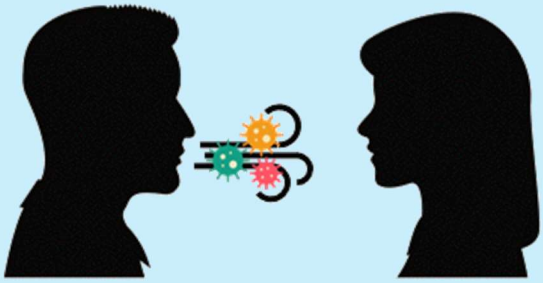
FLU, COVID-19, MEASLES, TUBERCULOSIS...
DISEASES THAT TRANSMIT THROUGH THE AIR

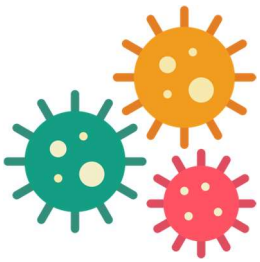
UNDERSTANDING AIRBORNE TRANSMISSION



DRAFT

This document is the intermediary result of a scientific mediation project on airborne diseases. It is the fruit of the collegial work of a multi-disciplinary group including clinicians, virologists, pneumologists, pediatricians, epidemiologists, aerosol specialists, engineers, scientific mediators, etc. It can be seen as the demonstrator or prototype of a larger project, and has enabled, among other things, the development of a collaborative and iterative working methodology.

Version 1.02 of 2025-05-12
Contact : info@letsair.org



EXAMPLES OF DISEASES FROM PATHOGENS

THAT CAN BE TRANSMITTED THROUGH THE AIR WE BREATHE

Viruses

- ✓ Adenovirus
- ✓ Bocavirus
- ✓ Varicella zoster virus
- ✓ Coronavirus
  MERS, SARS 1, SARS-CoV-2
- ✓ Influenza type A virus
  H1N1, H5N1, ...
- ✓ Influenza type B virus
- ✓ Morbillivirus
- ✓ Mumps virus
- ✓ Rhinovirus
- ✓ Rubivirus rubellae
- ✓ Respiratory syncytial virus (RSV)
- ✓ Variola virus
- ✓ ...

Bacteria

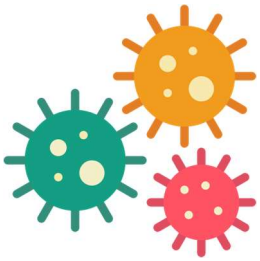
- ✓ Bordetella pertussis
- ✓ Corynebacterium diphtheriae
- ✓ Legionella pneumophila
- ✓ Streptococcus pneumoniae
- ✓ Mycobacterium tuberculosis
- ✓ ...

Fungi

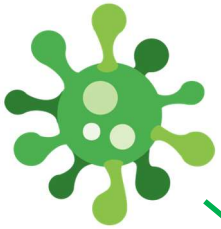
- ✓ Aspergillus
- ✓ Blastomyces dermatitidis
- ✓ Coccidioides immitis
- ✓ Histoplasma capsulatum
- ✓ ...

Associated Diseases

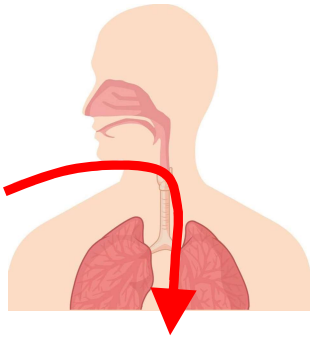
- Chickenpox
- Covid-19
- Influenzas
- Measles
- Mumps
- Common cold
- Rubella
- Bronchiolitis
- Smallpox
- Whooping cough
- Diphteria
- Legionella
- Meningitis
- Tuberculosis
- Aspergillosis
- ...



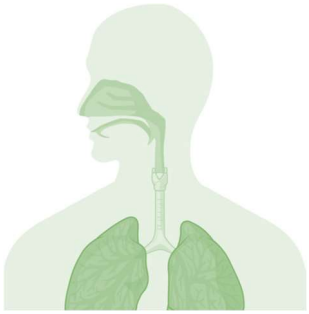
PATHOGENS, SYMPTOMS, DISEASES



A pathogen (virus, bacteria, fungi)



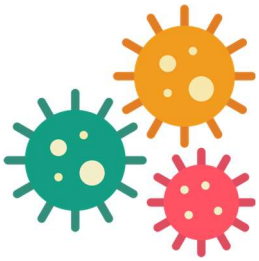
infects an exposed person



does not infect an exposed person

The person develops symptoms, is ill, develops the disease associated with the pathogen and is said to be **“symptomatic”**.

