European Respiratory Cluster Antwerp

Proceedings

Webinar ‘Covid-19 The issue of airborne transmission and how to minimize risks indoors’

June 19th 2020
Niel, Belgium

Supported by:

Acknowledgements

The workshop on '**Covid-19 The issue of airborne transmission and how to minimize risks indoors'** was held on June 19th 2020. The workshop was organized by the **European Respiratory Cluster Antwerp (eu.reca vzw).**

For this webinar we were able to convince outstanding researchers, medical experts and entrepreneurs to share their opinions and expertise. We are very grateful to all participants, but in particular to **prof. dr. Lidia Morawska** and **dr. Koen Vanden Driessche**, for sharing in a succinct and very accessible fashion the scientific evidence with regard to airborne transmission, the importance of following guidelines such as wearing masks, avoiding crowds, ensuring ventilation and adhering to a decent cough etiquette. Their extensive experience in the field of Covid-19, SARS 1 and TB is utterly relevant. We sincerely hope their insights will be part of the debate on how to defeat Covid-19. We are also grateful to **dr. Marianne Stranger** for her expertise with regard to indoor air quality, for moderating the workshop and for mobilizing participants that can help from within their respective agencies to make a difference.

We also thank the **entrepreneurs** partaking in the session for sharing their knowhow and their work with regard to creating a safe indoor environment.

We would also like to acknowledge **Genano Oy** for supporting the eu.reca Air Quality work stream, allowing us to develop these activities.

June 2020

Proceedings can be electronically downloaded from www.eureca.world.

WEBINAR COMPONENTS

The webinar consisted of 2 main parts. First the scientific evidence with regard to the airborne transmission of Covid-19 was outlined. Also, experiences with regard to TB, another airborne disease, were shared focusing on the importance of protective mouth masks and cough etiquette.

After this introduction, several commercially available mitigation strategies were discussed, from ventilation, over HVAC to air purification and UV pathogen elimination and the impact of microbial solutions. Afterwards, there was the opportunity for further discussion.

WELCOME
BY JADE VERREPT, COORDINATOR OF eu.reca vzw

In her welcome address, Jade Verrept, coordinator of eu.reca vzw, introduced the European Respiratory Cluster Antwerp (eu.reca), a young ecosystem entirely focused on everything that impacts the human lung. To advance respiratory innovation, eu.reca brings scientific and medical experts together with entrepreneurs and other stakeholders. The network stands for a hands-on approach, not only tackling relevant challenges, but always reaching out to present possible solutions.

As eu.reca's approach is based on interaction, initiatives such as round table workshops and webinars are important. In closing, Jade welcomed all participants from different backgrounds stressing that cross-fertilization between industry, academics, clinicians and governments is key to accelerate in the field of respiratory diseases.

SETTING THE SCENE : INTRODUCING THE BELGIAN CONTEXT BY MARIANNE STRANGER (VITO)

In Belgium the approach towards fighting Covid-19 has focused mainly on recommendations with regard to keeping a distance, washing hands and wearing protective mouth and nose masks when a safe distance cannot be maintained, though even then it is not mandatory. The airborne transmission route has thus far not been a major part of the discussion.

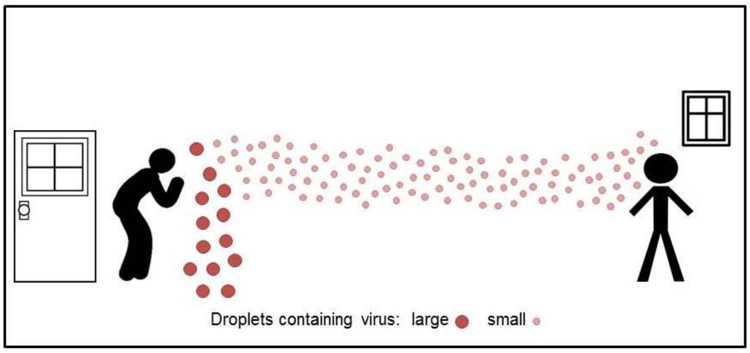
The most straightforward manner to reduce the risk of indoor pollution, would be to ensure a proper ventilation. Unfortunately, both the housing stock and school building stock in Belgium are utterly divers, ranging from new, energy-efficient, airtight houses equipped with mechanical ventilation systems to a majority of older constructions lacking any mechanical ventilation, relying entirely on window opening.

"It is crucial that the debate on building ventilation and Covid-19 includes the issue of airborne transmission. But also, one should realize that the solution is much more complicated than simply stressing the importance of good ventilation. Knowing that ventilation and aeration in Belgian school buildings, houses, and offices can be very poor, solutions are highly needed. Different situations require different approaches; it will be necessary to invest in further research in close collaboration with entrepreneurs to be able to ensure a safe indoor air climate. Not only with regard to this virus, but in general." Marianne Stranger, indoor air quality expert, VITO.

THE AIRBORNE TRANSMISSION OF COVID-19 BY PROF. LIDIA MORAWSKA (QUT)

