



# Meet de luchtkwaliteit !

Voor beter concentratievermogen en lagere  
besmettingskans virusinfecties  
leerlingen en medewerkers

November 10, 2021

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# Agenda

- Indoor luchtkwaliteit in relatie tot COVID19 virusverspreiding
- Advies vanuit binnen en buitenland
- Handmatige ventilatie in klaslokaal – experiment
- Aranet draadloos sensor systeem
- Casestudie: installatie Aranet sensor systeem bij ROCvA  
(Best Klimaat, Maurice Schalks)
- Conclusies



# Waarom luchtkwaliteit?

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NEWS FEATURE · 08 JULY 2020 · UPDATE 23 JULY 2020

## Mounting evidence suggests coronavirus is airborne – but health advice has not caught up

Governments are starting to change policies amid concerns that tiny droplets can carry SARS-CoV-2. And after months of denying the importance of this, the World Health Organization is reconsidering its stance.

TIME

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COVID-19 Is Transmitted Through Aerosols. We Have Enough Evidence, Now It Is Time to Act

The New York Times

Opinion

## Yes, the Coronavirus Is in the Air

Transmission through aerosols matters — and probably a lot more than we've been able to prove yet.

# Luchtkwaliteit in NL?

## 2. Adviezen

- Ventileer in de gebruikte ventilatiesystemen.
- Bij twijfel over de werking van de ventilatiesystemen.
- Indien er twijfels bestaan over een expertisering van de natuurlijke luchtkringloop.
- Lucht regelmatig koken en opwarmen.

Het is op dit moment onduidelijk of de ziekte zich vormen aerosolvormend

## DE SPAANSCHE GRIEP.

### EEN WAARSCHUWING VAN DEN CENTRALEN GEZONDHEIDSRAAD

De Centrale Gezondheidsraad deelt ons het volgende mede:

's-GRAVENHAGE, 15 Juli.

Met het oog op de mogelijkheid der verspreiding, ook in ons land, van de ziekte, die aangeduid wordt als „Spaansche griep“, komt het den Centraalen Gezondheidsraad gewenscht voor te herinneren aan een tweetal welbekende en hoogst nuttige wenken, in het belang der volksgezondheid. Het spreekt wel van zelf, dat andere maatregelen niet mogen worden verzuimd, als reinheid op lichaam, kleeding en woning, het inroepen van geneeskundige hulp bij ziekte en dergelijke meer, maar daarnaast is het noodig het volgende in acht te nemen:

10. Laat bij dag en nacht steeds zooveel mogelijk, overal, verse lucht in uw woning toe.

Laat ieder naar vermogen medewerken om voortdurende, flinke luchtverversching ook tot stand te brengen in allerlei plaatsen en inrichtingen, waar vele mensen bijeenkomen, als: scholen, kantoren, werkplaatsen, fabrieken, winkels, weeshuizen, kazernes, verspreidingslokalen, booten, trams, treinen enz.

Weest niet beducht voor flink wat versche lucht en bedenk, dat eene krachtige luchtverversching de smetstof verdrijven kan, die anders in een lokaal blijft hangen en mogelijk de besmetting overbrengt.

20. Laat, zooveel van u afhangt, geen stof worden opgejaagd in huis en in al de inrichtingen en plaatsen, hierboven genoemd.

Stof verontreinigt en prikkelt ogen, neus en keel en kan in een tijd van besmettelijke ziekte dubbel nadeelig zijn.

Droog opvegen van den vloer is voor een deel enkel stof opjagen. Het meest afdoende is ongetwijfeld het gebruik van een stofzuigtoestel, als men daar de beschikking over heeft of krijgen kan. Voor het overige dient stof opgenomen te worden liefst met vochtige dweilen en doeken<sup>®</sup> of anders, na besprinkeling met water; daarbij zijn deuren en ramen open te zetten.

Waardoor de ziekte reeds eenige uitbreiding mocht verkregen hebben, is het gewenscht het besmettingsgevaar van persoon op persoon zo mogelijk te ontgaan door aanraking, ook met de licht ongestelden, te vermijden, voor zover plicht en werkkring niet anders eischen.

Juist door hen, die in het begin eener besmettelijke ziekte zijn en slechts weinig den indruk van ongesteldheid geven, kan de besmetting worden overgebracht, indien zij in kantoren, scholen, werkplaatsen enz. met anderen in aanraking zijn.

Zij, die toezicht over deze inrichtingen hebben, doen wel hiermede te rekenen, en zulke half-zieken liever naar huis te laten gaan.

## Advies

van nieuwbouw) en lucht bedoeld.

expert over het

iderd: overleg met heden tot

a activiteiten zoals gadering, is het

ing van het virus. Een uitzondering eerder.



# Meten is weten

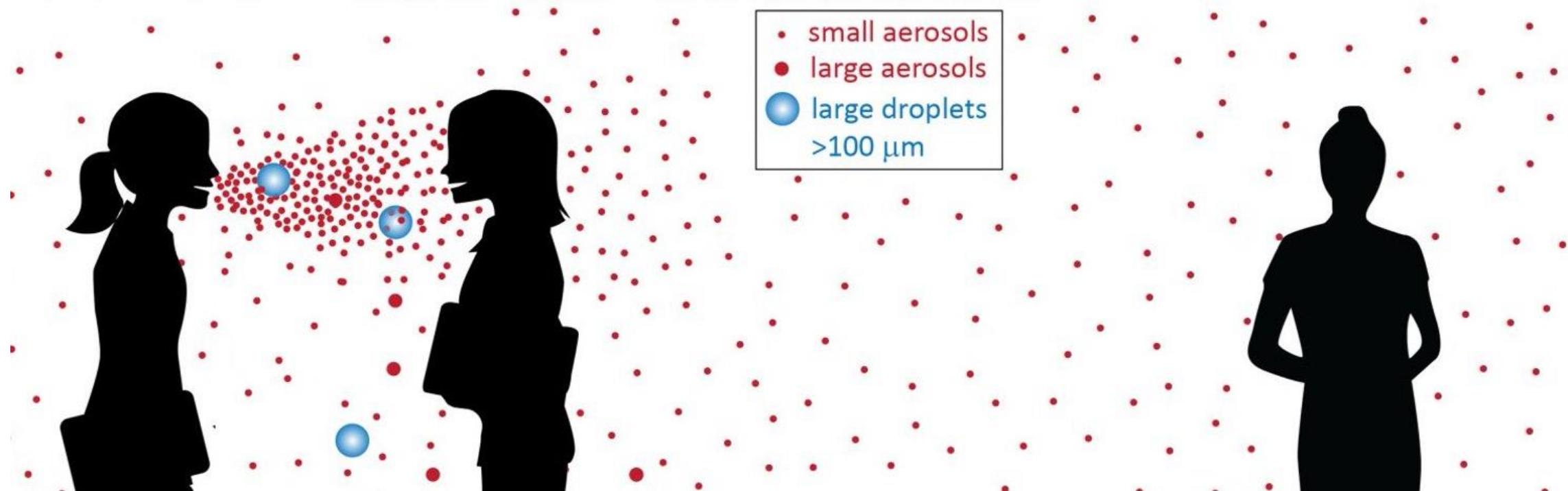
## petitie van binnenklimaat NL en TVVL aan politiek

Ventilatiennorm tegen het licht houden. Eisen voor luchtkwaliteit ipv alleen inrichtingseisen ventilatiesysteem

5 voorstellen:

- a. Maak stappenplan om gezond binnenklimaat in (overheids) gebouwen te realiseren
- b. Maak meetbare richtlijnen voor gezond binnenklimaat en meet luchtkwaliteit
- c. Maak CO<sub>2</sub> meting verplicht in publieke gebouwen (net als in Belgie)
- d. Maak wetgeving die maximale CO<sub>2</sub> waardes aangeeft als eis voor luchtkwaliteit
- e. Maak ventilatiennormen onderdeel van renovatie en isolatie projecten.

# COVID-19 is an airborne virus that mainly spreads via aerosols that float in the air



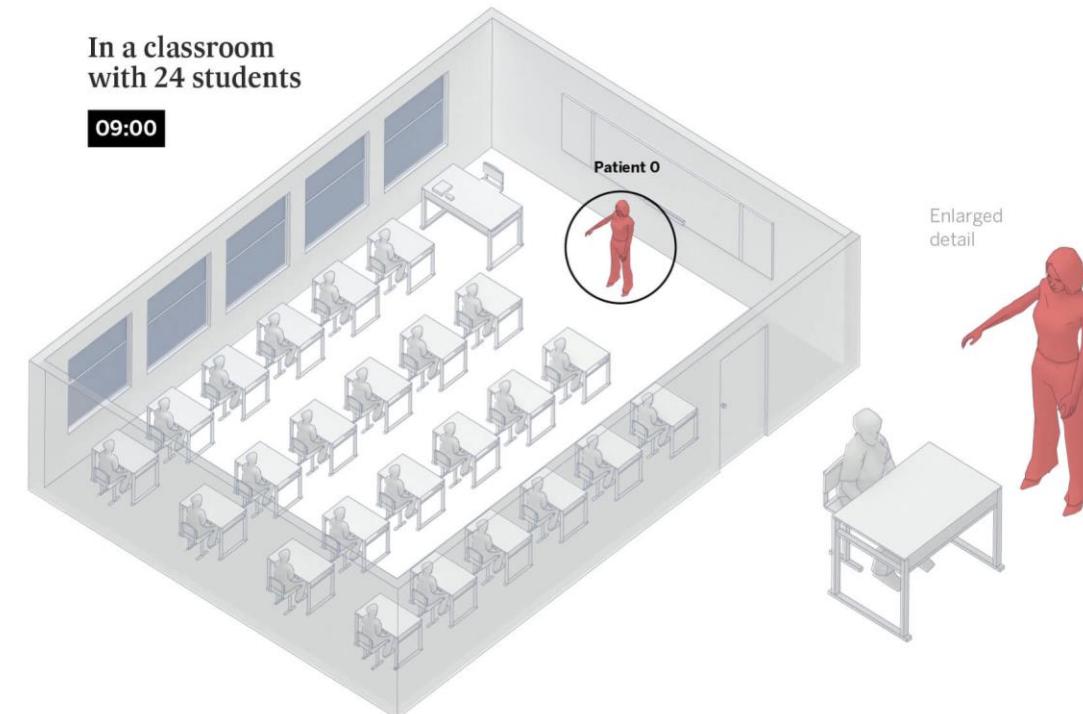
Graphic by Prof. Linsey Marr, published in [https://www.journalofhospitalinfection.com/article/S0195-6701\(21\)00007-4/fulltext](https://www.journalofhospitalinfection.com/article/S0195-6701(21)00007-4/fulltext)