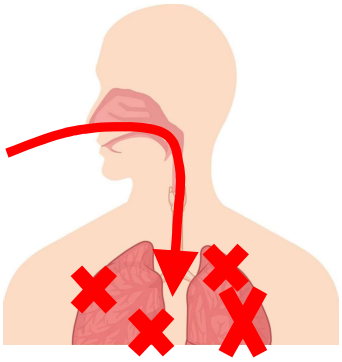
The person develops no symptoms, is infected but not ill, is said to be **“asymptomatic”**,



RESPIRATORY VIRUSES AND OTHER VIRUSES

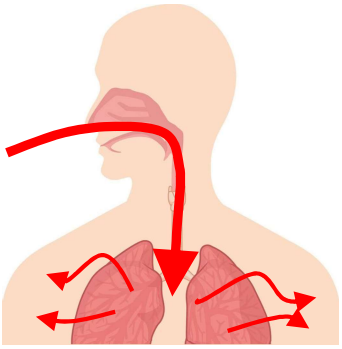
"IN & STAY" RESPIRATORY VIRUS

This is a virus whose entry point and target is the respiratory tract. This corresponds to viruses transmitted via the respiratory tract and essentially targeting the respiratory system: flu, parainfluenza, RSV, ...



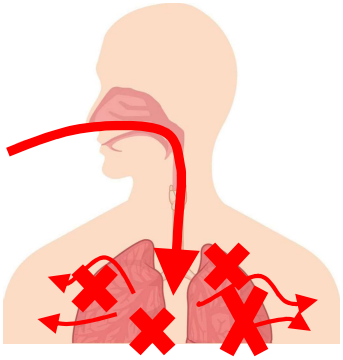
"IN & RUN" RESPIRATORY VIRUS

This a virus with a respiratory entry point but which do not primarily target the respiratory system: chickenpox, measles,...



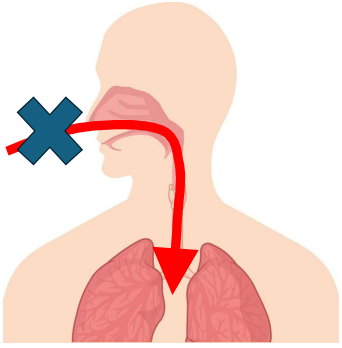
"IN & SPREAD" RESPIRATORY VIRUS

This a virus with a respiratory entry point then spreads to several organs: COVID-19