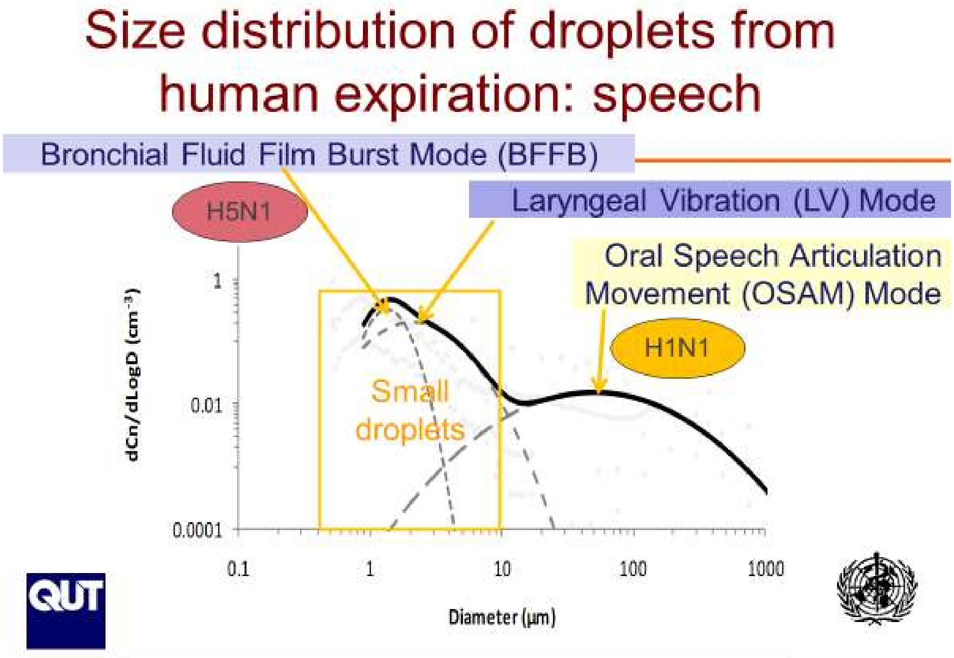
Having dedicated a lot of research on the airborne transmission of SARS-1, prof. Morawska and her team focused from the start of the SARS-CoV-2 outbreak on the risk of airborne transmission indoors, looking into the role of air flows on the transmission and the impact of mitigation strategies such as ventilation.

Mouth and nose are the sources of the spreading of **expiratory droplets**, which are aerosolized during all expiratory activities. Larger droplets can be transmitted by close contact (< 1.5m) or by touching surfaces where they were deposited. Smaller droplets behave like aerosols in the room and can impact other people in that same room (> 1.5m).



The scientific basis of airborne spread infections is in fact based on these droplets in the airstream of exhaled air. The droplet atomization in expiratory activities is the result of the passage of an airstream, at sufficiently high speed, over the surface of liquids. In this case, the liquids are present in the bronchi, trachea, larynx, pharynx, and nose. Earlier studies have indicated that during speech both the size distribution of droplets and their concentration varies a lot.

During speech there are three distinctive phases in the **expiratory process**: the first one, related to bronchial fluid, is the most prominent and contains the smallest droplets (below the 10 μm). The second phase is produced by the laryngeal vibrations, whereas the third and final phase is the result of oral speech articulation, which, several studies indicated, played an important role in the airborne transmission of H1N1-virus.

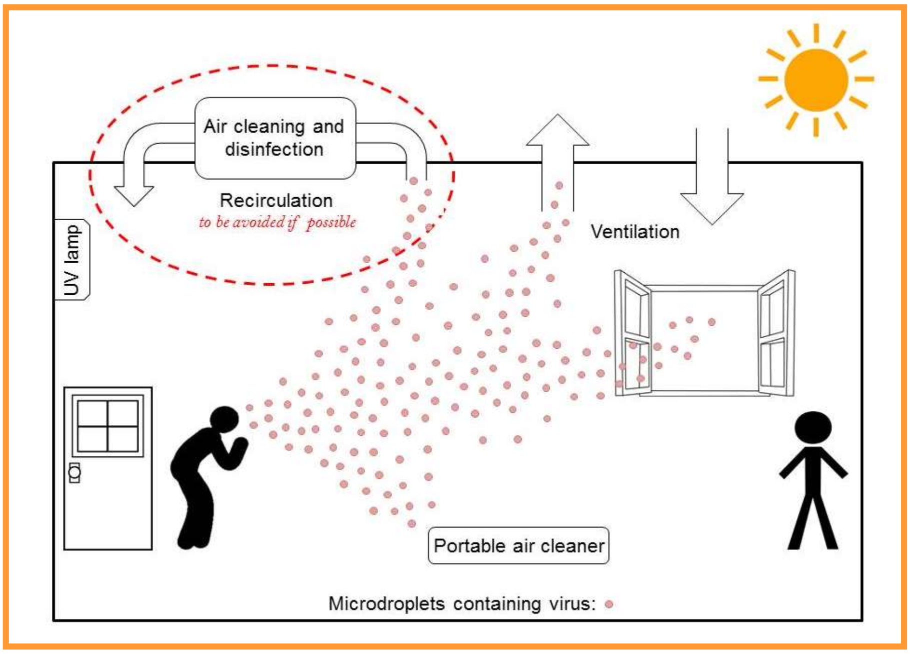


These conclusions were reached using a flow tunnel, which allowed for the measurement of the concentration of droplets and their size distribution in the exhaled air. As the person sitting in the tunnel is breathing into it, the aerosol particles are diffused and measured with different instruments. In terms of **concentration** prof. Morawska's team found that it **is defined by** the **activity**; the highest concentration having been determined during speaking, singing and coughing and much lower concentrations while breathing. (*Morawska, L., Johnson, G.R., Ristovski, Z.D., Hargreaves, M., Mengersen, K., Corbett, S., Chao, C.Y.H., Li, Y. and Katoshevski, D. Size distribution and sites of origin of droplets expelled during expiratory activities. Journal of Aerosol Science, 40: 256-269, 2009.*)

An experiment related to the Pseudomonas aeruginosa bacteria in cough aerosols from 19 infected Cystic Fibrosis patients, was also revealing, as it radically opposed two clinical dogma's, namely that aerosols only travel an arm length and remain infectious for mere seconds. The experimented indicated that **droplets easily travel the whole length of the tunnel** (4 metres and more) and **remain infectious for up to 45 minutes.** (*Knibbs et al., Thorax, 69: 740-745, 2014*)

These findings are directly relevant to Covid-19. Though, these types of studies and experiments have not yet been conducted into Covid-19, a lot of retrospective simulation studies have taken place with regard to the **SARS-1** pandemic in 2003. One of them, based on data of the Prince of Wales Hospital in Hong Kong, indicated that up to **60% of the transmission was caused by the airborne route.** (*Xian et al. 2017, Role of fomites in SARS transmission during the largest hospital outbreak in Hong Kong, PloS One, 12(7)*)

Understanding and recognizing this transmission route is very important in terms of mitigations.

