OCC-COVID WEBINAR SERIES
Science, Solutions and Success Stories

Tools in the Toolbox:

Carbon dioxide (CO_2) Monitoring and Risk Calculators

10 December 2021

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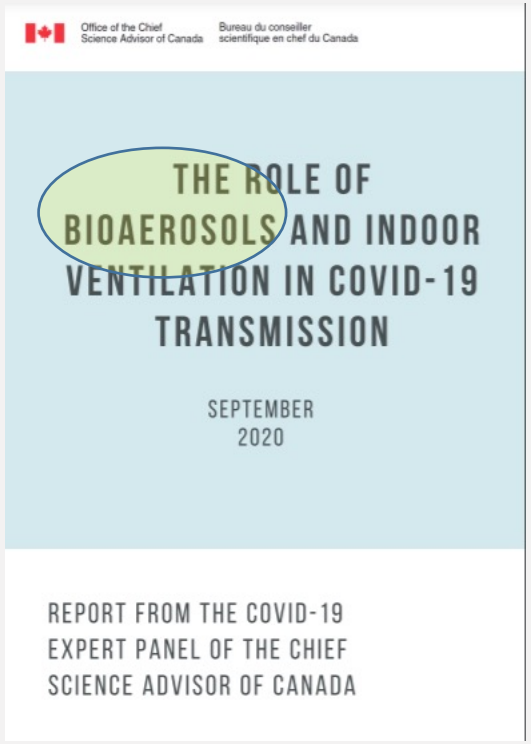
1989 2019 30 YEARS/ANS
Occupational Health Clinics for Ontario Workers Inc.
Centres de santé des travailleurs (ses) de l'Ontario Inc.

Prevention Through Intervention

SARS- CoV- 2

It’s airborne!

Occupational Health Clinics for Ontario Workers Inc.
Prevention Through Intervention

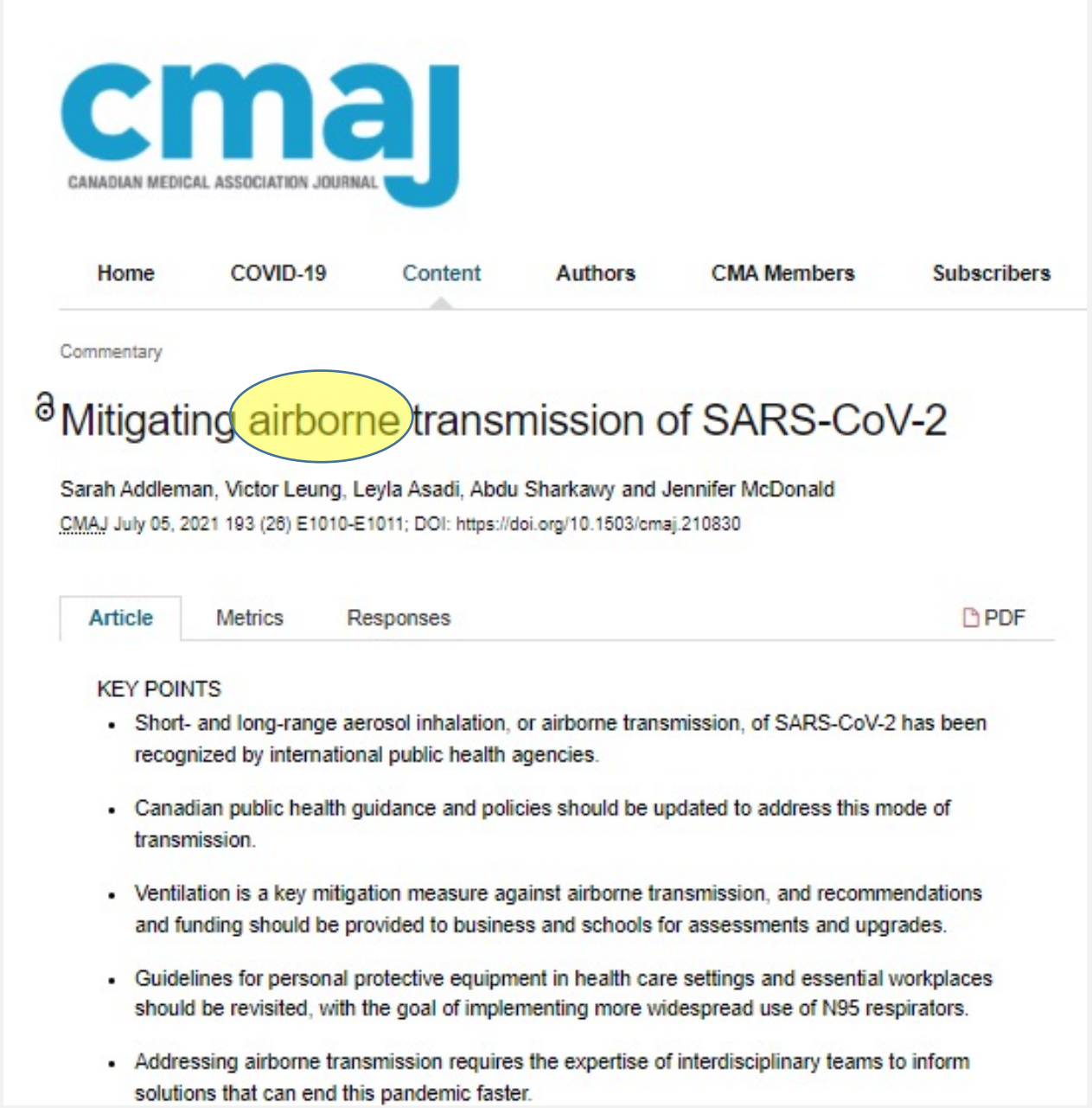


HOME > ALL AUDIO > ROB SNOW INTERVIEWS

LISTEN: COVID-19 is airborne, scientists agree - Dr. Jennifer McDonald on The Rob Snow Show May 18, 2021

Dr. Jennifer McDonald from The Ottawa Hospital joins Rob to discuss a new scientific study calling on governments around the world to prioritize indoor air quality standards to fight infectious diseases like COVID-19.

https://ottawa.citynews.ca/all-audio/rob-snow-interviews/listen-covid-19-is-airborne-scientists-agree-dr-jennifer-mcdonald-on-the-rob-snow-show-may-18-2021-3789105



https://www.cmaj.ca/content/193/26/E1010

3 December 2021 Risk assessment for SARS-CoV-2 variant:
Omicron VOC-21NOV-01 (B.1.1.529) **UK Health Security Agency**

3 December 2021 Risk assessment for SARS-CoV-2 variant: Omicron VOC-21NOV-01 (B.1.1.529) **UK Health Security Agency**

Indicator	Red, amber or green status*	Confidence level	Assessment and rationale
Transmissibility between humans	Amber	Low	**At least as transmissible as currently circulating variants** Omicron is transmitting rapidly and successfully. Increased transmissibility compared to Delta is biologically plausible with the presence of furin cleavage site and nucleocapsid changes associated in vitro with advantages for replication, as well as extensive changes to the RBD. Structural modelling suggests that the mutations present may increase human ACE2 binding affinity to a much greater extent than that seen for any other variant. Phylogeny suggests a recent emergence. Data from South Africa suggests that Omicron has a pronounced growth advantage there. However, this may be due to transmissibility or immune escape related, or both.
Infection severity			**Insufficient data**
Naturally acquired immunity	Red	Low	**Mutations suggestive of reduced protection from natural immunity and limited supporting epidemiological evidence** Based on experience with other variants, laboratory data on individual mutations, and structural modelling, the mutations present are very likely to reduce antibody binding and include changes in all 4 neutralising antibody binding sites in the RBD and also in antigenic sites in the S NTD. T cell epitope data is awaited. Analysis from South Africa suggests a reduction in protection from previous infection, including from recent Delta infection. There is no convalescent sera neutralisation data and no relative risk of reinfection analyses as yet.
Vaccine-derived immunity	Red	Low	**Mutations suggestive of reduced protection from vaccine derived immunity, no supporting evidence** The mutations present are likely to reduce antibody binding and include changes in all 4 RBD neutralising antibody binding sites. T cell epitope data is awaited. There is no vaccinee sera neutralisation data and no epidemiological data on vaccine effectiveness.
Therapeutics	Red	Low	**Mutations suggestive of reduced effectiveness of a treatment in UK clinical use** The mutations present are likely to reduce the binding of most available therapeutic monoclonal antibodies, based on structural modelling. On the same basis, they are unlikely to affect current small molecule antivirals. However, there is no laboratory or clinical data to support these predictions at present.

https://t.co/VD5uSNtYeY

Omicron ?

"**In case after case, a precautionary approach would have made a difference,**

said Possamai. "We were not only late in moving in that direction, but there was a real lack of transparency."

CBC News · Posted: Oct 17, 2020

Precautionary principle **more important than ever!**

Probable Transmission of SARS-CoV-2 **Omicron Variant** in Quarantine Hotel, Hong Kong, China, November 2021, Gu et al. 2021.

We report detection of severe acute respiratory syndrome coronavirus 2 Omicron variant (B.1.1.529) in an asymptomatic, ***fully vaccinated traveler*** *in a quarantine hotel in Hong Kong, China. The Omicron variant was also detected in a fully vaccinated traveler staying in a* ***room across the corridor from the index patient****,* ***suggesting transmission despite strict quarantine precautions****.*

It is not known whether these detected mutations might have affect the effectiveness of existing vaccines and virus transmissibility. However, detection of Omicron variant transmission between 2 fully vaccinated persons across the corridor of a quarantine hotel has highlighted this potential concern.

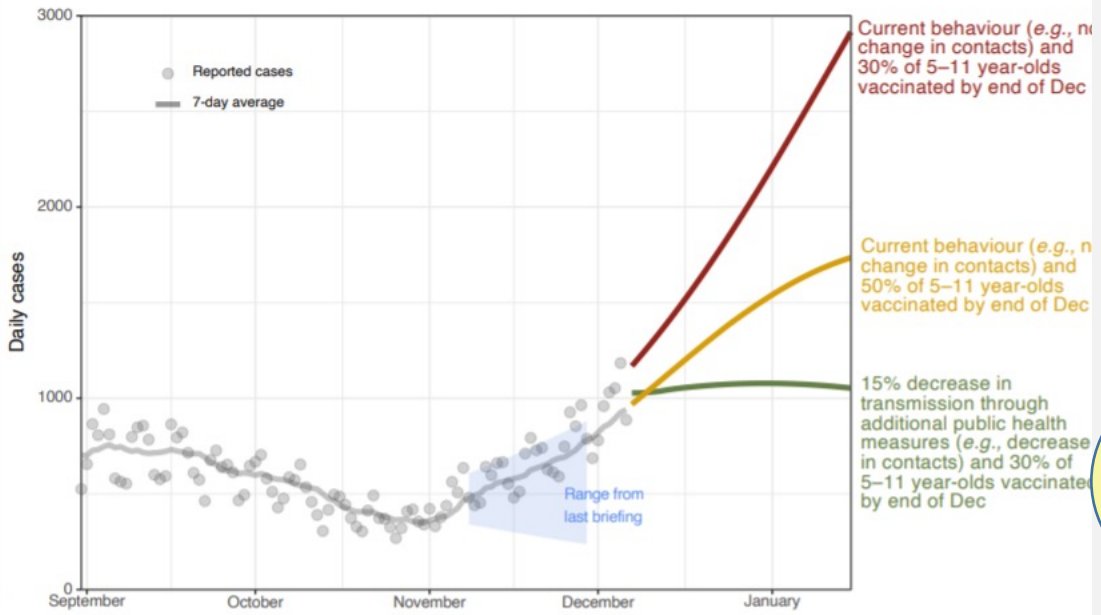
Airborne transmission across the corridor is the most probable mode of transmission.

Emerging infectious diseases. 2021 Dec 3;28(2). Pre-print. https://pubmed.ncbi.nlm.nih.gov/34860154/

Cases continue to rise substantially, even without Omicron. To flatten the curve, we need to reduce transmission by increasing vaccination and public health measures.

Figure shows predictions based on a consensus across models from 4 scientific teams.

- All scenarios assume continuing current public health measures.
- All scenarios include vaccinating kids 5-11 years of age, but differ on the proportion of kids vaccinated by end of December.
- Different models use different approaches and assumptions.
- Omicron not included in these scenarios, and would likely worsen these projections.



Predictions informed by modeling from McMasterU, PHO, WesternU, YorkU
Data (Observed Cases): covid-19.ontario.ca

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Additional public health measures

https://covid19-sciencetable.ca/wp-content/uploads/2021/12/Update-on-COVID-19-Projections_2021.12.07_English-1.pdf

Tools in the Toolbox:

Simple Solutions for a “COVID-Safe” season

Carbon dioxide (CO2) Monitoring and Risk Calculators

1) Introduce carbon dioxide monitoring as a tool in the tool box.
2) Provide an overview of “risk assessment calculators” from complex to simple.
3) Focus on **simple calculators** that everyone can use.
4) Provide some guidance and solution (s) that we can all apply.