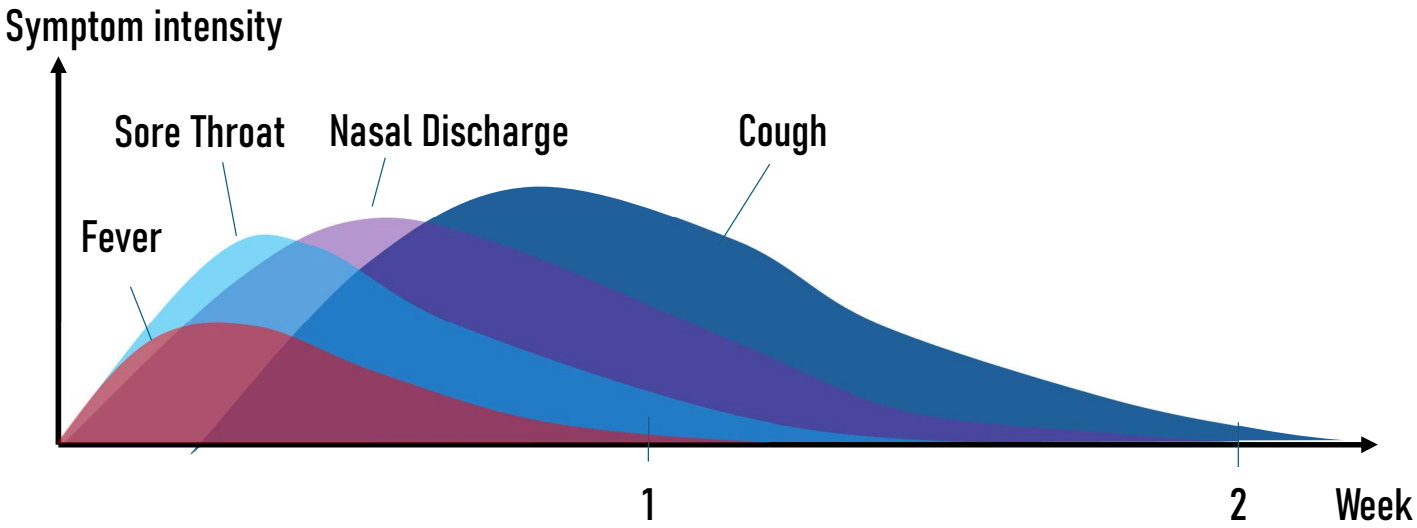
NON-RESPIRATORY VIRUS

There are viruses that are clearly not respiratory and whose entry point and target are not respiratory: HIV, HBV, ...

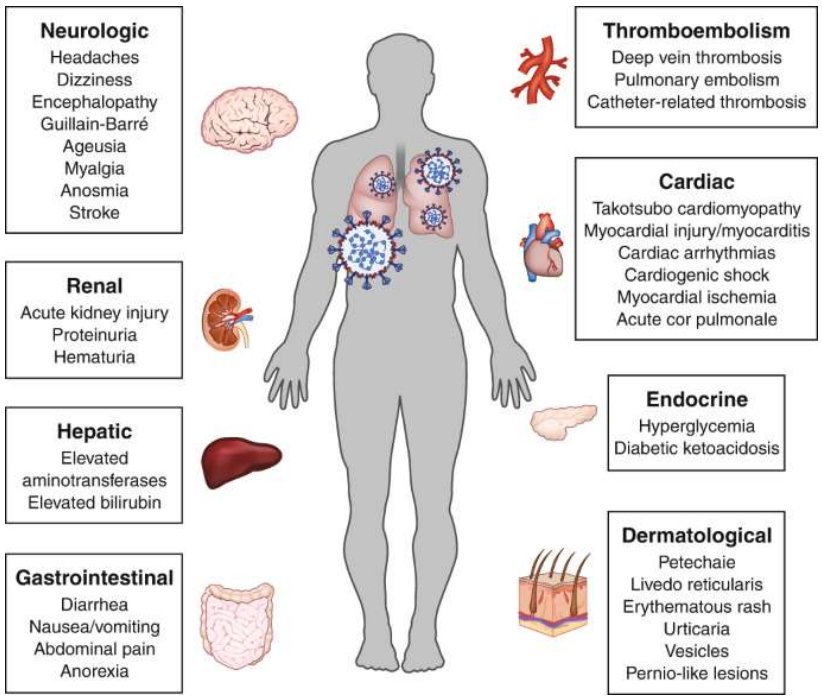


NATURE AND EVOLUTION OF SYMPTOMS

When infected by a pathogen, several symptoms may appear at different times during the illness. The number and intensity of symptoms can vary from person to person. This graph below is for illustrative purposes only.



In the case of COVID-19, a wide range of organs can be affected.

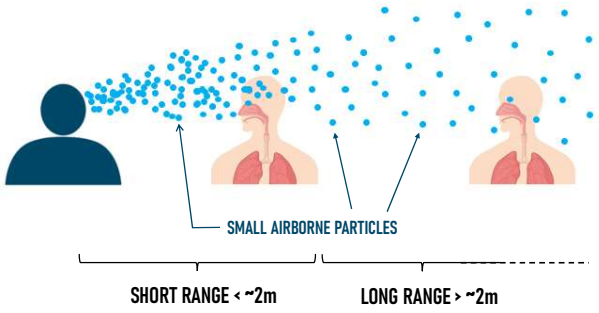


Gupta, A., Madhavan, M.V., Sehgal, K. *et al.* Extrapulmonary manifestations of COVID-19. *Nat Med* **26**, 1017–1032 (2020). https://doi.org/10.1038/s41591-020-0968-3