# Mondmasker helpt (deels)



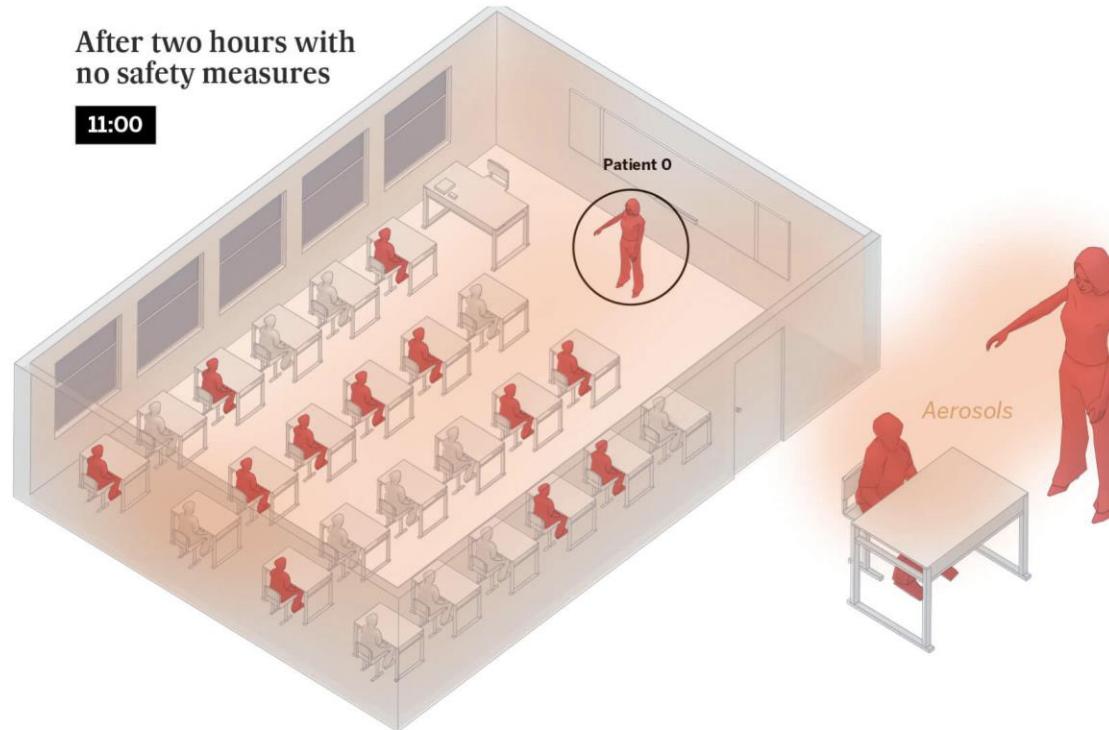
Conventional surgical  
masks only stop 30% of  
the small aerosol  
droplets

**The riskiest scenario** is a classroom with no ventilation and the teacher – patient 0 – as the infected person.



Source: El País newspaper based upon research from professor Jimenez, research university of Boulder Colorado, USA. Simulation model based upon 'Covid Airborne Transmission Estimator' developed by professor Jose Luis Jimenez.

If two hours are spent in the classroom with an infected teacher, **without taking any measures** to counter the number of aerosols, there is the risk that up to 12 students could become infected.

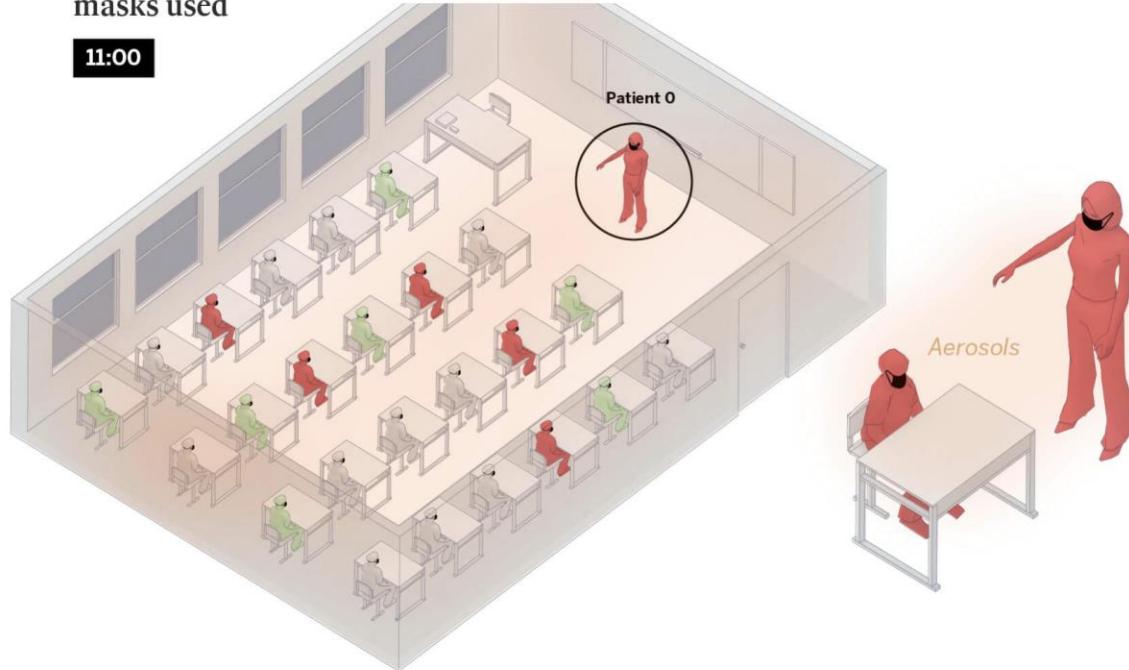


Source: El País newspaper based upon research from professor Jimenez, research university of Boulder Colorado, USA. Simulation model based upon 'Covid Airborne Transmission Estimator' developed by professor Jose Luis Jimenez.

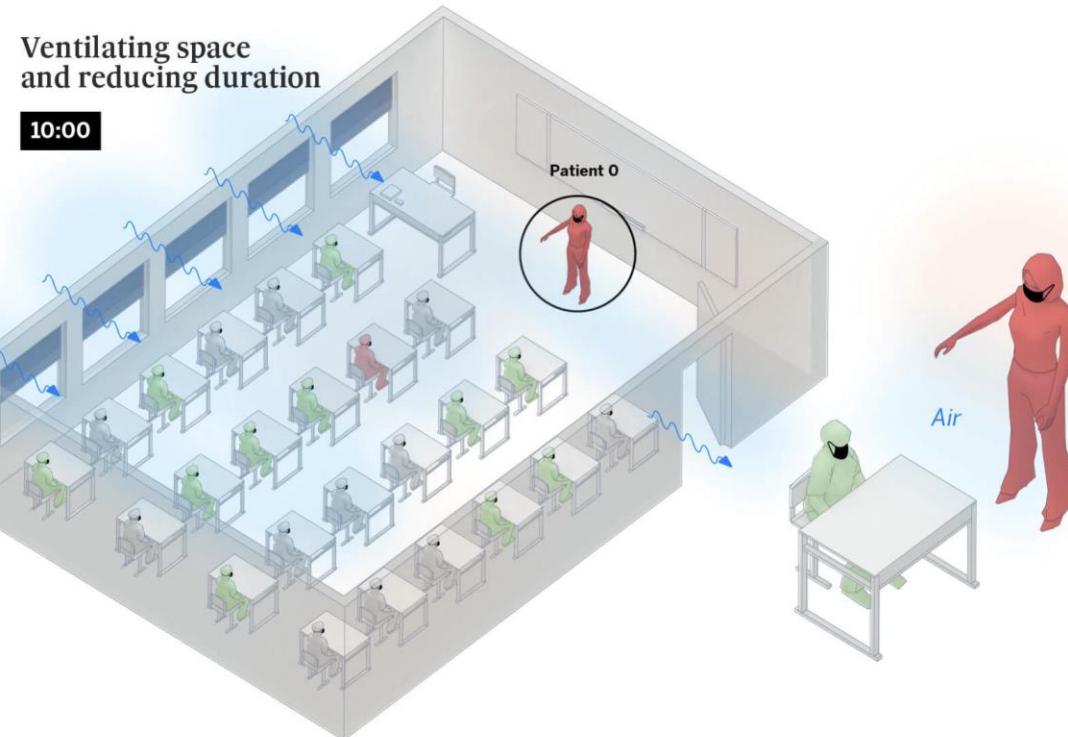
If everyone is wearing a face mask, the number that could become infected drops to five. In real outbreaks, it has been noted that any of the students could become infected irrespective of their proximity to the teacher as the aerosols are distributed randomly around the unventilated room.

### Only face masks used

11:00



If the room is ventilated during the lesson, either with fresh air or mechanically, **and the class is stopped after an hour** in order to completely refresh the air, the risk drops dramatically.



Source: El País newspaper based upon research from professor Jimenez, research university of Boulder Colorado, USA. Simulation model based upon 'Covid Airborne Transmission Estimator' developed by professor Jose Luis Jimenez.