Carbon Dioxide Concentrations vs. Health Effects & Indoor Air Quality (IAQ)			
CO_2 ppm	CO_2 in % of Air	Duration	Effects
350 - 500 ppm	0.035% - 0.05%		Typical outdoor CO_2 level - 0.3% by volume
600	0.06%	Hours/undefined	reduced mental performance for some
1,000	0.10%	Hours/undefined	reduced test scores common in classrooms
1,200	0.12%	Hours/undefined	Indoors indicates poor fresh-air ventilation
2,500	0.25%	Hours/undefined	Significantly reduced mental performance for some
3,000-3,500	0.3%	6+ hrs.	Perceived reduced IAQ w/ bio effluents present Regulation in some Provinces put that limit at 3,500 ppm for 8 hours
5,000	0.5%	6+ hours	Reduced mental performance, found in some classrooms Prior NASA SMAC CO_2 limit for long term space voyage (obs) Regulation in some Provinces use that as a limit for industrial or other workplaces (with a duration threshold of 8 hours)
10,000	1%	minutes +	Drowsiness
12,000	1.2%		Headache complaints
20,000	2%	min. to hrs.	Awareness of poor IAQ
Above 20,000	> 2%	min. to hrs.	Heaviness in chest, difficulty breathing, possible acidosis after several hours
30,000	3%	minutes	Breathing rate doubles]
50,000	5%	minutes	Breathing rate 4 x normal, threshold of toxicity
Above 20,000	> 5%	minutes	Toxic, unconsciousness, death

Courtesy of Dr. Stephane Bilodeau

Carbon dioxide

↑

< 600 ppm best

1,000 ppm	0.10%	Hours undefined	reduced test scores common in classrooms

1) Beware of getting elevated concentrations from your own breath. Should measure CO_2 at a distance at least 2 metres from any person. (Todd Irick, Occupational Hygienist OHCOW, pers comm).

2) No one (to my knowledge) has correlated CO_2 with particle concentrations (Dr. Lisa Brosseau pers comm).

3) The biggest problem with relying on CO_2 as a surrogate for ventilation is that it **tells you very little about air patterns in a room**, which are much more important than people seem to recognize. If there are dead or recirculating zones (as in the Guanghzu restaurant), the number of air changes will not have any impact on that (Dr. Lisa Brosseau pers comm).

CO_2 monitoring limitations (beware)

- not representative of risk related to non-airborne transmission pathways
- doesn't account for re-circulated air that has undergone filtration
- doesn't consider other control measures, such as the use of masks as source control, nor the use of respiratory protection, nor contributions of CO_2 from other sources.

Notwithstanding, if the limitations are well understood, a precautionary approach supports the use of CO_2 monitoring as a useful and relatively low-cost tool to make real-time assessments of relative infection risk, which should lead to improvements being made to improve ventilation in indoor spaces.

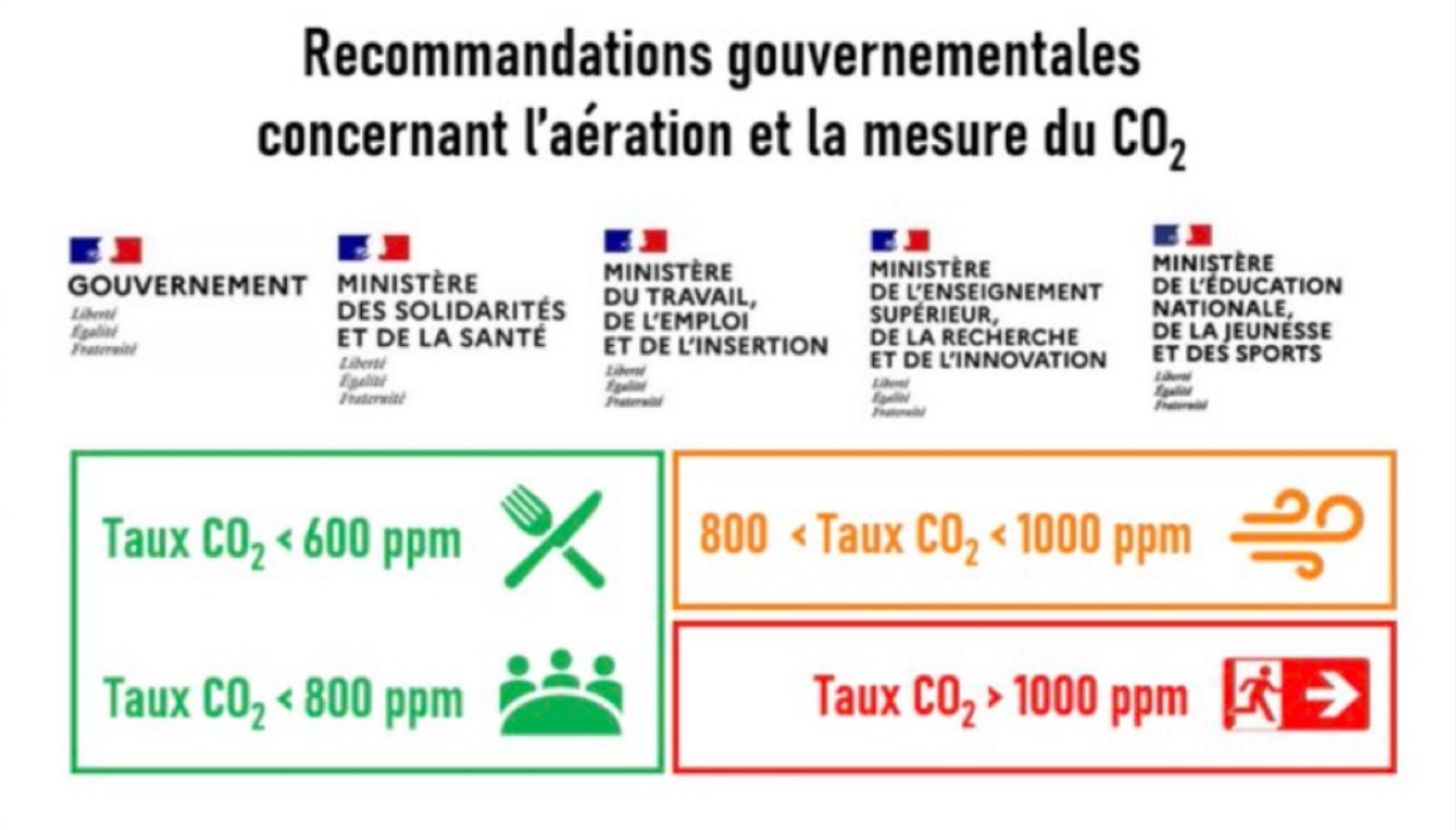
OzSAGE

Measurements should be taken at multiple locations within a room or space and repeated periodically during the time the room or space is occupied.

A building wide system with central reporting and monitoring is desirable in all spaces with high occupancy, including healthcare, schools, aged-care and critical workplaces.

OzSAGE

French recommendations CO_2



https://solidarites-sante.gouv.fr/

NEW ZEALAND|Education
Covid 19 Delta outbreak: Ministry of Education ordering air purifiers, CO2 monitors for schools
2 Dec, 2021 10:52 PM

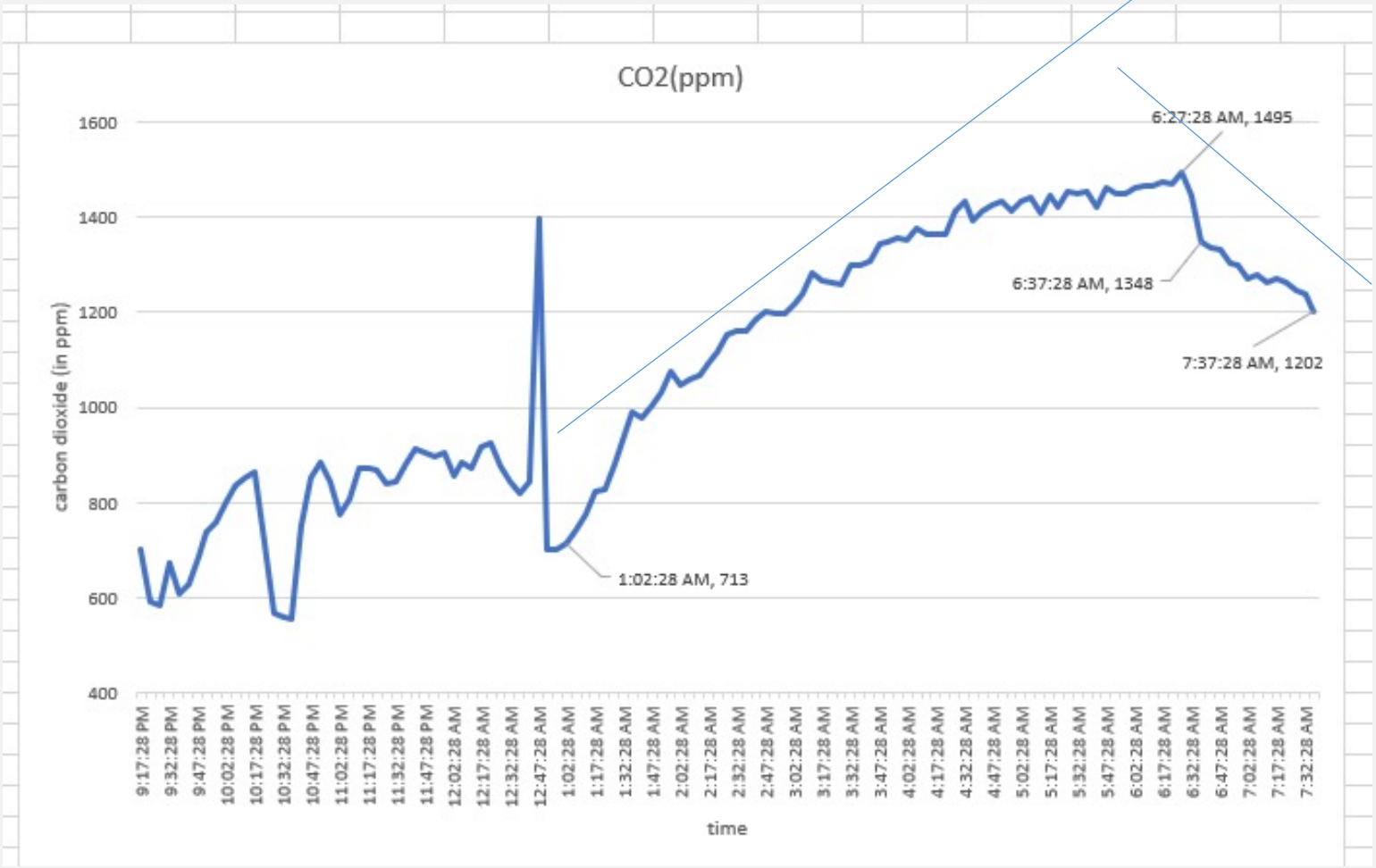
In New Zealand the ministry also planned to bring in carbon dioxide monitors as part of a "ventilation toolkit" for schools.

https://www.nzherald.co.nz/nz/covid-19-delta-outbreak-ministry-of-education-ordering-air-purifiers-co2-monitors-for-schools/RD5L2QKV4YH3ZIBKRMB5R2ZW3U/

Those monitors are already being trialled; Niwa announced yesterday CO2 monitors were temporarily being installed in 18 classrooms across three schools, to help the Ministry of Education see how classrooms are being used and the impacts on ventilation.

Niwa principal scientist for air quality, Dr Ian Longley, installs an air monitoring device at Epuni Primary School in Lower Hutt. Photo / Niwa - Rebekah Parsons-King

Suggestions for occupational hygienists, engineers, HVAC technicians and other!



Looking at, and analysing information from **decay curves,** is another useful way to **estimate ACH**

Using decay curves from continuous monitoring to estimate (ACH) from each curve over consecutive days

Risk Tools

How do we rank and show where improvements are absolutely necessary.

We must treat higher risks first.

- More comprehensive tools requiring specialist (technical) input.
- Simple tools that we can all use to keep our families safe etc.

This two-part webinar series provided a platform for developers to summarize their risk assessment tools so that they may be better understood and compared by potential users in the ISIAQ community. **Read about the tools**.

ISIAQ Modeling Infection Risk from Indoor Aerosol Exposure to SARS-CoV-2 Tools Summary

https://www.isiaq.org/docs/Risk_Tool_Webinar-Tools_summary.pdf

Tool	Link	Comments
COVID-19 Infection Risk Manager **Prezant, B.,** Ongsono, D., Palmer, K. Publication Reference or Web Reference	https://vue-covid-product.web.app https://covid-risk-manager.web.app	Description including video and white paper & calculator). Compartment model (single zone) for calculating concentration in air, Wells-Riley for calculating risk of infection. A point estimate of risk of infection is provided in the output, as well as the number of infections arising based on the occupancy specified. Time to re-occupancy is provided based on reduction in airborne concentration by 99% based on exponential dilution law.
COVID-19 Aerosol Transmission Estimator Prof. Jose L. Jimenez, University of Colorado-Boulder, USA Publication Reference or Web Reference	http://tinyurl.com/covid-estimator https://doi.org/10.1111/ina.12751	The estimator is a box model of dispersion of contaminants indoors (virus-containing aerosols and CO2 from exhaled breath), that predicts the average indoor concentration of both for a given indoor activity. The size of the space, ventilation and air cleaning, occupancy, number of repetitions of the event, and activity are specified by the user.
Harvard-University of Colorado Boulder **Portable Air Cleaner Calculator** for Schools **Joseph Allen**, Jose Cedeno-Laurent, **Shelly Miller**	https://tinyurl.com/portableaircleanertool	Quick 'rule of thumb' selection guide for portable air cleaners Look for portable air purifier with HEPA filter Look for high clean air delivery rate **Avoid add-ons (e.g., ionizers, ultraviolet lights)**
Fate and Transport of Indoor Microbiological Aerosols (FaTIMA) W. Stuart Dols and Brian Polidoro	https://www.nist.gov/services-resources/software/fatima https://doi.org/10.6028/NIST.TN.2095	The web-based tool Fate and Transport of Indoor Microbiological Aerosols (FaTIMA) allows for the determination of the indoor fate of microbiological aerosols associated with ventilation, filtration, deposition and inactivation mechanisms.