HOW ARE AIRBORNE DISEASES TRANSMITTED?
THE ROLE OF INFECTIOUS RESPIRATORY PARTICLES

BY BREATHING SMALL AIRBORNE PARTICLES

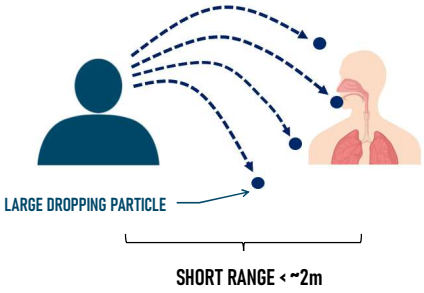
INHALATION AND DEPOSITION OF PARTICLES IN THE UPPER RESPIRATORY TRACT



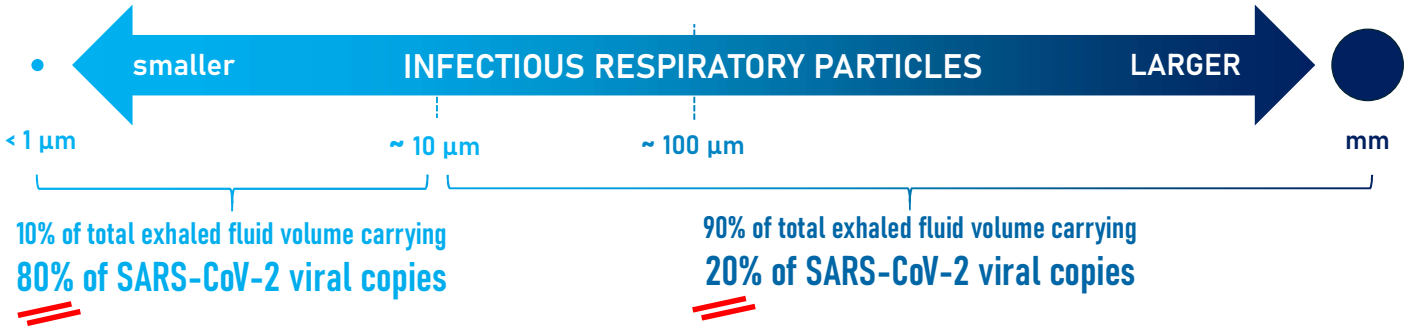
- transmission by airborne particles (also known as "aerosols")
- trajectories are influenced by airflow
- suspended in the air, sometimes for hours
- can travel long distances

BY RECEIVING LARGE DROPPING PARTICLES

DEPOSITION OF PARTICLES ON THE MUCOUS MEMBRANES OF THE MOUTH, NOSE, EYES



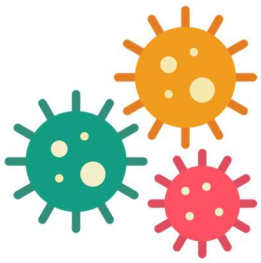
- transmission by semi-ballistic particles (also known as "droplets")
- trajectories are governed by gravity
- fall quickly after travelling a few meters
- do not travel long distances



Infectious Respiratory Particles exist on a continuous spectrum of sizes (from sub-microns to millimeters in diameter) and their behavior and trajectories in the air depend on several parameters : ambient air temperature, velocity, humidity, sunlight (ultraviolet radiation), airflow distribution within a space...

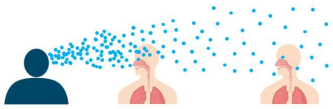
The two diagrams above are a simplified representation, showing the behavior of physical particles from the smallest (left) and largest (right) in size. The transition from one behavior to another is continuous, with hybrid and often complex overlap. The two routes correspond to « Inhalation » and « Direct deposition » modes of transmission, as defined by the WHO.

The limits of 10µm and 100µm and percentages are approximate and serve as an indication.

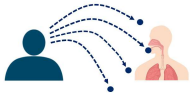


TERMINOLOGIES FOR DISEASES THAT TRANSMIT THROUGH THE AIR

Numerous terminologies have been used in the past to describe the two routes of contamination: inhalation and direct deposition. These terminologies have evolved over time and vary according to the disciplines concerned (physics, health, etc.). Here are a few examples of terminology found in articles or reports:

Mode of contamination: Inhalation	Mode of contamination: Direct deposition
	
SHORT & LONG RANGES AIRBORNE PARTICLES	SHORT RANGE SEMI-BALLISTIC PARTICLES
AIRBORNE PARTICLES	BALLISTIC PARTICLES
World Health Organization	INFECTIOUS RESPIRATORY PARTICLES
AEROSOLS / DROPOSOLS	DROPLETS
AEROSOL PARTICLES	LARGER DROPLETS
BIOAEROSOLS / VIROSOLS	DROPLETS
AIRBORNE DROPLETS	BALLISTIC DROPLETS
AIRBORNE DROPLET NUCLEI	DROPLETS

To make it easier for non-specialists to discover the subject, we recommend using the following terms:

	
SMALL AIRBORNE PARTICLES	LARGE DROPPING PARTICLES

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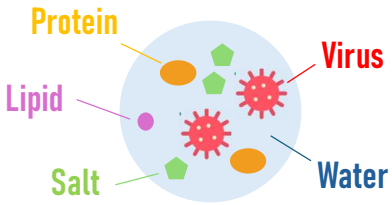
WHAT IS AN AEROSOL ?