# Handmatige ventilatie in klaslokaal

## experiment met Aranet sensors

Size of classroom: 6m x 2.75m x  
11.2m

Setting 1

Break



Setting 2

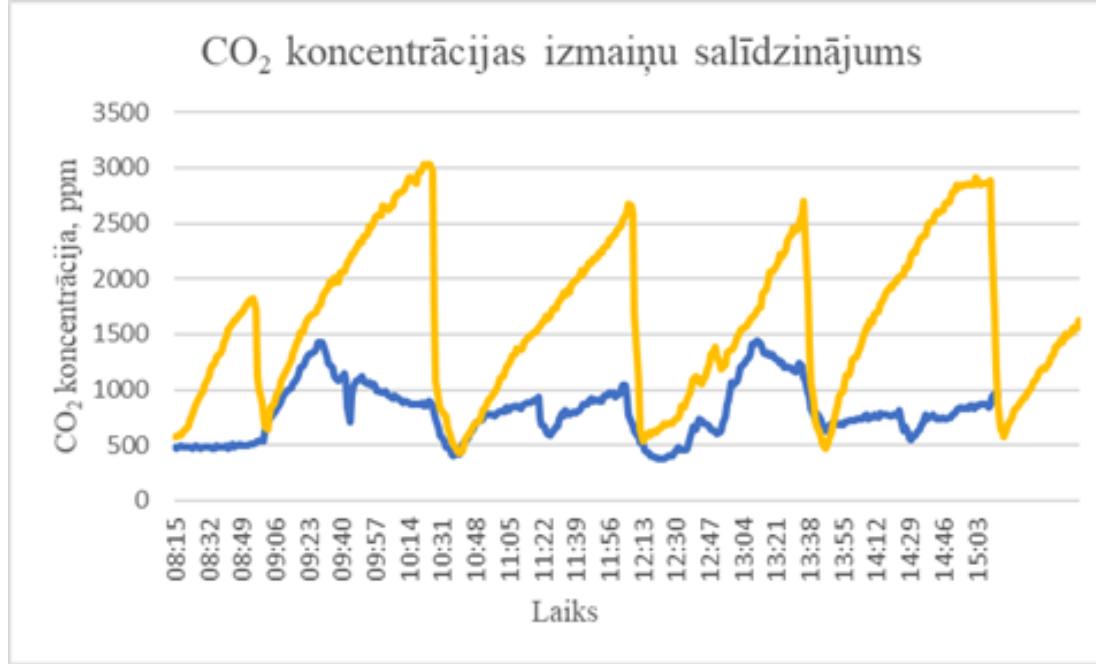
Break



+ during class



# Hoe vaak moet ramen of deuren open ?



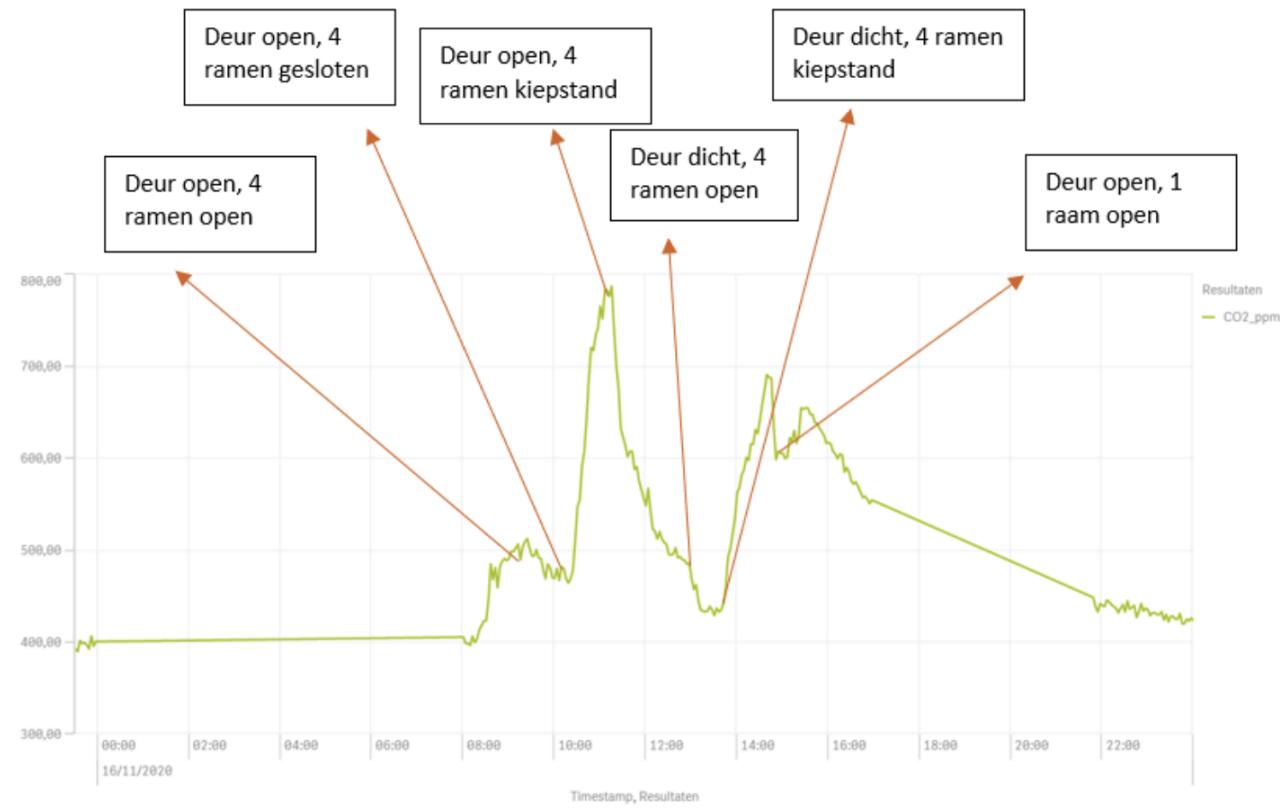
Setting 1: Only 19% of time  
CO<sub>2</sub> is OK (<1000ppm)

Setting 2: 79% of time CO<sub>2</sub> is OK

But only 60% of time temperature  
was acceptable (experiment  
performed in January in Northern  
Europe, Latvia)

# Meten is weten (2)

## petitie van binnenklimaat NL en TVVL aan politiek

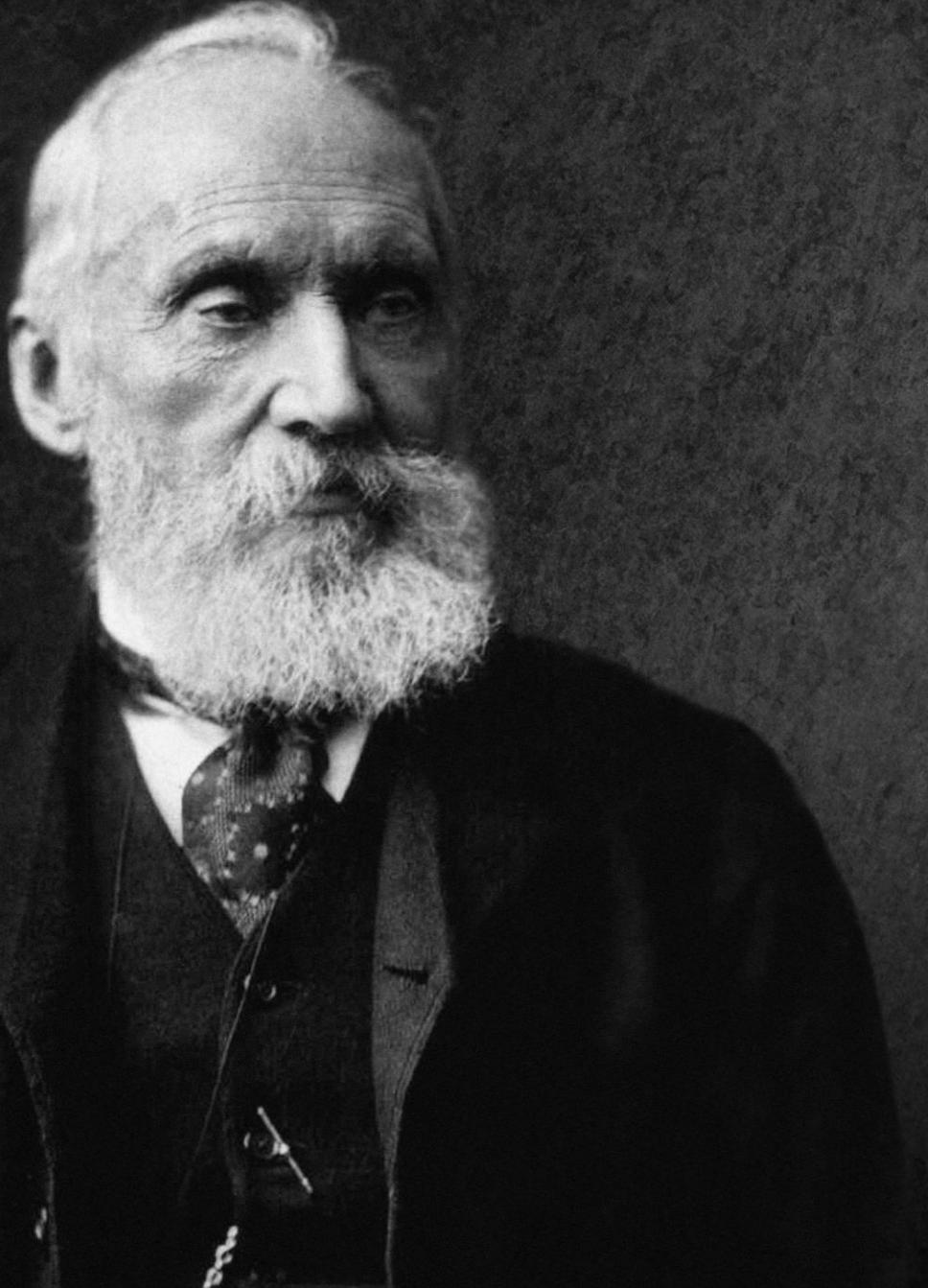


**Afbeelding B7.1:** Verloop van de CO<sub>2</sub>-concentratie gedurende de dag bij het openen of sluiten van ramen of deuren

# CO<sub>2</sub> is de indicator voor mate van 'frisse' lucht



- Aanbeveling: 60m<sup>3</sup>/h air circulation per person
- This equates to approximately 800ppm CO<sub>2</sub> concentration

A black and white portrait of a man with a full, bushy white beard and receding hairline. He is wearing a dark suit jacket over a white shirt and a patterned tie. The background is dark and textured.

