory tracts." [7] Diseases that are commonly spread by coughing or sneezing include bacterial meningitis, chickenpox, common cold, influenza, mumps, strep throat, tuberculosis, measles, rubella, whooping cough, SARS and leprosy.

Droplet

"Droplet transmission occurs when respiratory droplets generated via coughing, sneezing or talking contact susceptible mucosal surfaces, such as the eyes, nose or mouth. Transmission may also occur indirectly via contact with contaminated formites with hands and then mucosal surfaces. Respiratory droplets are large and are not able to remain suspended in the air thus they are usually dispersed over short distances."[8]

The pathogen-containing particles, also called *Flügge droplets* (after Carl Flügge), are 0,1–2 mm in diameter, and are reduced by evaporation to *droplet nuclei* – small (smaller than 100 μ in diameter), dry particles that can remain airborne for long periods.[9]

Organisms spread by droplet transmission include respiratory viruses (e.g., influenza, parainfluenza virus, adenovirus, respiratory syncytial virus, human metapneumovirus), *Bordetella pertussis*, pneumococci, diphtheria, and rubella.[10]

Fecal–oral

Direct contact is rare in this route for humans in developed countries, but relatively common for humans in developing countries, especially those living in urban slums without access to adequate sanitation. More common in developed countries are the indirect routes; foodstuffs or water become contaminated (by people not adequately washing their hands before preparing food or tending to patients, or untreated sewage being released into a drinking water supply) and the people who eat and drink them become infected. In some developing countries, many people are not connected to sewer systems, and where they are, most sewage is discharged into the environment without treatment. However, a bigger problem in some developing countries is open defecation which leads to disease transmission via the fecal-oral route, especially for children. Even in developed countries there are periodic system failures resulting in a sanitary sewer overflow. This is the typical mode of transmission for the infectious agents of (at least): cholera, hepatitis A, polio, Rotavirus, *Salmonella*, and parasites (e.g. *Ascaris lumbricoides*).

Sexual

This refers to any disease that can be caught during sexual activity with another person, including vaginal or anal sex or (less commonly) through oral sex (see below). Transmission is either directly between surfaces in contact during intercourse (the usual route for bacterial infections and those infections causing sores) or from secretions (semen or the fluid secreted by the excited female) which carry infectious agents that get into the partner's blood stream through tiny tears in the penis, vagina or rectum (this is a more usual route for viruses). In this second case, anal sex is considerably more hazardous since the penis opens more tears in the rectum than the vagina, as the vagina is more elastic and more accommodating.

Some diseases transmissible by the sexual route include HIV/AIDS, chlamydia, genital warts, gonorrhea, hepatitis B, syphilis, herpes, and trichomoniasis.

Oral sexual

Sexually transmitted diseases such as HIV and hepatitis B are thought to not normally be transmitted through mouth-to-mouth contact, although it is possible to transmit some STDs between the genitals and the mouth, during oral sex. In the case of HIV this possibility has been established. It is also responsible for the increased incidence of herpes simplex virus 1 (which is usually responsible for oral infections) in genital infections and the increased incidence of the type 2 virus (more common genitally) in oral infections.

Oral

Diseases that are transmitted primarily by oral means may be caught through direct oral contact such as kissing, or by indirect contact such as by sharing a drinking glass or a cigarette. Diseases that are known to be transmissible by kissing or by other direct or indirect oral contact include all of the diseases transmissible by droplet contact and (at least) all forms of herpes viruses, namely Cytomegalovirus infections herpes simplex virus (especially HSV-1) and infectious mononucleosis.

Direct contact

Diseases that can be transmitted by direct contact are called contagious (contagious is not the same as infectious; although all contagious diseases are infectious, not all infectious diseases are contagious). These diseases can also be transmitted by sharing a towel (where the towel is rubbed vigorously on both bodies) or items of clothing in close contact with the body (socks, for example) if they are not washed thoroughly between uses. For this reason, contagious diseases often break out in schools, where towels are shared and personal items of clothing accidentally swapped in the changing rooms.

Some diseases that are transmissible by direct contact include athlete's foot, impetigo, syphilis (on rare occasions, if an uninfected person touches a chancre), warts, and conjunctivitis.

Vertical

This is from mother to child (more rarely father to child), often *in utero*, during childbirth (also referred to as perinatal infection) or during postnatal physical contact between parents and offspring. In mammals, including humans, it occurs also via breast milk. Infectious diseases that can be transmitted in this way include: HIV, hepatitis B and syphilis. Many mutualistic organisms are transmitted vertically.[11]

Iatrogenic

Transmission due to medical procedures, such as touching a wound, an injection or transplantation of infected material. Some diseases that can be transmitted iatrogenically include: Creutzfeldt–Jakob disease by injection of contaminated human growth hormone, MRSA and many more.

Vector-borne

A *vector* is an organism that does not cause disease itself but that transmits infection by conveying pathogens from one host to another.[12]

The route of transmission is important to epidemiologists because patterns of contact vary between different populations and different groups of populations depending on socio-economic, cultural and other features. For example, low personal and food hygiene due to the lack of a clean water supply may result in increased transmission of diseases by the fecal-oral route, such as cholera. Differences in incidence of such diseases between different groups can also throw light on the routes of transmission of the disease. For example, if it is noted that polio is more common in cities in underdeveloped countries, without a clean water supply, than in cities with a good plumbing system, we might advance the theory that polio is spread by the fecal-oral route. It can be minimised to a certain extent if we all consider being sure of what we do.