Aerosol refers to the suspension, in a gaseous medium (air, in most cases), of liquid or solid particles, or both, with negligible limit falling velocity. In air, under normal conditions, this corresponds to particles between a few fractions of a nanometer and 100µm in size. The aerosol is therefore a two-phase system formed by particles and the carrier gas. Nevertheless, the term aerosol is often used in practice to refer only to particles in the air.

in "Les aérosols physique et métrologie", Boulaud, D. and A. Renoux, Paris, Tec Doc Lavoisier(1998)

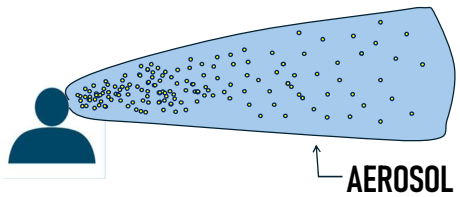
Bioaerosols (short for biological aerosols) are aerosols whose airborne particles contain living microorganisms (viruses, bacteria, molds and protozoa) and substances or by-products derived from these organisms. In the case of a virus, the composition of an airborne infectious particle will be as follows:



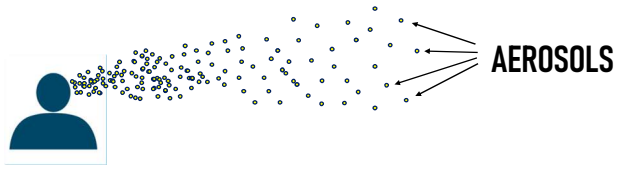
Components of an airborne infectious particle

In scientific literature, aerosol (or bioaerosol) describes a group of particles or cloud, but also designates each particle or "aerosol (bioaerosol) particle"; this can lead to confusion and inaccuracy :

