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Biological hazards

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At the end of the course, you will be able to:

- ✓ Define biological agents in the context of occupational health
- ✓ Recognize routes of exposure
- ✓ Make a biological risk assessment
- ✓ Be familiar with the prevention and control measures
- ✓ Connect environmental health challenges to the broader One Health and climate change perspectives.

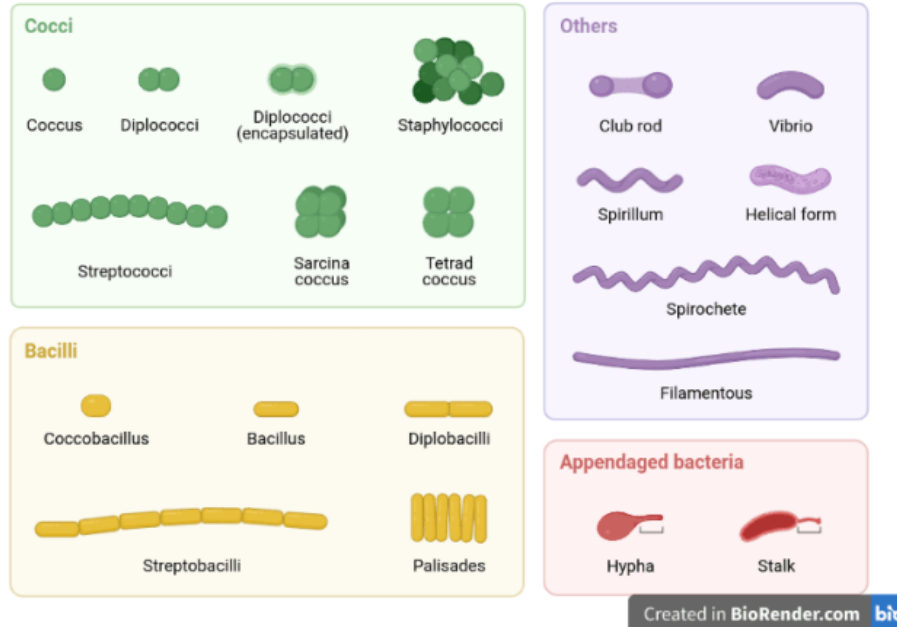
Definitions

Biological pollutants are living organisms or substances derived from living organisms that can adversely affect human health by causing

- infection,
- allergy or
- intoxication.

Biological agents

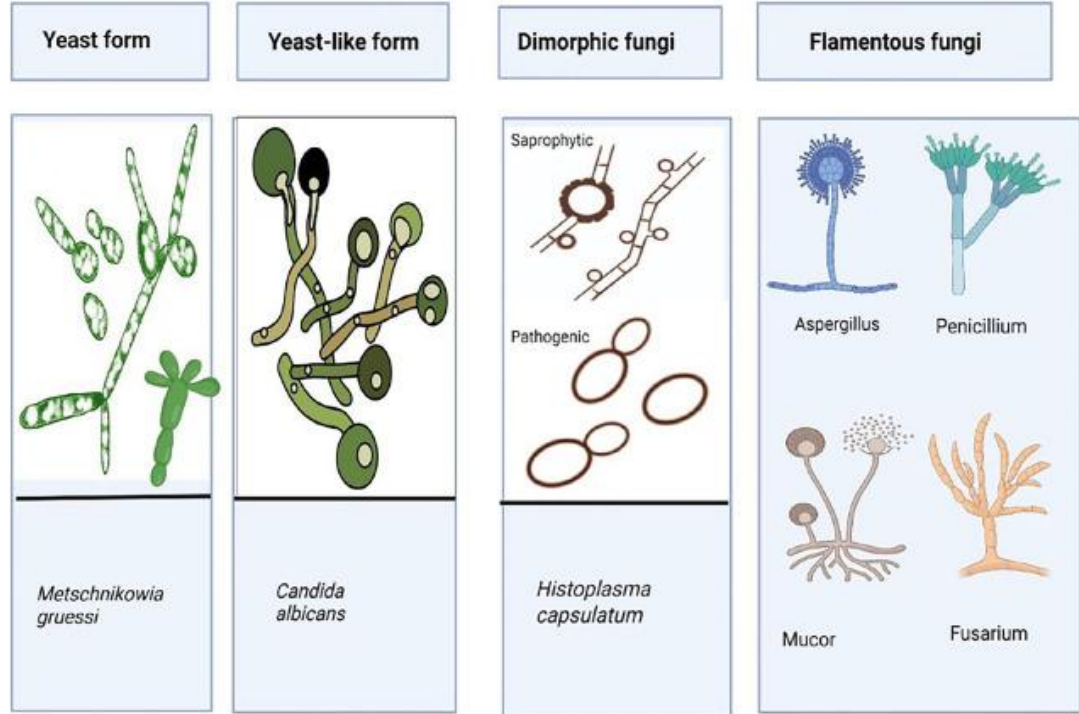
Bacteria (1 to 10 microns) lack a true nucleus and membrane-bound organelles. Their genetic material consists of a single circular DNA molecule located in a region called the nucleoid.



Biological agents

Fungi (1 to 100 microns)

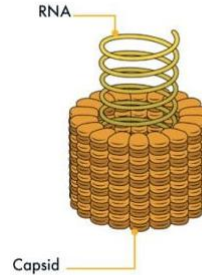
eukaryotes that are characterized by the presence of chitin in the cell wall.



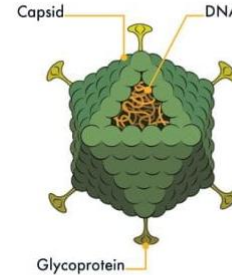
Biological agents

Virus (20 nm – 250 nm) are acellular infectious agents made of genetic material and a protein coat that requires a host cell to replicate

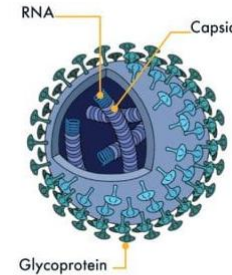
Types of Viruses



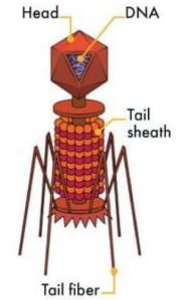
Helical viruses, like the Tobacco Mosaic Virus, which infects a number of different types of plants, have a slinky-shaped capsid that twists around and encloses its genetic material.



Polyhedral viruses, like adenoviruses, which are known to cause a range of illnesses from pink eye to pneumonia, are composed of genetic material surrounded by a many-sided capsid, usually with 20 triangular faces.



Spherical viruses, like the infamous Coronavirus, are essentially helical viruses enclosed in a membrane known as an envelope, which is spiked with sugary proteins that assist in sticking to and entering host cells.



Complex viruses, like bacteriophages, which infect and kill bacteria, resemble a lunar lander, and are composed of a polyhedral “head” and a helical body (or “tail sheath”), and legs (or “tail fibers”) that attach to a cell membrane so that it can transfer its genetic material.

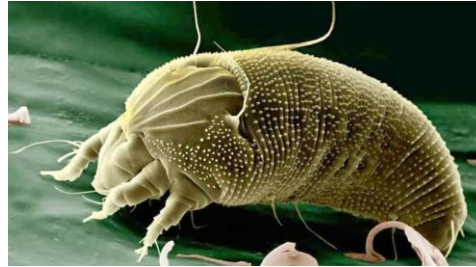
Biological agents

Protozoa (8–10 microns)

Toxoplasma gondii (toxoplasmosis)



Mites (200 micrometers to 3 millimeters)



Biological agents are living organisms

Species specificity

- Whooping cough (*Bordetella pertussis*) in humans
- Brucellosis (*Brucella spp.*) in ruminants and humans
- Foot-and-mouth disease in cattle, goats, and sheep

Specific environmental conditions (humidity level, light, temperature)

Legionella pneumophila multiplies in fresh water at temperatures between 25°C and 45°C and at pH values between 5.6 and 9.6.

Nutritional requirements

Some bacteria feed on hydrocarbons and can be used for bioremediation, while others feed on organic or mineral matter.

Reproduction

Baker's yeast, *Saccharomyces cerevisiae*, doubles its population in 24 hours at 37°C.
The bacterium *Escherichia coli* doubles its population in 30 minutes at 37°C.

Limited lifespan

Influenza viruses survive only a few hours in dried secretions.
Pathogenic leptospires do not multiply in the external environment, but they can survive for up to six months in water or muddy soils with a slightly alkaline pH, very low salinity, and protected from sunlight.

