Utilisation of airborne infection risk model – Case day care centre

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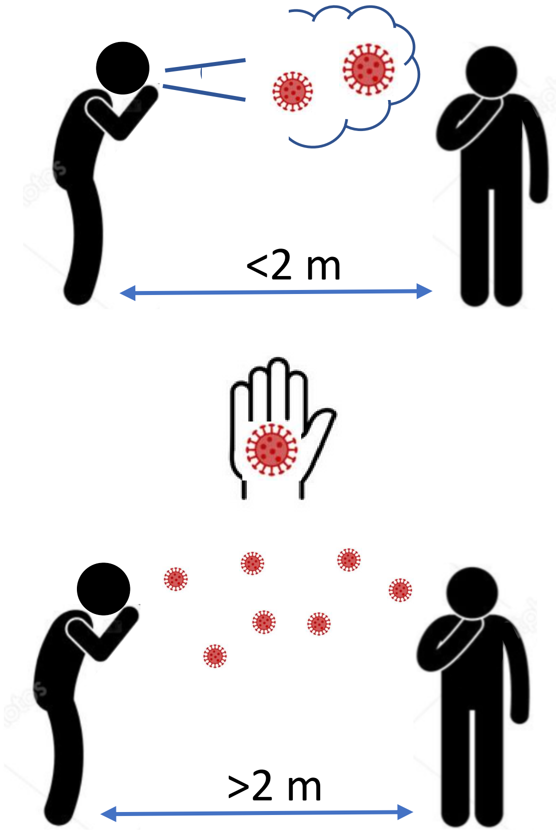
EXCELLENCE IN PANDEMIC RESPONSE AND ENTERPRISE SOLUTIONS

Infectious respiratory disease spread

- Usually spread through pathogens carried by respiratory secretions and which are shed during coughing, sneezing, speaking and even breathing
- Transmission routes: droplet, contact (direct), fomite (indirect), airborne
- The relative importance of each mode is not known accurately
- For COVID-19 airborne transmission is significant



Airborne transmission risk factors

Viral load in respiratory tract
- Pathogen
- Varies greatly person to person

Activity - Emission
- Number of index persons - prevalence
- Breathing rate
- Droplet size
- Droplet production
- Evaporation
- Mask

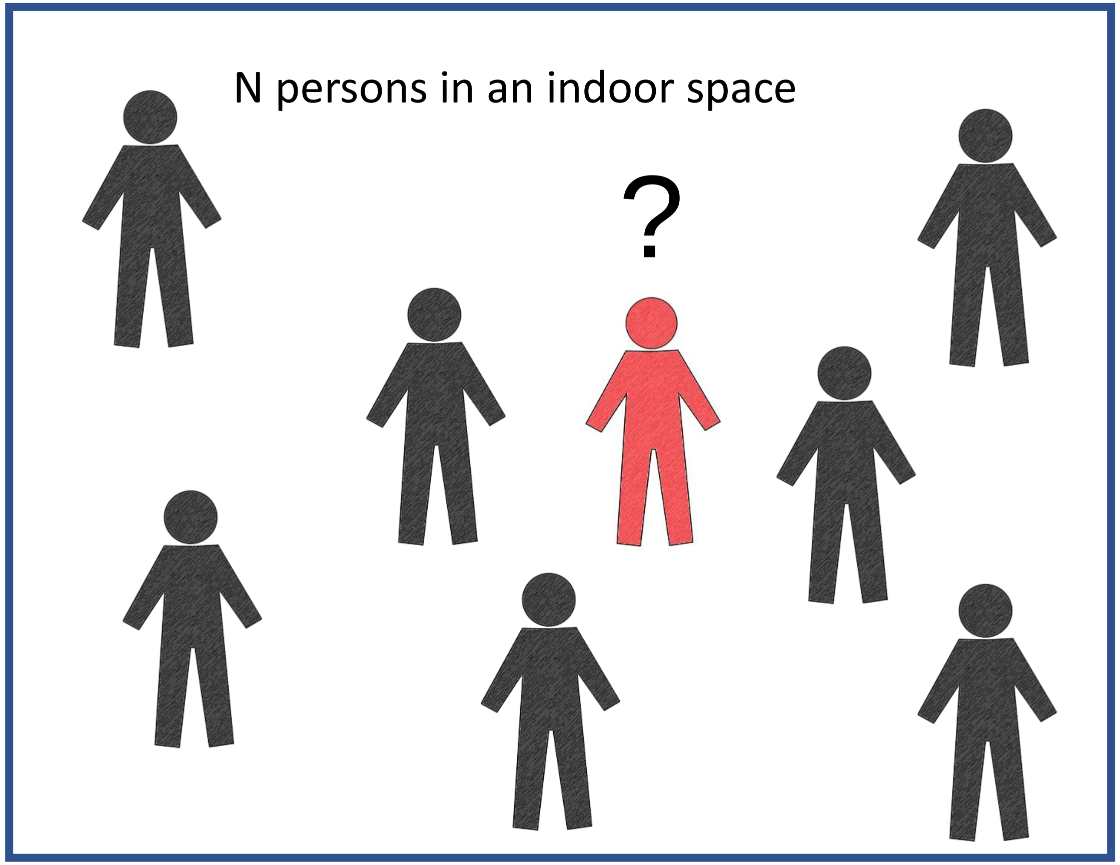
Inactivation
- Relative humidity
- Temperature
- Droplet size
- Time
- UV-light

