ENERGY MANAGEMENT

CHALMERS UNIVERSITY OF TECHNOLOGY

Ventilation och Corona

– vad vi vet och vad vi tror att vi vet

Lars Ekberg

Folkhälsomyndigheten

Augusti 2020
”Coronaviruset (SARS-CoV-2) som orsakar sjukdomen covid-19 smittar inte som luftburen smitta utan som droppsmitta”.

December 2020
“…covid-19 räknas inte som en luftburen smitta”

September 2021
”Vistelse i små utrymmen med bristfällig ventilation kan utgöra risk för smittspridning”

Från ett webbinarium i REHVAs regi april 2020

Country	Transmission Modes Protection	Protective Measures
Czech Rep	Airborne, Droplets, Contact	Masks, Ventilation, Confinement, Distancing , Hygiene, Disinfection, Behavior
Portugal	Droplets, Contact	Confinement, Distancing , Hygiene, Disinfection, Behavior
Sweden	Contact	Hygiene, Disinfection, Behavior

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Från ett webbinarium i REHVAs regi apr

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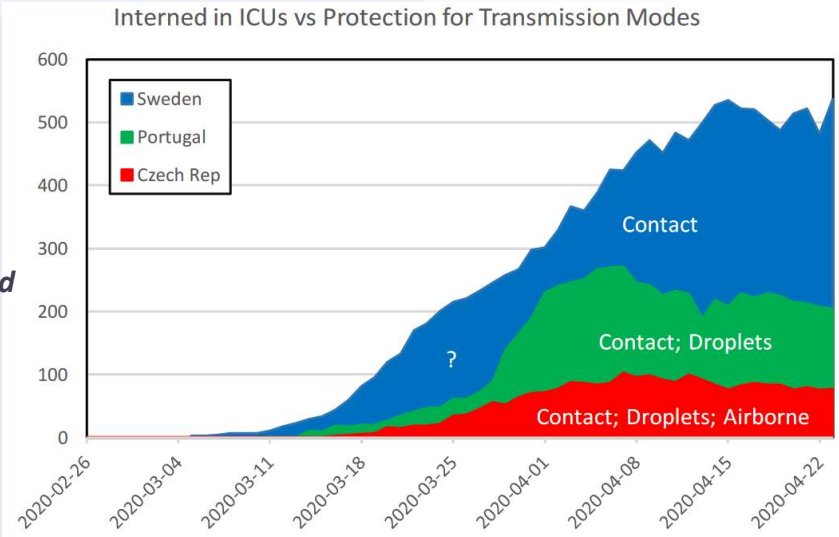
Sweden	Contact	Hygiene, Disinfection, Behavior

Antal patienter i intensivvård



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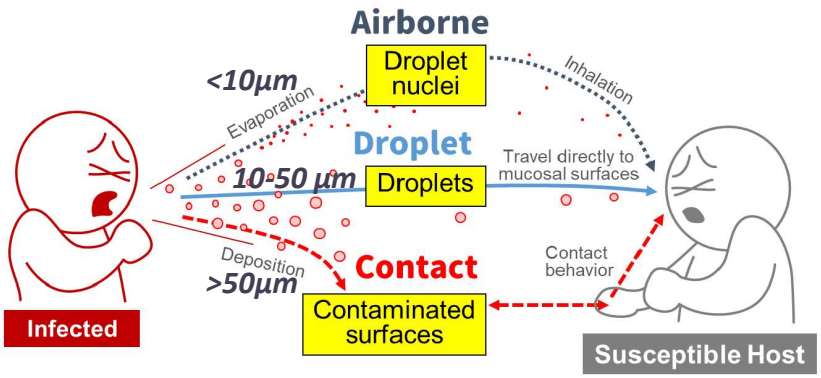
The routes of spreading pathogens in indoor environments



SHASE (2020) Role of ventilation in the control of the COVID-19 infection: Emergency presidential discourse. *The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan* (SHASE)

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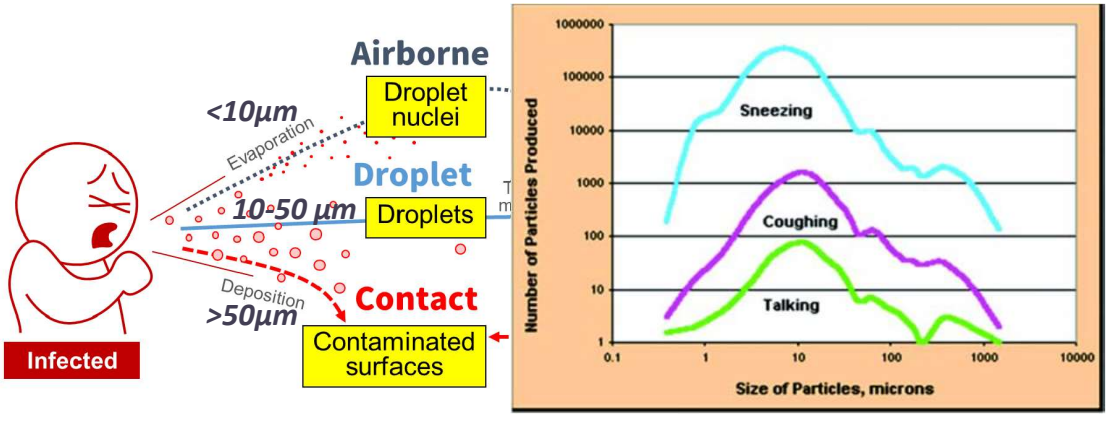
The routes of spreading pathogens in indoor environments