The effects on health

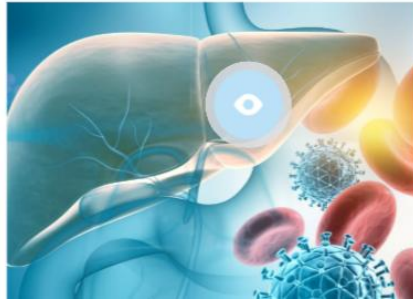
4 Types of Risks



DISEASE
CAUSED
BY TOXINS



INFECTION



CANCER



ALLERGY

Risk of Infection


Mechanism: Entry and subsequent multiplication of a biological agent in the body

Examples: Influenza, Hepatitis B, Leptospirosis, Tuberculosis

Host specificity

Route of entry

Mode of transmission

Si Route of penetration = Mode of transmission  Contamination

Quantity of biological agents
Host immune status

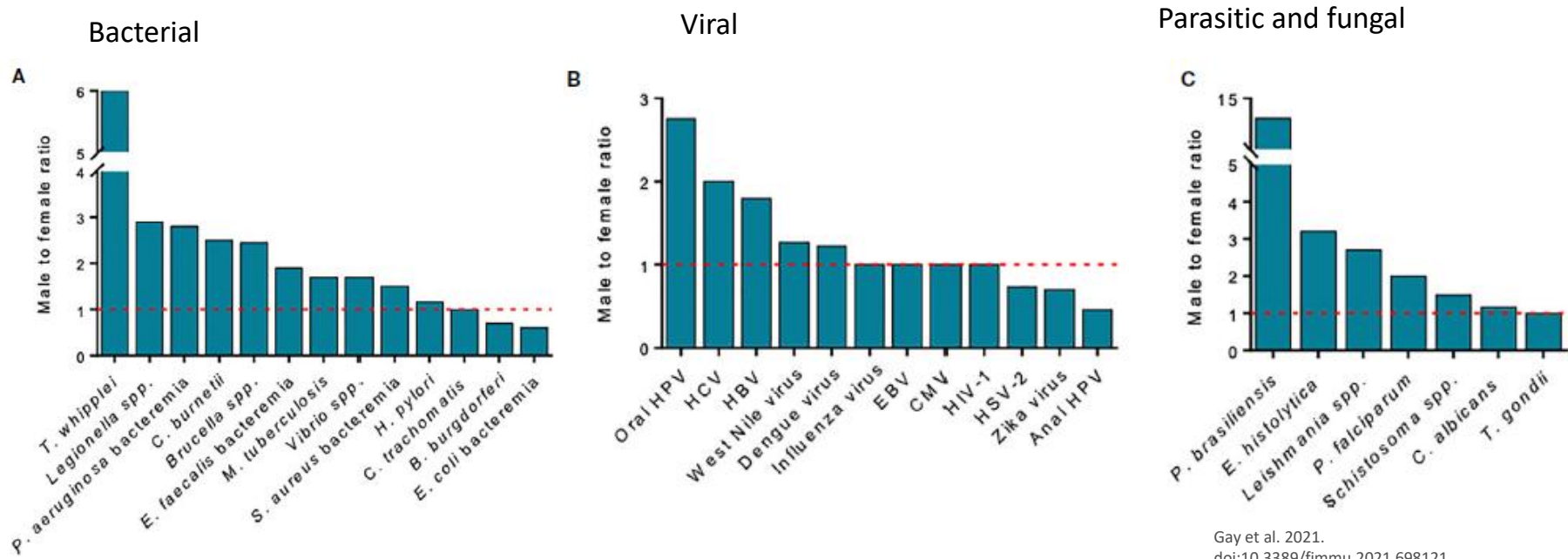


Development of an infection

Immunity and infection

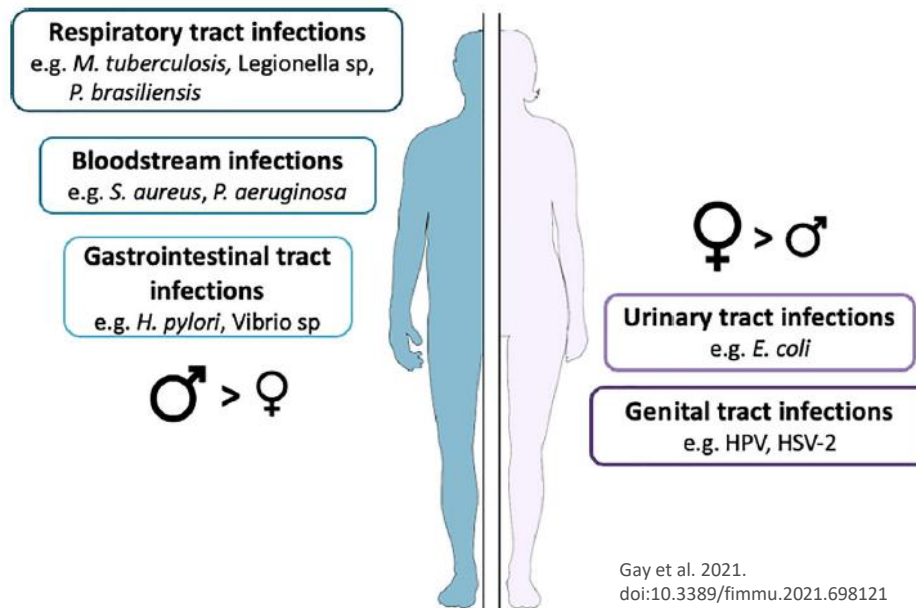
- Development of immunity (previous exposure)
- Acquisition of immunity (vaccination)
- Decrease in immunity – opportunistic infection

Prevalence of infections according to sex

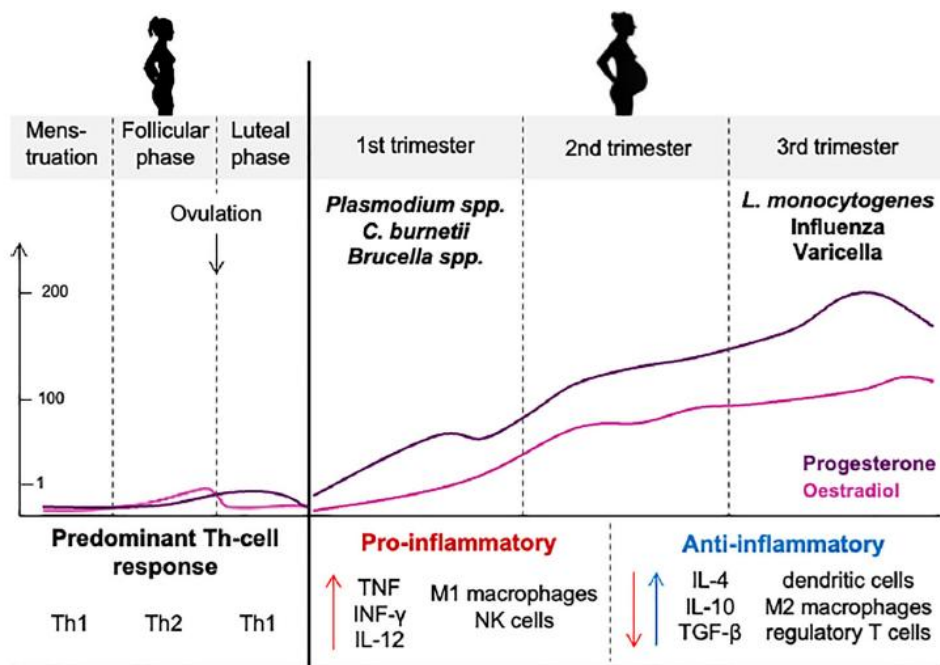


Gay et al. 2021.
doi:10.3389/fimmu.2021.698121

Prevalence of infections according to anatomical characteristics



Evolution of susceptibility to infections

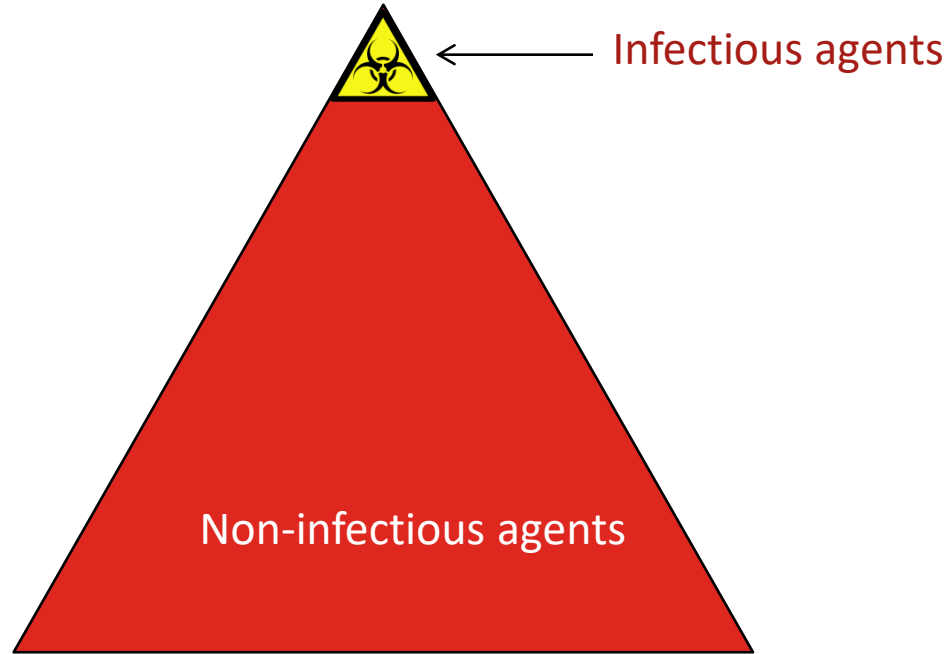


The increase in hormone levels during pregnancy contributes to the immune system changes necessary for a successful pregnancy, but it also increases women's susceptibility to infectious diseases.

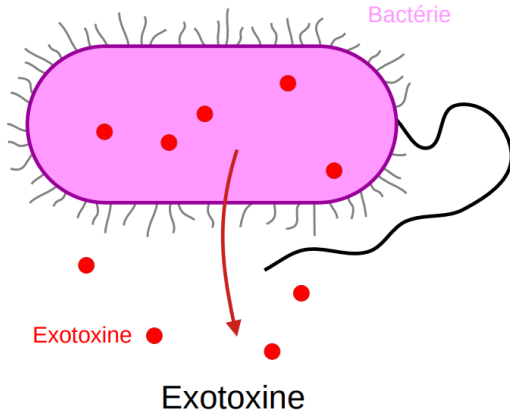
Pregnant women are:

- 7 times more likely to be hospitalized,
- 2 times more likely to die from influenza virus,
- 3 times more likely to develop severe dengue as well as fatal *Plasmodium falciparum* infections than non-pregnant women.