Removal
- Ventilation rate
- Ventilation effectiveness
- Deposition
- Air purifying

Exposure
- Concentration
- Exposure time
- Activity – susceptible
- Breathing rate
- Mask

Infections
- Infective dose – pathogen/strain dependent
- Individual variation
- Different populations
- Vaccination status

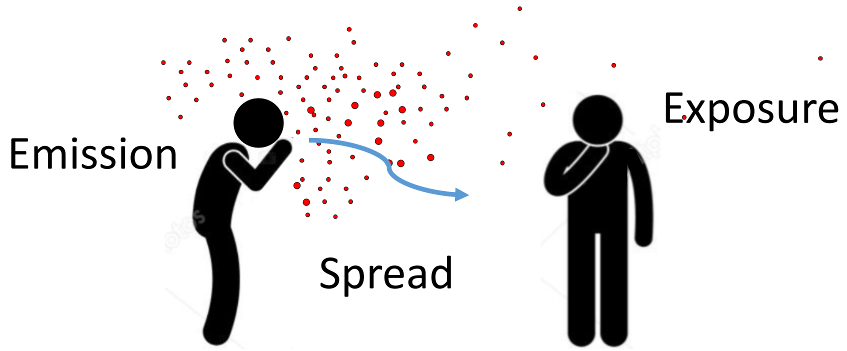
Airborne infection risk modelling: emission



Asymptomatic and presymptomatic persons: do not know that they are infected but still can transmit the disease

- What is the number of infectors in a certain indoor space?
  - Probable number $N_i = p \cdot N$ where p is the prevalence of the disease
- What is the pathogen emission rate?
  - Depends on viral load of respiratory fluids and droplet emission rate
- Large variations and uncertainties!

Airborne transmission risk modelling



$$C = \frac{G}{(\lambda + \lambda_{IA} + \lambda_D)V + q_{AC}E}$$

$$D = C \cdot t \cdot Br \cdot fi$$

$$R = 1 - \exp(-0.693 \frac{D}{D_{50}})$$

Airborne concentration → **Inhalation dose** → **Infection risk**

Emission rate G
Inactivation rate λ_{IA}
Deposition rate λ_D
Ventilation rate λ
Room volume V
Air cleaner CADR $q_{AC}E$