Farhad Memarzadeh, ASHRAE Transactions, 2011

SHASE (2020) Role of ventilation in the control of the COVID-19 infection: Emergency presidential discourse. *The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan* (SHASE)

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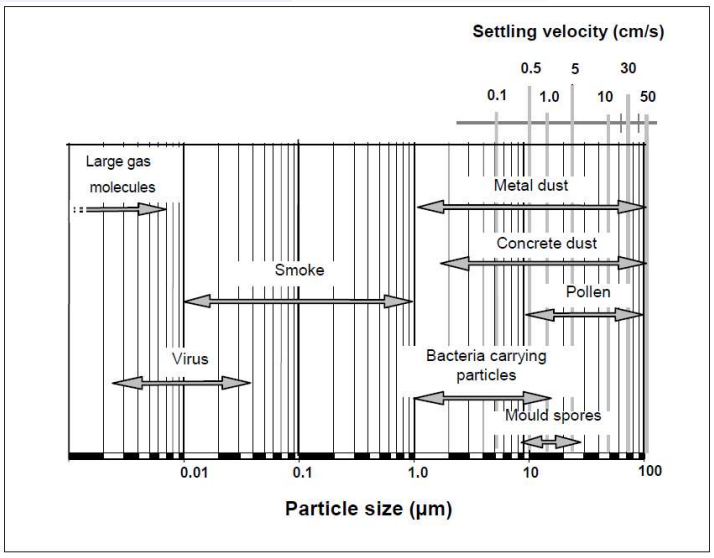

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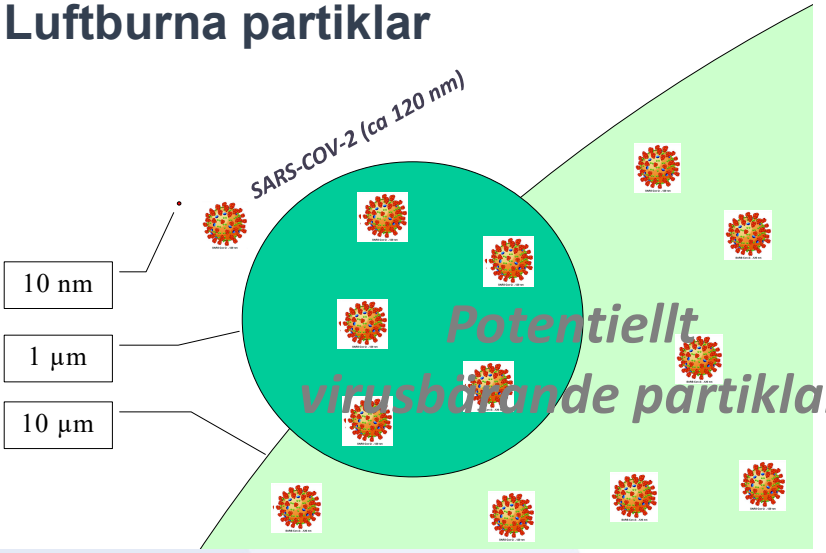
Luftburna partiklar



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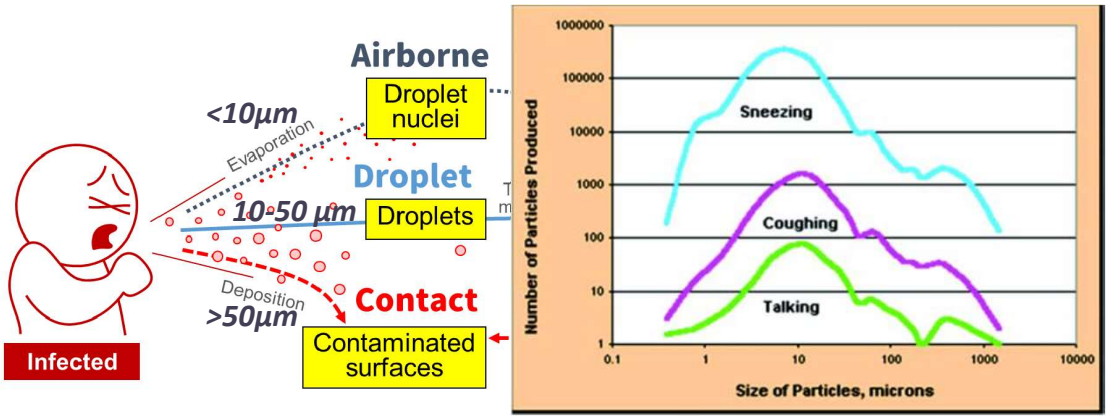
The routes of spreading pathogens in indoor environments