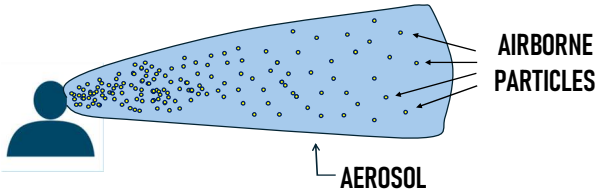
AEROSOL SEEN AS A CLOUD OF PARTICLES



AEROSOLS SEEN AS AIRBORNE PARTICLES



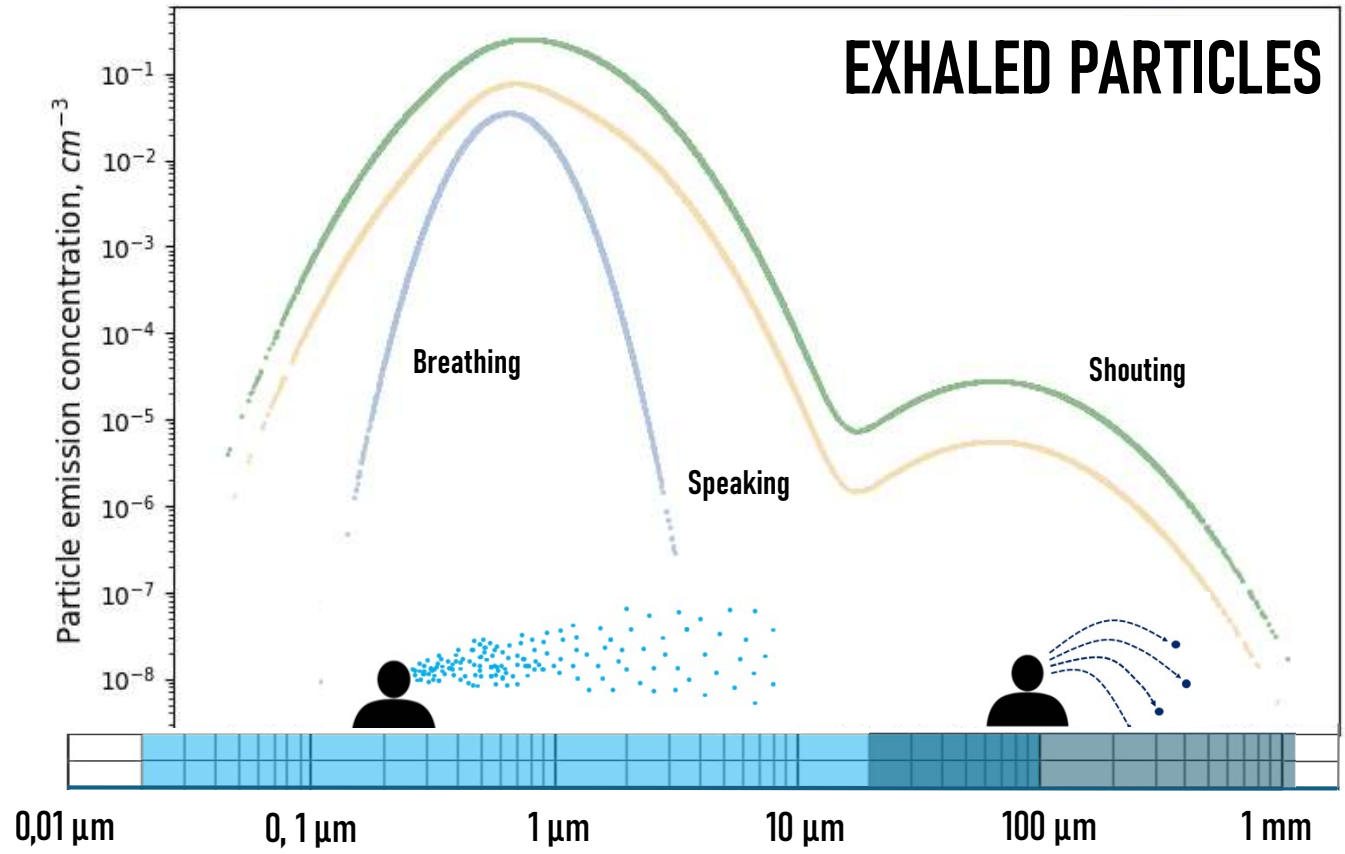
Our recommendation: it is preferable to use the term 'aerosol' ('bioaerosol') to designate the cloud of particles suspended in the air, and to refer to the constituents of this aerosol (bioaerosol) cloud as "Particles". We can then specify that these are "airborne particles".



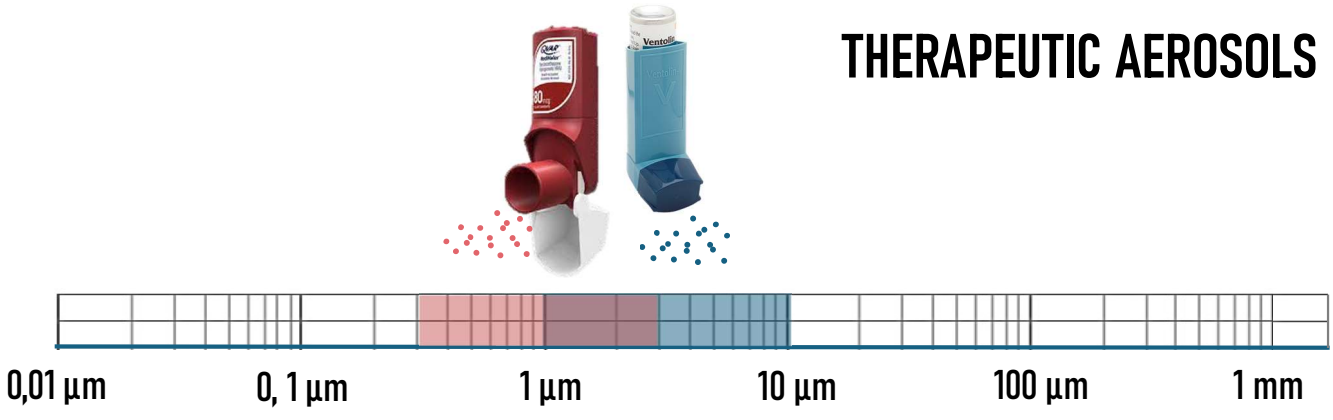
An aerosol is made up of airborne particles.

EXHALED PARTICLE SIZE

The number of particles exhaled by a human depends on the size considered. These particles are generated in different parts of our anatomy, which explains the variations in size. Their distribution and number depend on the activity performed: breathing, speaking, shouting.