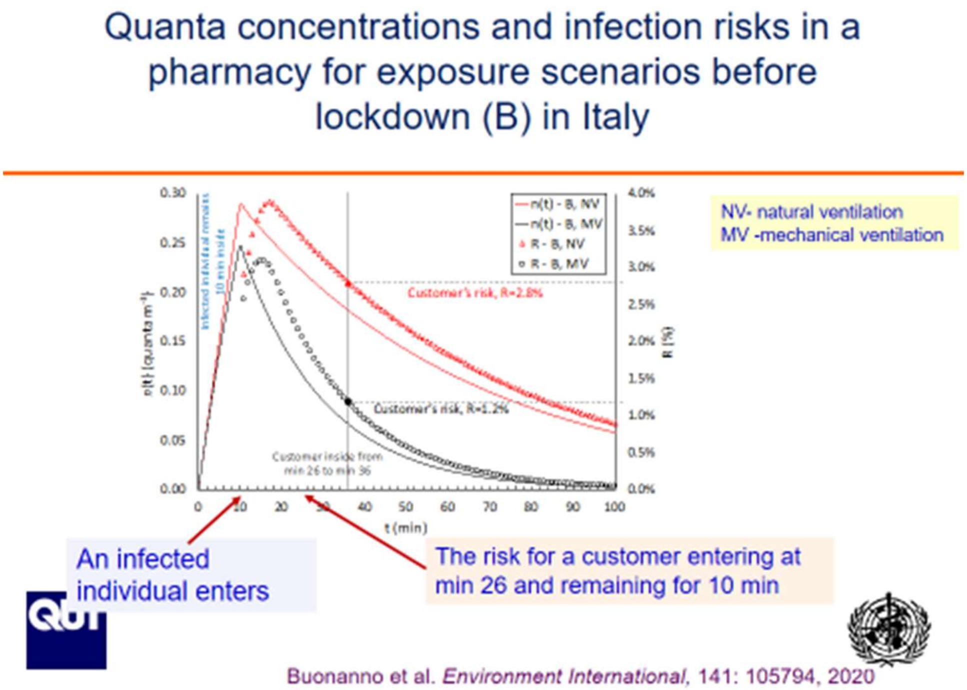


"To limit the airborne transmission, we need to focus on appropriate building engineering controls including sufficient and effective ventilation (providing a space with outdoor air either by mechanical or natural means), possibly enhanced by particle filtration and air disinfection, avoiding air recirculation, and avoiding overcrowding." Prof. Lidia Morawska, Director of the International Laboratory for Air Quality and Health, QUT.

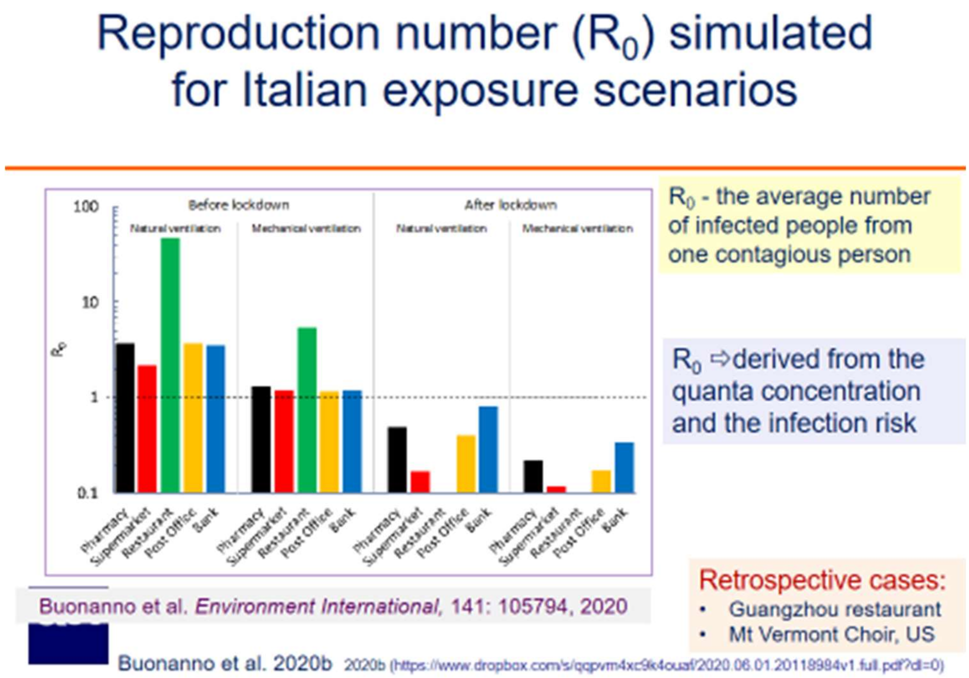
It is important to notice that the existing **ventilation guidelines for** removing CO_2, exhaled by the occupants in a space, are different from the guidelines used for controlling infection transmission. In the case of **infection transmission**, one speaks in units of quantum. A quantum being the dose of infectious airborne droplets required to cause infection in 63% of susceptible persons. The emitted quanta depend on the location of the pathogen in the respiratory tract, the individual physiology of the respiratory tract, the stage of the disease, the type of respiratory activity, and the virus itself. But in spite of these complexities, there are existing methods for a quantitative risk assessment of infection transmission. The **Wells-Riley model** is particularly suited to this, working with parameters such as the number of infected people in a particular environment, the number of infectious quanta, the average respiratory ventilation rate (the number susceptible people inhaling the infectious quanta), the duration of the exposure, and the volume of infection-free (outdoor) air supplied in the room (m^3/h).