SHASE (2020) Role of ventilation in the control of the COVID-19 infection: Emergency presidential discourse. *The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan* (SHASE)

Farhad Memarzadeh, ASHRAE Transactions, 2011

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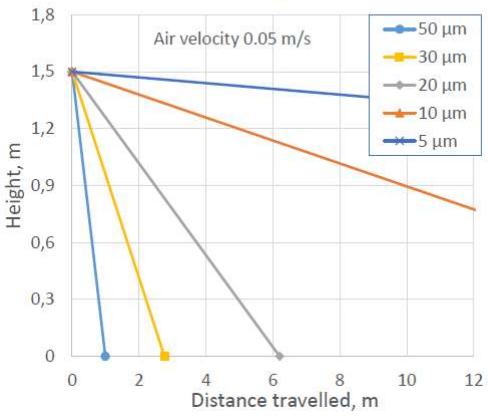
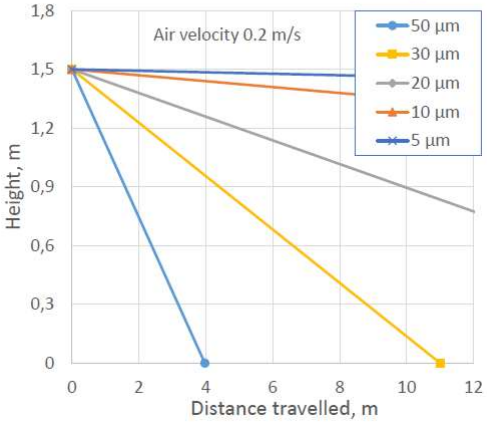
Traveling distance estimates for droplets





Kurnitski, J. REHVA (2020)

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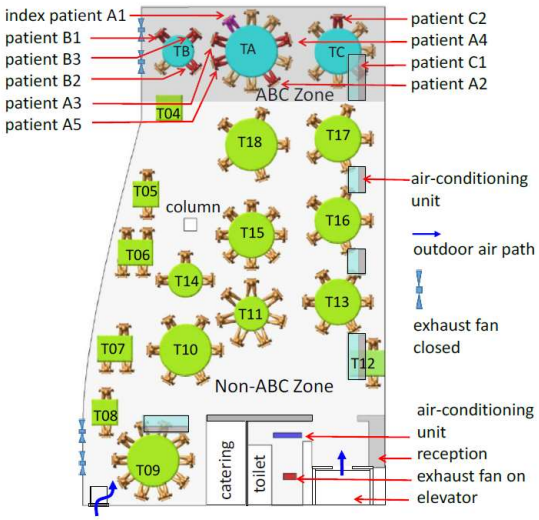
Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant



- En person smittade 9 andra
- Dålig ventilation:
  i detta fall: ca 1 l/s
- Varför smittades inte fler?

Yugo Li, et al. (2020)

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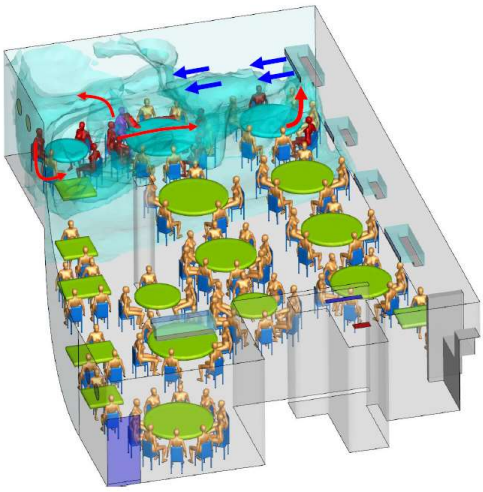
Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant

45% av dem i ABC zonen

11% av alla i hela restaurangen



- En person smittade 9 andra
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Yugo Li, et al. (2020)

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Om det hade varit Mässlingen så hade säkert fler smittats

Mängd "smittsamma partiklar" som avges per timma

Kan inte mätas – men kan beräknas från epidemiologiska studier.

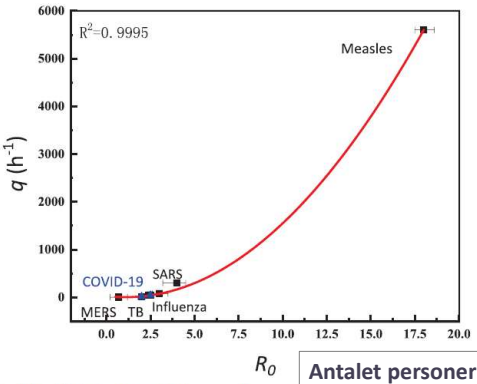

Fig. 1 The fitted curve between the qua
and basic reproductive number (R_0) (wit

Antalet personer som smittas av varje sjuk person

Hui Dai, Bin Zhao (2020)

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Och om vi tar bort Mässlingen…

Mängd "smittsamma partiklar" som avges per timma

Kan inte mätas – men kan beräknas från epidemiologiska studier.