Airborne concentration
Exposure time t
Breathing rate Br
Deposited fraction f_i

Infective dose D_{50}
infection risk of a single viral RNA copy
p_{RNA}

Case study: Kindergarten in Helsinki

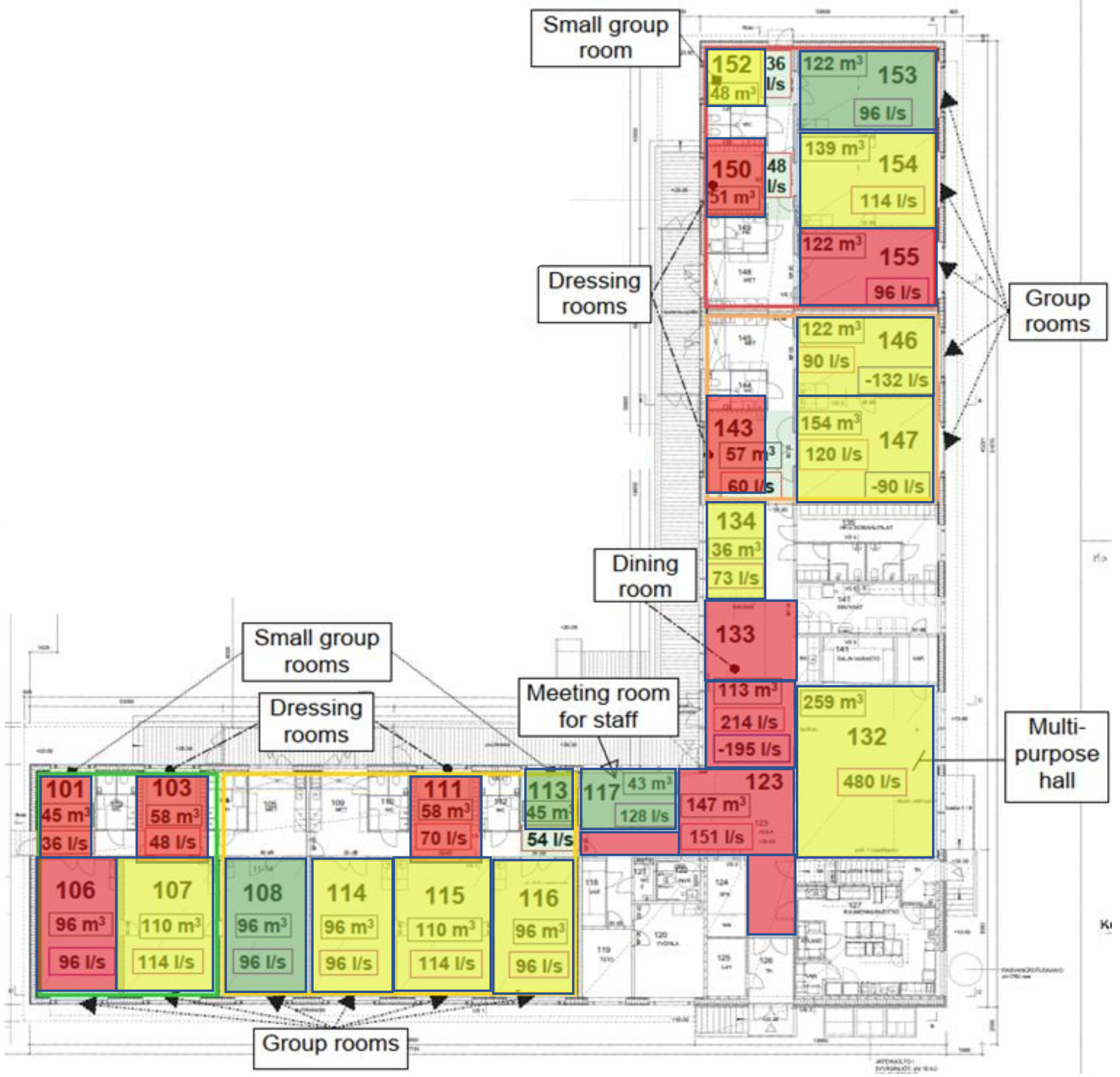
- Day care centre equipped with mechanical ventilation
- Constant air flow rate
- Air change rate in different rooms 0.9-3.8 1/h
- Daily occupation and activity was collected by an questionnaire
- Infection transmission risk was calculated for each room on hourly basis

Infection probability

Probability: High

Probability: Medium

Probability: Low



Persons at risk

Number of persons: High

Number of persons: Medium

Number of persons: Low

Conclusions

- The developed model is a simple and robust tool for calculating airborne infection transmission risk in indoor spaces
- Requires as input values
  - Number of persons in indoor spaces and their activity level
  - Disease prevalence in community
  - Estimation of pathogen viral load and infectious dose
- Limitations
  - Long-range airborne transmission only, assumption of uniform concentration
  - Does not take into account close range transmission (fomite, droplet and near field aerosol)
- Most useful for finding hot spots where the infection transmission risk is at least temporarily increased due to favourable conditions or human behaviour

beyond
the obvious

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