Vectors may be mechanical or biological. A mechanical vector picks up an infectious agent on the outside of its body and transmits it in a passive manner. An example of a mechanical vector is a housefly, which lands on cow dung, contaminating its appendages with bacteria from the feces, and then lands on food prior to consumption. The pathogen never enters the body of the fly. In contrast, biological vectors harbor pathogens within their bodies and deliver pathogens to new hosts in an active manner, usually a bite. Biological vectors are often responsible for serious blood-borne diseases, such as malaria, viral encephalitis, Chagas disease, Lyme disease and African sleeping sickness. Biological vectors are usually, though not exclusively, arthropods, such as mosquitoes, ticks, fleas and lice. Vectors are often required in the life cycle of a pathogen. A common strategy used to control vector borne infectious diseases is to interrupt the life cycle of a pathogen by killing the vector.

Tracking

Tracking the transmission of infectious diseases is called disease surveillance. Surveillance of infectious diseases in the public realm traditionally has been the responsibility of public health agencies, either on the (inter)national or a local level. Public health staff rely on health care workers and microbiology laboratories to report cases of reportable diseases to them. The analysis of aggregate data can show the spread of a disease and is at the core of the specialty of epidemiology. To understand the spread of the vast majority of non-notifiable diseases, data either need to be collected in a particular study, or existing data collections can be mined, such as insurance company data or antimicrobial drug sales for example.

For diseases transmitted within an institution, such as a hospital, prison, nursing home, boarding school, orphanage, refugee camp etc., infection control specialists are employed, who will review medical records to analyze transmission as part of a hospital epidemiology program, for example.

Because these traditional methods are slow, time-consuming, and labor-intensive, proxies of transmission have been sought. One proxy in the case of influenza is tracking of influenza-like illness at certain sentinel sites of health care practitioners within a state, for example.[13] Tools have been developed to help track influenza epidemics by finding patterns in certain web search query activity. It was found that the frequency of influenza-related web searches as a whole rises as the number of people sick with influenza rises. Examining space-time relationships of web queries has been shown to approximate the spread of influenza[14] and dengue.[15]

Computer simulations of infectious disease spread have been used.[16] Human aggregation can drive transmission, seasonal variation and outbreaks of infectious diseases, such as the annual start of school, bootcamp, the annual Hajj etc. Most recently, data from cell phones have been shown to be able to capture population movements well enough to predict the transmission of certain infectious diseases, like rubella.[17]

Relationship with virulence and survival

Pathogens must have a way to be transmitted from one host to another to ensure their species' survival. Infectious agents are generally specialized for a particular method of transmission. Taking an example from the respiratory route, from an evolutionary perspective viruses or bacteria that cause their host to

develop coughing and sneezing symptoms have a great survival advantage, as they are much more likely to be ejected from one host and carried to another. This is also the reason that many microorganisms cause diarrhea.

The relationship between virulence and transmission is complex, and has important consequences for the long term evolution of a pathogen. Since it takes many generations for a microbe and a new host species to co-evolve, an emerging pathogen may hit its earliest victims especially hard. It is usually in the first wave of a new disease that death rates are highest. If a disease is rapidly fatal, the host may die before the microbe can be passed along to another host. However, this cost may be overwhelmed by the short term benefit of higher infectiousness if transmission is linked to virulence, as it is for instance in the case of cholera (the explosive diarrhea aids the bacterium in finding new hosts) or many respiratory infections (sneezing and coughing create infectious aerosols).

Beneficial microorganisms

The mode of transmission is also an important aspect of the biology of beneficial microbial symbionts, such as coral-associated dinoflagellates or human microbiota. Organisms can form symbioses with microbes transmitted from their parents, from the environment or unrelated individuals, or both.

Vertical transmission

Vertical transmission refers to acquisition of symbionts from parents (usually mothers). Vertical transmission can be intracellular (e.g. transovarial), or extracellular (for example through post-embryonic contact between parents and offspring). Both intracellular and extracellular vertical transmission can be considered a form of non-genetic inheritance or parental effect. It has been argued that most organisms experience some form of vertical transmission of symbionts.[18] Canonical examples of vertically transmitted symbionts include the nutritional symbiont Buchnera in aphids (transovarially transmitted intracellular symbiont) and some components of the human microbiota (transmitted during passage of infants through the birth canal and also through breastfeeding).

Horizontal transmission

Some beneficial symbionts are acquired horizontally, from the environment or unrelated individuals. This requires that host and symbiont have some method of recognizing each other or each other's products or services. Often, horizontally acquired symbionts are relevant to secondary rather than primary metabolism, for example for use in defense against pathogens,[19] but some primary nutritional symbionts are also horizontally (environmentally) acquired.[20] Additional examples of horizontally transmitted beneficial symbionts include bioluminescent bacteria associated with bobtail squid and nitrogen-fixing bacteria in plants.

Mixed-mode transmission

Many microbial symbionts, including human microbiota, can be transmitted both vertically and horizontally. Mixed-mode transmission can allow symbionts to have the "best of both worlds" – they can vertically infect host offspring when host density is low, and horizontally infect diverse additional

hosts when a number of additional hosts are available. Mixed-mode transmission make the outcome (degree of harm or benefit) of the relationship more difficult to predict, because the evolutionary success of the symbiont is sometimes but not always tied to the success of the host.[21]

See also

- Bioaerosol
- Bugchasing
- Infectious disease: Transmission
- Transmission risks and rates

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