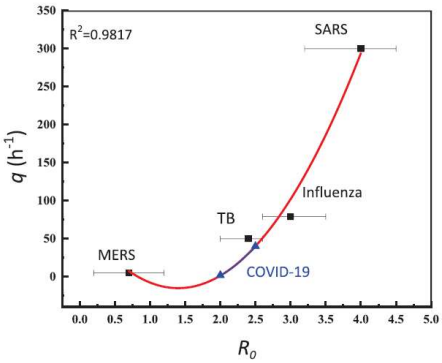

Fig. 2 The fitted curve between the quant
and basic reproductive number (R_0) (witho

Antalet personer som smittas av varje sjuk person

Hui Dai, Bin Zhao (2020)

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Hur inverkar ventilationen?

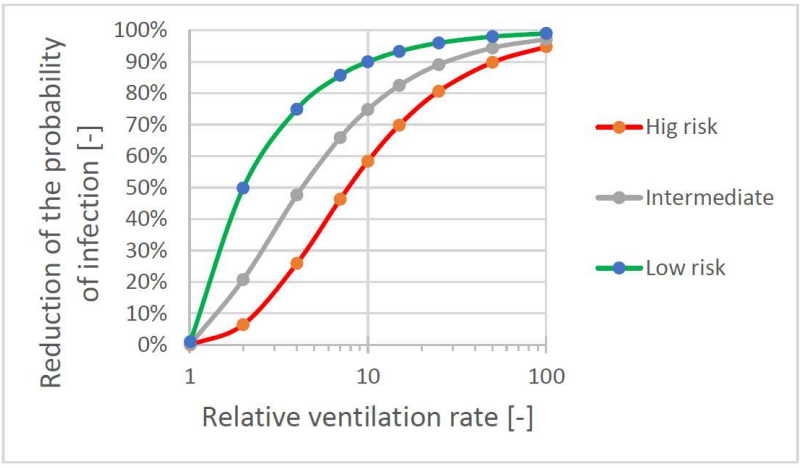

Figure 8. Reduction of the probability of infection calculated for three risk levels situations using Eq 2.

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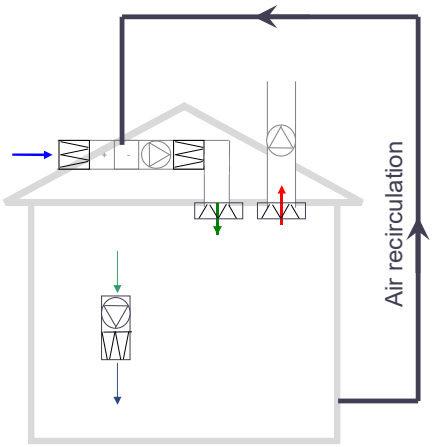
We can model the probability of infection

The Wells-Riley model was originally described by Riley et al. (1978)

$$p = \frac{infection\ cases}{susceptibles} = 1 - e^{-\frac{E \cdot k_{br} \cdot \tau}{V \cdot \sum k}}$$

$$\frac{dC}{dt} = \frac{E}{V} - (k_{vent} + k_{dep} + k_{vd})C$$



- Emission rate
- Breathing rate
- Exposure time
- Room volume
- Removal rate (ventilation, deposition, virus activity decay, air cleaning)

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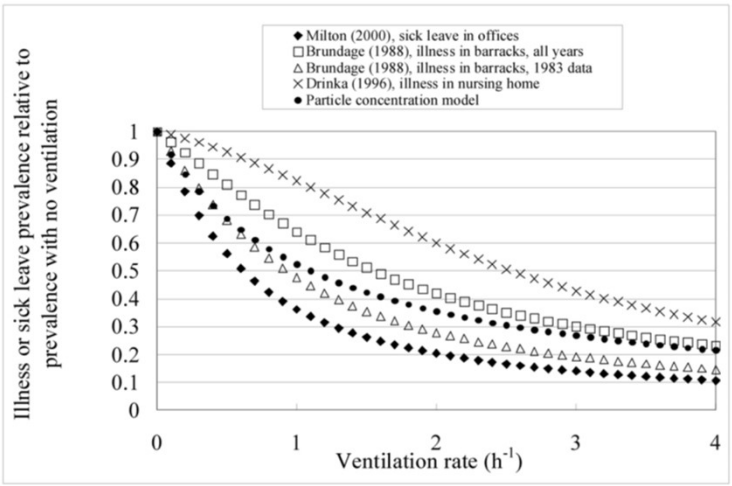
The influence of ventilation rate in offices

Increased ventilation reduces disease transmission



(Fisk et al. 2003)

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REHVA provides a tool

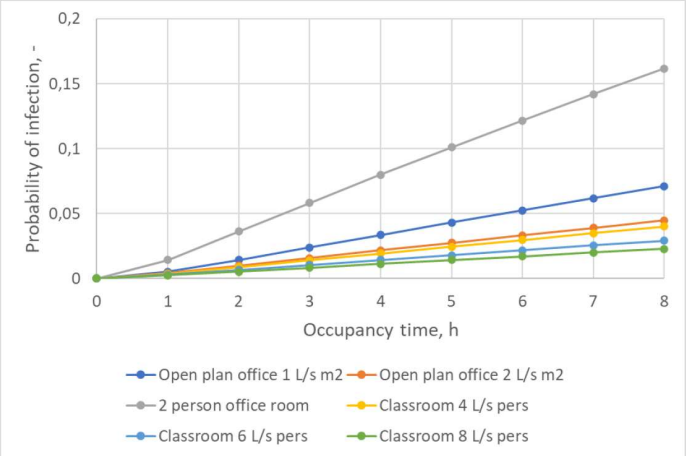

Figure 6. Probability of infection as a function of occupancy time for selected cases according to the REHVA-model (https://www.rehva.eu/covid19-ventilation-calculator).