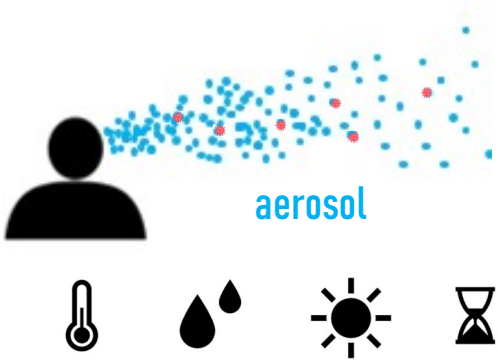
Airborne infectious particles are well suited to being inhaled into our lungs. Some of these particles are the same size as those making up the therapeutic aerosols generated by inhalers, designed to target certain parts of the lungs.



INFECTIONS & RISKS

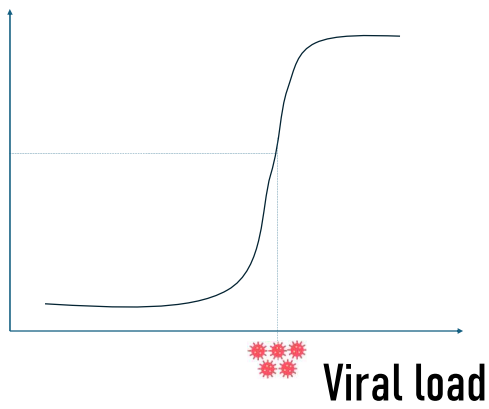
VIRAL LOADS

- Carried by airborne infectious particles.
- A virus may be more present in small particles.
- Load depends on particle size, time, temperature, humidity, UV exposure, ...



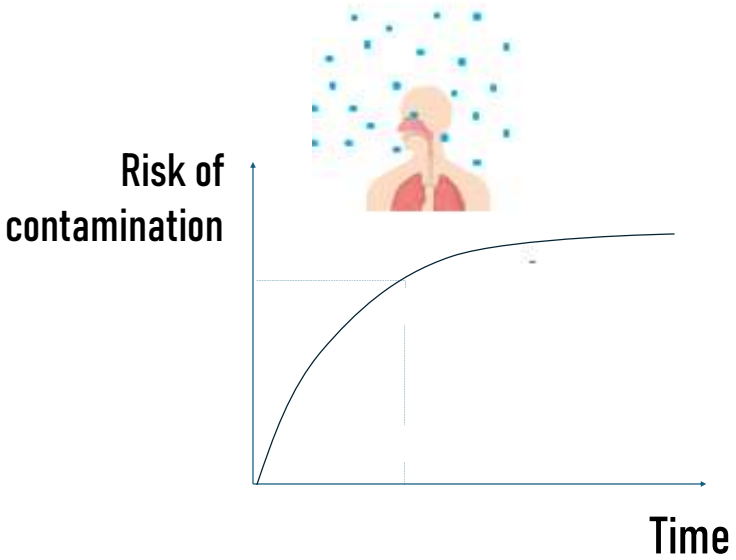
INFECTIOUS DOSE

- Depends on virus type/variant,
- Depends on receptor type and localization
- For a given viral load, we rather define a probability of infection