YOU CAN ONLY  
IMPROVE WHAT YOU  
CAN MEASURE.

- LORD KELVIN



CO<sub>2</sub>





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# Aranet: draadloos sensor netwerk

Base Station



868 MHz  
or  
920 MHz

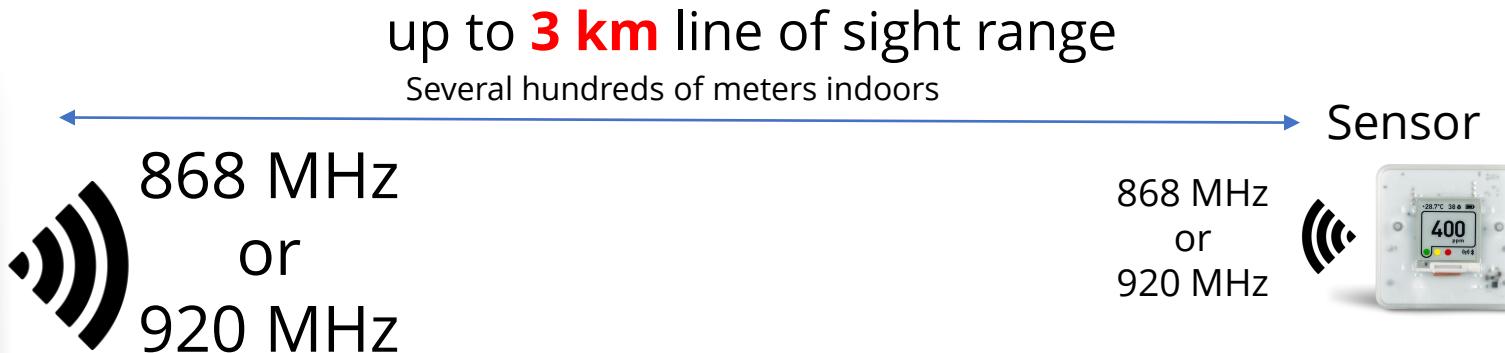
Sensor  
868 MHz  
or  
920 MHz





# Aranet: draadloos sensor network

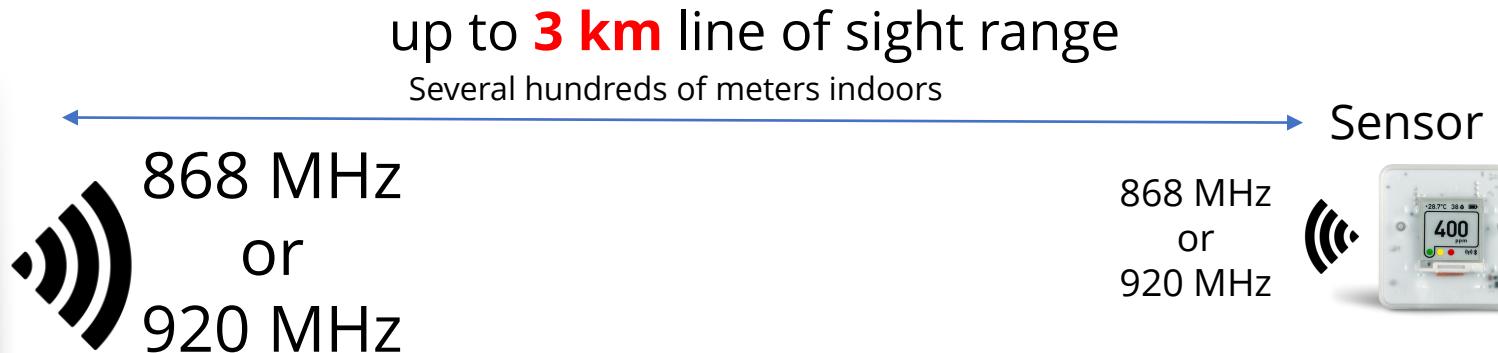
Base Station





# Aranet: draadloos sensor netwerk

Base Station



**1; 2; 5 or 10 minute**  
transmission intervals





# Aranet: draadloos sensor netwerk

Base Station



**1; 2; 5 or 10 minute**  
transmission intervals



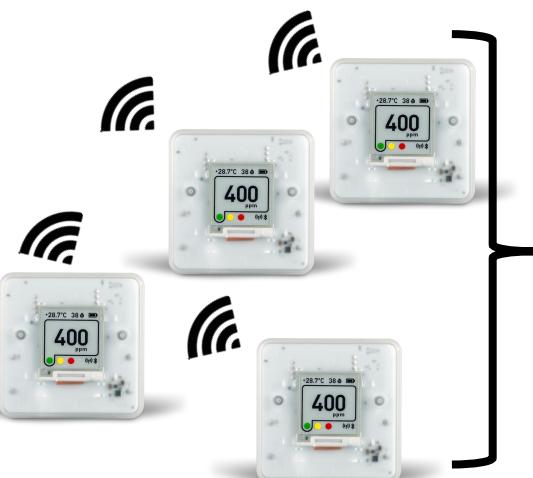
up to **3 km** line of sight range

Several hundreds of meters indoors

868 MHz  
or  
920 MHz

Aranet 4Sensor

868 MHz  
or  
920 MHz

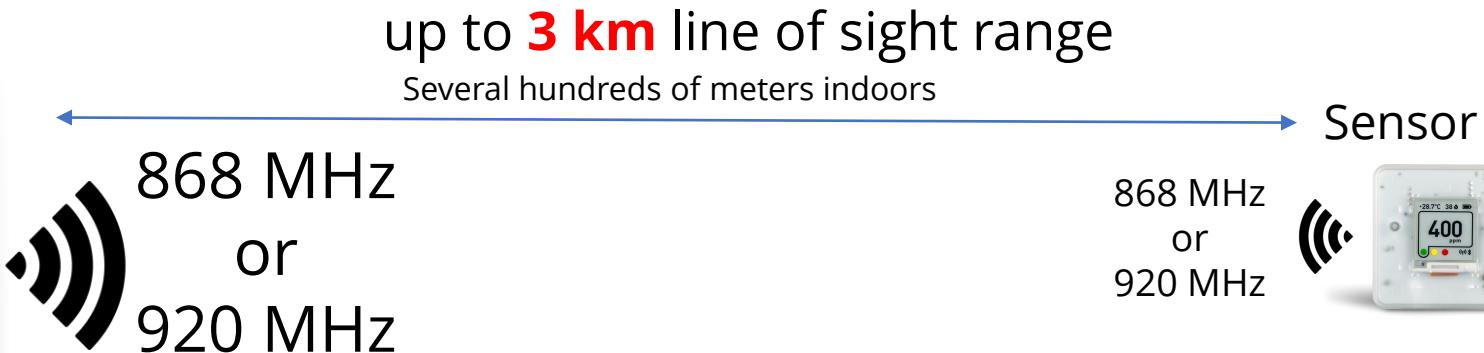


**x100 sensors**  
per Base  
Station

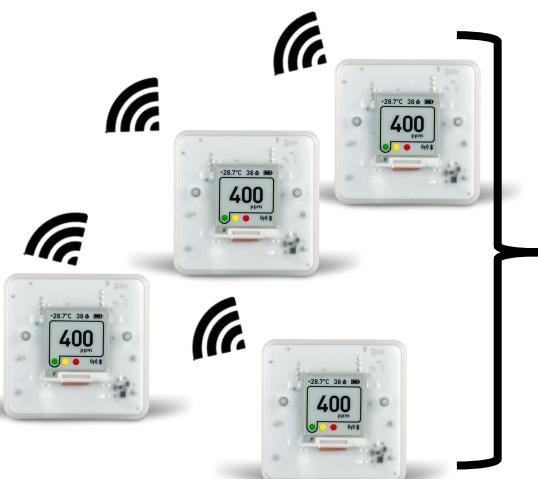


# Aranet: draadloos sensor netwerk

Base Station



**1; 2; 5 or 10 minute**  
transmission intervals



**x100 sensors**  
per Base Station



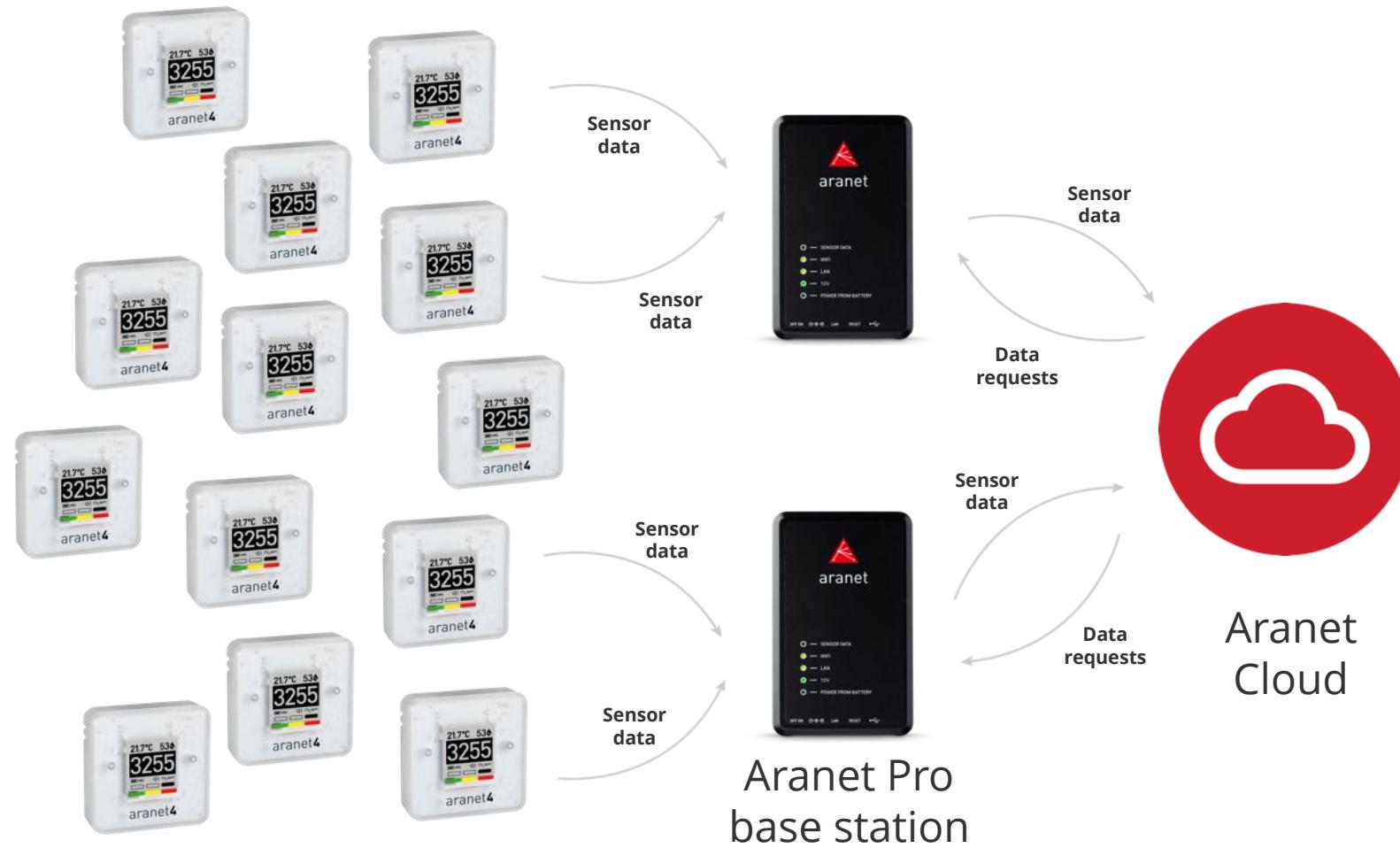
**Up to 2 year**  
battery life



# Aranet ecosysteem biedt een 'end-to-end' oplossing voor het meten van luchtkwaliteit

## Key components of Aranet wireless ecosystem:

- **Aranet 4 air quality sensors** placed in classrooms
- **Aranet Pro Base station** collecting and storing data from wireless sensors
