

Air transmission of microorganisms- Aerosols & Droplet nuclei

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Airborne transmission

(Fernstrom and Goldblatt 2013)

- **Airborne transmission is defined as the transmission of infection by expelled particles that are comparatively smaller in size and thus can remain suspended in air for long periods of time.**

(OR)

- **Airborne transmission refers to situations where droplet nuclei (residue from evaporated droplets) or dust particles containing microorganisms can remain suspended in air for long periods of time.**
- Infection may be transmitted over short distances by large droplets, and at longer distances by droplet nuclei generated by coughing and sneezing.
- Airborne transmission allows organisms to enter the upper and lower respiratory tracts.
- Potentially expose a much higher number of susceptible individuals at a much greater distance from the source of infection.
- Depending on environmental factors (e.g., meteorological conditions outdoors and fluid dynamic effects and pressure differentials indoors), airborne particles are easily measured 20 m from their source.
- Common examples of diseases transmitted by the airborne (aerosol) route (e.g. tuberculosis, measles and chickenpox).

Aerobiology

(Fernstrom and Goldblatt 2013)

- **Aerobiology is the study of the processes involved in the movement of microorganisms in the atmosphere from one geographical location to another, including the aerosolized transmission of disease.**
- **Aerobiology requires an understanding not only of the biological particles being moved by the air but also of physics, as various physical processes explain the movement of air and particles suspended in it.**
- **Bio-aerosol Properties:**
 - **Physical attributes**
 - **Physical shape • Diffusion • Gravitation (Density) • Temperature**
 - **Electrostatic forces • Relative humidity • Air currents, ventilation**
 - **Biological attributes**
 - **Biological materials hygroscopy • Morphology of micro-organism**
 - **Shape changes due to dehydration/rehydration cycles**

Aerosols (Tellier et al. 2019)

- **‘Aerosols’ refer to particles in suspension in a gas, such as small droplets in air.**
- **It is generally accepted that:**
 - **Small particles of $< 5\text{--}10\ \mu\text{m}$ aerodynamic diameter that follow airflow streamlines are potentially capable of short and long range transmission; particles of $< 5\ \mu\text{m}$ readily penetrates the airways all the way down to the alveolar space, and particles of $< 10\ \mu\text{m}$ readily penetrates below the glottis**
 - **Large droplets of diameters $> 20\ \mu\text{m}$ refer to those that follow a more ballistic trajectory (i.e. falling mostly under the influence of gravity), where the droplets are too large to follow inhalation airflow streamlines.**
 - **‘intermediate particles’ of diameters $10\text{--}20\ \mu\text{m}$, will share some properties of both small and large droplets, to some extent, but settle more quickly than particles $< 10\ \mu\text{m}$ and potentially carry a smaller infectious dose than large ($> 20\ \mu\text{m}$) droplets.**



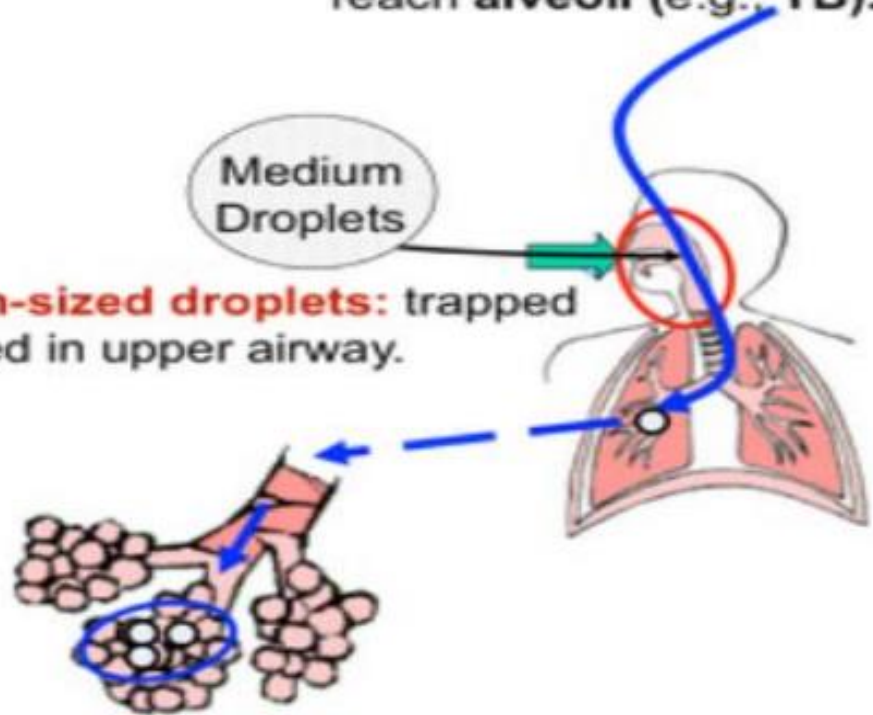
Largest droplets fall to ground in seconds; may persist in dust, but not an important cause of infection.