A study in the Prince Charles Hospital in Brisbane on the impact of ventilation (outdoor air exchange per hour) on the airborne infection risks of Influenza, Tuberculosis, and Rhinovirus learned that the curves of infection risk for the different pathogens decrease dramatically the higher the outdoor air exchange per hour. (*Knibbs et al. American Journal of Infection Control, 39: 866-872, 2011*)

Another model quantified the quanta concentrations and infection risks in a pharmacy for **exposure scenarios** before lockdown in Italy. An infected individual enters at minute 10, a second person entered the pharmacy at minute 26 after the and remains for 10 minutes. As soon as the infected person entered, the number of quanta increases and so does the risk of infection. The data shows that the risk can vary with the mode of ventilation and the intensity of ventilation.



Another study was performed in Italy focussing on **R₀** – the average number of infected people from one contagious person – **and quanta concentration & infection risk** in several environments like a pharmacy, supermarket, restaurant and post office both before lockdown (no limit to amount of customers and normal ventilation conditions) and after lockdown. Noticeably, after lockdown R_0 was significantly lower.



And even more recently a study defined the evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant in Guangzhou, an actual situation, not a hypothetical case. This study reveals that the airflow was to blame for the number and location of infected cases. So the issue is not the air conditioning as such, but rather the direction of its airflow. This case clearly underlines the necessity to put new guidelines in place for engineering controls of ventilation to make sure that the virus is effectively removed from the air. (*Yuguo Li, Aerosol transmission of Sars-CoV-2, posted April 22, 2020 doi: https://doi.org/10.1101/2020.04.16.20067728. medRxiv preprint).*

"It is crucial to accept that airborne transmission is happening ; it is a matter of scientific evidence. Non-believers make statements such as 'The evidence so far is very weak', or 'This could raise fear', or 'Most countries are successful in halting epidemics with the current WHO recommendations' or 'Infection control on ventilation systems may come at unnecessary additional cost.' These statements, however, are based on beliefs, not science. Only by accepting the facts, can we focus on solutions. Every year, epidemics of numerous respiratory infections strike, sicken millions, kill thousands and cause economic loses of billions of dollars. The measures taken should therefore be adaptable, in a flexible manner, to the specific risks and demands." Prof. Lidia Morawska.

Q&A

The tunnel experiment is a closed environment experiment. What do you know about the traveling time of infected aerosols in the open air?

Several parameters determine the traveling time in outdoor and indoor air such as diffusion or air current, with the latter being the most important one in this case. An air current takes the particle from one place to another. This is the most efficient way for the particles to travel. Imagine somebody smoking a cigarette in a room.

After a while you will smell it in the adjacent room, meaning the particles didn't diffuse, but were taken from the place where they originated to the place where you are.

Do we have data for COVID-19 to the amount of SARS-CoV-2 virus needed, so the infectious dose?

With regard to the modelling in our studies we worked with simulations based on the infectious dose of SARS-1. Though more and more information is being gathered on Covid-19 in ongoing studies.

In contrast to other pathogens, there is no conclusive evidence that coughing is the main motor of transmission, but how sound is the evidence with regard to other exhalation actions such as loudly speaking, shouting or singing. There are clearly cases where singing played a role, considering outbreaks in choirs, but is it justified to focus policy on these activities? How good is the evidence about the contribution of exhalation activities to the transmission and aerosol production?

There have been many such outbreaks since the start of the pandemic. Initially people were oblivious, but gradually, throughout the progress of the pandemic, people became very precautious. Yet, if we look retrospectively at the outbreaks, we see that they kept occurring even when people were taking all the precautions, including social distancing, not touching, etc. It would be difficult to justify that the transmission occurred due to a close-range contact if precautions were taken. The modelling we are doing relates well to what we find retrospectively. The problem is that not every outbreak can be modelled, and research will always be retrospective. Many people talk about super spreaders as an explanation for these outbreaks. But I don't think this can be the only ingredient. **For a big outbreak, you need three parameters (1) at least 1 infected person, (2) no ventilation or very low ventilation, and (3) the time spent must be relatively large.** These are the ingredients. Luckily, we do not see this kind of outbreaks happening in passing or in supermarkets because the time spent there is relatively short. But in many indoor occasions the ingredients are present, resulting in a high infection risk.

What is the most relevant mitigation method to avoid the spread of the virus: limit the time spent close to people or assure sufficient distance between people?

These are both important factors at the same time. There is no single transmission route of importance. If someone coughs or sneezes next to you, then very quickly you can get an infectious dose. We cannot exclude one measure; all the precaution measures must be taken into consideration at all times.

Are there data available on the necessary ventilation rate to minimalize the airborne transmissions? Would there be a minimum ventilation rate required to reduce the risk of virus transmission?

During my presentation, I show the infection risk versus ventilation rate for 3 different pathogens (influenza, tuberculosis, and Rhinovirus). These models are fairly simple, not taking into account the activities of people and the infectious dose they are emitting. We get requests from all over the world to do this kind of modelling for COVID-19. We are talking about a new type of guidelines on the requirements of the infection risk.

What about mitigation and all the systems to prevent the airborne spread of the virus, like ventilation, air cleaning strategies or, HVAC maintenance. How do you think these technologies, and the variety of these technologies, can help to fight COVID-19 or other viruses and what will be needed in the future to make them even more effective?

Just to be clear, I am not an engineer. I do believe, however, that the control measurements that are being used such as UV light are not the first line of defence, but rather one of the following. The first line of defence is effective ventilation, also taking into account the flow direction in a particular place. If sufficient ventilation cannot be realized, air cleaning and disinfection become relevant. And particularly where air recirculation is in place and cannot be avoided, it is necessary to take extra precautions.

When you go to the second line of defence, for instance in the case of UV light, it is always important to consider well how to put it in place, where to put it in place and ensure that it does not interfere with normal operation. So, though I am convinced that these technologies are useful and necessary in some environments and situations, I would not use them en masse in all indoor environments.