Infectious vs. Non-infectious

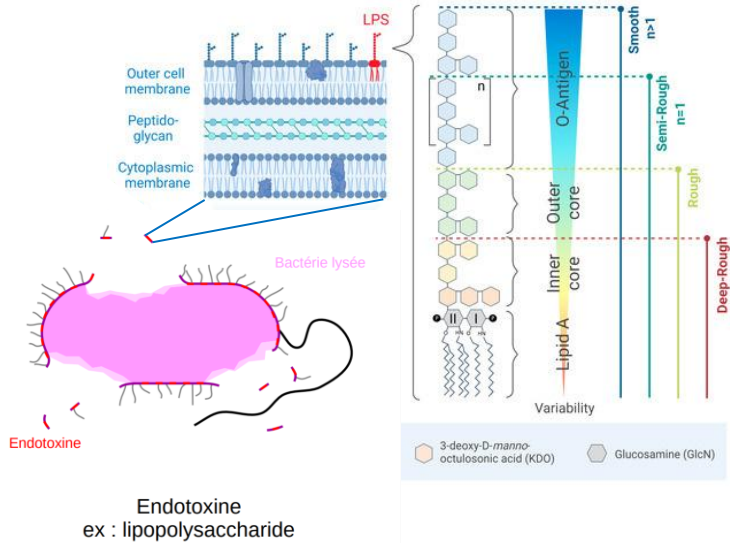


Toxic risks



	Exotoxin
Species that produce the toxin	<ul style="list-style-type: none"> Some species of gram-positive and gram-negative organisms
Method of release	<ul style="list-style-type: none"> Actively secreted
Gene location	<ul style="list-style-type: none"> Plasmid or bacteriophage
Toxicity level	<ul style="list-style-type: none"> High toxicity
Vaccines	<ul style="list-style-type: none"> Available for some toxins in the form of toxoids
Properties	<ul style="list-style-type: none"> Heat-labile
Examples	<ul style="list-style-type: none"> <i>Vibrio cholera</i> <i>Diphtheria</i> <i>Salmonella</i> <i>Shigella</i> <i>Clostridium tetani</i> <i>Clostridium botulinum</i> <p style="text-align: right;">} Enterotoxins } Neurotoxins</p>

Toxic risks



	Endotoxin
Species that produce the toxin	<ul style="list-style-type: none"> ○ Gram-negative organisms ○ Listeria
Method of release	<ul style="list-style-type: none"> ○ Bacterial cell lysis or fragmentation
Gene location	<ul style="list-style-type: none"> ○ Bacterial chromosome
Toxicity level	<ul style="list-style-type: none"> ○ Low toxicity
Vaccines	<ul style="list-style-type: none"> ○ No vaccines available
Properties	<ul style="list-style-type: none"> ○ Heat-stable
Examples	<ul style="list-style-type: none"> ○ <i>Neisseria meningitidis</i> ○ <i>Escherichia coli</i> ○ <i>Pseudomonas</i>

Massive exposure through inhalation of contaminated dust

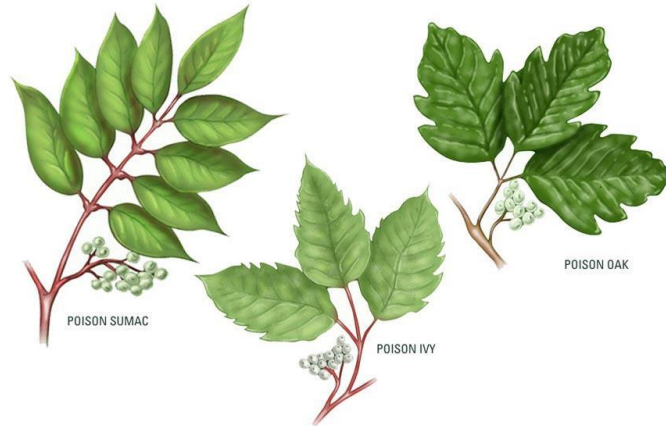
Symptoms similar to influenza, including fever, myalgia, and one or more respiratory symptoms.

Toxic risks

Direct contact



GIANT HOGWEED



POISON SUMAC

POISON IVY

POISON OAK

Manifestations:



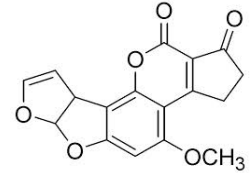
Occupational cancers

Cancer = a malignant tumor formed by the uncontrolled multiplication of cells

Agents responsible for liver cancer:

Viral infection: Hepatitis B virus (HBV)

Exposure to mycotoxins: Prolonged exposure to aflatoxins can promote cancer development.



Cancer risk and occupational exposure to aflatoxins in Denmark:

Daily intake for workers via the respiratory route of approximately 170 ng
Liver cancer and for cancers of the biliary tract increased by two- to three-fold
significance after a 10-year latency

Allergic Risks

Allergy = a person's hypersensitivity to a substance present in the environment that is harmless to the majority of people.

In the **workplace**, biological agents that cause sensitization are mainly transmitted **via the respiratory route**.

Manifestations:

- Rhinitis
- Asthma
- Hypersensitivity pneumonitis

Occupational allergies

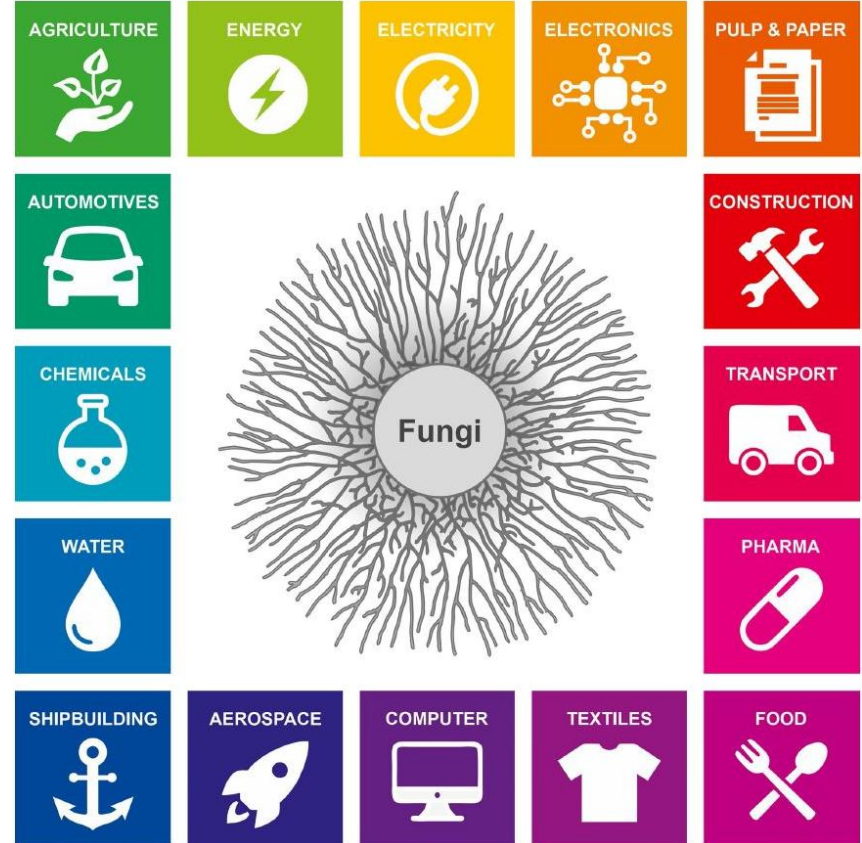
Bacteria: Enzymes like subtilisins in detergents or impurities like grain weevils in flour.

Fungi: Spores and metabolites from molds or fungi used in industry.

Industries profiting from the metabolic capacities of filamentous fungi

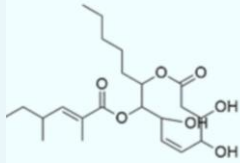
Meyer *et al.* 2020

<https://doi.org/10.1186/s40694-020-00095-z>

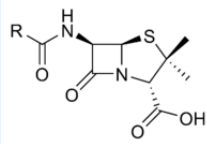


Fungal metabolites

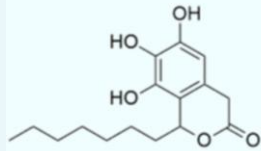
Antibiotics



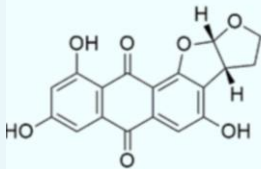
Phomol



Penicillin

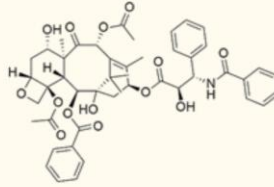


Cytosporone D

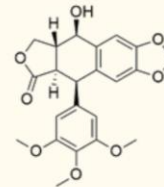


Isoversicolorin C

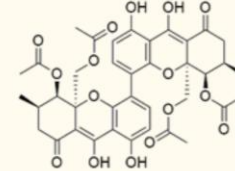
Anticancer



Paclitaxel

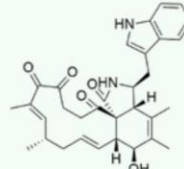


Podophyllotoxin

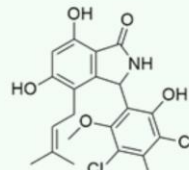


Phomoxanthone A

Antifungal

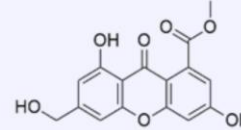


Chaetoglobosin G

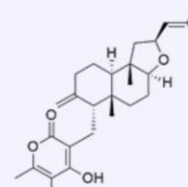


Pestalachloride A

Immunosuppressants

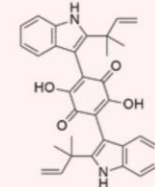


Conioxanthone A

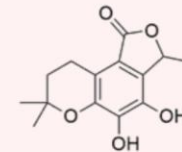


Subglutinol A

Antiviral



Hinnuliquinone



Fuscinarin

Occupational allergies

Bacteria: Enzymes like subtilisins in detergents or impurities like grain weevils in flour.

Fungi: Spores and metabolites from molds or fungi used in industry.

- **Baker's asthma:** Inhalation of airborne **alpha-amylase** dust, especially from fungal sources, is a major cause of occupational asthma among bakers.

- **Contact dermatitis:** Direct contact with alpha-amylase powder can cause skin reactions.

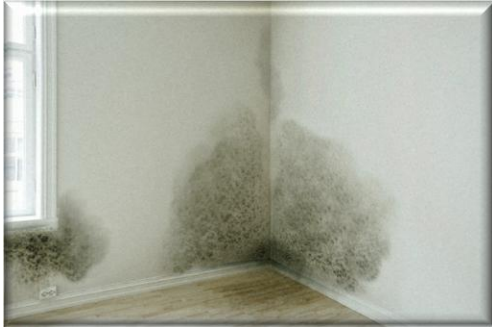
Plants: Pollen or components from flours like wheat, rye, or barley.

Arthropods: Dust and body parts from mites and insects.

Animals: Dander, bodily fluids, and other proteins from animals.