- **Aranet Cloud** enabling centralized monitoring across all classrooms and schools



# Case study: ROC van Amsterdam



*Door:*

**Maurice Schalks**



*Uw onafhankelijk partner  
voor een beter binnenklimaat!*

# Onze disciplines



- Onderzoek
- Advies
- Projectbegeleiding
- Beheer
- Implementatie Aranet

# Onderzoek



- Klimaatklachten
- Verduurzaming (ook bestaande installaties!!)
- Onbalans WKO



# Advies



- Optimalisatie bestaande & nieuwe installaties
- Verduurzaming
- Aanpassing/uitbreiding installaties



# Projectbegeleiding

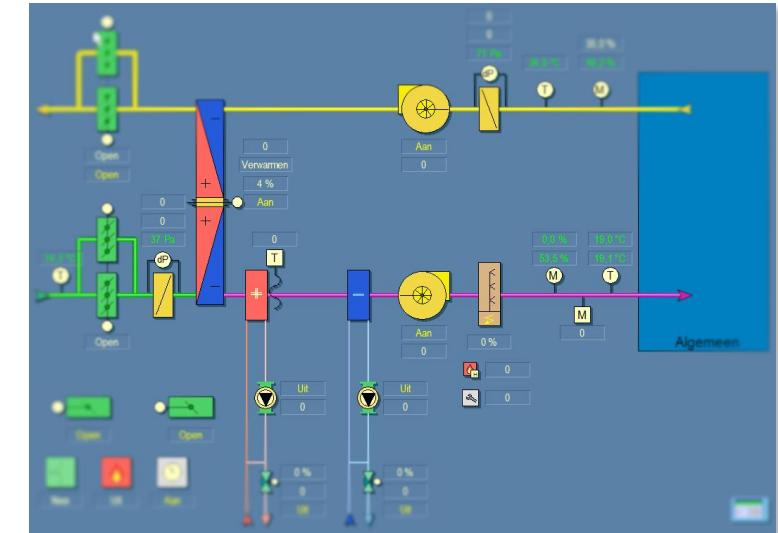


- Aanpassingen vanuit onderzoek

# Beheer



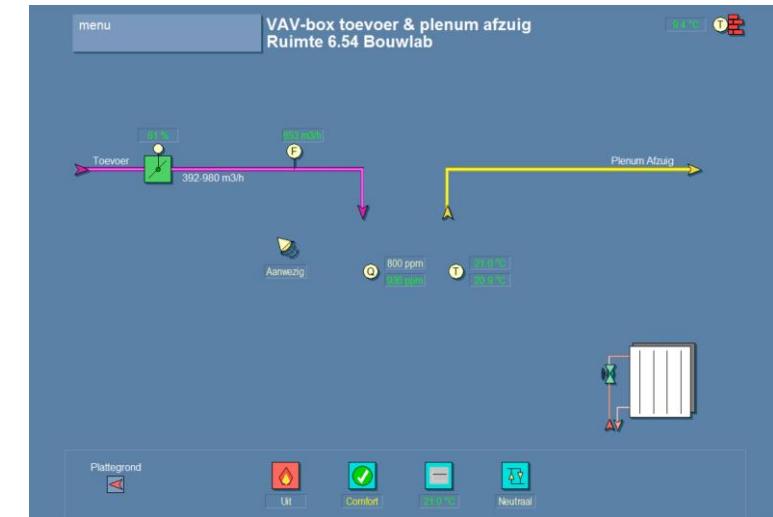
- Comfortverbetering
- Energiereductie
- Instellen naar ontwerpwaardes
- Sturen op balans WKO installatie



# Implementatie Aranet CO2 datalogger ROCVa



- Frisse Scholen 2021
- Ruimteregeling of conventionele installatie?



# Frisse Scholen 2021



- Luchtkwaliteit
  - Klasse A (uitmuntend – CO<sub>2</sub> max. 1200 ppm)
  - Klasse B (goed – CO<sub>2</sub> max. 950 ppm)
  - Klasse C (voldoende – CO<sub>2</sub> max. 800 ppm)



Rijksdienst voor Ondernemend Nederland

## Programma van Eisen Frisse Scholen 2021

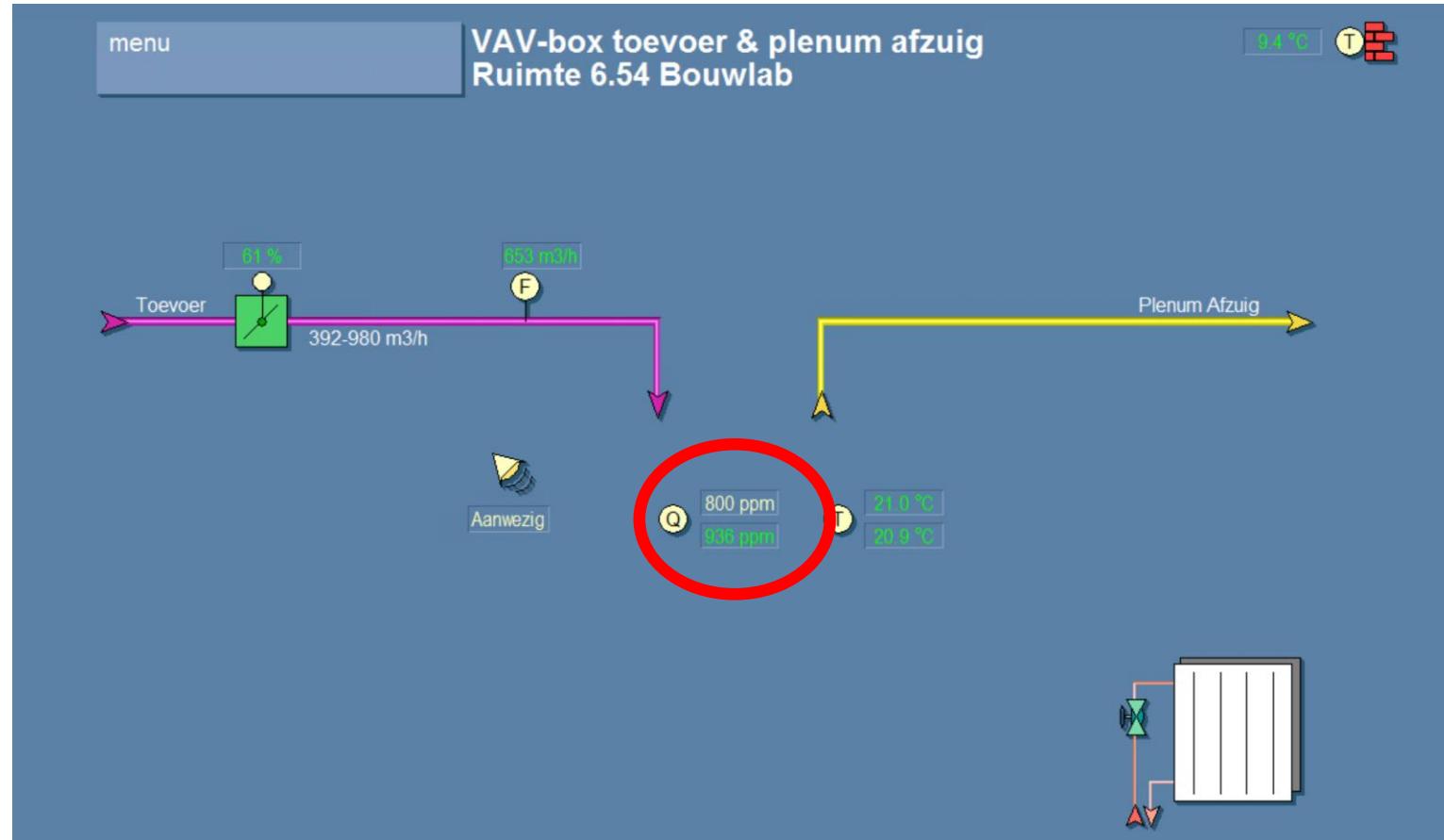
In opdracht van het ministerie van Binnenlandse Zaken en Koninkrijksrelaties.