There has also been a lot of discussion about portable air cleaners, which are used in many places, particularly in Asia, not necessarily for the purpose of infection prevention, but simply to clean the air as outdoor pollution can be very high. There is a range of devices and a range of manufacturers. Many of these work well, in particular those with HEPA filters, but some of them are much less effective. And even then, one has to consider not only whether the device is effective, but also the circumstances in which you want to use it. For instance if you put a device in a large open space, than it might be less effective in cleaning the air ; so it is not just the device but also how you intend to use it. But certainly there are situations where they are necessary and can be complementary to other available ventilation measures. But first there is ensuring good ventilation and avoiding air flow from one person to another.

In Belgium, we have a lot of buildings without technical ventilation. So, the main way of ventilation is opening the windows or doors to let the fresh air in. But what in winter? Would you recommend opening the windows or moving to the second line of defence, namely air cleaning?

Try to always induce ventilation; natural ventilation is always the best option, because you do not risk any technical failures or wrong use, both of which can occur in mechanical ventilation. If this is not possible, for instance due to cold weather, technical ventilation can be recommended. But keep in mind, if you close the windows because it is too cold outside, you create exactly an environment which will prompt an infection spread. This was what happened with the choir ; it was cold outside, so they closed all windows and created a situation where ventilation was insufficient. There is no simple solution, but closing everything up will always lead to a rise in infection risk.

In case of ceiling air condition with a close loop, what would be the infection risk?

In the case of close loop meaning air recirculation ; it can be safe if the system is working properly and contains adequate filtration to prevent the virus from re-entering. However, there are many risks if the filter does not function properly, is cracked and so on. That is why there is a recommendation against recirculation. However, everything must be seen in its proper context. If you cannot open windows and you are working with mechanical ventilation, you have no choice but have to make sure that everything (filter, ducts,…) is working properly and maintained regularly.

MASKS TO PREVENT AIR CONTAMINATION WITH TB AND OTHER AIRBORNE TRANSMITTED DISEASES BY DR. KOEN VANDEN DRIESSCHE (UZA)

When talking about airborne transmitted pathogens one has to distinguish between those that transfer from patient to patient and those you get from the environment. TB is the only obligate airborne transmitted pathogen. Rubeola (virus causing measles) and Variola (virus causing smallpox) are preferentially airborne transmitted pathogens, whereas there are a lot of opportunistically airborne transmitted pathogens such as the Varicella-Zoster virus causing chicken pox.

With regard to TB the airborne transmission was demonstrated by prof. Riley who took a sample of exhaust air from rooms filled with TB patients and released it in cages with guinea pigs, effectively infecting the pigs and demonstrating the airborne transmission of TB.

A more controversial airborne transmitted pathogen is norovirus. An interesting case in this regard occurred in Derby (UK) where, at a restaurant, a customer fell ill and vomited at her table. The vomit was rapidly cleaned up by one of the waiters with a mop and disinfectant. The meal continued, yet over the next days 53 other people got norovirus disease. The closer they were sitting to the incident, the more likely they were infected.

With regard to TB the airborne transmission is clearly demonstrated. Interesting for the discussion today, is a study performed by Wood. He sent former TB patients, recently diagnosed TB patients, and healthy people with GPS trackers into the Kape town community. The GPS coordinates recorded for all participants throughout the period that they were monitored, was added as a layer to this map. He also added a CO_2 monitor; high CO_2 levels indicate you are inhaling air someone else exhaled. The higher the CO_2 levels, the more infection with TB occurred.

With regard to the question if face masks are effective in blocking the spread of TB, critics have argued that smaller particles will escape through the gaps in ill-fitting masks. And although there is evidence that air indeed escapes a mask, prof. Riley argued this does not matter, because covering your cough will effectively prevent droplets from evaporating in small airborne particles, thus avoiding airborne transmission. A similar setting to Morawska's flow tunnel indicated that CF patients wearing surgical mouths mask whilst coughing saw a reduction of the airborne *P. aeruginosa* load by an average of 88%. (*Koen Vanden Driessche, Niel Hens, Peter*

Tilley, Bradley S. Quon, Mark A. Chilvers, Ronald de Groot, Mark F. Cotton, Ben J. Marais, David P. Speert, James E. A. Zlosnik. The American Journal of Respiratory and critical Care Medicine. 2015 Oct 1). An ongoing study in Cape Town of the Stellenbosch University indicates (pilot results) that mouth masks are effective in reducing the airborne transmission of TB whilst coughing. Important to notice is that the study also indicated that there were no particles isolated whilst patients were breathing, proving that coughing is the driver behind airborne transmission of TB. Cough etiquette is therefore very important with regard to stopping TB.

Is cough etiquette relevant with regard to stopping COVID-19 transmission? There is a lot of evidence that airborne transmission is a driver of the COVID-19 epidemic. There are several studies emerging indicating that wearing a mask whilst coughing, blocks the generation of infectious SARS-CoV-2 particles. However, the question remains whether in case of Covid-19, coughing is indeed a main transmission route.

"A retrospective study at the University Hospital Antwerp among infected patients revealed that of 38 patients who could indicate who infected them, the majority indicated that person was not coughing. The role asymptomatic patients play in spreading the virus, further indicates that contrary to earlier WHO statements coughing is not a main driver for Covid-19. However, wearing a mask also prevents droplets from evaporating when speaking or breathing. So wearing a mask has huge potential to stop Covid-19. " Dr. Koen Vanden Driessche, pediatric infectious diseases, University Hospital Antwerp.

BASIC PRINCIPLES OF VENTILATION BY PROF. IVAN VERHAERT (UANTWERP)

MITIGATION STRATEGIES

Ventilation

Looking at a pollutant in an indoor environment from an engineering point of view, the key factors in determining the risk of contamination are (1) the amount of ventilation and where you are ventilating from, (2) the risks (pollutant mass) and (3) the presence of absorbers such as filters or UV lamps.