Allergens

(molds, pollen, faeces, urine, animal hair and saliva)



Swiss population suffering of allergy:

- 20% to pollen
- 6% to house dust mites
- 1 to 10% to molds
- 4% to cats and 3% to dogs

Biological Risk Assessment

Transmission Chain



Reservoirs:

Human,
Animal,
Environment: building, water, waste, soil

Transmission routes:

inhalation,
ingestion,
contact with skin or mucous membranes,
inoculation

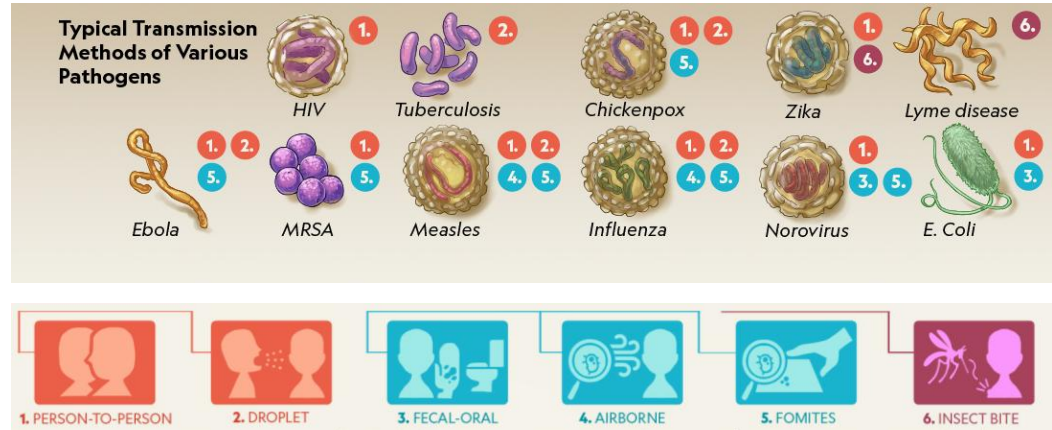
Host factors:

immunity,
specific conditions such as pregnancy or
immunosuppression

Approach to Biological Risk Assessment:

- Search for the presence of reservoirs
- Identify exposing activities

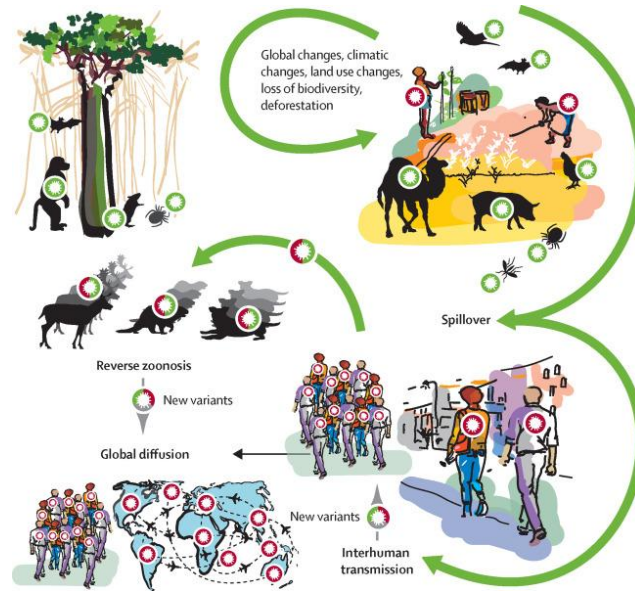
Identify the hazard = identify the reservoir



Emergence of a zoonotic disease

For a new pathogen to become a threat to human populations, the following are required:

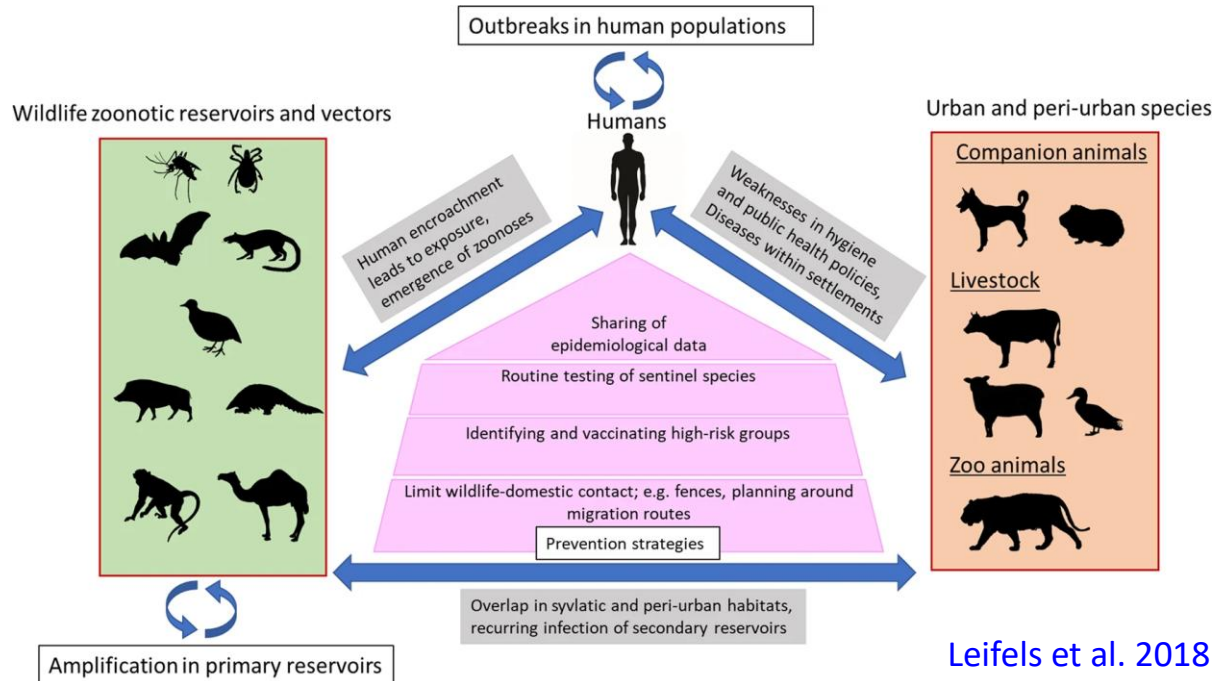
1. Contact between humans and the animal reservoir



3. Expansion of the pathogen's geographic range beyond the initial zone of zoonotic transmission

2. The pathogen must possess—or develop—the ability to transmit from human to human

Identify the hazard = identify the reservoir



Leifels et al. 2018

- COVID-19
- Rabies
- *Salmonella* infection
- West Nile virus infection
- Q Fever (*Coxiella burnetii*)
- Anthrax
- Brucellosis
- Lyme disease
- Ringworm
- Ebola



Identify the hazard in Built Environment

Microorganism	Common Sources in Built Environments	Main Health Effects / Diseases
<i>Mycobacterium tuberculosis</i>	Airborne in enclosed, poorly ventilated spaces	Tuberculosis
<i>Streptococcus pneumoniae</i>	Airborne droplets in crowded or poorly ventilated areas	Pneumonia, otitis, meningitis
<i>Streptococcus pyogenes</i>	Contaminated surfaces, airborne droplets	Pharyngitis, scarlet fever, skin infections
<i>Legionella pneumophila</i>	Hot water systems, cooling towers, humidifiers	Legionnaires' disease (severe pneumonia)
<i>Pseudomonas aeruginosa</i>	Damp surfaces, biofilms in water systems	Respiratory and wound infections, especially in hospitals
<i>Aspergillus fumigatus</i>	Ventilation systems, construction dust, damp walls	Allergies, aspergillosis (lung infection)
<i>Staphylococcus aureus</i>	Human skin, surfaces, door handles, hospital equipment	Skin infections, wound infections, pneumonia, sepsis

Identify the hazard = identify the reservoir

Occupational environment : Reservoir containing a known biological agent

Healthcare settings



Biology, Biotechnology, Pharmacology
laboratories



Veterinary



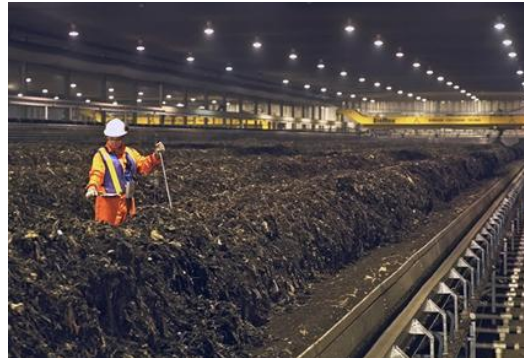
Identify the hazard = identify the reservoir