Airborne risk infection calculator

The QUT International Laboratory for Air Quality and Health has made available a downloadable Airborne Infection Risk Calculator (AIRC tool). More generally, the target users are the technical professionals working to minimize the risk of airborne disease transmission by implementing the **five-step framework** outlined by Morawska et al. (2020):

1. Use engineering controls to reduce the risk of airborne infection;
2. Use existing systems to increase ventilation rates (outdoor air change rate) and enhance ventilation effectiveness;
3. Eliminate air-recirculation within ventilation systems so as to just supply fresh (outdoor) air;
4. Supplement ventilation with filtration systems to capture airborne microdroplets; and
5. Avoid over-crowding

More detail around how to use the calculator is provided here in the manual.

Ventilation Checklist (COVID-19)

Following the Hierarchy of Controls, ventilation and filtration provided by HVAC systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. This Ventilation Checklist (COVID-19) can be used as a guide to assess the suitability of ventilation in the workspace/building that are to be occupied.

Project

City "Reduced Probability of Infection" (CityRPI) for indoor airborne virus transmission

 Ali Katal ·  Leon Wang ·  Maher Albettar

Goal: CityRPI (https://cityrpi.web.app/) is a web-based platform for estimating the possibilities and risks of airborne transmission of COVID-19 in indoor spaces. CityRPI is developed by a team led by Dr. Liangzhu (Leon) Wang at Concordia University Building Environment (CUBE) Lab. The indoor airborne infection risk could be reduced by different strategies, including wearing a face mask, improving indoor ventilation condition (more outdoor air, add a duct filter to your HVAC system, using a portable air purifier), staying less time (to reduce possible exposure time), and reducing the number of occupants in a space. The website provides a tool to compare these different strategies. As a building owner or user, you can find the most to the least effective strategies to reduce the risk of infection in your building.

https://cityrpi.web.app/

March 12 – Airing It Out: Ventilation Solutions and Tools at a Critical Time

Building on our "Air" on the Side of Caution session, this sequel offers further guidance around ventilation solutions and tools to help control the COVID-19 virus in workplaces.

Moderator: Dr. Kevin Hedges, OHCOW

Evaluation, Monitoring and Mitigation of SARS-CoV-2 Airborne Transmission Risks in Cities and Buildings

Dr. Liangzhu (Leon) Wang, Concordia University

VIEW SLIDES

Strategic Safety Measures to Mitigate Indoor Risk of Viral Transmission

Thomas Smith, 3 Flow

VIEW SLIDES

More Important than Ever: Air Treatment in the Age of COVID-19

Dr. Jeffrey Siegel, University of Toronto

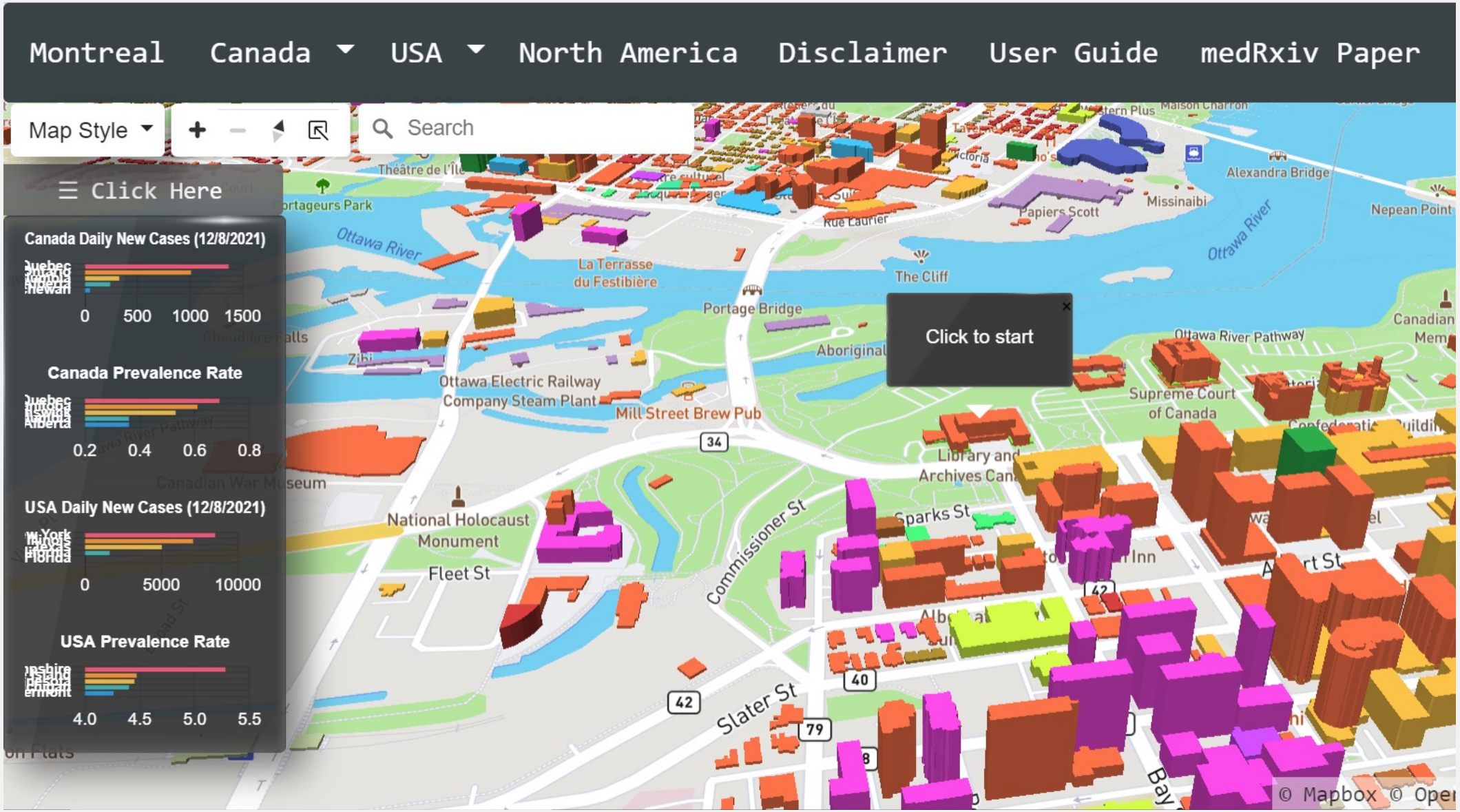
VIEW SLIDES

Success Story: Putting Knowledge Into Action to Get Air-Purifiers in School

Dr. Sarah Addleman, Aerosol Transmission Coalition

The four sessions above are all available in this one video:

Evaluation, Monitoring and Mitigation of SARS-CoV-2 Airborne Transmission Risks in Cities and Buildings Dr. Liangzhu (Leon) Wang, Concordia University https://www.ohcow.on.ca/events/occ-covid-webinar-series/#1633725590142-163b4634-9dcb



For building owners or users

AIHA CDC https://www.backtoworksafely.org/cdc https://www.cov-irt.org/exposure-assessment-tool/

AIHA

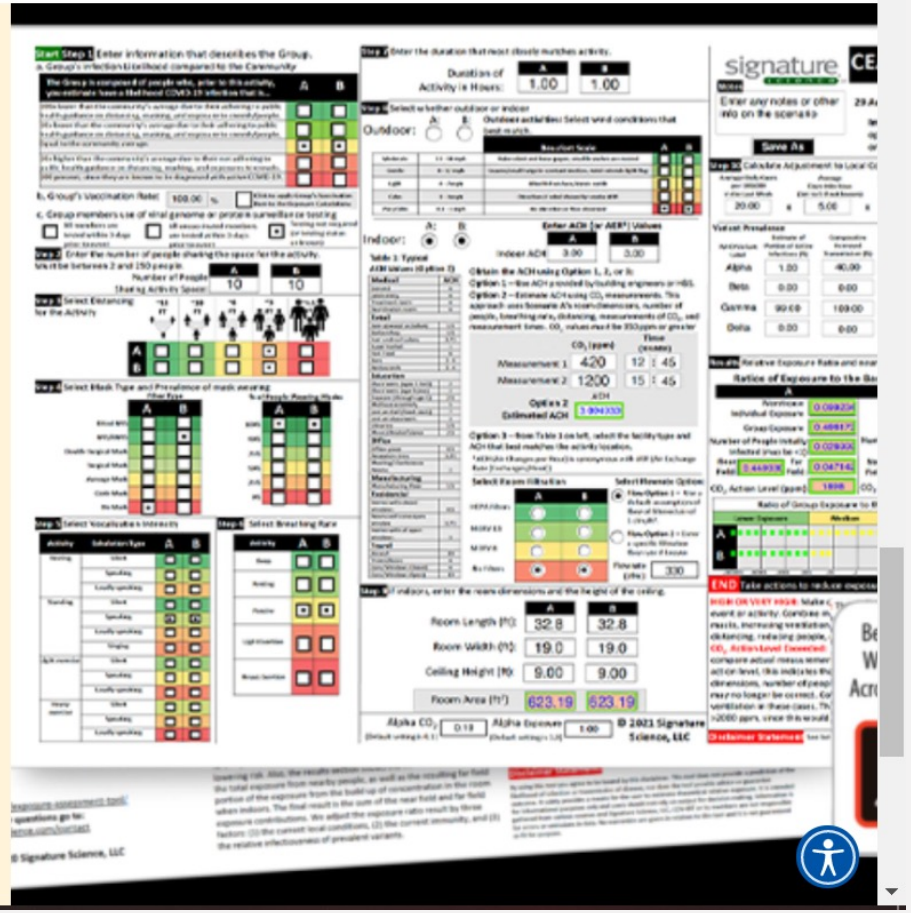
AIHA Feedback/Questions Find a Consultant Search GET UPDATES →

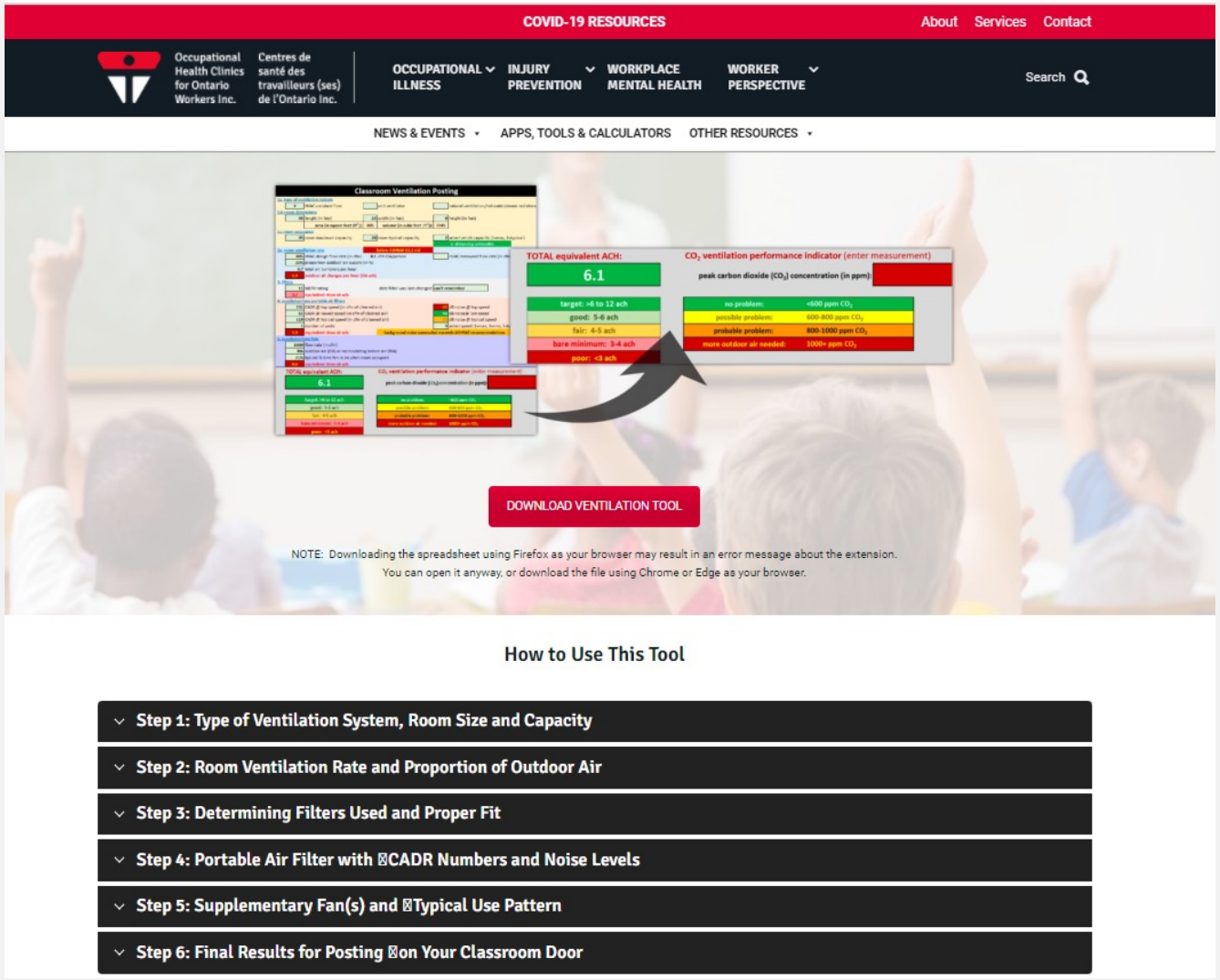
Back to Work Safely Pandemics Resource Center What is Occupational Health & Safety?