Largest Droplets

Smallest droplets (<25 μm) evaporate leaving "**droplet nuclei**" of bacilli that can reach **alveoli** (e.g., TB).

Medium Droplets

Medium-sized droplets: trapped & cleared in upper airway.



Sources of Bio-aerosols

- **Infectious persons**
 - Breathing, talking, coughing, sneezing, vomiting
 - Health Care sources
 - Nebulizers
 - Sputum induction
 - Bronchoscopy
- **Indoor sources:**
 - Humidifiers
 - Heating
 - ventilation, and air conditioning (HVAC) systems
 - Washing, flushing toilet, showering, sweeping floor
 - Dusts in air conditioners, ceiling tile, carpet Laboratory activities
- **Outdoor sources:**
 - Cooling tower water
 - Dusts: construction, roads

- Term “aerosol transmission” used to describe pathogens that can cause disease via inspirable particles of any size.

Bio-aerosol Size and Persistence in the Air

A droplet of	will fall in
100 μm	10 seconds
40 μm	1 minute
20 μm	4 minutes
10 μm	20 minutes
5-10 μm	30-45 minutes
$\leq 5 \mu\text{m}$ Droplet nuclei	May be inhaled to alveoli

TABLE 1: Droplet or airborne microorganisms released from various activities.

Activity	Approximate particle count	Units
Sneezing [36]	40,000	Per sneeze
Bowel evacuation [37]	20,000	Per event
Vomiting [38]	1,000	Per event
Coughing [36]	710	Per cough
Talking [36]	36	Per 100 words

- **If the infected patients produce infectious droplets of varying sizes by breathing, coughing or sneezing, transmission between individuals by both short-range large droplets and airborne small droplet nuclei are both possible, depending on the distance from the patient source.**

Respiratory Droplet

(Atkinson et al. 2009)