Reservoir containing an unknown biological agent

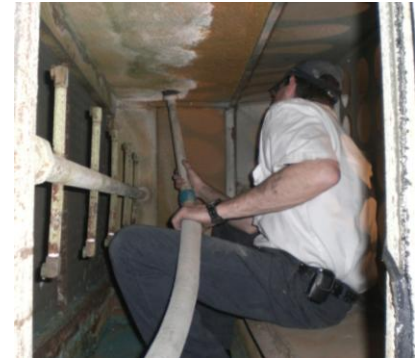
Handing food & feed



Derived materials

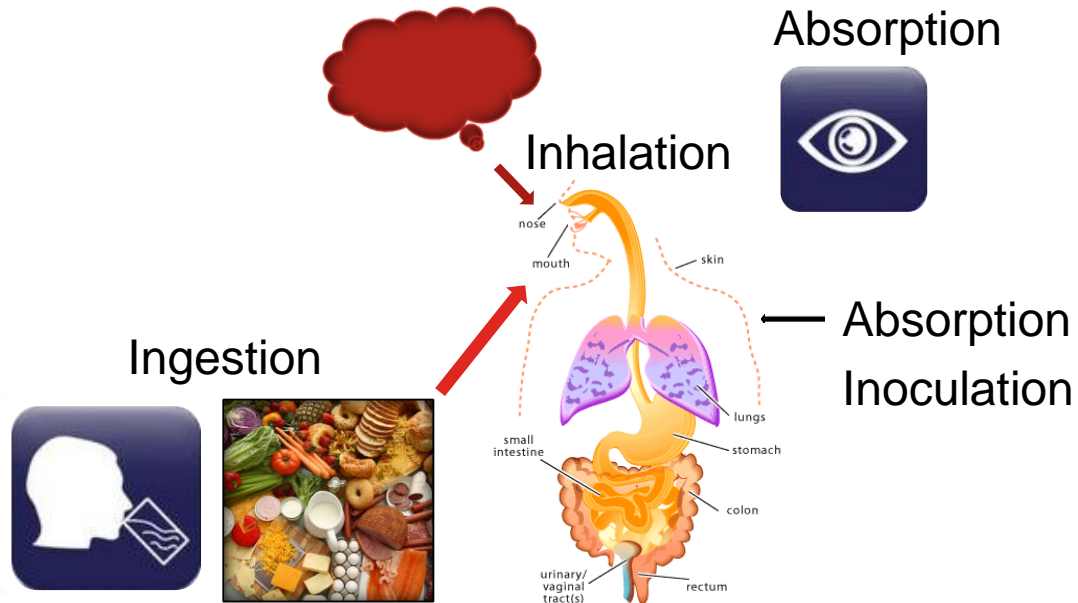


Building materials



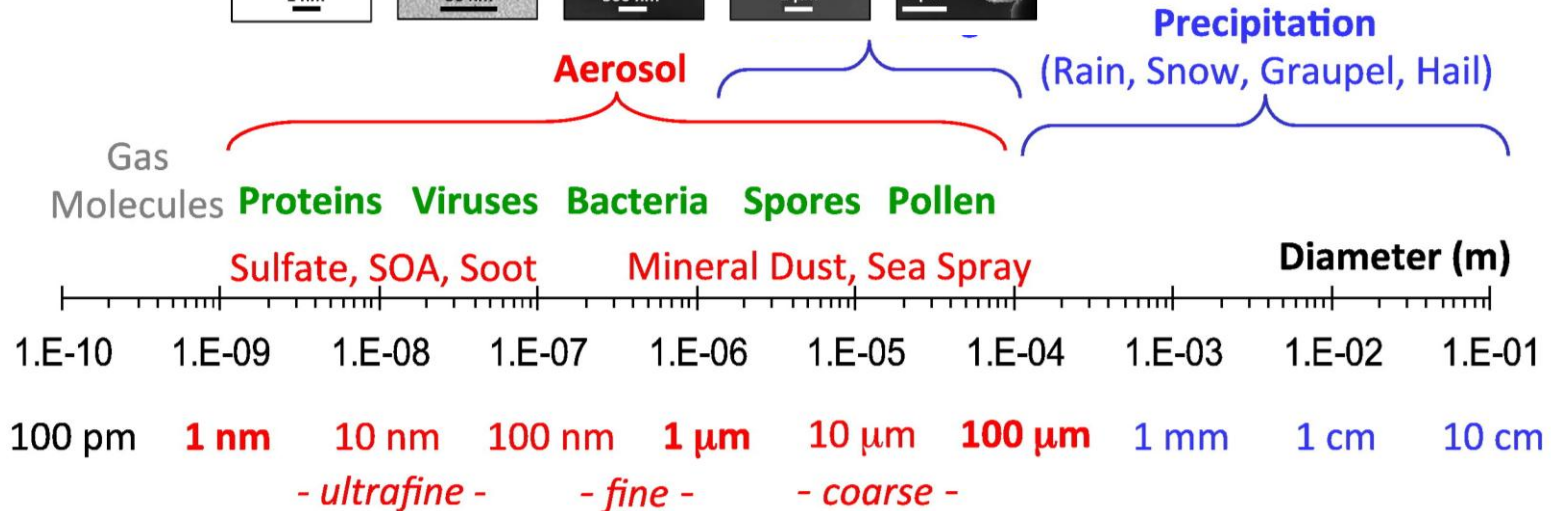
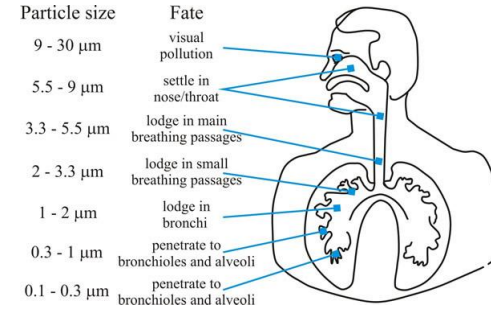
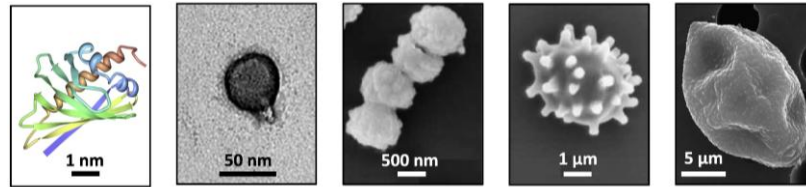
Identify exposures

Roads of exposure = road of transmission?

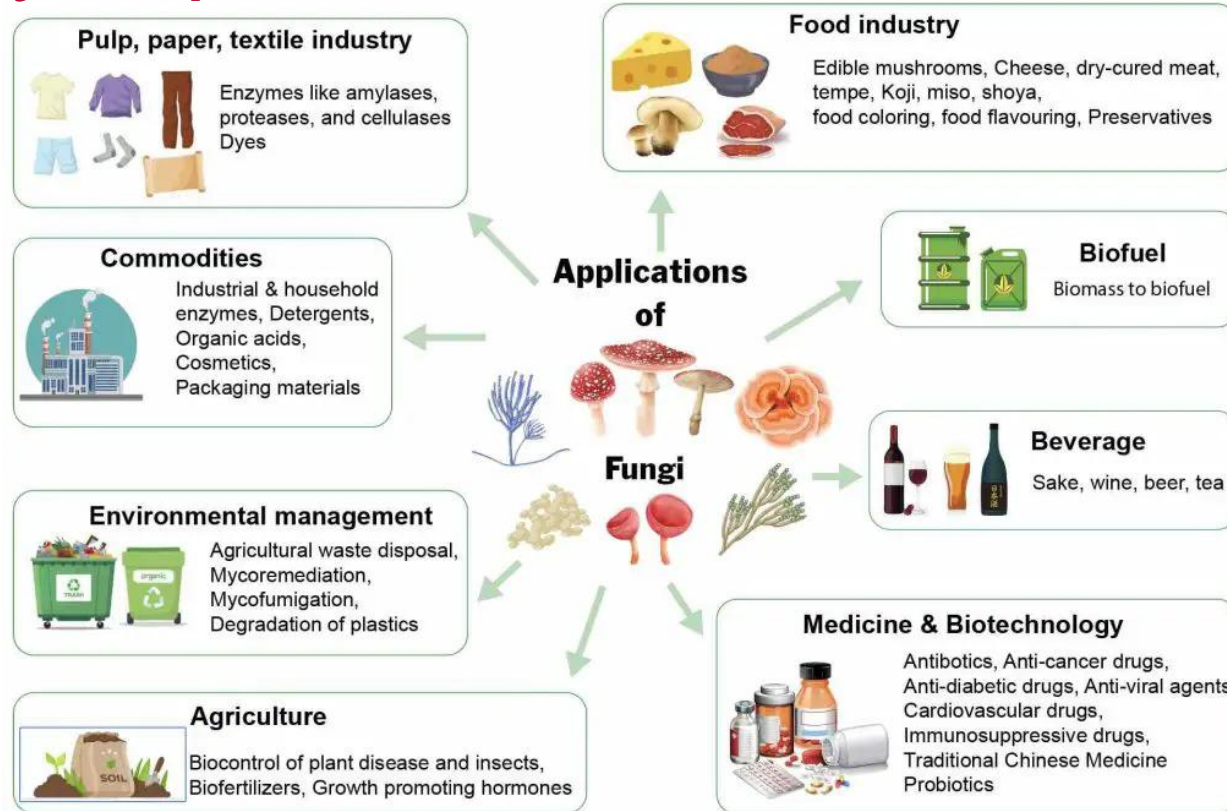


Bioaerosols

airborne particles, either living or derived from living organisms



Identify exposures



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Identify exposures

Food Items produced by Molds



Miso
- Soybeans + *Aspergillus oryzae*



Soy sauce
- Soybeans + *Aspergillus oryzae*



Oncom
- Peanuts + *Neurospora sitophila*



Tempeh
- Soy cheese + *Rhizopus oligosporus*



Red Yeast Rice
- Rice + *Monascus purpureus*



Roquefort cheese
- Cheese + *Penicillium roqueforti*



Salami
- Meat + *Penicillium spp.*



Traditional Chinese medicine
i.e., *Cordyceps sinensis*
(caterpillar fungus)

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Identify exposures

Activities in contact with human blood, body fluids and sharp objects

Blood is not dangerous in itself, but it is a vector for the transmission of many biological agents.



- Hepatitis B Virus (HBV)
- Hepatitis C Virus (HCV)
- Human Immunodeficiency Virus (HIV)

Identify exposures

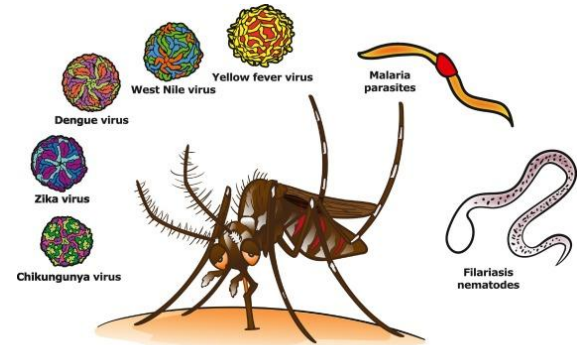
Activities at risk of Stinging & Biting



Tetanus, rabies
Oral microbiome



Lyme disease
Tick-borne encephalitis



Risk Prevention Approach

Act on the Reservoir

- Remove conditions that favor the development of biological agents (regular cleaning, functional ventilation, maintenance, etc.)
- Eliminate pathogenic biological agents (vaccination, early diagnosis, screening)
- Substitute pathogenic biological agents (biological research laboratory, biotechnology)
- Contain the reservoir of pathogenic biological agents
- Control the introduction of contaminated animals

Control of bioaerosol-related risks

Implement the **STOP** measures:

Substitution - substitute materials / change processes.