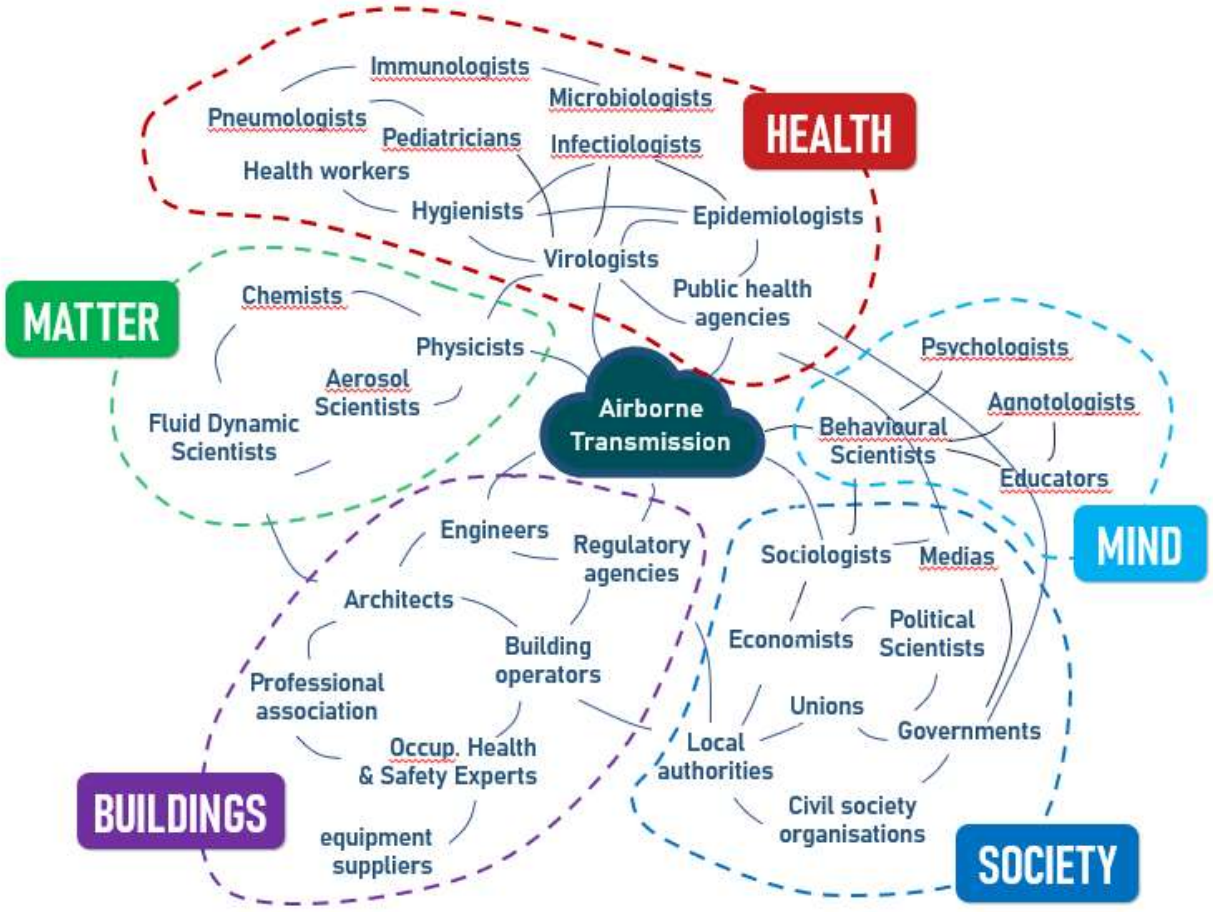
RISK ASSESSMENT

- Depends on the person
- Depends on exposure conditions
- Depends on exposure time
- ...



PREVENTION STAKEHOLDERS

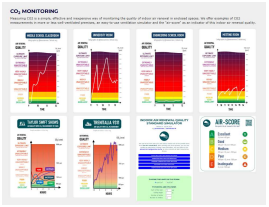
The means of limiting airborne contamination are well known, and in some cases have been for over a century: masks, ventilation of premises, air filtration. The difficulty in implementing these measures, particularly in buildings open to the public, is the large number of stakeholders involved. Below, we have attempted to model the main stakeholders involved in airborne contamination.



FOR FURTHER INFORMATION

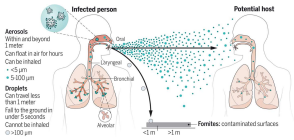
letsair.org

This is our website with information and infographics on CO_2 monitoring, ventilation and air filtration.



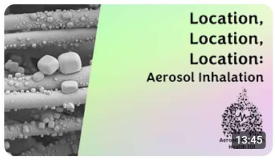
Chia C. Wang et al. paper

An excellent introduction to airborne transmission of respiratory viruses



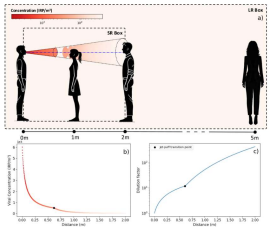
Al Haddrell's YouTube Channel

This aerosol scientist offers short, clear and accessible instructional videos to help you understand the many scientific aspects of airborne transmission and aerosol inhalation.



Andre Henriques et al. paper

A very clear and didactic article on the risks of airborne contamination. If you want to know more about aerosol science and simulation models, we recommend you start with this article.

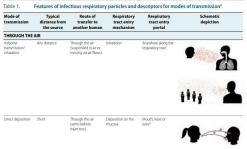


Pr Clive Beggs hearing at UK COVID-19 inquiry

During the hearing, Prof. Beggs described the difficulties of having inhalation transmission recognized as the main mode of contamination for COVID-19. He reports on the latest research in this field.

WHO report on proposed terminology

The World Health Organization has published a document proposing a terminology for pathogens that transmit through the air. Our scientific mediation document, which you are now reading, attempts to be compatible with this report.



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