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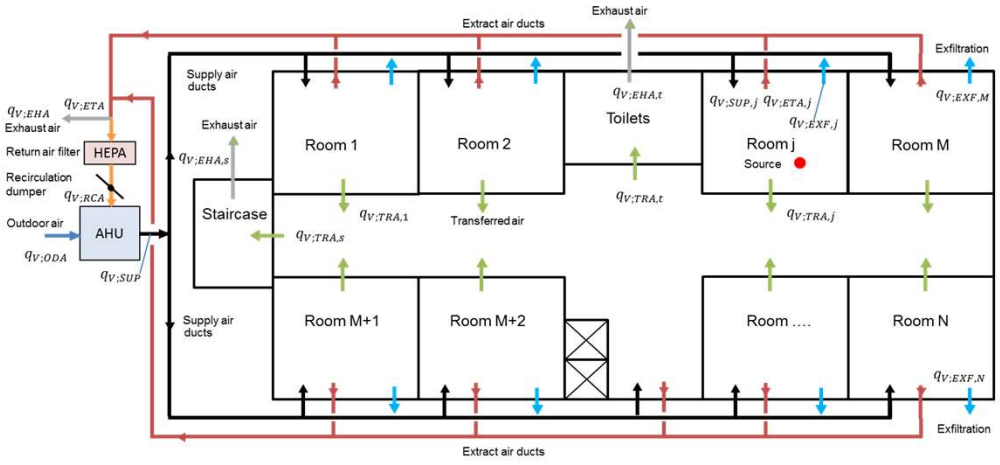
REHVA provides also a multi room tool



Mazzarella, L. (2020) REHVA Journal 5, 2020

https://www.rehva.eu/activities/covid-19-guidance/covid-19-multi-room-calculator

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What about air movement between rooms?

Just 0.2°C will transfer 25 l/s

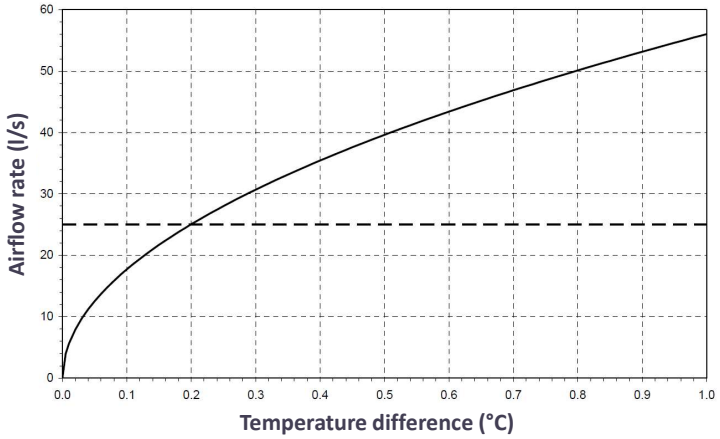
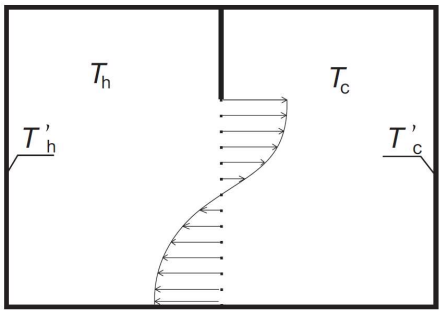


Figure 5.3 Airflow rate in each direction in the door opening as a function of the temperature difference



(Blomqvist, C. 2009)

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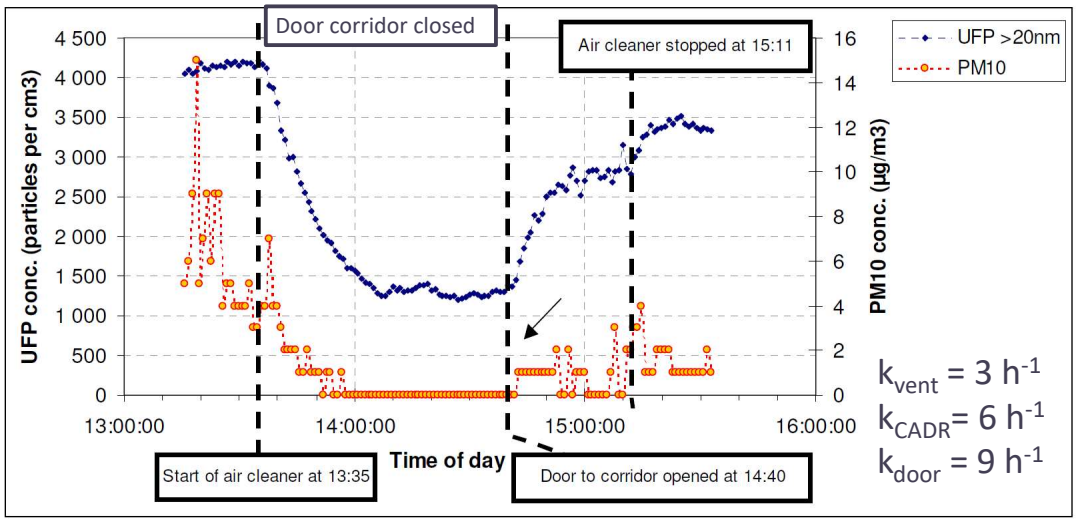
What about air cleaning devices?