With regard to the first factor it is important to stress that recirculation is to be avoided; try to **ventilate with clean air**, preferably outside air. Also important to notice is that air conditioners as such are no risk as such ; they need just need to be used cautiously, meaning that sufficient additional ventilation has to be present.

Increasing ventilation is the best approach in fighting the virus, so **open your windows.** If you have mechanical ventilation, have it operate continuously ; it will help remove virus particles. Moreover, the fresh air supplied per person should be at least 10 l/per second per supplied person. A volume that has to be increased in environments where people are performing physical activities. If you have a CO2 based ventilation, lower the CO2 set point, increasing the indoor air quality by creating **higher ventilation rates.**

Recirculating air flows are to be avoided, because they spread pollutants in the air. An example is an air conditioning system with recirculating airflow, which will give a false feeling of safety, because while the air provided might feel fresh, it is not clean. Also requiring extra attention are heat recovery devices in mechanical ventilation systems, often part of air handling units. Ensure that these systems avoid leakage by creating overpressure in supply and underpressure in exhaust.

The second line of defence is made up by filtration. Careful ; many filters do not affect the virus particles, because they are too small to be captured. Ventilation systems using **HEPA filters** for instance capture particles above 0,3 µm, but the virus is 0,1 µm, implicating that stand-alone virus particles will not be targeted, but as soon as the virus settles on droplets or other particles, it will grow in size and be stopped. **Electrostatic workers** are also options and effective, though often these devices are portable and work small range. **UVC light** is also an option, but is mostly used in hospitals and industry.

It can also be interesting to **measure your indoor air quality** to better know when to ventilate. CO_2 can be used as an indicator, as it is also related to the number of people in the room. CO_2 has to be below 950 ppm or 800 ppm.

"A low cost measure to create awareness, could be to install lights that give a signal when CO_2 is high and windows should be opened. It might encourage people to be more sensible to the need of adequate ventilation." Prof. Ivan Verhaert, energy systems and applied thermodynamics, University of Antwerp.

In short, maintaining a good air quality is very important. Supply as much outdoor air as possible, getting to a ventilation rate of at least 10l/second per person. Do not switch off ventilation during weekends or holidays but put them on a lower rate.

Also an interesting read in this regard are the Rehva Guidelines, https://www.rehva.eu/activities/covid-19-guidance, Talk on COVID-19.

CLEANLINESS OF VENTILATION SYSTEMS BY SEPPE THYS (HAMSTER CLEANING) AND ROBRECHT SOLLIE (ABN)

HVAC

A professionally cleaned and well-maintained ventilation system is a requirement for good air quality. Optimal ventilation systems dilute aerosols produced by people and thus diminish the risk of airborne transmitted infections. In other words, though cleaning will not actively destroy the virus, it does assure good air flow and ventilation rate necessary to have a safe environment. Clogged filters or obstructed air ducts reduce air flow, enhancing the infection risk.

Unfortunately, in practice, a lot of ventilation systems are not assessed, have no regular cleaning, nor a maintenance strategy. Hopefully, the COVID-19 pandemic will be a wake-up call for people to realize that ventilation systems are key to indoor air quality, which in turn has an important health impact.

"The key issue is, we have to reduce the infection risk. Social distancing plays a part in it, the time spend with infectious people plays a role in it and ventilation plays a role in it. And for a ventilation system to work optimally, it has to be clean.", Seppe Thys, CEO, Hamster Cleaning.

On the other hand, ventilation systems that are subjected to a cleaning strategy, with a yearly check-up and an assessment of the cleaning, do not need extra measures for COVID-19. Furthermore both European standards (EN 12097 and EN 15780) and Belgian legislation (codex for Healthy Workspaces) clearly define the extent to which and way in which ventilation systems have to be cleaned and maintained.

With regard to your HVAC system and the way it functions, the goal today should be to get the used air out of the building and fresh air in. The advice today would be to adequately extract the air , to extend operation hours of ventilation units, to shut off any unfiltered recirculation, to minimise air circulation without HEPA filter (in AC units) and implement UV-C, as it will kill the virus (though it will have no impact on factors such as fine dust).

With regard to filters, the same frequency can be used to change out normal filters. HEPA H14-filters on the other hand do capture viruses and bacteria, as well as other indoor pollutants. Today, these filters are already in use in pharmacy, biosafety cabins and the like. ABN has developed the SteriOffice which through a combination of HEPA filters and high pressure keeps the virus out.

"Covid-19 brings radical change in HVAC approach. Technical maintenance goes hand in hand with hygienic maintenance.", Robrecht Sollie, strategic advisor, ABN

AIR PURIFICATION BY UV-LIGHT BY FAHMI YIGIT (VIROBUSTER)

UV-light

Virobuster was established in 2002 as an answer to the challenges of the SARS-1 epidemic and today has over 20 years of experience in **UV-pathogen cleaning**. Throughout the years the company's focus has shifted to the influence of bad air on food production in the food industry. Recently, though, they have returned to health care, focusing on mitigating airborne pathogen transmission.

The core of air cleaning system is the **UV-C reactor**; air is forced through the reactor, in which the power of the reactor (more than 1700 Watt/m^2) destroys the pathogens. To give you an idea ; fungi are eliminated at a level of 1200 Watt/m^2, the SARS-CoV-2 virus at a level of 40 Watt/m^2.
The difference between classic UV-C and the concept of Virobuster UV-C relies on an innovative reflection system. Normally lamps are used to create the necessary energy, Virobuster adds reflection to the equation, impacting both use of energy and efficiency.

There is a fundamental difference between HEPA filters and UV-C. HEPA filters are particularly suited to capture dust, pollen, tobacco and molds. UV-C is more effective against bacteria, viruses and also molds, but steritubes get in trouble with bigger and non-organic particles. HEPA filters in turn fail to capture small, single virus particles, which makes UV-C more effective when targeting the virus.

"The combination between a low level filter and a UV-C solution is ideal, as it deals with the entire spectrum of polluents. ", Fahmi Yigit, technical director, Virobuster.