Technical/engineering - ventilation, containment, water/humidity control

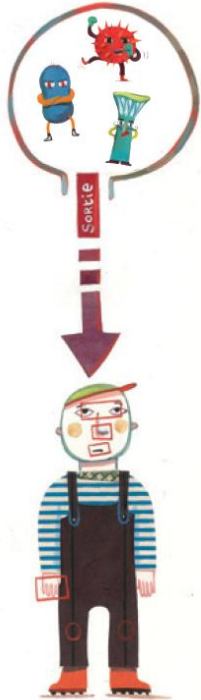
Organizational - good hygiene, training and awareness, work practices

Personal Protective Equipment (PPE) – respiratory protection, barrier protection

Propose

- Worker Vaccination
- Prophylactic treatment before traveling to an endemic area
- Treatment or vaccination after accidental exposure
- Specific precautions

Factors contributing to emerging infectious diseases

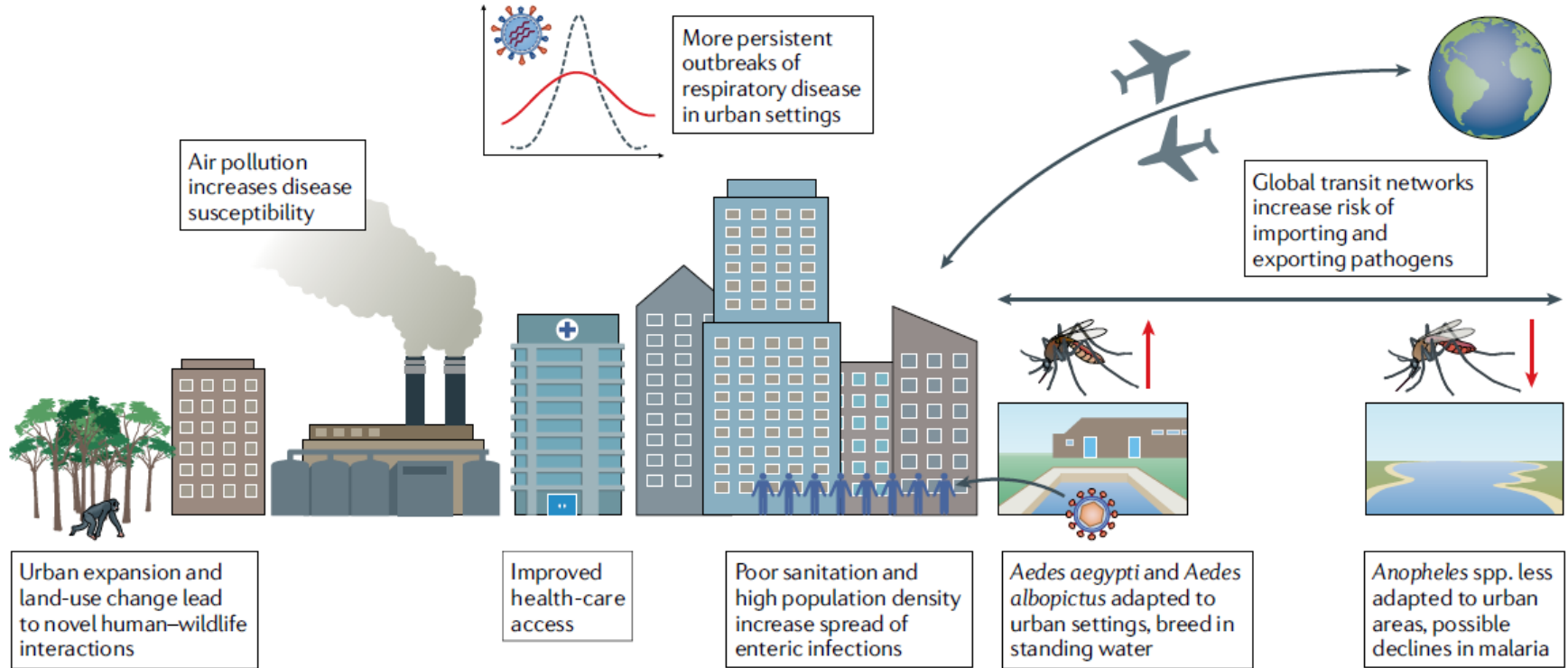


Emergence / Increase in infectiousness

Increase in exposure risk

Increase in the number of individuals susceptible to infection

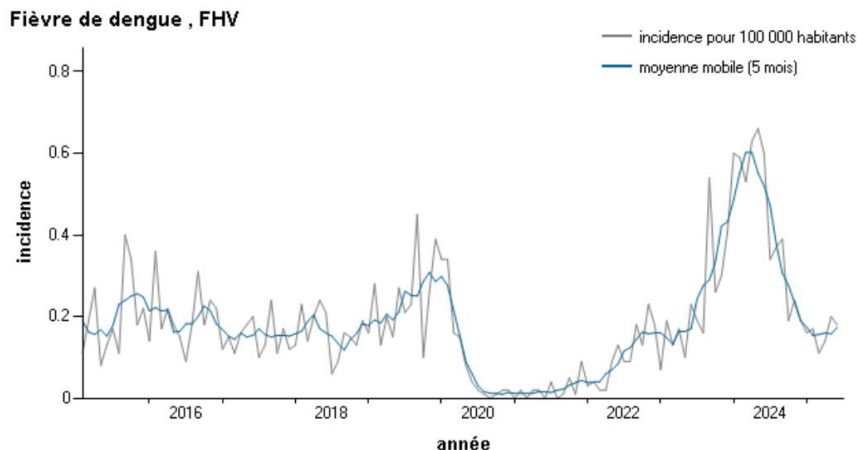
Impacts of urbanization on infectious diseases



Cases of Dengue fever in Switzerland

Introduction of dengue viruses through travel-associated cases, returning from epidemic or endemic countries.

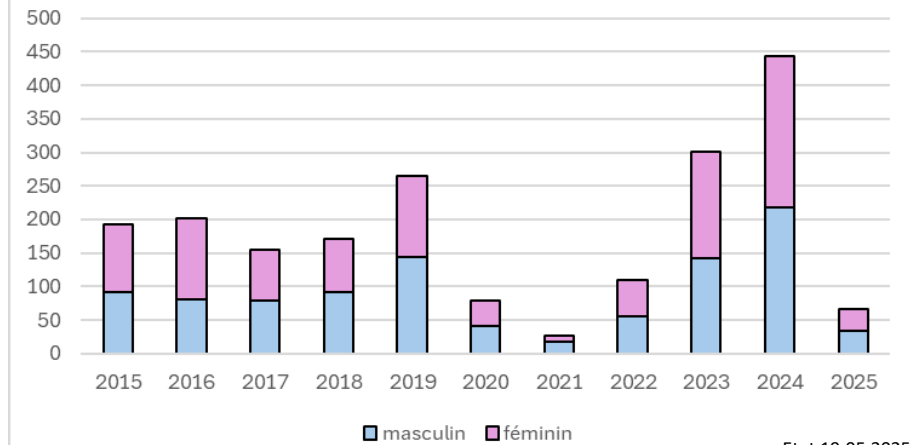
Incidences mensuelle pour 100 000 habitants



BAG OFSP UFSP SFOPH

Etat 19.05.2025

Cas déclarés de dengue selon le sexe



Etat 19.05.2025

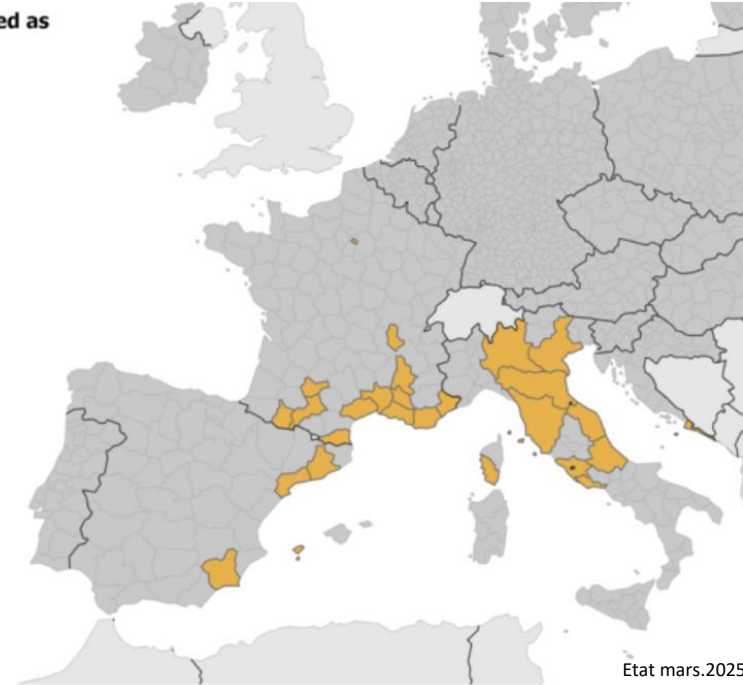
Source: BAG OFSP UFSP SFOPH

Local Transmission of the Dengue Virus in the EU/EEA, from 2010 to the Present

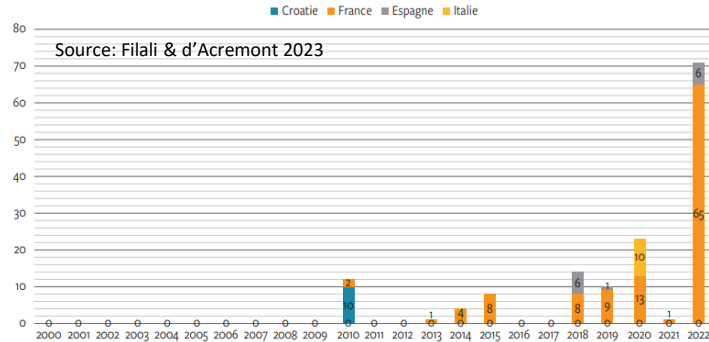
Presence of the vector
 +
 Introduction of the viruses through travel-associated cases returning from epidemic or endemic countries
 =
 Local transmission

NUTS 2 and NUTS 3 regions reported as Place of Infection since 2010

- Region of infection
- No cases reported
- Not included



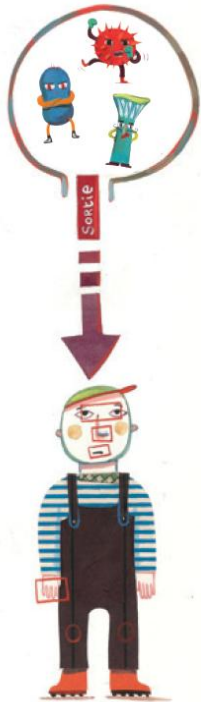
Number of locally acquired dengue cases in Europe



Source: Filali & d'Acremont 2023

Etat mars.2025
 Source: ECDC

Emerging diseases



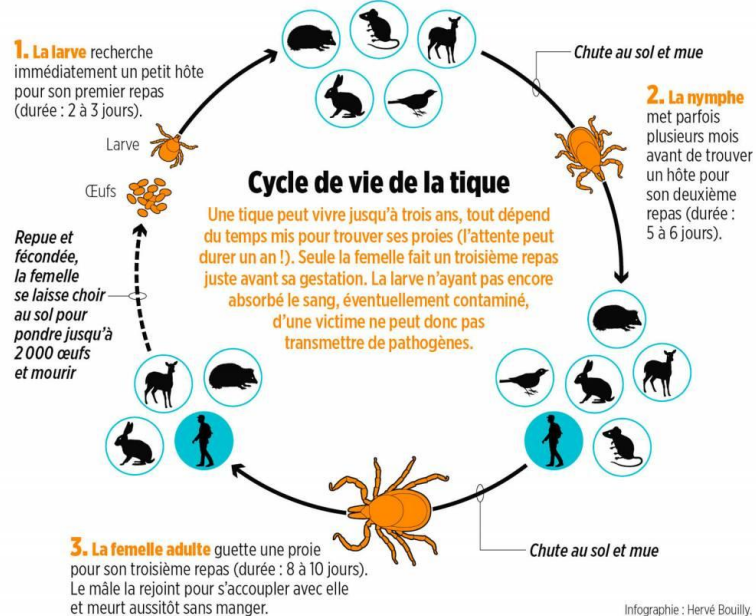
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Increase in exposure risk