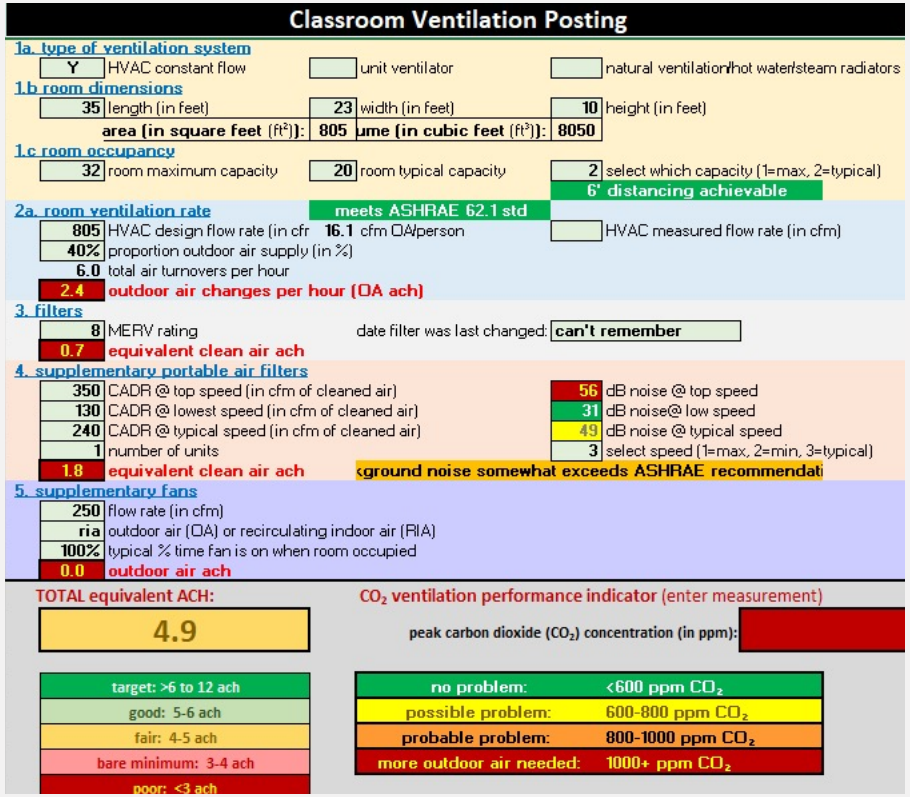
SARS-CoV-2 Exposure Assessment Tool

This simple-to-use tool, released as a Beta version, allows users to estimate a group-wide relative exposure to SARS-COV-2 associated with various activities. The tool facilitates understanding of the relative importance of factors that contribute to increased exposure. It incorporates both scientific principals and recent findings regarding virus characteristics to assess relative exposure based on the key mechanistic and epidemiological factors. NOTE: The developers of this tool are in the process of submitting a peer-reviewed article for publication in the Journal of Occupational and Environmental Hygiene (JOEH).

LEARN MORE →



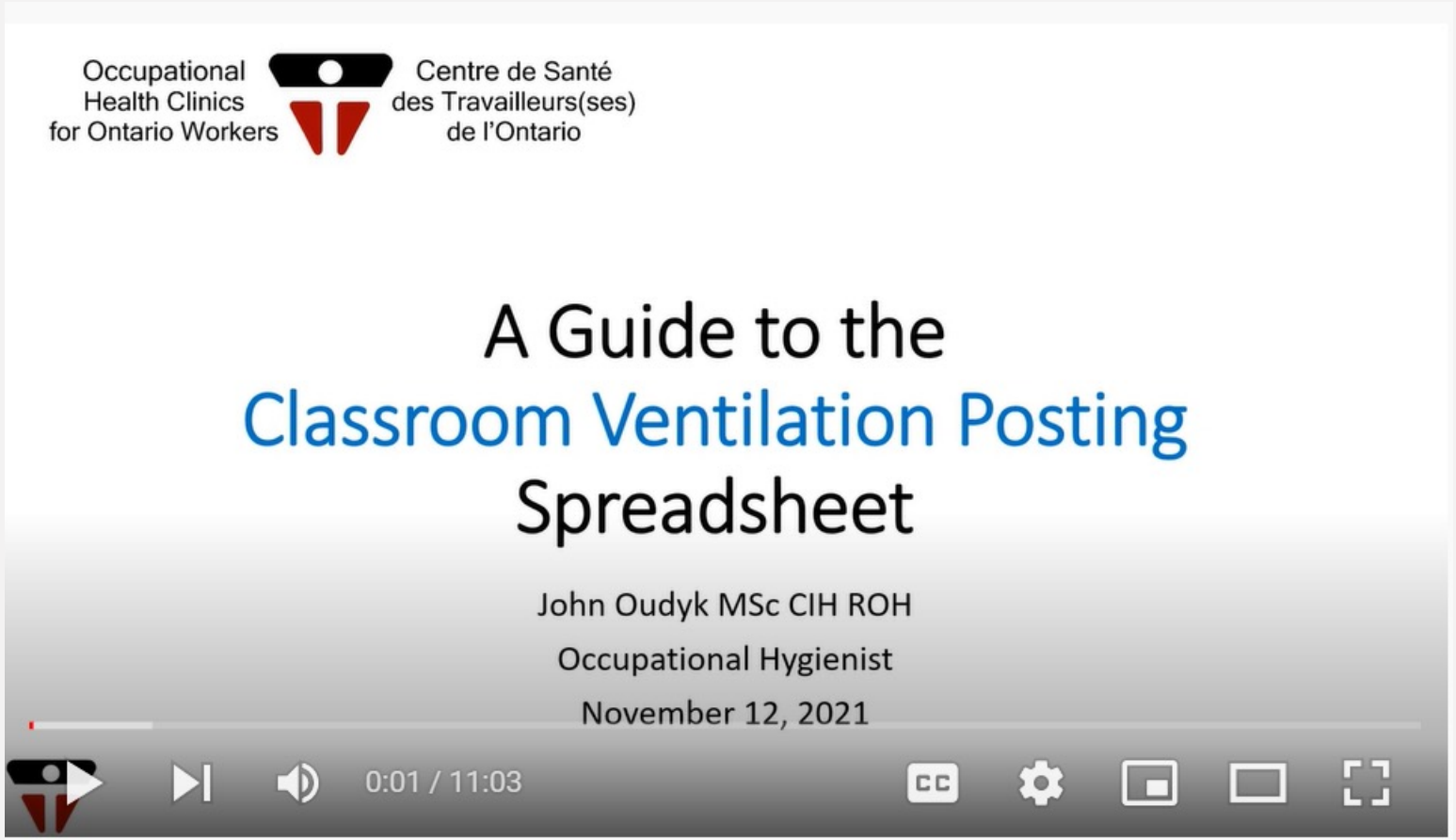




OHCOW classroom-ventilation calculation tool.

Occupational Health Clinics for Ontario Workers Inc.
Prevention Through Intervention

https://www.ohcow.on.ca/covid-19/classroom-ventilation-calculation-tool/



Please watch you will find this useful for your child's school and classroom (ventilation)

https://www.youtube.com/watch?v=6-Btz4w97Tk

Risk Tools

How do we rank and show where improvements are absolutely necessary.

We must treat higher risks first.

- More comprehensive tools requiring specialist (technical) input.
- Simple tools that we can all use to keep our families safe etc.

Ontario COVID-19 Regional Risk Tool:

Risk Legend

Minimal risk – low to absent community transmission

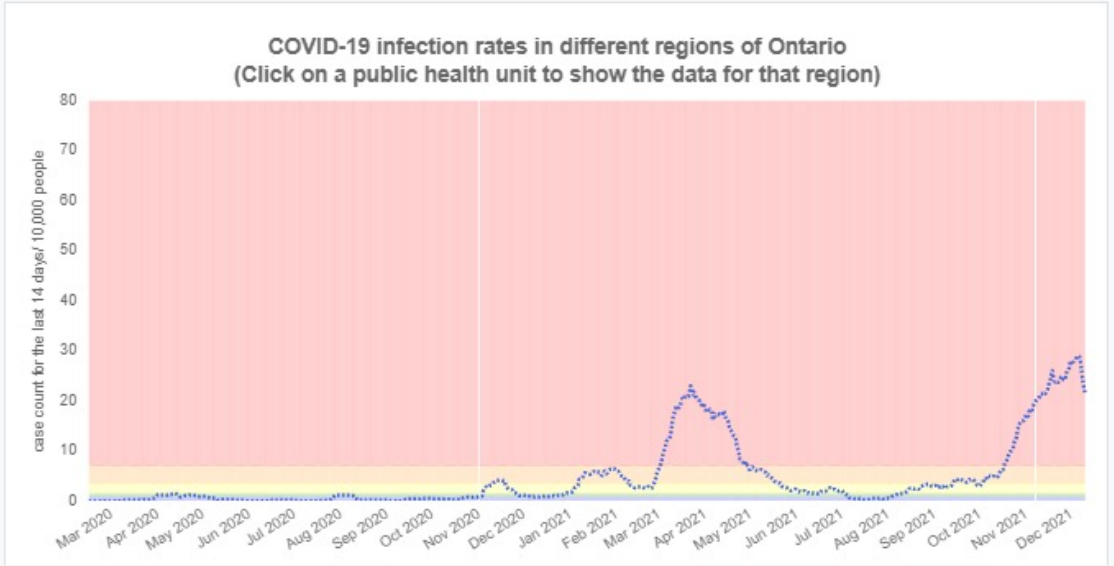
Controlled risk – some sporadic community activity – controlled occasional minor outbreaks

Some community risk – regular sporadic activity – controlled occasional larger outbreaks

Wider community risk – regular activity – periodic outbreaks

High risk – uncontrolled community transmission &/or outbreaks

Minimal risk	Controlled risk	Some community risk	Wider community risk	High risk
low to absent community transmission	some sporadic community activity	regular sporadic activity	regular activity outbreaks	uncontrolled community outbreaks
0-0.7 cases in the last 14 days per 10,000 people	0.7-1.4 cases in the last 14 days per 10,000 people	1.4-3.5 cases in the last 14 days per 10,000 people	3.5-7 cases in the last 14 days per 10,000 people	7+ cases in the last 14 days per 10,000 people



Regional Risk Table At A Glance

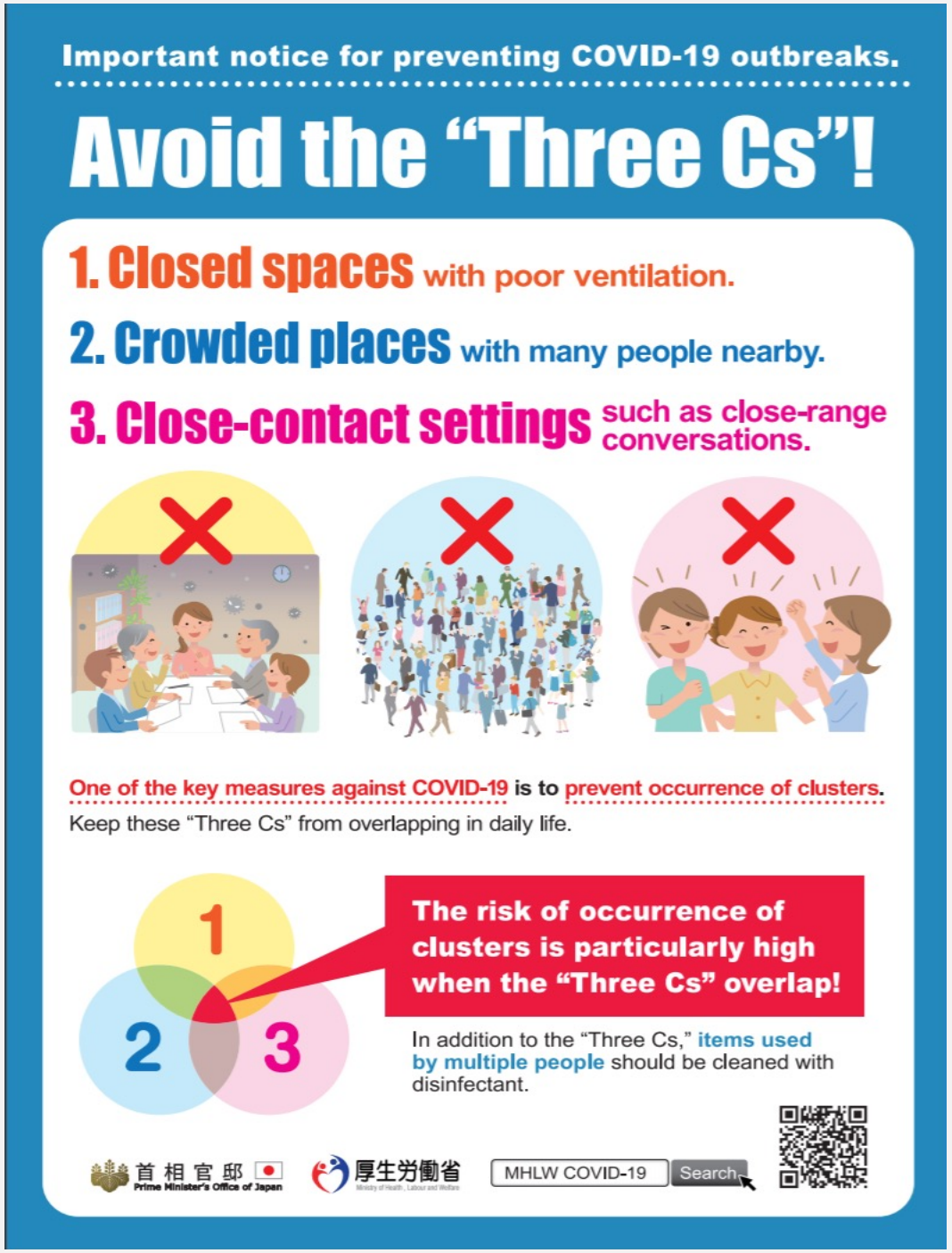
Rank	Region Public Health Unit (PHU)	Regional Infection Risk Level*	ON Framework Categories**
1	Algoma Public Health Unit	High risk	CONTROL
2	Sudbury & District Health Unit	High risk	CONTROL
3	Timiskaming Health Unit	High risk	CONTROL
4	Windsor-Essex County Health Unit	High risk	CONTROL
5	Kingston, Frontenac and Lennox & Addington Public Health	High risk	CONTROL
6	Simcoe Muskoka District Health Unit	High risk	CONTROL
7	Chatham-Kent Health Unit	High risk	CONTROL
8	Haldimand-Norfolk Health Unit	High risk	CONTROL
9	Southwestern Public Health	High risk	CONTROL
10	Brant County Health Unit	High risk	CONTROL
11	Hastings and Prince Edward Counties Health Unit	High risk	CONTROL
12	Thunder Bay District Health Unit	High risk	CONTROL
13	Lambton Public Health	High risk	CONTROL
14	Huron Perth District Health Unit	High risk	RESTRICT
15	Eastern Ontario Health Unit	High risk	RESTRICT
16	Region of Waterloo, Public Health	Wider community risk	RESTRICT
17	Niagara Region Public Health Department	Wider community risk	RESTRICT
18	Halton Region Health Department	Wider community risk	RESTRICT
19	Middlesex-London Health Unit	Wider community risk	CONTROL
20	Wellington-Dufferin-Guelph Public Health	Wider community risk	RESTRICT
21	Renfrew County and District Health Unit	Wider community risk	RESTRICT
22	Ottawa Public Health	Wider community risk	RESTRICT
23	Hamilton Public Health Services	Wider community risk	RESTRICT
24	York Region Public Health Services	Wider community risk	RESTRICT
25	Durham Region Health Department	Wider community risk	PROTECT
26	Grey Bruce Health Unit	Wider community risk	PROTECT
27	Toronto Public Health	Wider community risk	RESTRICT
28	Peterborough Public Health	Wider community risk	PROTECT
29	Peel Public Health	Wider community risk	PROTECT
30	Leeds, Grenville and Lanark District Health Unit	Wider community risk	PROTECT
31	Haliburton, Kawartha, Pine Ridge District Health Unit	Some community risk	PROTECT
32	Northwestern Health Unit	Some community risk	PROTECT
33	North Bay Parry Sound District Health Unit	Some community risk	PROTECT
34	Porcupine Health Unit	Some community risk	PREVENT