The UV-C system only uses sunlight, and even after 9.000 hours, you maintain the same efficiency. It is user-friendly with no necessity for cleaning, nor risk for the user. The advantage of the system is that you can simply put it on when needed, assuring it is also cost-efficient. With regard to implementing this technology, there are three options ; a retrofit into existing air ducts, integration into a new air handling unit and an end-of-pipe solution at the grid, so at the last point of entrance into the room.

Today, it is widely used in the medical field, air handling units, hospitals, transport industry, food industry, etc. Publications with regard to effectiveness against viruses are ample and available.

With regard to this pandemic, we should also consider **downflow ventilation** instead of traditional overhead ventilation, in which both the influx and exhaust of air happen via the ceiling. Operation theatres function differently; they bring in air at the top and exhaust at the bottom, creating a downflow forced convection. This will force virus particles to flow downward instead of swirling between the occupants of the room. This situation can be induced by standalone units.

AIR PURIFICATION ON NANO-SCALE BY MARC VAN MAEL (GENANO)

Air purification

Genano is a Finnish company, focused on air purification through an internationally patented **nanotechnology**. This technology sucks dirty air into the purifiers ionization chamber. The **ionised electricity** then cleans the air of ultrafine particles (including viruses), capturing particles down 3n and effectively destroying the DNA and RNA of the virus, even of single virus particles. Genano purifiers or the only purifiers that can reach nanoparticle size. A carbon filter on top filters out any ozone.

"I have been extremely concerned about this topic, though I am not a virologist or a doctor, but an entrepreneur who's been engaged in the field of air quality for many years. After the outbreak of Corona virus the interest in our product spiked, mostly in China to where we shipped over 300 purifiers. I tried to reach out to our governments about the risks of airborne transmission, but that has proven difficult. I am happy that all speakers today have been confirming the issue of airborne transmission and hope it will give us time to prepare for the upcoming winter. Together we should continue to create awareness and prove that we have enough technology available to defeat the virus in the air." Marc Van Mael, Genano

Genano has chosen to create a practical solution; **mobile units** that clean and recirculate air, realizing that it is not always possible to ventilate with outside air. These units can be placed in any environment and will clean the air at a rate of 100 up to 500 m^3/h. Depending on the size of the room, we can achieve up to 6 air changes/h.

The advantage of this technology is furthermore that it does not use filters that can get clogged up, no loss or pressure drops, no energy loss and no living particles whatsoever in the membrane. The technology is well-proven, with tests from universities in the Nordics, China and Australia. During the first outbreaks of SARS-1 and MERS we were active in Saudi-Arabia, where we proved the value of our machines in medical environments. The advantage of our mobile units is that they can be **easily deployed in other environments**, such as an office, restaurant or day-care centre. We even have small units to implement in elevators.

MICROBIAL APPROACH FOR AIR CLEANING BY FILIP WILLOCX (LIVING TECHNOLOGIES)

Microbial Solutions

BioOrg works on bacterial cleaning and the mitigation of infection risk by pathogens. A recent study indicated that the use of **benign Bacillus** spp. of BioOrg **purifies the indoor air of particulate matter**, to which the virus often attached itself. By removing particulate matter from the air, the risk of Covid-19 infections and severity of the disease diminishes.

Scientific papers of a nationwide cross-sectional study of Harvard University indicate that there is a risk related to the exposure to **air pollution and COVID-19** mortality. A small increase of only 1 $\mu g/m^3$ in PM2.5 is associated with an 8% increase in the COVID-19 death rate. Another article reported that the risk of COVID-19 is associated with long-term exposure to air pollution. (*Xiao Wu and Rachel C. Nethery, April 24, 2020, Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study, Harvard University)*

A study in China showed similar results, demonstrating that an increase of 10 $\mu g/m^3$ in PM2.5 was found to be associated with an increase in the number of COVID-19 cases, as well as an increase in severe infection. (*Risk of COVID-19 is associated with long-term exposure to air pollution, Huaiyu Tian, Yonghong Liu, Hongbin Song, Chieh-Hsi Wu, Bingying Li, Moritz U. G. Kraemer, Pai Zheng, Xing Yan, Guang Jia, Yuxin Zheng, Nils Chr. Stenseth, Christopher Dye, April 24 2020*)

"Several studies highlight the importance of air quality improvements to health benefits, specifically in the case of Covid-19. The unique BioOrg ecosystem consists of 11 benign Bacillus spp. with proven purification capacity of pollutants in the air and visible dust on surfaces." Filip Willocx, managing partner BioOrg

A study performed by the University of Leuven compared the indoor air quality with regard to 5 parameters (CO2, aldehydes, particulate matter, polycyclic aromatic hydrocarbons and VOC's) in 2 buildings with similar ventilation rate and similar number of occupants. One building was treated with BioOrg, the other not. The building where BioOrg was used showed a reduction of particulate matter PM2.5 by 50% as compared to the control group 7%. Considering the relationship between the presence of PM10 and PM2.5 in indoor environments and the severity of Covid-19, it is safe to conclude that purifying the air of such pollutants will in turn reduce the risks of Covid-19 infections and the severity of the disease.

The bacterial ecosystem of BioOrg has proven **antiviral activities** against SARS-CoV-2, though it requires a new definition of a "virucide". The BioOrg ecosystem has antiviral activity due to the fact that high numbers of Bacillus spp. dry out surfaces and create a biofilm, effectively limiting the survival of viruses on surfaces. Furthermore, Bacillus spp. also produce biosurfactants with known antiviral activity. And finally, they also produce extracellular enzymes that will destroy the RNA of the SARS-CoV-2 virus. Prof. Neyts (Rega Institute, Belgium) was asked to objectively test and evaluate the BioOrg ecosystem against SARS-CoV-2 in 2 tests; the first one being a curative setting, meaning the viruses were put on a surface and BioOrg was nebulized onto the virus. It was then checked how many viruses survive at the 5 minute mark (which allows for the term "virucide"), after 1 hour and again after 2 hours. There was a significant reduction of the number of virus particles during time; the virus population was divided by 4 every hour. A second test was even more interesting, showing in a preventive setting the reducing effect of BioOrg on the growth of viruses. After 5 minutes there was no effect, but after 1 hour the number of virus particles was reduced by 25 units / hour.