Increase in the number of individuals susceptible to infection

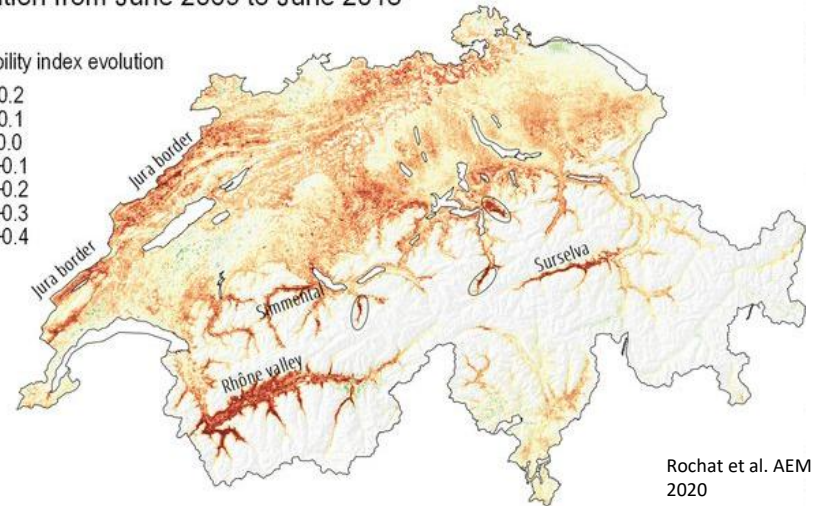
Expansion of the distribution range of the tick *Ixodes ricinus*

Ticks live in forests and grassy areas.



Evolution from June 2009 to June 2018

Suitability index evolution



- Habitat augmenté en surface de 4000 km² (passé de 16% à 25 % du territoire Suisse)
- Habitat étendu jusqu'à 2000 mètres d'altitude
- Nombre augmenté dans les régions situées entre 500 et 1000 mètres

Borreliosis (Lyme Disease)

Between 5% and 30% of ticks — and up to 50% in certain areas — carry the bacterium *Borrelia burgdorferi*. The probability of becoming infected after a tick bite is on average between 1.5% and 6%. It takes approximately 12 to 24 hours before the *Borrelia* bacteria present in the tick's intestine enter the bloodstream of the bitten person.

Clinical presentation:

Stade1:



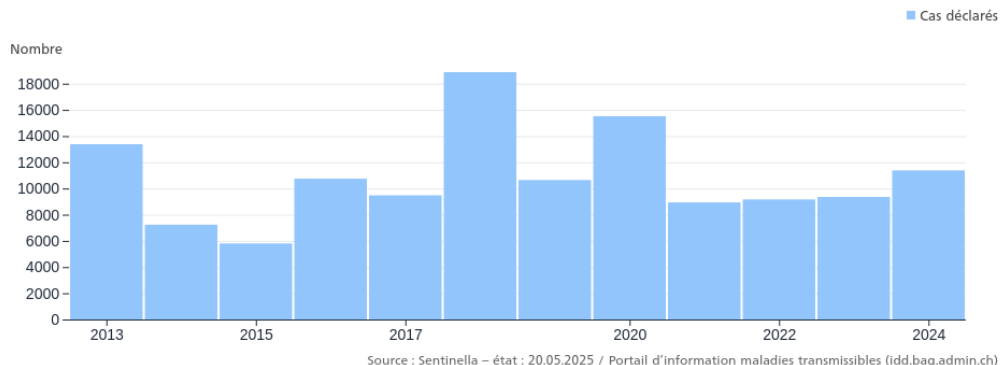
ERYTHEME MIGRANT dans 50% des cas

Stade2 et 3

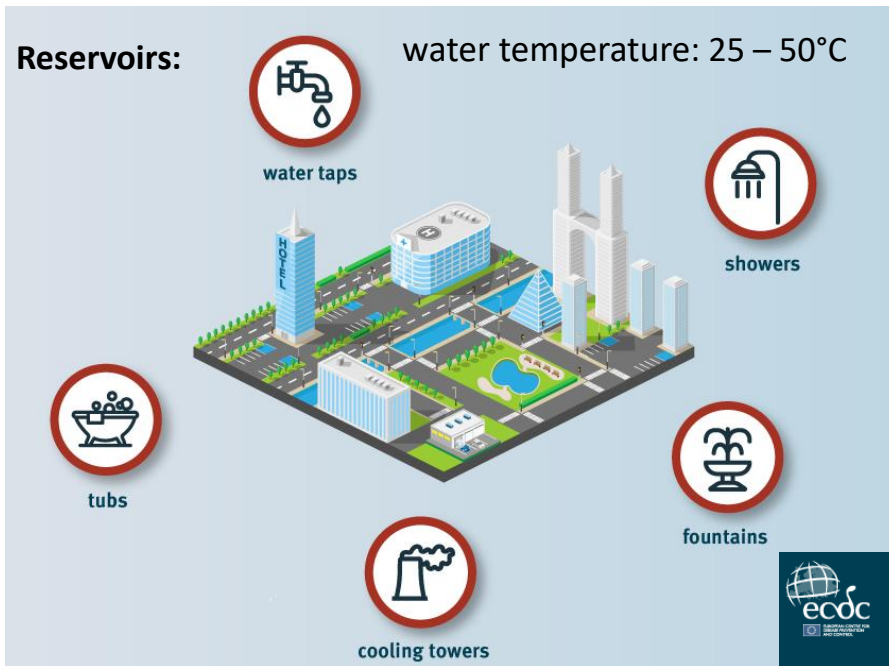
- Lyme arthritis
- Neuroborreliosis
- Acrodermatitis

Évolution temporelle des cas de borrélose

Consultations ambulatoires (extrapolation), Suisse, du 01.01.2013 au 31.12.2024



Risk of Exposure to *Legionella*



Transmission:

Emission of bioaerosols from a water reservoir contaminated by *Legionella*, through: spraying, bubbling, or high-pressure impact on a surface.

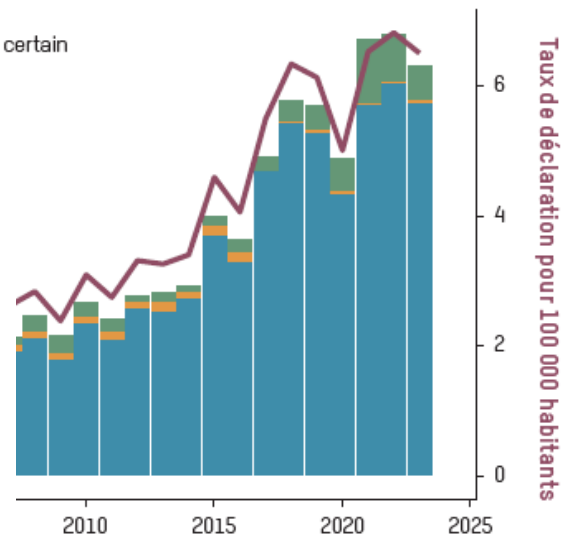
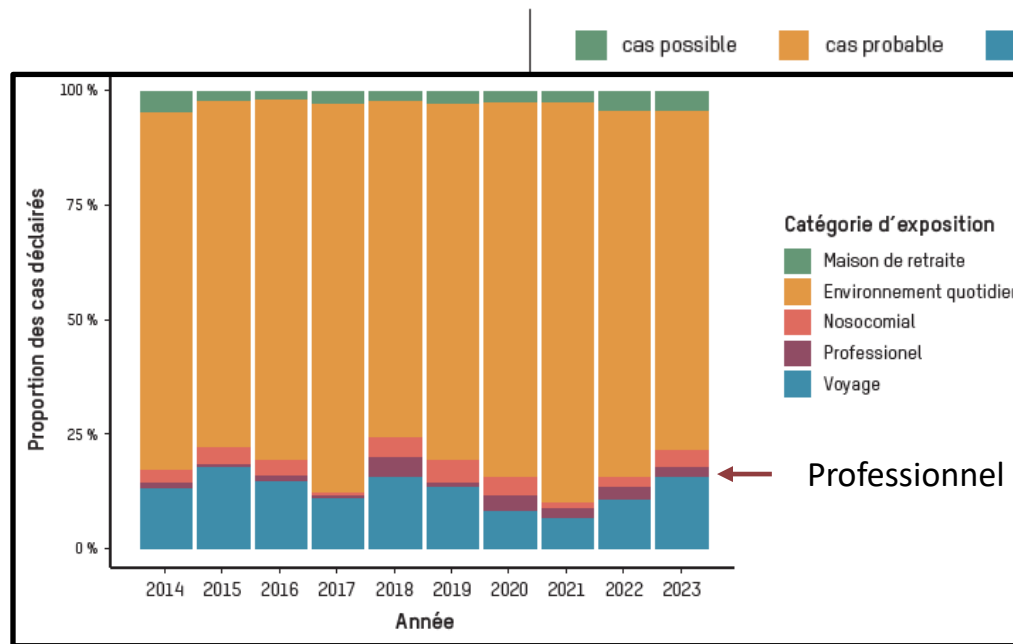
Diseases:

Pontiac fever
Legionellosis (Legionnaires' disease)

At-risk populations:

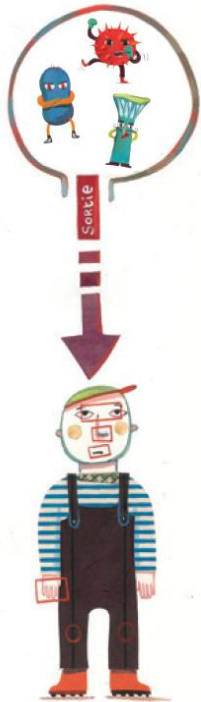
Over 50 years old
Smokers
Individuals with weakened immune systems, or
Those under immunosuppressive treatment