* These tools translate Reported case data published by Public Health Ontario as a 14 day rolling count (divided by population to create a rate per 10 000 people) to understand and compare Ontario regional SARS CoV2 transmission risk. Recent numbers can be delayed and are less reliable, particularly over weekends, so risk may be underestimated.

** The Ontario Framework Category is an estimation of the official provincial colour-coding as explained in COVID-19 Response Framework: Keeping Ontario Safe and Open (see slide 9) based only on the weekly incidence rate per 100,000, but absent the other factors considered locally (e.g. % positivity of daily tests, the reproductive number (Rt = the number of new cases traced from each known case), the number and status of outbreaks, trend in cases without an epi connection, hospital and ICU capacities, and, PHU capacity for contact tracing). We are also not able to assign "Grey = Lockdown" since this category is based on a judgement call by local authorities. Therefore, the ON categories assigned in this table may not necessarily align with the official version but are provided for translation and reconciliation with Prevention Tips below.

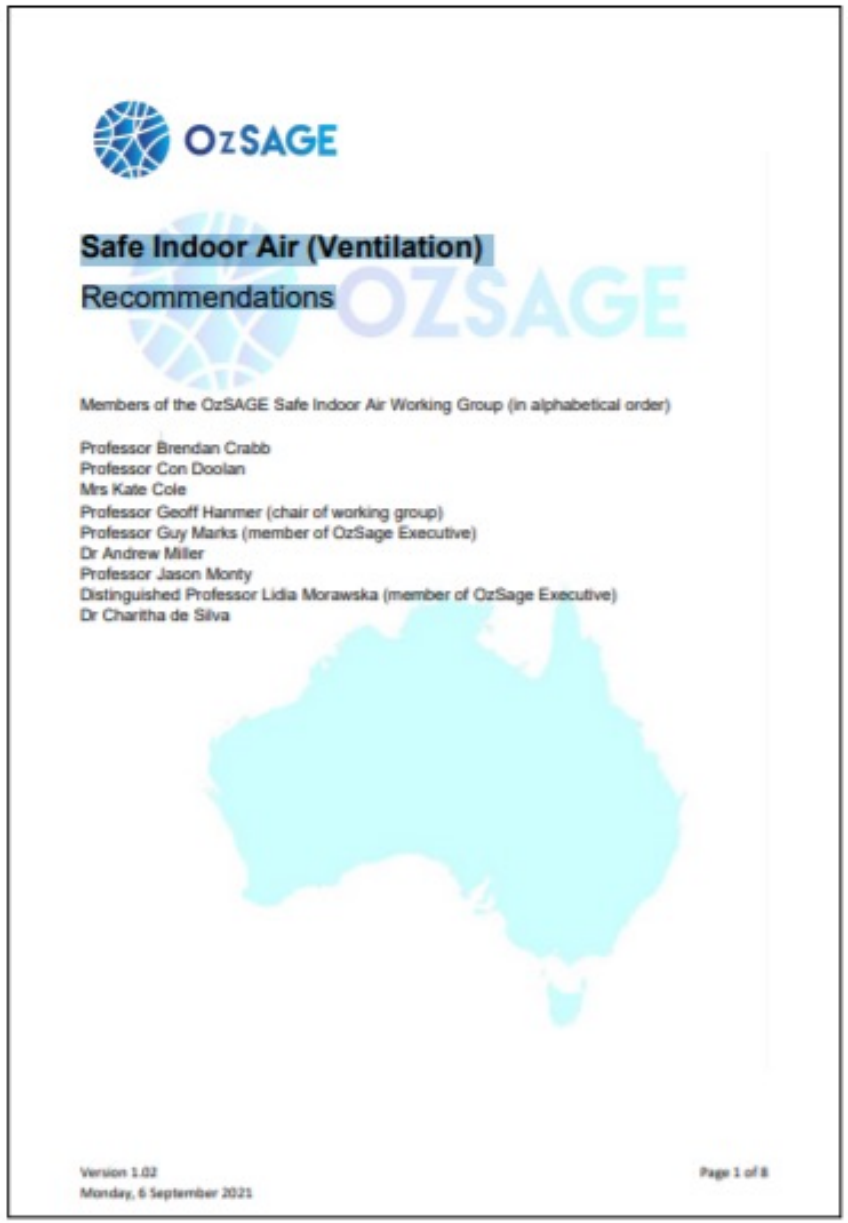
Sudbury & District Health Unit

https://www.ohcow.on.ca/covid-19/regional-risk-tool-tips/#risktable



Japan avoided a lockdown by telling everyone to steer clear of the 3 C's.

Source: https://www.mhlw.go.jp/content/10900000/000619576.pdf



Overarching Principles

High risk can be identified with: **The three V's and T** (any of these is a red flag, and more than one indicates higher risk):

Venue: Multiple people indoors, where social distancing is often harder.

(poor) Ventilation: Staying in one place with limited fresh air.

Vocalization: Talking, shouting or singing will increase aerosolization of the virus.

Time: The amount of time spent in the venue in relation to the risk. Less time is better.

https://ozsage.org/working_group/safe-indoor-air-ventilation/

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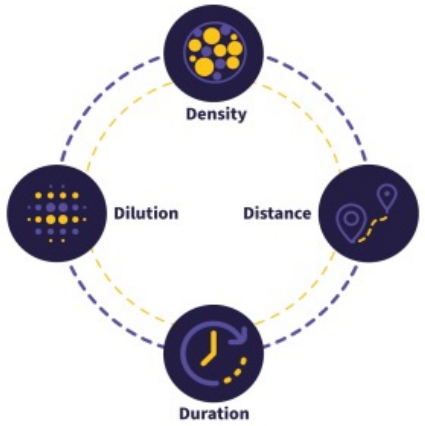
CARE



Vaccination and human diagnostic are critically important.

Given that a primary **transmission route for COVID-19 is airborne,** medical mitigation strategies MUST be complemented with environmental control solutions to reduce the risk of transmission.

This is a **holistic approach that is more comprehensive.**

*Duration/Density = Risk Factors | Dilution/Distance = Risk Mitigation Factors

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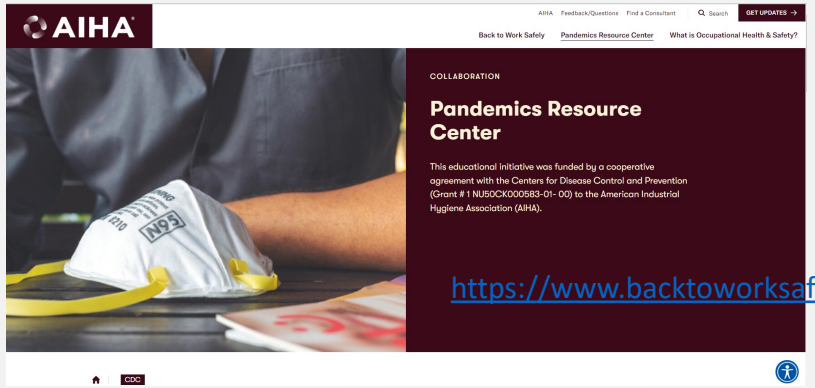

https://www.backtoworksafely.org/cdc

*Duration/Density = Risk Factors | Dilution/Distance = Risk Mitigation Factors

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How to determine and assess your risk.

COMMIT TO CARE

Reducing exposure to an airborne virus is the most important thing you can do in reducing its spread.

Viruses that transmit as airborne particles - such as the viruses that cause COVID-19 and measles - pose a significant risk as they can travel long distances – up to 20 to 30 feet – and stay active in the air for at least 4 hours.

Consider the 4Ds to determine the risk category:

Risk Factors

Duration
How long will the employee or others be indoors?
The longer time spent indoors, the more the air becomes filled with invisible airborne particles.

Density
How many people are in the space, how many are not vaccinated, how many people are sick and not showing signs, and how many are not wearing masks? As these numbers increase, so does the risk.

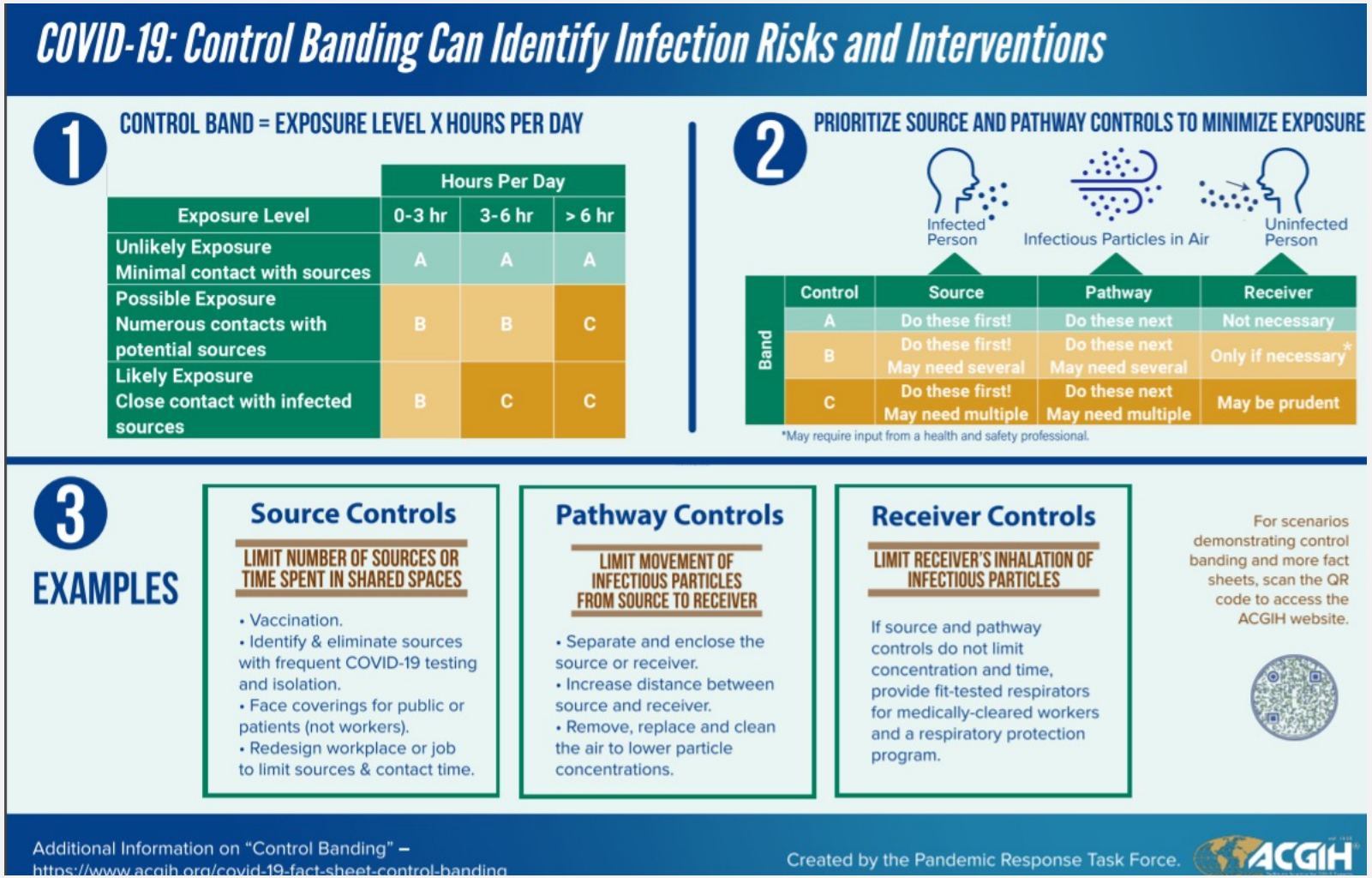
Risk Mitigation Factors

Dilution
Being outdoors is relatively safe compared to being indoors thanks to how easy it is to dilute the virus due to more open space, moving air, and the aid of sunlight to stop the virus.