The BioOrg system has proven results against SARS-CoV-2 over time. However, to be considered an actual virucide, regulation prescribes that results must be significant after only 5 minutes (e.g. alcohol > 70%). BioOrg means to negotiate a definition for **long term disinfectants**, meaning products that can significantly reduce viruses over time.

Q&A

When cleaning air ducts, do you notice a difference in their cleanliness depending on the material (plastic, zinc, aluminium,…) and the airflows?

"Absolutely, the contamination of the air ducts is depending on the material that was used, their size, the design, whether its pulsion or extraction obviously. Air flow going through pulsion air ducts is normally filtered, so these will be contaminated on a much lower speed than extraction ducts. Many other factors are relevant as well : is the building situated in a city or countryside, what is the ventilation being used for… The material itself isn't that much of a defining factor, far more important is the way the ducts are structured (curves, bends,…)." Seppe Thys, Hamster Cleaning.

In air conditioning you often create condense of droplets; is there any data on the possible viral load of those?

"There are some studies concerning airborne ventilation that go into this. It is not something to be too concerned about. The lifespan of the virus is rather low, so the impact on the infection risk in this manner is low as well." Ivan Verhaert, UAntwerpen

The ventilation rate at the Guangzhou restaurant was 1l/second per person, which is extremely low. In Flanders in schools that have mechanical ventilation, we measured 24 classrooms, 20% of which had a rate of less than 3l/second per person and 60% less than 6L/per second per person. What are your ideas on this?

"This is a problem, indeed. The best way to ventilate a classroom is to open the windows, but obviously in autumn and winter this can be difficult. I refer to the Netherlands where there has been done a lot of research on the sick building syndrome. I think looking into this and taking similar measures could help. Ensuring a good ventilation rate, and monitoring it are very important general rules. There are some sensors that are not expensive that follow up CO_2, these could help create awareness regarding ventilation. One should keep in mind that in schools ventilation as designed does not always reflect the actual situation, as often the ventilation rate in practice is reduced out of acoustic concerns." Ivan Verhaert, UAntwerpen

What are the recommendations on stand-alone ventilators and COVID-29?

"It is important to avoid creating a situation where airstreams are flowing from one-person's face to another person's face. Standalone units can provide a solution in certain environments (where you cannot open windows, where it is too warm,…), but the direction of the air flow should be monitored." Marianne Stranger, VITO

"With regard to downflow ventilation one has to take into account that it might cause comfort loss from a thermodynamic point of view. In operation theatres this is not so much an issue, but in an office environment, it might lead to people turning down the ventilation which is the opposite of what you want to achieve. Upflow ventilation where you lower the positioning of the pulsion, but extract through the ceiling might be closer to the Belgian context. With an upflow air stream on the other hand the risk the risk of resuspension of settled dust, kicks in. Several studies indicate that viruses might survive in dust, so that it to be avoided. The difficulty is that the ideal situation with regard to reducing the infection risk, might clash with thermodynamics, making the equation complex." Ivan Verhaert, UAntwerpen.

What is the efficiency of HEPA filters towards viruses?

HEPA filters target particles above 0,3 µm, whereas the virus is 0,1 µm. This implicates that a HEPA filter will not capture a standalone particle. It will however capture viral loads that have attached themselves to expired droplets or other particles and that are therefore bigger in size. Do check, however, because not all HEPA filters have the same effectiveness.

Are there trials planned to compare the effectiveness of different mitigation strategies: for example the effectiveness of wearing masks to air cleaning methods?

"It would be very useful. For now, we have no knowhow of such trials being planned. In fact many of the mitigation strategies discussed, have not yet been tested for Covid-19 specifically; we assume that they work, because they did so for other airborne viruses. But more research, trials and validation studies are highly needed and it is important to collaborate on these." Marianne Stranger, VITO

Would it not be useful to organize a session tailored to the situation specifically in schools. In Asia, even in Africa, school children are required to wear masks, and in Belgium we assume there is no problem. There is a huge need for protocols to open schools safely and in an epidemiologically designed way.

"There is confusion with regard to effectiveness of masks, who should wear them and in which circumstances. It is clear that they stop larger droplets; for smaller aerosols other mitigation strategies are necessary as well. There has been a lot of confusing messaging on this topic, from WHO as well, but everybody around the table is very willing to participate in an endeavour focused on schools." Marianne Stranger, VITO

Is there a risk in congestion ; could the exhaust of the ventilation system of a car, contaminate the driver in a nearby vehicle?

The dilution is too big, for this to cause a risk. Being with someone in a car is another story. Similar in fact to elevators ; which are also confined spaces. Here masks are definitely necessary.

Conclusions

We have to accept that with regard to Covid-19 close contact is not the only transmission route ; the evidence is strong with regard to airborne transmission as well. Preventive measures and mitigation strategies should therefore surpass the guidelines that have been issued this far, focusing on personal hygiene, cough etiquette and social distancing, and include clear directives regarding ventilation, air cleaning and protective masks as well.

The second part of the session, fortunately, highlighted that there are in fact many solutions through which the infection risk can be reduced. As indicated in the Q&A it is necessary to look into specific settings, such as schools or venues where lots of people gather, and devise protocols to ensure that this can happen safely. There is also a clear need for trials and validation studies.

As a network, eu.reca is very willing to continue to bring together stakeholders together to focus on this topic and be a voice that will hopefully convince Belgian policy makers of the necessity to focus on the airborne risk.

Gold sponsors:
eu.reca European Respiratory Cluster Antwerp
Aptar pharma
SANOFI
HH Harro Höfliger
Provincie Antwerpen