>>Duurzaam, Agrarisch, Innovatief  
en Internationaal Ondernemen

# Ruimteregeling of conventionele installatie?



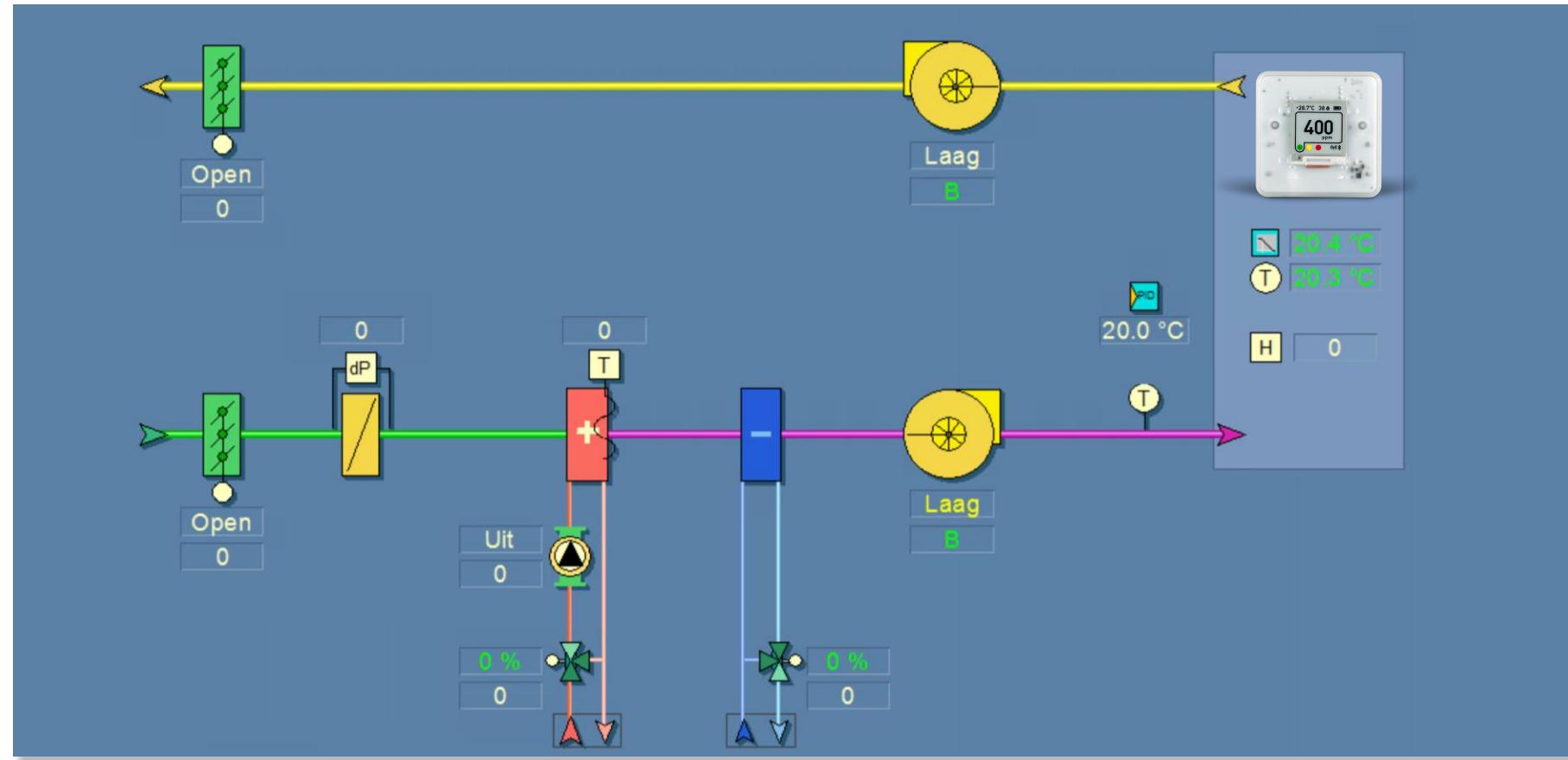
- Ruimteregeling met VAV systeem



# Ruimteregeling of conventionele installatie?



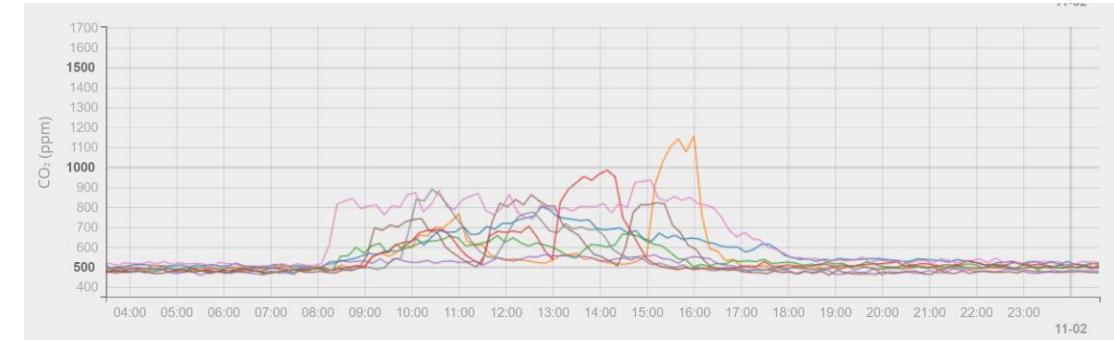
- Conventionele installatie



# Implementatie Aranet



- Eenvoudig programmeren
- Alarmeren
- Cloud-oplossing / monitoring





# Aranet wordt ingezet in educatieve instellingen over de hele wereld.



**OGVO**

Onderwijsgemeenschap Venlo & Omstreken

**HARVARD**  
UNIVERSITY



**Caltech**



**VNIVERSITAT  
DE VALÈNCIA**



**University of Colorado  
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**COLUMBIA  
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EDUCATION**

**EASTSIDE  
PREPARATORY  
SCHOOL**



**NBCUniversal**



**ACLU**  
AMERICAN CIVIL LIBERTIES UNION  
FOUNDATION

**EPFL**

**CrossFit®**

**Hostess Brands**

**abc NEWS**

# Case study: ROC van Amsterdam



## Aranet set up:

- 12 lokaties, meer dan 100 sensoren
- Streven <800ppm (frisse scholen klasse A)
- Beter inregelen ventilatie systeem door meetgegevens
- Meer klimaat comfort
- Inlezen gegevens op eigen database of op Aranet Cloud



**ROCvA KIEST VOOR  
EXTRA KLIMAATCONTROLE  
MET ARANET DRAADLOZE  
CO<sub>2</sub> SENSOREN**

# Conclusies

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- Luchtkwaliteit essentieel voor minimaliseren risico Covid19 besmetting op scholen en universiteiten.

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- Luchtkwaliteit essentieel voor minimaliseren risico Covid19 besmetting op scholen en universiteiten.
- CO<sub>2</sub> is goede variabele om mate van 'frisse' lucht te meten

# Conclusions



- Aranet - industry leading wireless sensor network

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- Simple plug-and-play setup

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- Free software – graphs, reports, centralised alarms

# Conclusions



- Aranet - industry leading wireless sensor network
- Simple plug-and-play setup
- Long range radio
- Free software – graphs, reports, centralised alarms
- Integrations with existing systems/data bases

Bedankt voor uw aandacht  
Bezoek onze stand op het innovatieplein



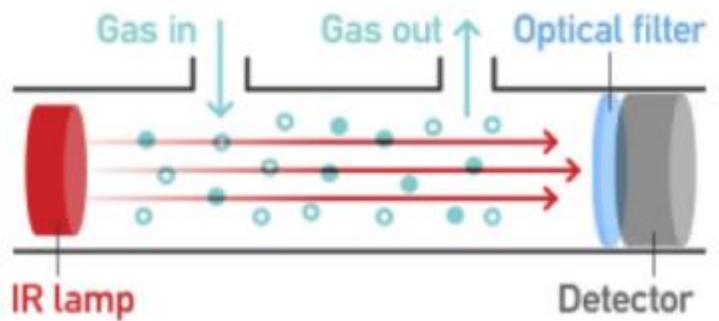
Erik van der Made  
Aranet Benelux  
[Erik.vandermade@aranet.com](mailto:Erik.vandermade@aranet.com)

# Backup slides



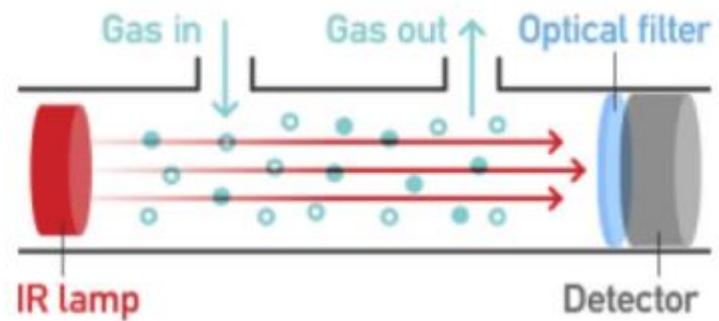


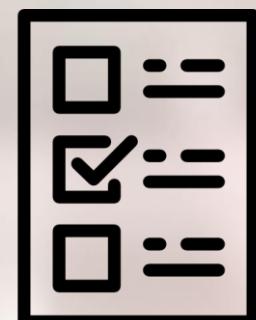
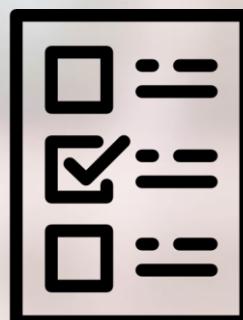
# How to measure CO<sub>2</sub>?