Distance
How far or near are people around one another?
People with COVID-19 exhale a high amount of viral particles, which is why being close to an infected person increases the risk of infection for you.

AIHA® aiha.org | 25

The Control Banding (CB) approach is extremely useful, especially where there is uncertainty about the risk, and when figuring out where to assign additional controls.



ACGIH formed the [Pandemic Response Task Force](). **Led by Dr. Lisa Brosseau**

What about selection of filtering facepiece respirator (FFR).

Table 1. Time to Infectious Dose for an Uninfected Person (Receiver)*

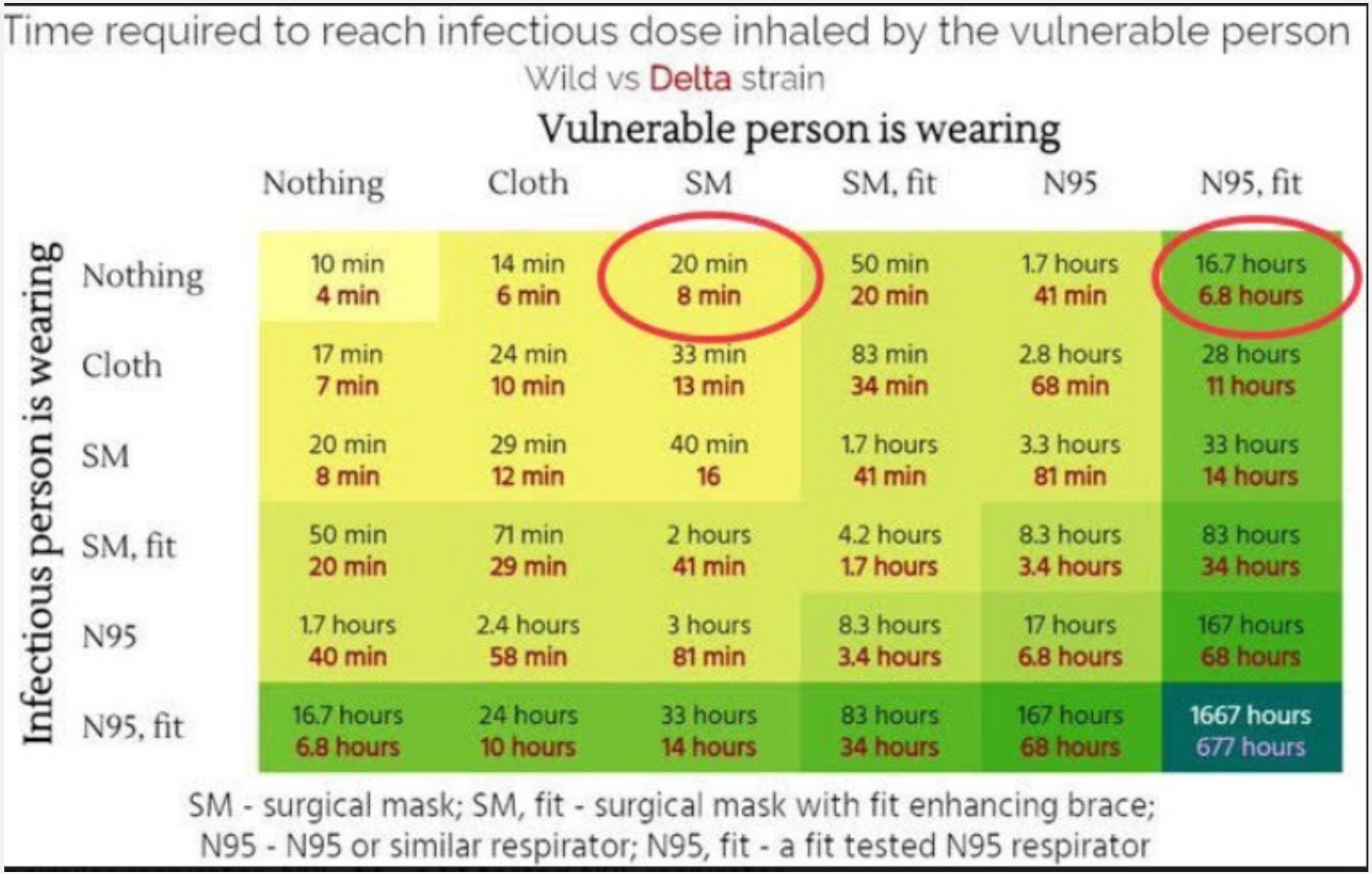
Source is wearing (% outward leakage)		Receiver is wearing (% inward leakage): Nothing	Typical cloth mask	Typical surgical mask	Non–fit-tested N95 FFR	Fit-tested N95 FFR
		100%	75%	50%	20%	10%
Nothing	100%	15 min	20 min	30 min	1.25 hr	2.5 hr
Typical cloth mask	75%	20 min	26 min	40 min	1.7 hr	3.3 hr
Typical surgical mask	50%	30 min	40 min	1 hr	2.5 hr	5 hr
Non–fit-tested N95 FFR**	20%	1.25 hr	1.7 hr	2.5 hr	6.25 hr	12.5 hr
Fit-tested N95 FFR	10%	2.5 hr	3.3 hr	5 hr	12.5 hr	25 hr

*The data for % inward and outward leakage of cloth and surgical masks were derived from a study by Lindsley et al (2021). Data for non–fit-tested N95 FFRs come from a study by Brosseau (2020). Data for fit-tested N95 FFRs are derived from the OSHA-assigned protection factor of 10 for half-facepiece respirators. Also, times were established before wide circulation of the more transmissible Delta variant.

**FFR = filtering facepiece respirator; N95 = not oil-proof, 95% efficient at NIOSH filter test conditions

COMMENTARY: What can masks do? Part 1: The science behind COVID-19 protection. CIDRAP

https://www.cidrap.umn.edu/news-perspective/2021/10/commentary-what-can-masks-do-part-1-science-behind-covid-19-protection


Time required to reach infectious dose inhaled by the vulnerable person
Wild vs Delta strain
Vulnerable person is wearing
Nothing
Cloth
SM
SM, fit
N95
N95, fit
Infectious person is wearing
Nothing
10 min
4 min
14 min
6 min
20 min
8 min
50 min
20 min
1.7 hours
41 min
16.7 hours
6.8 hours
Cloth
17 min
7 min
24 min
10 min
33 min
13 min
83 min
34 min
2.8 hours
68 min
28 hours
11 hours
SM
20 min
8 min
29 min
12 min
40 min
16
1.7 hours
41 min
3.3 hours
81 min
33 hours
14 hours
SM, fit
50 min
20 min
71 min
29 min
2 hours
41 min
4.2 hours
1.7 hours
8.3 hours
3.4 hours
83 hours
34 hours
N95
1.7 hours
40 min
2.4 hours
58 min
3 hours
81 min
8.3 hours
3.4 hours
17 hours
6.8 hours
167 hours
68 hours
N95, fit
16.7 hours
6.8 hours
24 hours
10 hours
33 hours
14 hours
83 hours
34 hours
167 hours
68 hours
1667 hours
677 hours
SM - surgical mask; SM, fit - surgical mask with fit enhancing brace;
N95 - N95 or similar respirator; N95, fit - a fit tested N95 respirator

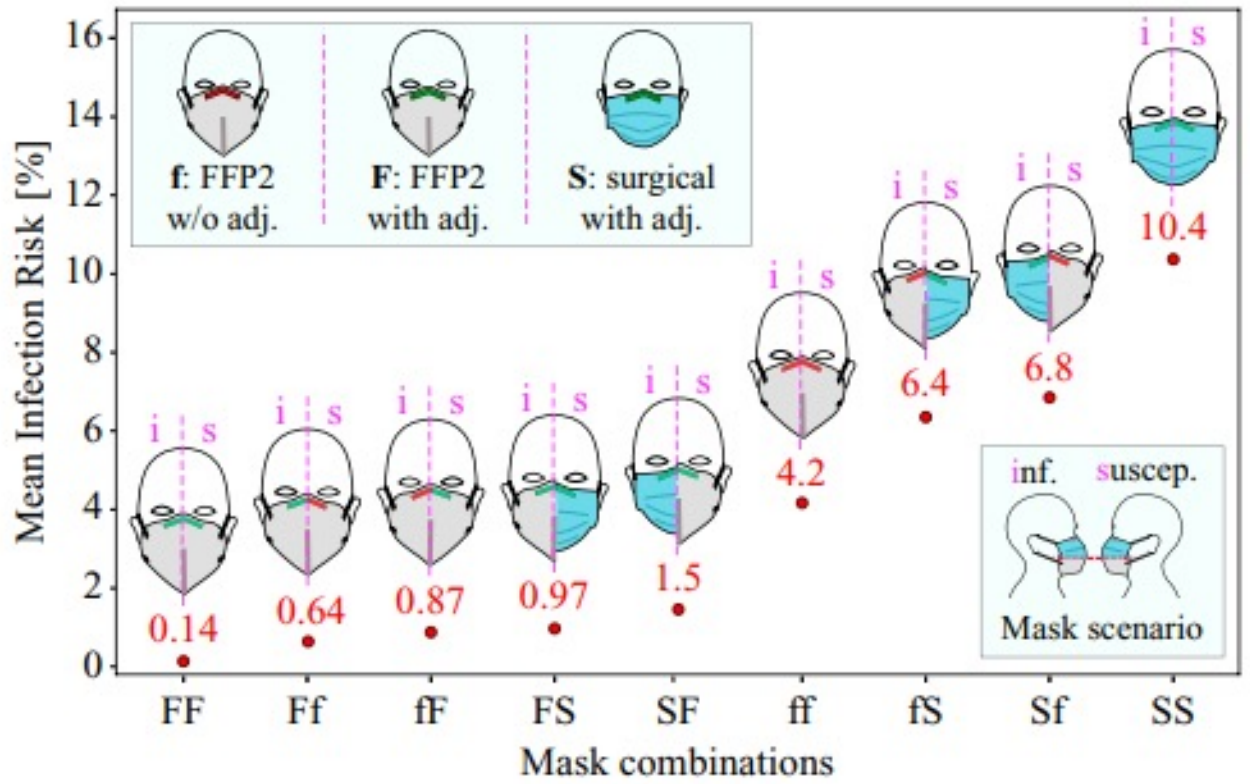
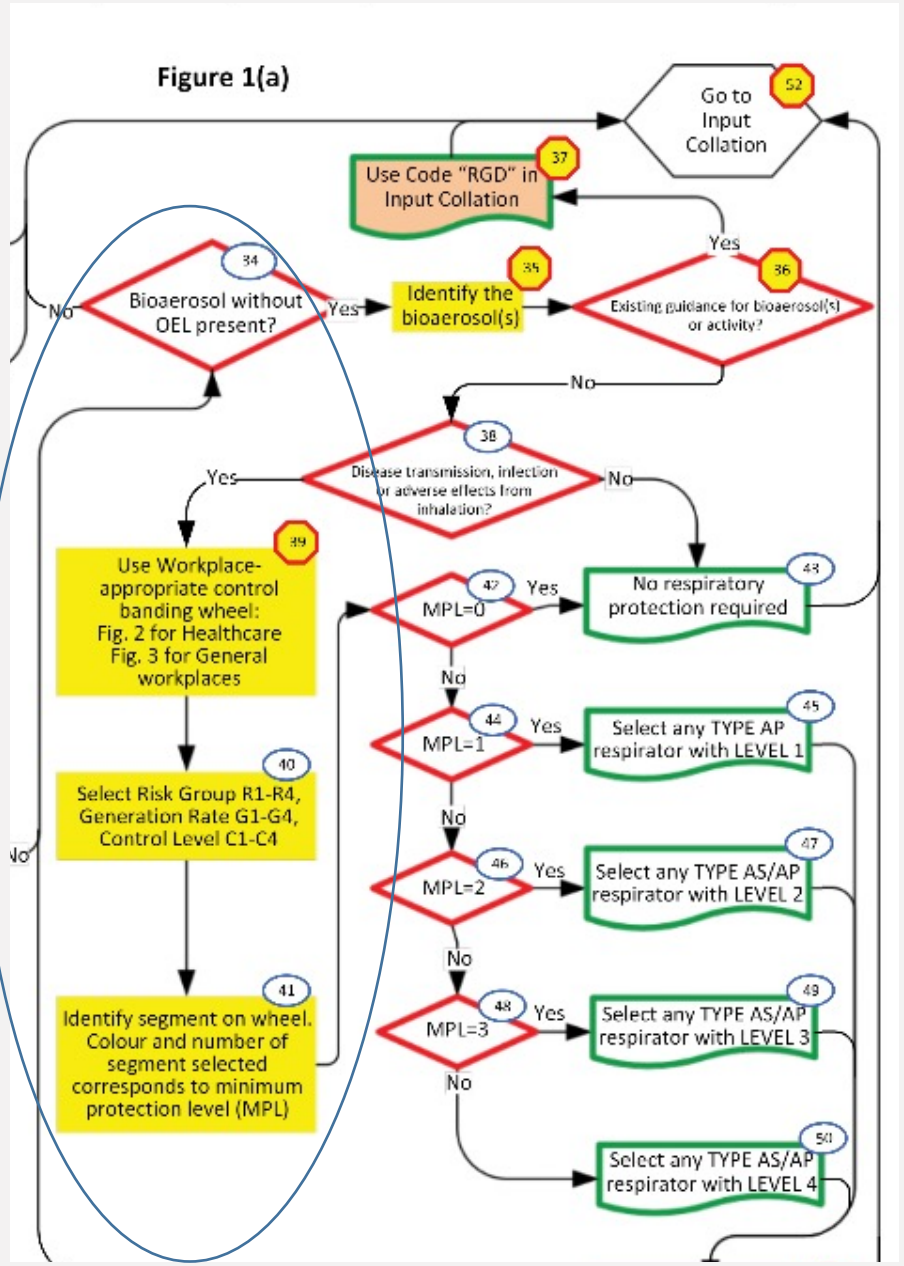


Fig. 6. Mean risk of infection in mask scenarios with different mask combinations for a duration of 20 min. The horizontal axis shows the combination of masks used by the infectious and susceptible with two characters; the first character corresponds to the type of mask worn by the infectious, and the second character corresponds to that of susceptible. Mask types and fittings are abbreviated as follows: f, FFP2 mask without adjustment (Fig. 2, case *i*); F, FFP2 mask with adjustment (Fig. 2, case *ii*); S, surgical mask with adjustment (Fig. 2, case *v*). Other parameters used for generating results shown in this plot are $f_d = 1.0$, $d_{0,max} = 50$ μm, $w = 4$, viral load $\rho_p = 10^{8.5}$ virus copies per mL, and $ID_{63.21} = 200$.