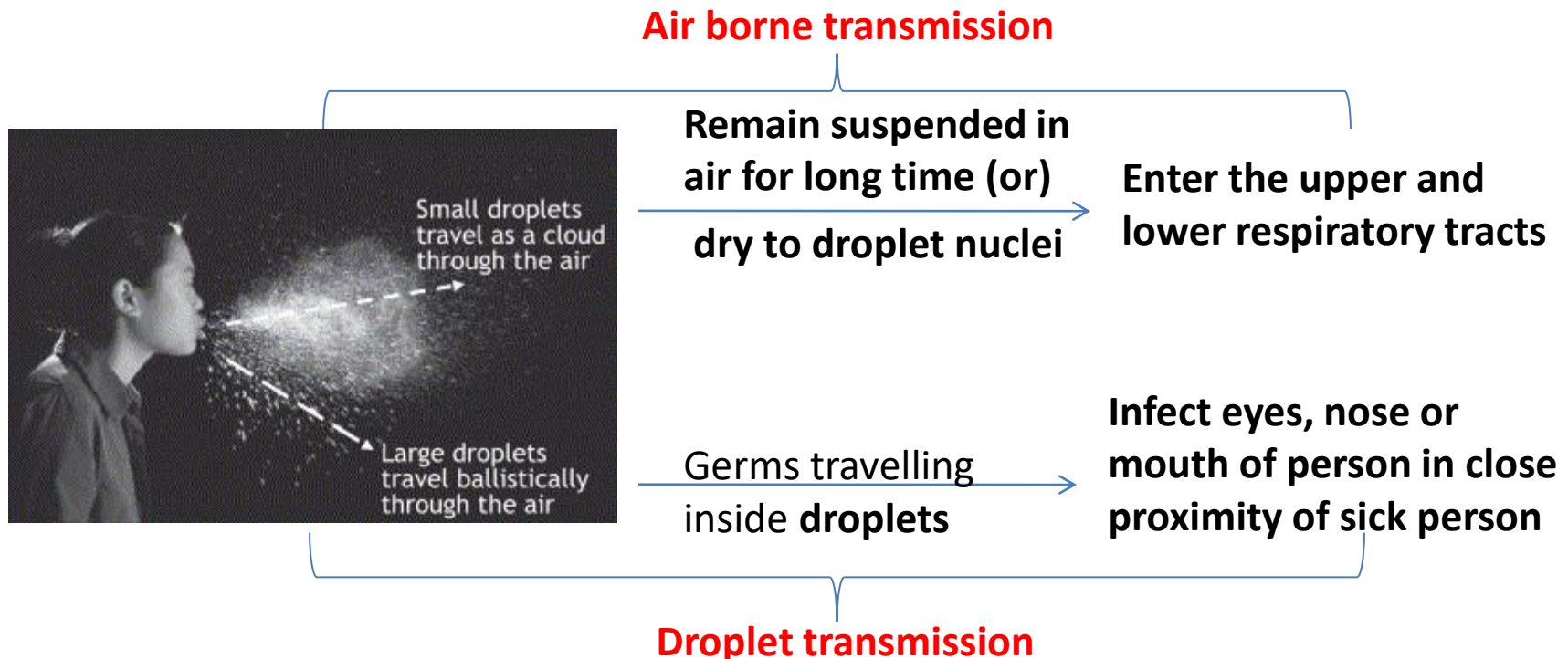
- The term “droplet”, as used in this context, consists mostly of water with various inclusions, depending on how it is generated.
- A respiratory droplet is a small aqueous droplet produced by exhalation, consisting of saliva or mucus and other matter derived from respiratory tract surfaces.
- Droplet sizes range from $<5 \mu\text{m}$ to $1000 \mu\text{m}$. Large droplets (larger than about $100 \mu\text{m}$, but depending on conditions) fall to the ground or another surface before drying, but smaller ones fall slowly and dry so quickly that they usually become aerosolized particles.
- Naturally produced droplets from humans (e.g. droplets produced by breathing, talking, sneezing, coughing) include various cells types (e.g. epithelial cells and cells of the immune system), physiological electrolytes contained in mucous and saliva (e.g. Na^+ , K^+ , Cl^-), as well as, potentially, various infectious agents (e.g. bacteria, fungi and viruses).
- Droplets that dry in the air become droplet nuclei which float as aerosols and can remain suspended in air for considerable periods of time.

Droplet nuclei

- Droplet nuclei are referred to the dried residue formed by evaporation of droplets coughed or sneezed into the atmosphere or by aerosolization of infective material.
- The amount of solid matter in a droplet ultimately determines its minimal size limit.
- Airborne droplet nuclei develop when the fluid of pathogenic droplets (1-5 μm in size; micrometre = one-thousandth of a millimetre) evaporates.
- They are so small and light they may remain suspended in the air for several hours. Thus, they may also infect persons entering a room which has been left by a patient long ago.
- Also, airborne droplet nuclei can be widely dispersed by air currents.
- Tuberculosis, chickenpox, measles and possibly also influenza may be transmitted this way.

Difference between airborne and droplet transmission

- **Airborne** spread happens when a germ floats through the air after a person talks, coughs, or sneezes. **Droplet** spread happens when germs travelling inside **droplets** that are coughed or sneezed from a sick person enter the eyes, nose, or mouth of another person.



Questions

- What is aerobiology?
- Write an essay on role of aerosol in air transmission of disease.
- Differentiate between Respiratory droplet and droplet nuclei.
- Write short note on air borne transmission
- What are the sources of bioaerosols
- Difference between air borne and droplet transmission