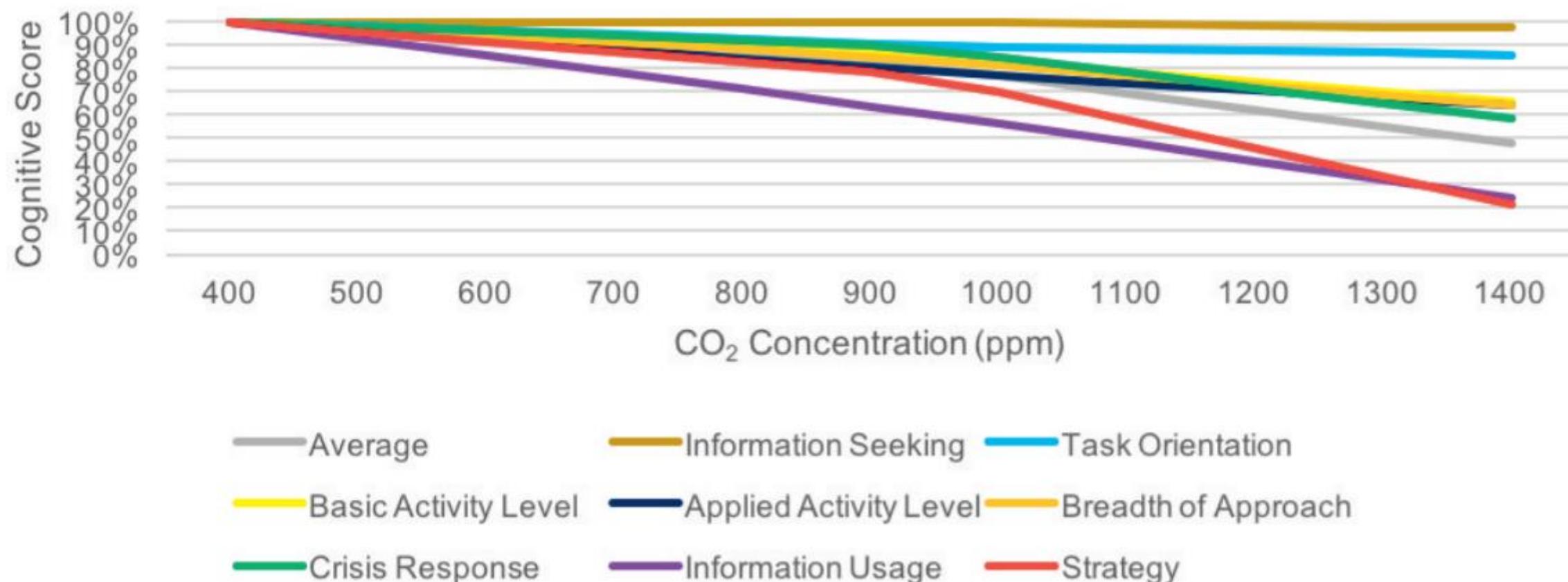




# How to measure CO<sub>2</sub>?

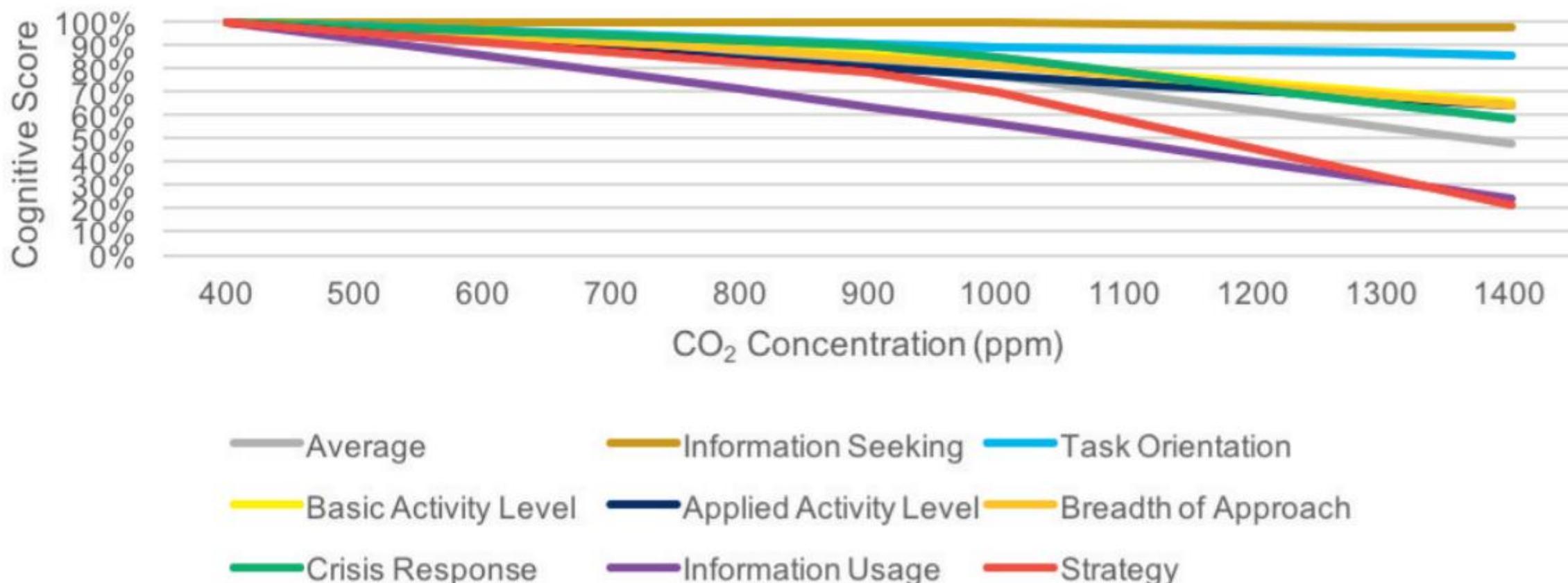






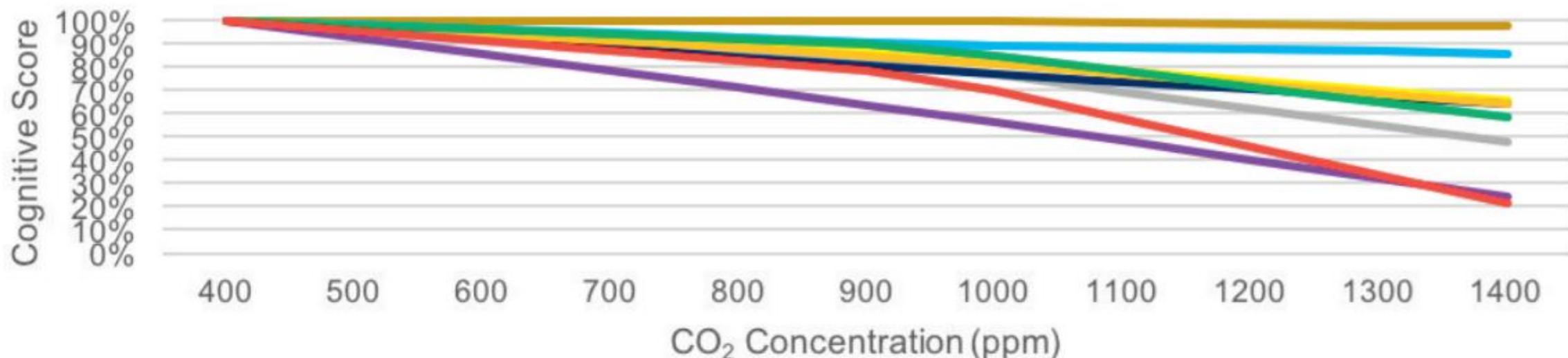


$\text{CO}_2 \uparrow$  945 ppm =   $\downarrow 15\%$





$\text{CO}_2 \uparrow$  945 ppm =   $\downarrow 15\%$



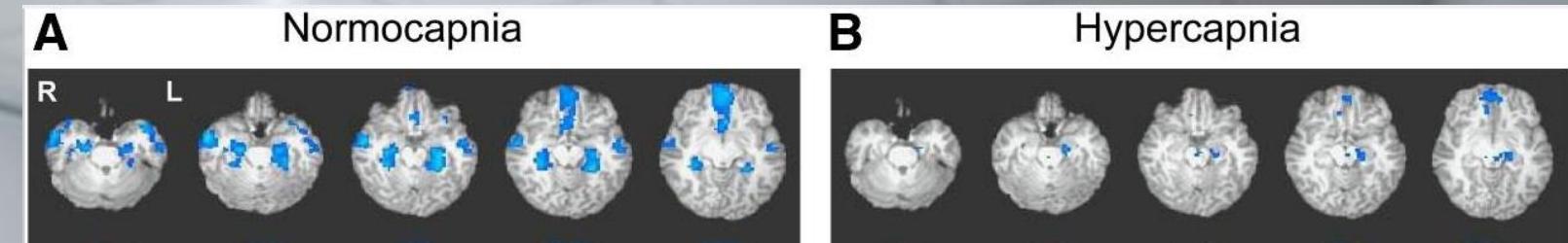
Average      Information Seeking      Task Orientation  
Basic Activity Level      Applied Activity Level      Breadth of Approach  
Crisis Response      Information Usage      Strategy