Bagheri et al. 2021

[An upper bound on one-to-one exposure to infectious human respiratory particles | PNAS]

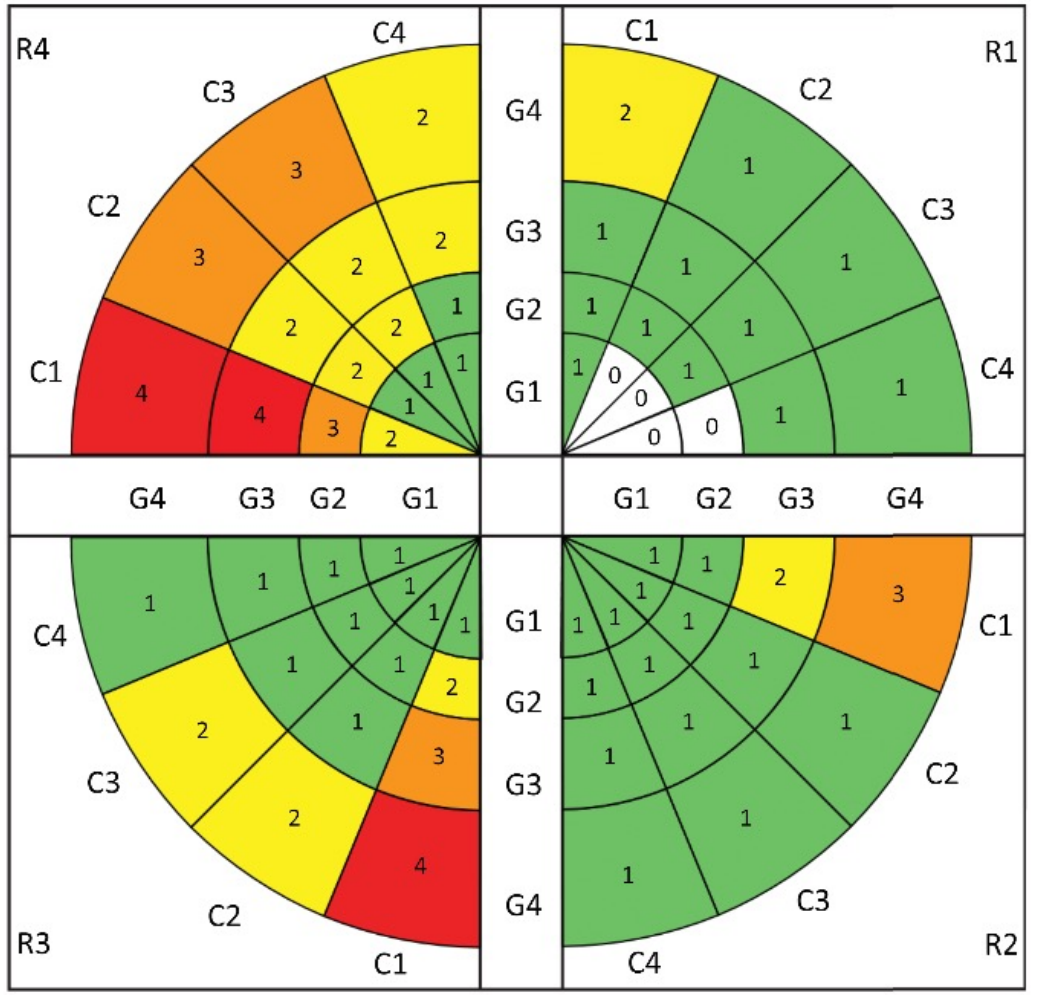
PNAS December 7, 2021 118 (49) e2110117118;
https://doi.org/10.1073/pnas.2110117118



Control banding approach for bioaerosols in general workplace environments

(See Clauses 7.3.4.2 and 7.3.4.3.4 to 7.3.4.3.8, Figure 1, and Annex K.)

General workplace environments	
Risk group	
Agents not associated with disease or serious adverse health effects in healthy adult humans	R1
Agents associated with human disease or adverse health effects that are rarely serious and for which preventive or therapeutic interventions are usually available	R2
Agents associated with serious or lethal human disease or adverse health effects for which preventive or therapeutic interventions might be available (high individual risk but low community risk)	R3
Agents likely to cause serious or lethal human disease or adverse health effects for which preventive or therapeutic interventions are not usually available (high individual risk and high community risk)	R4
Generation rate	
Low release of bioaerosol / pathogen — vacuuming with a HEPA filter	G1
Medium release of bioaerosol / pathogen — soaking then shovelling	G2
High release of bioaerosol / pathogen — misting then shovelling	G3
Very high release of bioaerosol / pathogen — dry sweeping	G4
Control level	
Indoor — poorly ventilated ACH ≤ 1	C1
Indoor — ventilation 1 < ACH ≤ 4 Outdoor — no wind	C2
Indoor — ventilation 4 < ACH ≤ 6 Outdoor — low wind	C3
Indoor — ventilation > 6 Outdoor — moderate wind	C4



CAN / CSA Z94.4.18 **National Standard of Canada** – Selection Use and Care of Respirators

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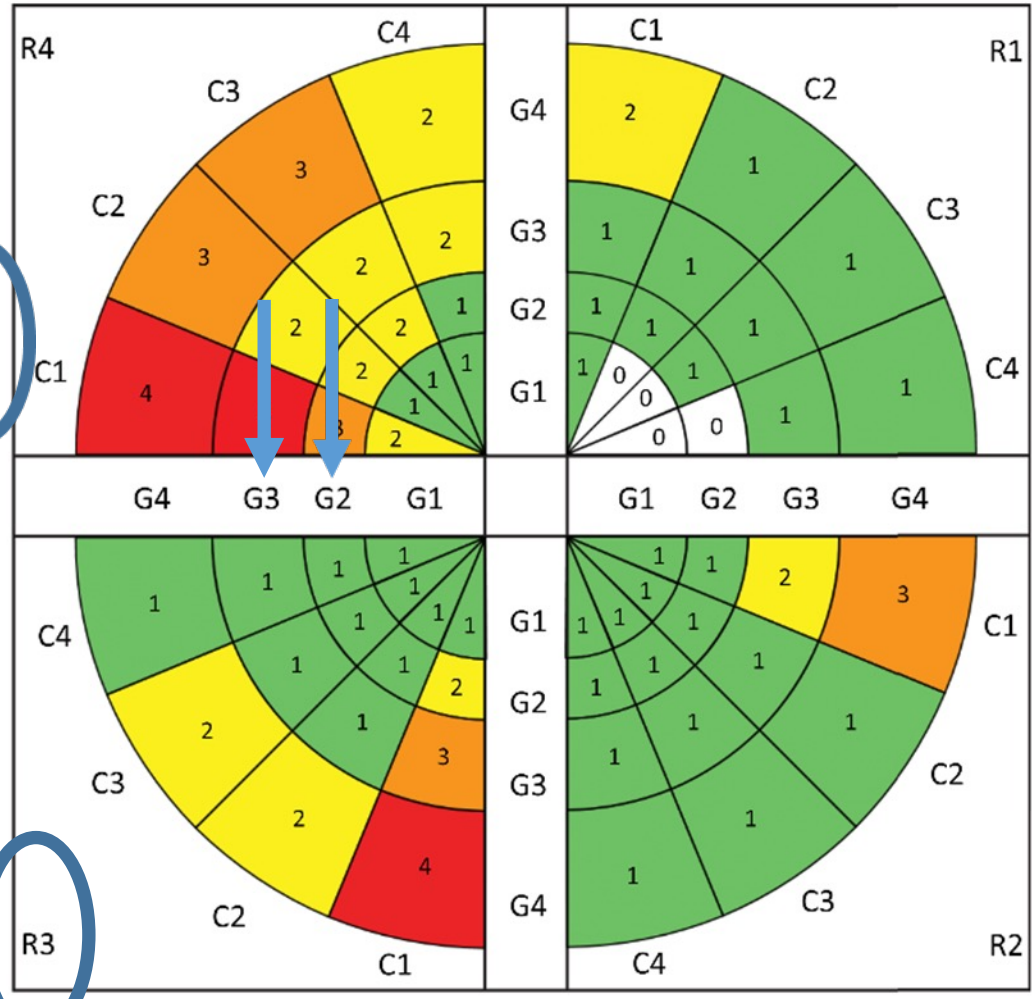


Acceptable level						Air-purifying options	APF
0	1	2	3	4	5		
					5	No air-purifying option available	10000
				4 to 5		Powered air-purifying full-facepiece Powered air-purifying helmet/hood with SWPF study	1000
			3 to 5			Powered air-purifying half-facepiece Air-purifying (negative-pressure) full-facepiece	50
		2 to 5				Powered air-purifying loose-fitting facepiece/visor Powered air-purifying helmet/hood without SWPF study	25
	1 to 5					Air-purifying (negative-pressure) half-facepiece (including filtering facepieces)	10
						No respiratory protection required	<1

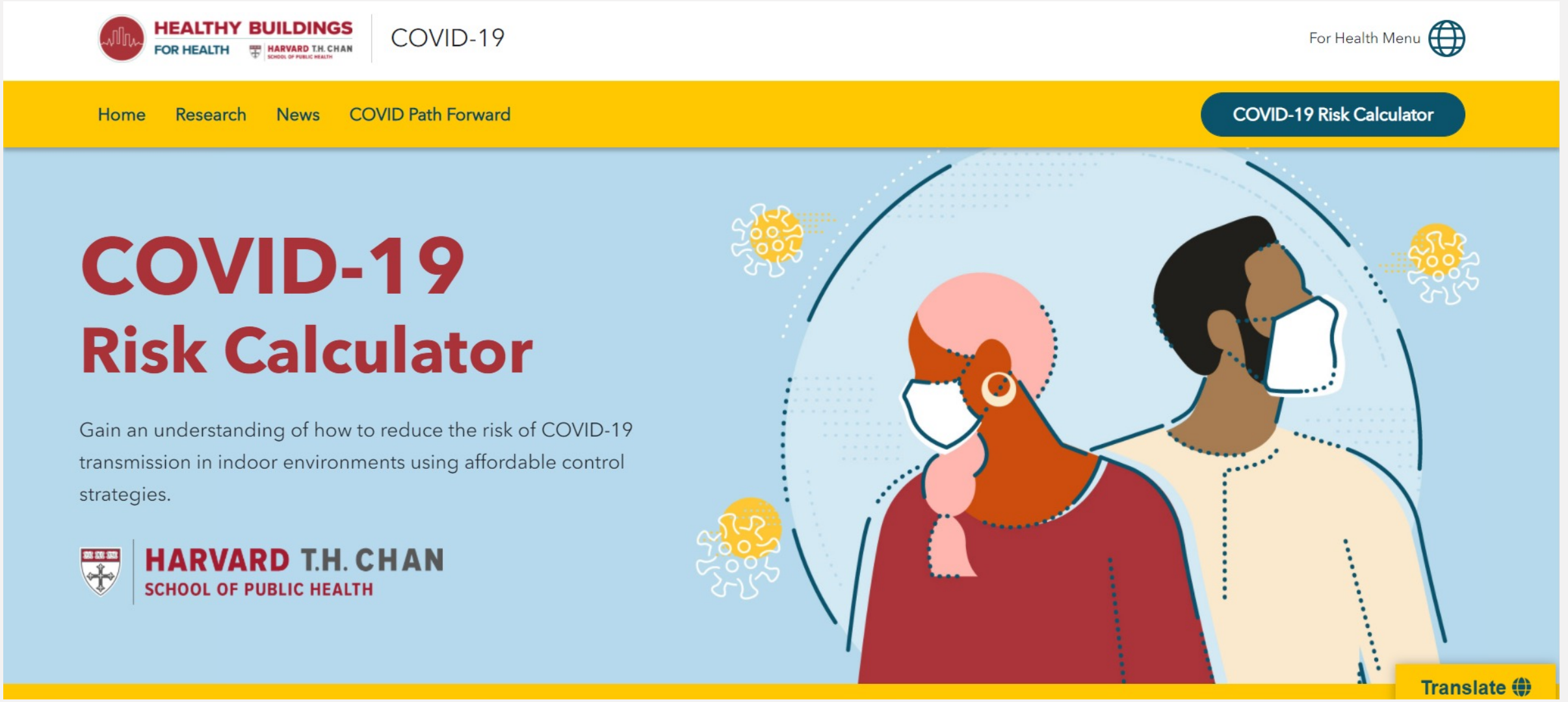
See also irsst tool →

https://www.irsst.qc.ca/en/institute/medias/news-releases/id/281/support-tool-for-choosing-respiratory-protection-against-bioaerosols-in-the-workplace