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What about COVID-19 and humidity?

What about COVID-19 and humidity?

Infectiousness decreases by:

- Inactivation of the virus
- Particle settling
- Ventilation

Increased temperature and humidity promotes inactivation

Increased humidity promotes settling *(supposedly bigger particles)*

…true ?

What is the relative importance of the humidity?

Droplet shrinkage by evaporation

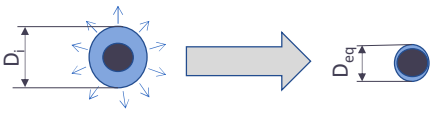

Table 2. Respiratory droplet size transformation.

RH	Model-based D_{eq}/D_i ratios[a]			Experimentally derived D_{eq}/D_i ratios[b]
	D_i = 0.1 μm	D_i = 1 μm	D_i = 10 μm	
10%	0.401	0.402	0.402	0.391
20%	0.407	0.407	0.407	0.395
30%	0.412	0.412	0.412	0.398
40%	0.416	0.417	0.417	0.401
50%	0.422	0.423	0.424	0.427
60%	0.429	0.431	0.432	0.437
70%	0.439	0.443	0.444	0.449
80%	0.456	0.464	0.465	0.464
90%	0.490	0.513	0.516	0.502

[a]Calculated according to the SS-VA model of Mikhailov et al. [23].
[b]Calculated based on volume additivity using experimental data from Tang et al. [25] and Bagger et al. [26].
[c]Difference between modeled and experimental D_{eq}/D_i ratios for D_i = 10 μm.
doi:10.1371/journal.pone.0021481.t002

Particle size about the same, regardless of humidity

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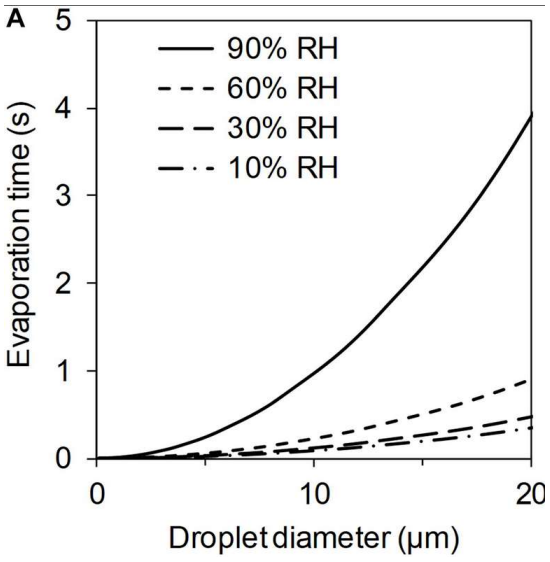
Yang and Marr (2011) Dynamics of Airborne Influenza A Viruses Indoors and Dependence on Humidity

Droplet evaporation

Evaporation speed is much faster than the removal by ventilation etc.



Alsved, M., et al., Effect of aerosolization and drying on the viability of Pseudomonas syringae cells. Frontiers in Microbiology, 2018.

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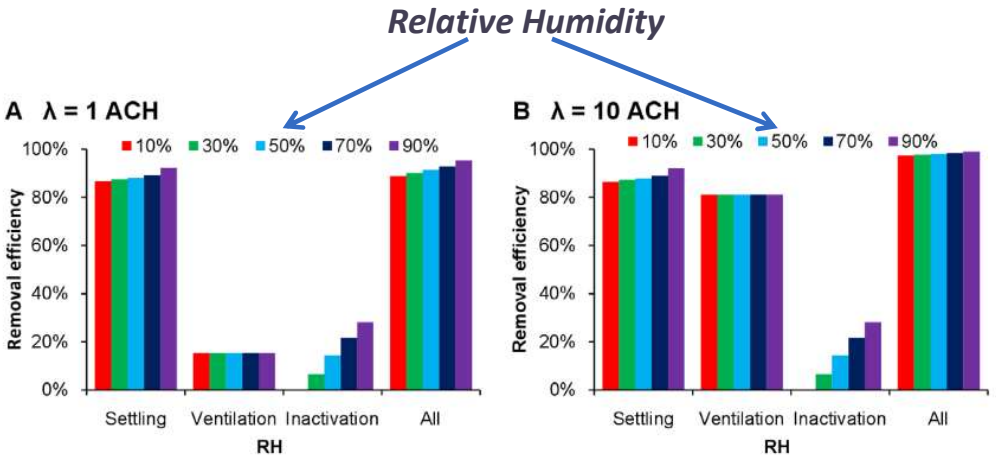
The mecanisms and their total effect (influenza virus)



Yang and Marr (2011) Dynamics of Airborne Influenza A Viruses Indoors and Dependence on Humidity

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Vilka råd ska vi då följa?