An increase in the number of Legionnaires' disease cases



OFSP, état : 25.07.2024 15:28

Emerging diseases



Emergence / Increase in infectiousness

Increase in exposure risk

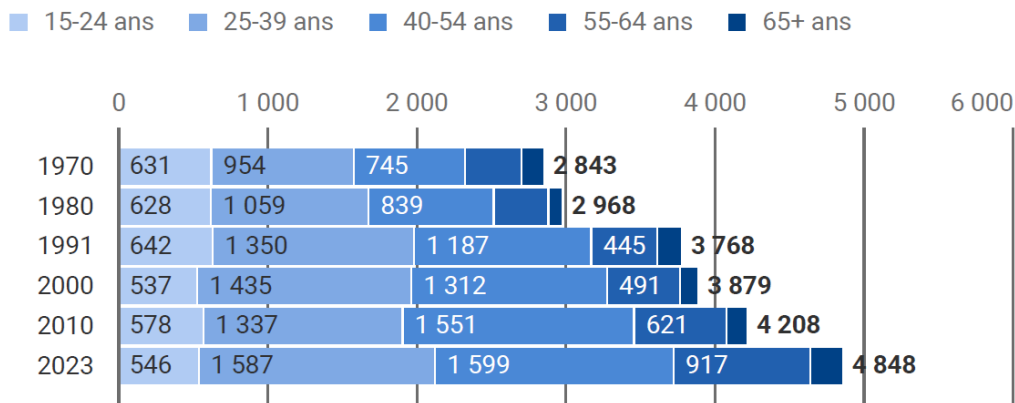
Increase in the number of individuals susceptible to infection

Aging of the Working Population

Personnes actives occupées selon l'âge

G3

En milliers, 15 ans et plus



État des données: 05.07.2024

Source: OFS – Recensement fédéral de la population (RFP) et
Enquête suisse sur la population active (ESPA)

gr-f-03.02-2345-2400-03

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Part des personnes actives occupées selon l'âge

En %, 15 ans et plus

T3

	15-24 ans	25-39 ans	40-54 ans	55-64 ans	65+ ans
1970	22,2	33,6	26,2	13,5	4,6
1980	21,2	35,7	28,3	12,4	2,5
1991	17,0	35,8	31,5	11,8	3,8
2000	13,9	37,0	33,8	12,7	2,7
2010	13,7	31,8	36,9	14,8	2,9
2023	11,3	32,7	33,0	18,9	4,1

Source: OFS – Recensement fédéral de la population (RFP)
et Enquête suisse sur la population active (ESPA)

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56% de la
population active a
> 40 ans

55

More women working in at risk occupational places

Incidence of occupationally acquired infectious diseases

High-income regions:

Men: 4.8%

Women: 32.5%

Other regions:

Men: 3.1%

Women: 20.7%

Key Messages to Remember



- Biological risks evolve with work practices, emerging pathogens, and environmental changes.



- Continuous risk assessment and regular adaptation of protective measures are necessary.



- Communication and ongoing training are major levers in a context of constant change.

? And now?

How can we sustainably adapt our protection strategies in the face of constantly evolving biological risks?

Legislation

832.321

**Ordonnance sur la protection des travailleurs contre les
risques liés aux microorganismes**

(OPTM)

du 25 août 1999 (Etat le 1^{er} janvier 2020)

Directive 2000/54/EC on biological agents

Biological agents' shall be classified into four risk groups, according to their **level of risk of infection**:

Group 1 biological agent means one that is unlikely to cause human disease

Group 2 biological agent means one that can cause human disease and might be **a hazard to workers**; it is **unlikely to spread** to the community; there is usually effective prophylaxis or treatment available;

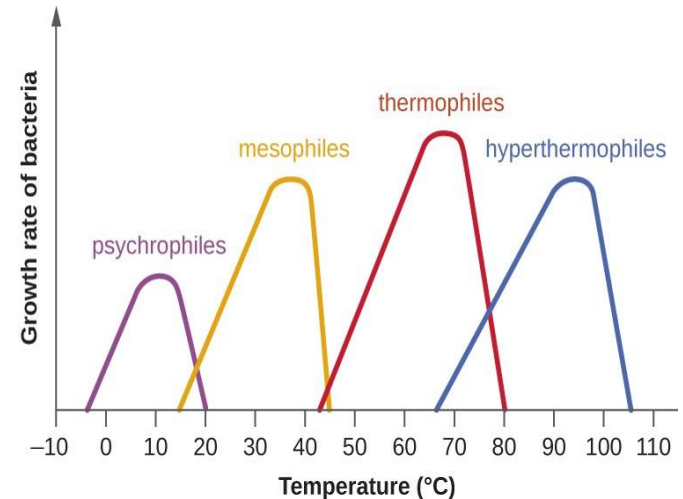
Group 3 biological agent means one that can **cause severe human disease** and present a **serious hazard to workers**; it may present a **risk of spreading** to the community, but there is usually **effective prophylaxis or treatment available**;

Group 4 biological agent means one that **causes severe human disease** and is a **serious hazard to workers**; it may present a **high risk of spreading** to the community; there is usually **no effective prophylaxis or treatment available**.

Guideline values for non-pathogenic airborne micro-organisms

SUVA recommendations:

- Total cultivable mesophilic germs: 10,000 colony-forming units (CFU)/m³ air.
- Gram-negative bacteria: 1'000 CFU/m³ air.
- Cultivable fungi: 1'000 CFU/ m³ air.
- Endotoxins: 1'000 endotoxin units/m³ = 100 ng/m³ air (Holland, 90 EU)



European norm

EN 14126:2003 (SN_EN_14126_F) is the standard to determine whether protective clothing offers necessary protection against infective agents, which prescribes the requirements for materials, seams and garments. For protective clothing which passes EN 14126:2003, wording “-B” will be added behind “TYPE” classification, namely “TYPE 3-B”, “TYPE 4-B” and “TYPE 5-B”. A standard is reviewed every 5 years.

EN 14126:2003 includes 5 test methods to determine the protection class against several specific biological hazards. The higher the protection class, the higher the protection level.

ISO 16603:2004 – Resistance to penetration by blood and body fluids using synthetic blood

Occupational Exposure Limits (OELs)

OEL set at 60 ng/m³ for all enzymes from 2018 in EU

This limit is adopted by the European Chemicals Agency (ECHA)

(including fungal alpha-amylase in the sector of bakery ingredients suppliers and enzyme manufacturers)

Legislation for mycotoxins

Commission Regulation (EC) No 1881/2006
setting maximum levels for 8 mycotoxins in foodstuffs :

Aflatoxins, in particular in food for young children

Ochratoxin A

Patulin

Deoxynivalenol

Zearalenone

Fumonisin

T-2 & HT-2 toxin

Citrinin

Commission Recommendation 2012/154/EU

Ergot alkaloids

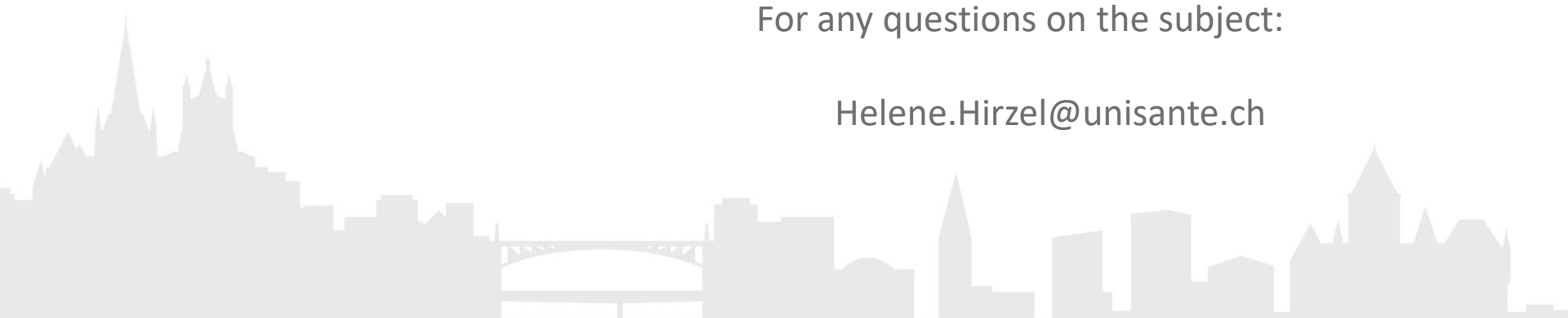
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de médecine générale
et santé publique · Lausanne

Thank you for your attention

For any questions on the subject:

Helene.Hirzel@unisante.ch

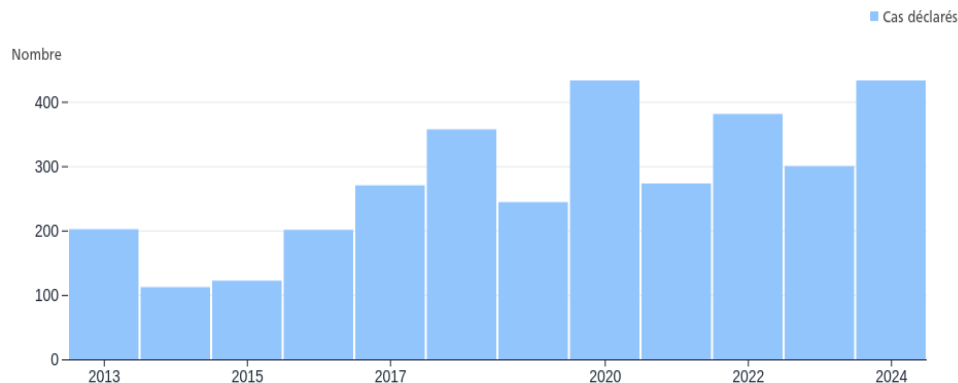


Méningo-encéphalite à tiques (FSME)

- maladie infectieuse virale transmise par les piqûres de tiques
- 0,5% des tiques sont vectrices des virus de la FSME
- symptômes pseudo-grippaux pouvant dégénéré en méningite

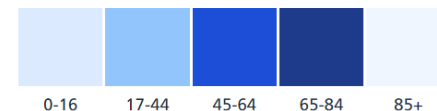
Évolution temporelle des cas de FSME déclarés

Système de déclaration obligatoire, Suisse et Principauté de Liechtenstein, du 01.01.2013 au 31.12.2024



Source : Système de déclaration obligatoire – état : 20.05.2025 / Portail d'information maladies transmissibles (idd.bag.admin.ch)

Cas par classe d'âge:



Cas par sexe:



Répartition géographique en 2024