$\text{CO}_2 \uparrow$  1400 ppm =   $\downarrow 50\%$

↓ Neural activity

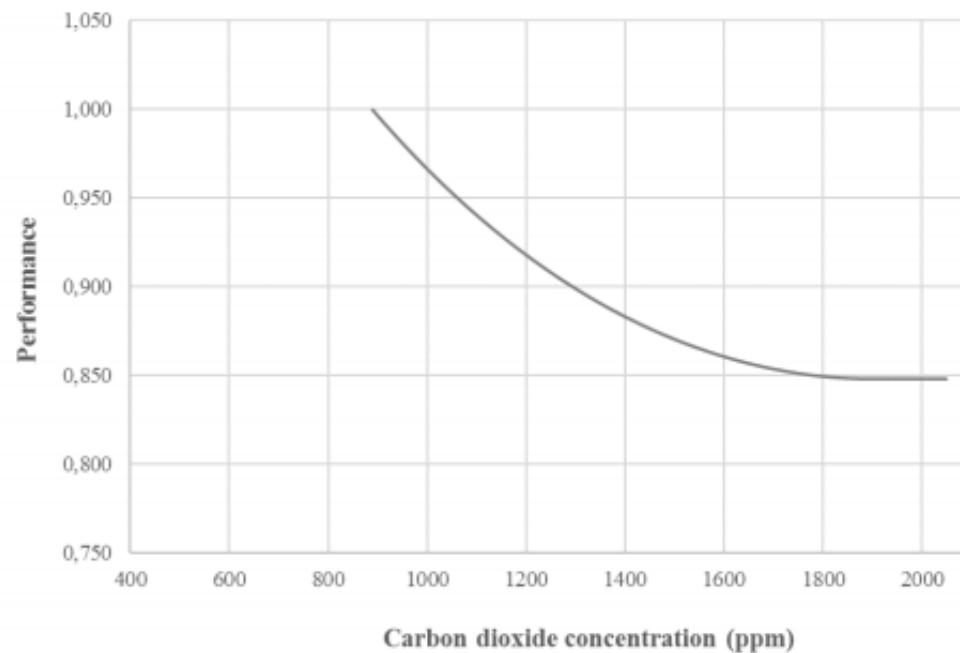
↓ Brain metabolic activity

↓ Communication  
between brain regions



Source: Xu F, Uh J, Brier MR, et al. The influence of carbon dioxide on brain activity and metabolism in conscious humans. *J Cereb Blood Flow Metab*. 2011;31(1):58-67. doi:10.1038/jcbfm.2010.153

# Speed and reaction time of pupils as a function of CO<sub>2</sub> concentration



Source: Petersen, Steffen & Jensen, Kasper & Pedersen, Ann & Rasmussen, Henriette. (2015). *The effect of increased classroom ventilation rate indicated by reduced CO<sub>2</sub>-concentration on the performance of schoolwork by children*. Indoor Air. 26. 10.1111/ina.12210.



# Effects on immune system



IMMUNITY

## Detection of Airborne Rhinovirus and Its Relation to Outdoor Air Supply in Office Environments

Theodore A. Myatt, Sebastian L. Johnston, Zhengfa Zuo, Matthew Wand, Tatiana Kebadze, Stephen Rudnick, and Donald K. Milton

Departments of Environmental Health and Biostatistics, Harvard School of Public Health, Boston, Massachusetts; and Department of Respiratory Medicine, National Heart and Lung Institute, Faculty of Medicine, Imperial College of London, London, United Kingdom

Rhinoviruses are major causes of morbidity in patients with respiratory diseases; however, their modes of transmission are controversial. We investigated detection of airborne rhinovirus in office environments by polymerase chain reaction technology and related detection to outdoor air supply rates. We sampled air from 9 A.M. to 5 P.M. each workday, with each sample run for 1 work week. We directly extracted RNA from the filters for nested reverse transcriptase-polymerase chain reaction analysis of rhinovirus. Nasal lavage samples from building occupants with upper respiratory infections were also collected. Indoor carbon dioxide ( $\text{CO}_2$ ) concentrations were recorded every 10 minutes as a surrogate for outdoor air supply. To increase the range of  $\text{CO}_2$  concentrations, we adjusted the outdoor air supply rates every 3 months. Generalized additive models demonstrated an association between the probability of detecting airborne rhinovirus and a weekly average  $\text{CO}_2$  concentration greater than approximately 100 ppm, after controlling for covariates. In addition, one rhinovirus from a nasal lavage contained an identical nucleic acid sequence similar to that in the building air collected during the same week. These results suggest that occupants in buildings with low outdoor air supply may have an increased risk of exposure to infectious droplet nuclei emanating from a fellow building occupant.

*Indoor Air* 2007; 17: 7–18  
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INDOOR AIR  
doi:10.1111/j.1600-0863.2006.00445.x

### Review Article

Role of ventilation in airborne transmission of infectious agents in the built environment – a multidisciplinary systematic review

**Abstract** There have been few recent studies demonstrating a definitive association between the transmission of airborne infections and the ventilation of buildings. The severe acute respiratory syndrome (SARS) epidemic in 2003 and current concerns over the risk of an avian influenza (H5N1) pandemic, have made a review of this area timely. We searched the main literature databases between 1960 and 2005, and then screened titles and abstracts, and finally selected 40 original studies based on a set of criteria. We established a review panel comprising medical and engineering experts in the fields of microbiology, medicine, epidemiology, indoor air quality, building ventilation, etc. Most panel members had experience with research into the 2003 SARS epidemic. The panel systematically assessed 40 original studies through both individual assessment and a 2-day face-to-face consensus meeting. Ten of 40 studies reviewed were considered to be conclusive with regard to the association between building ventilation and the transmission of airborne infection. There is strong and sufficient evidence to demonstrate the association between ventilation, air movements in buildings and the transmission/spread of infectious diseases such as measles, tuberculosis, chickenpox, influenza, smallpox and SARS. There is insufficient data to specify and quantify the minimum ventilation requirements in hospitals, schools, offices, homes and isolation rooms in relation to spread of infectious diseases via the airborne route.

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nature  
sustainability

REVIEW ARTICLE  
<https://doi.org/10.1038/s41893-019-0323-1>

## Direct human health risks of increased atmospheric carbon dioxide

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Growing evidence suggests that environmentally relevant elevations in  $\text{CO}_2$  (<5,000 ppm) may pose direct risks for human health. Increasing atmospheric  $\text{CO}_2$  concentrations could make adverse exposures more frequent and prolonged through increases in indoor air concentrations and increased time spent indoors. We review preliminary evidence concerning the potential health risks of chronic exposure to environmentally relevant elevations in ambient  $\text{CO}_2$ , including inflammation, reductions in higher-level cognitive abilities, bone demineralization, kidney calcification, oxidative stress and endothelial dysfunction. This early evidence indicates potential health risks at  $\text{CO}_2$  exposures as low as 1,000 ppm—a threshold that is already exceeded in many indoor environments with increased room occupancy and reduced building ventilation rates, and equivalent to some estimates for urban outdoor air concentrations before 2100. Continuous exposure to increased atmospheric  $\text{CO}_2$  could be an overlooked stressor of the modern and/or future environment. Further research is needed to quantify the major sources of  $\text{CO}_2$  exposure, to identify mitigation strategies to avoid adverse health effects and protect vulnerable populations, and to fully understand the potential health effects of chronic or intermittent exposure to indoor air with higher  $\text{CO}_2$  concentrations.

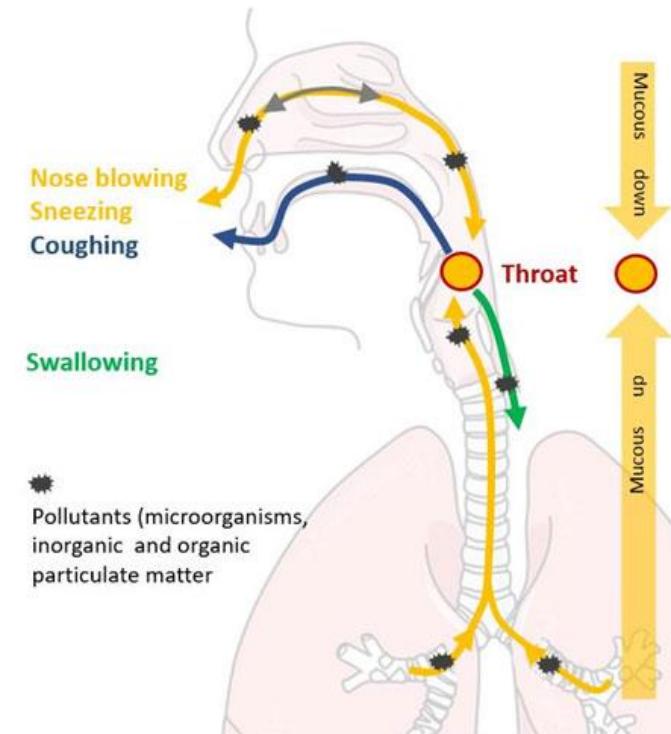


# Other Parameters: Relative Humidity



**IMMUNITY**

- Low humidity dries the mucus membranes in the nose and throat
- Recommended humidity: 40%-60%



**Mucociliary Clearance as "Moving Carpet Lift"**