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T ex REHVAs råd

1. Ventilation rates
2. Ventilation operation times
3. Overrule of demand control settings
4. Window opening
5. Toilet ventilation
6. Windows in toilets
7. Flushing toilets
8. Recirculation
9. Heat recovery equipment
10. Fan coils and split units
11. Heating, cooling and possible humidification setpoints
12. Duct cleaning
13. Outdoor air and extract air filters
14. Maintenance works
15. Indoor air quality (IAQ) monitoring

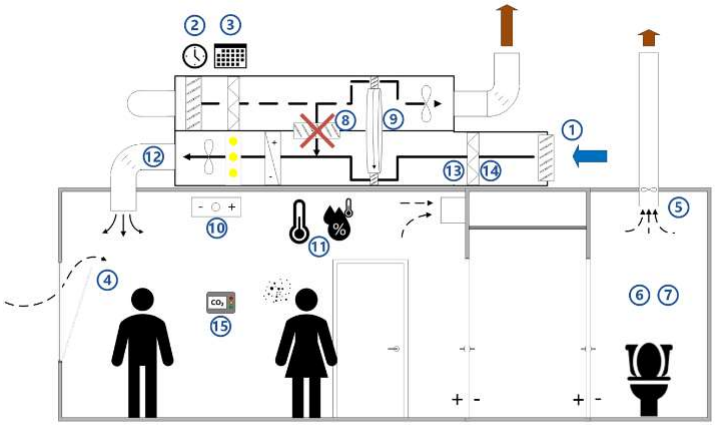

Figure 5. Main items of REHVA guidance for building services operation.

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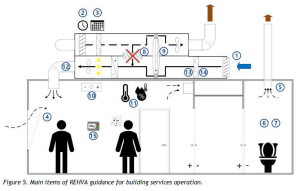
REHVAs råd 1-7



1. Provide adequate ventilation of spaces with outdoor air
2. Switch ventilation on at nominal speed at least 2 hours before the building opening time and set it off or to lower speed 2 hours after the building usage time
3. Overrule demand-controlled ventilation settings to force the ventilation system to operate at nominal speed
4. Open windows regularly (even in mechanically ventilated buildings)
5. Keep toilet ventilation in operation at nominal speed in similar fashion to the main ventilation system
6. Avoid opening windows in toilets to maintain negative pressure and the right direction of mechanical ventilation air flows
7. Instruct building occupants to flush toilets with closed lid

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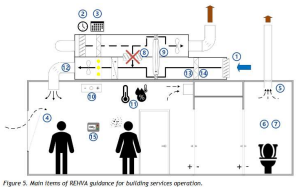
REHVAs råd 8-15



8. Switch air handling units with recirculation to 100% outdoor air
9. Inspect heat recovery equipment to be sure that leakages are under control
10. Ensure adequate outdoor air ventilation in rooms with fan coils or split units
11. Do not change heating, cooling and possible humidification setpoints
12. Carry out scheduled duct cleaning as normal (additional cleaning is not required)
13. Replace central outdoor air and extract air filters as normal, according to the maintenance schedule
14. Regular filter replacement and maintenance works shall be performed with common protective measures including respiratory protection
15. Introduce an IAQ (CO_2) sensor network that allows occupants and facility managers to monitor that ventilation is operating adequately.

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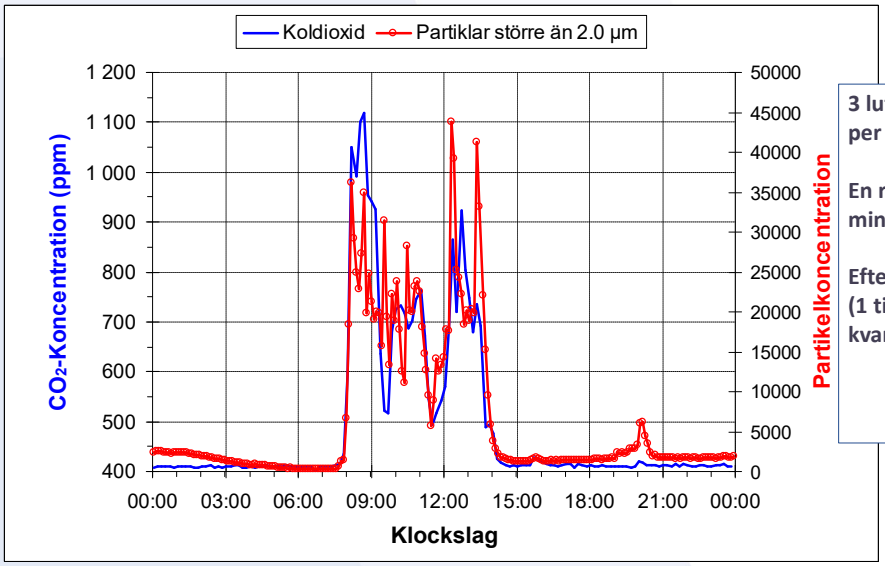
Ventilation på 2 tim före och 2 tim efter – vettigt?



3 luftomsättningar per tim
->
En rumsvolym per 20 minuter -> 37% kvar

Efter 3 rumsvolymer (1 tim) är det ca 5% kvar

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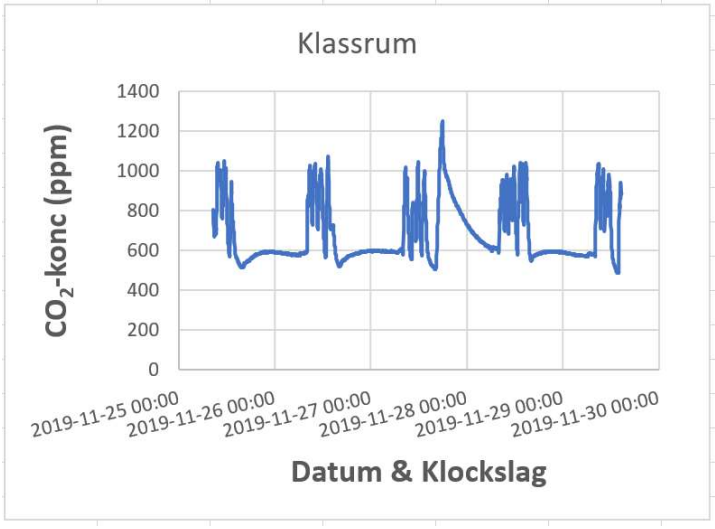
Ett exempel till



Avständ vent nattetid

Mycket tät byggnad

Läckage motsvarande 0,1 oms/tim

En rumsvolym per 10 tim

5% kvar efter 30 tim

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Stäng av behovsstyrning – Vettigt?

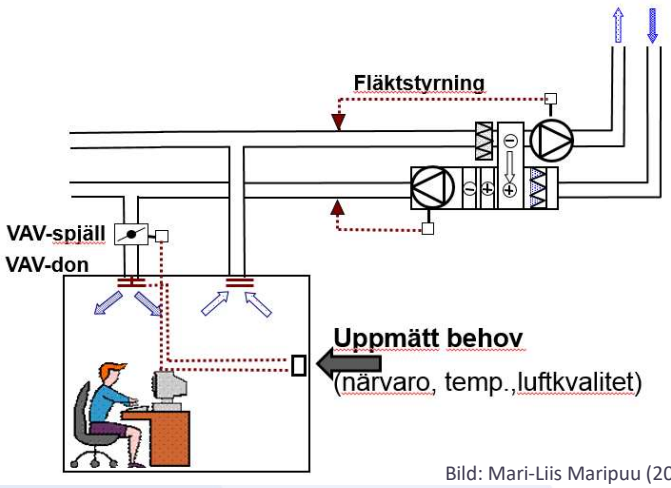

Bild: Mari-Liis Maripuu (2009)

Vad händer om alla rum ska ha fullflöde samtidigt ?

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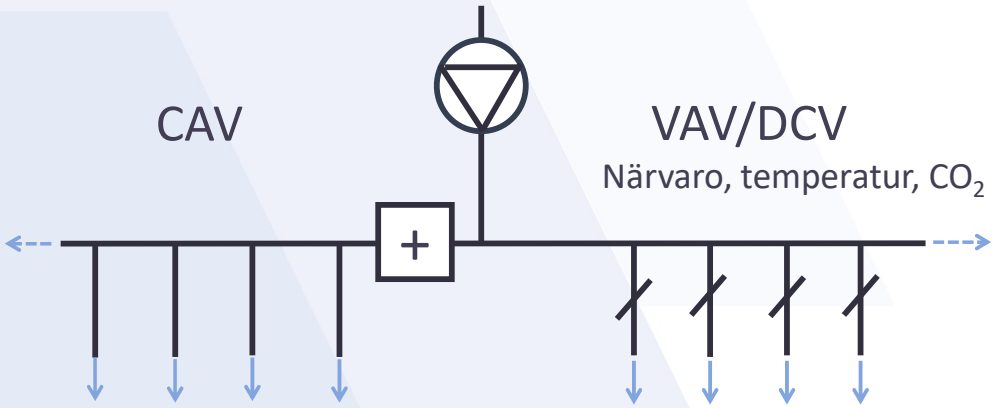
Nej, se istället till att det fungerar som det ska!



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Det finns alltså råd – och en del är goda

- https://www.rehva.eu/activities/covid-19-guidance/rehva-covid-19-guidance
- http://www.scanvac.eu/nvg.html
- https://www.svenskventilation.se/ventilation/halsa/forebygga-luftburen-smitta/
- https://www.who.int/publications/i/item/9789240021280

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Thank you
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