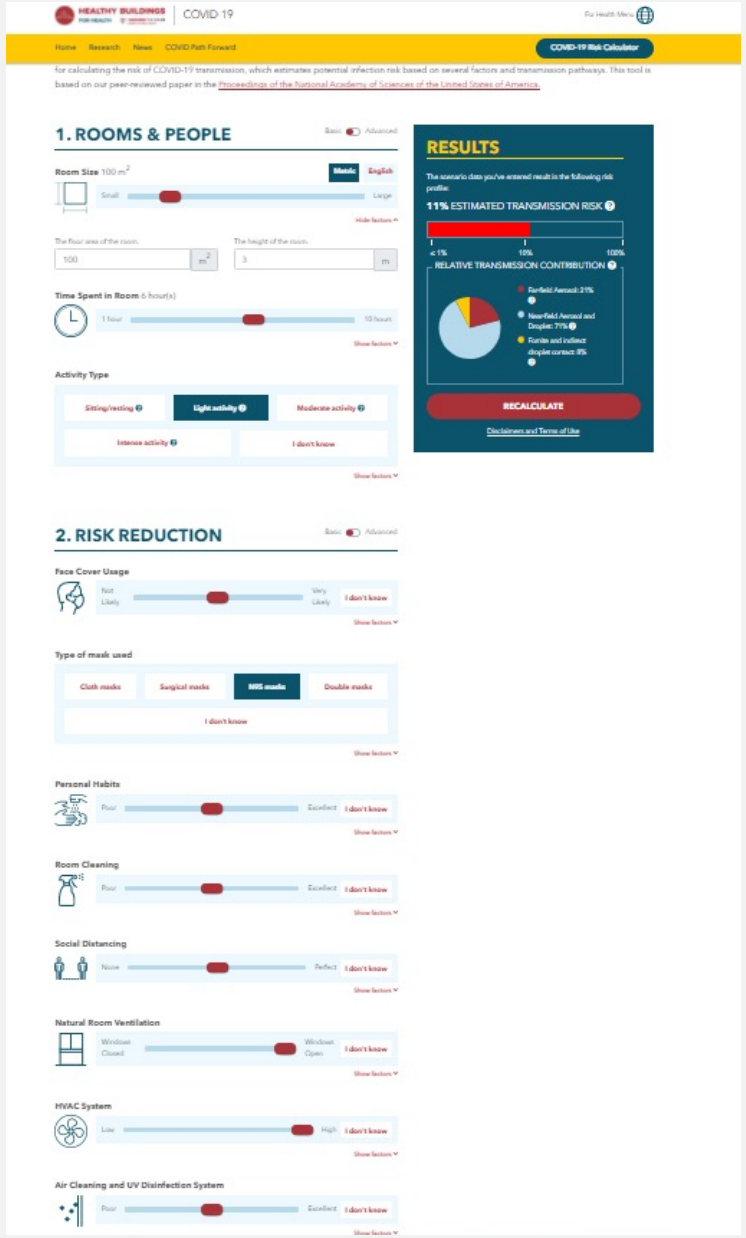
Tools in the Toolbox:

Simple Solutions for a “COVID-Safe” season

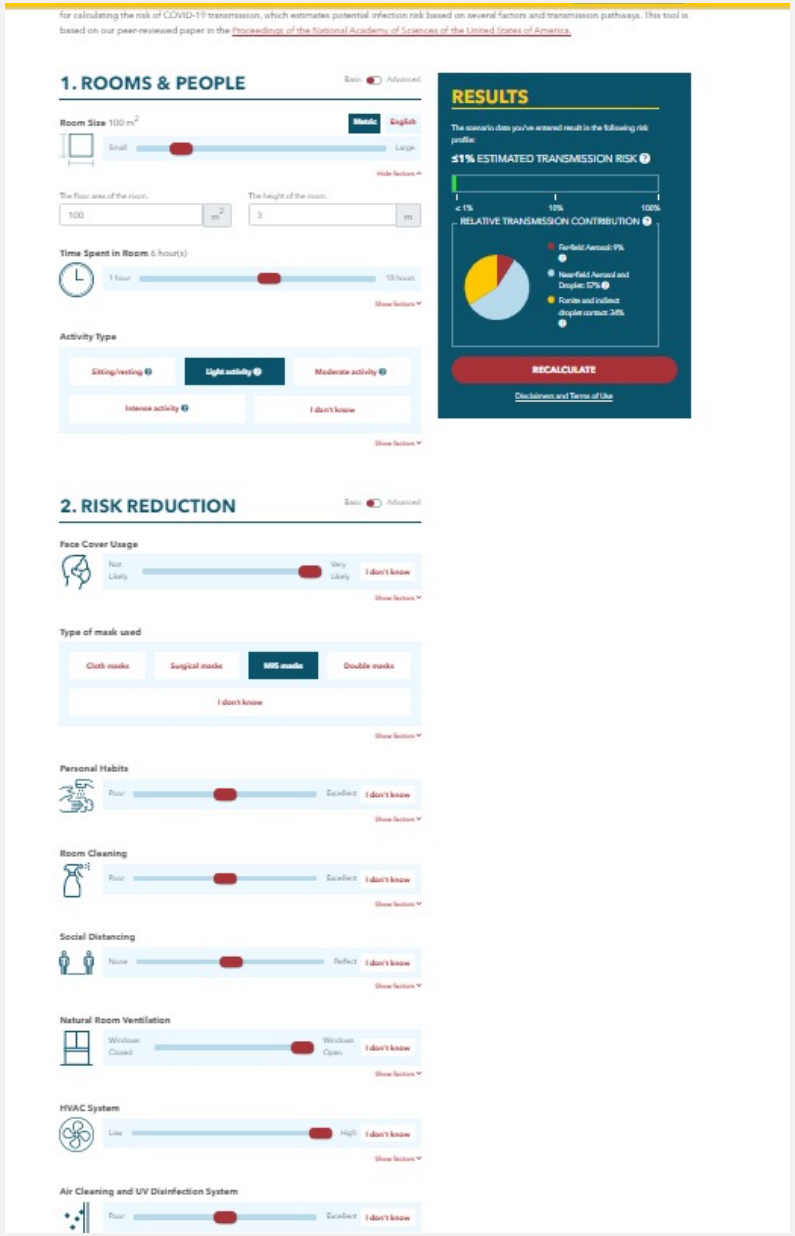
Focus on **simple calculators** that everyone can use.

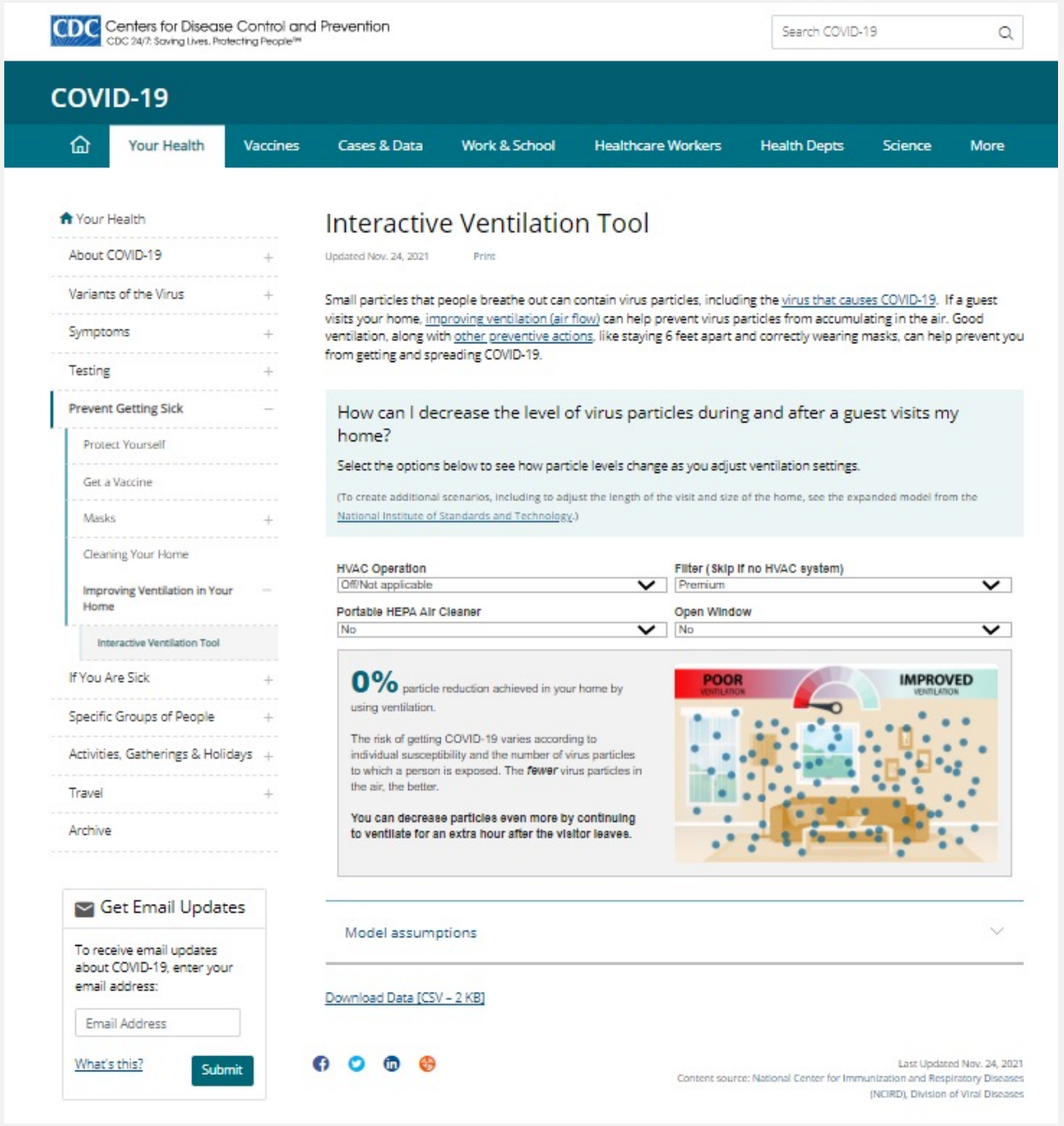


https://covid-19.forhealth.org/covid-19-transmission-calculator/



N95 face (covering very likely)
Reduced 11% transmission risk to ≤ 1%

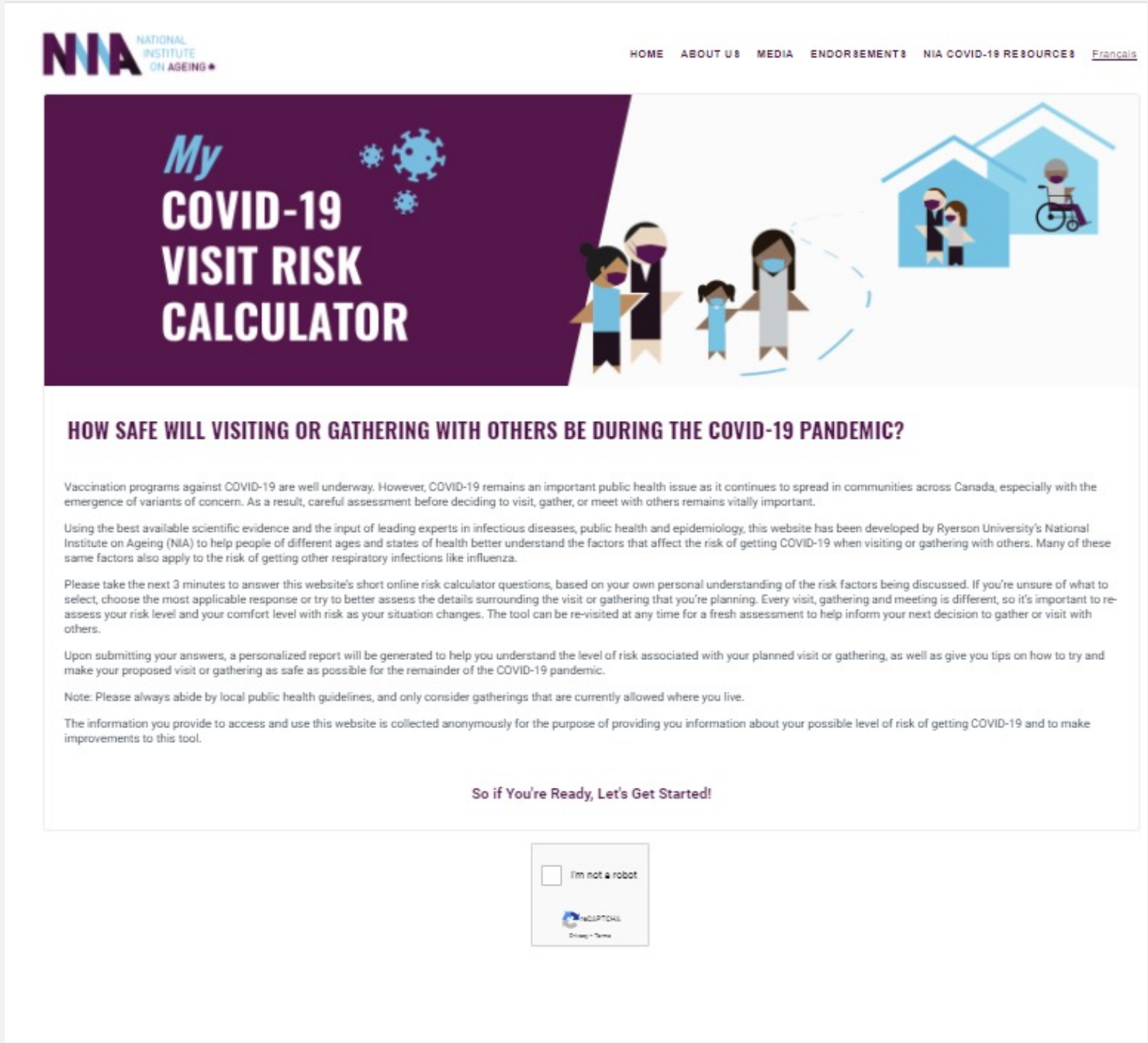




Interactive Ventilation Tool

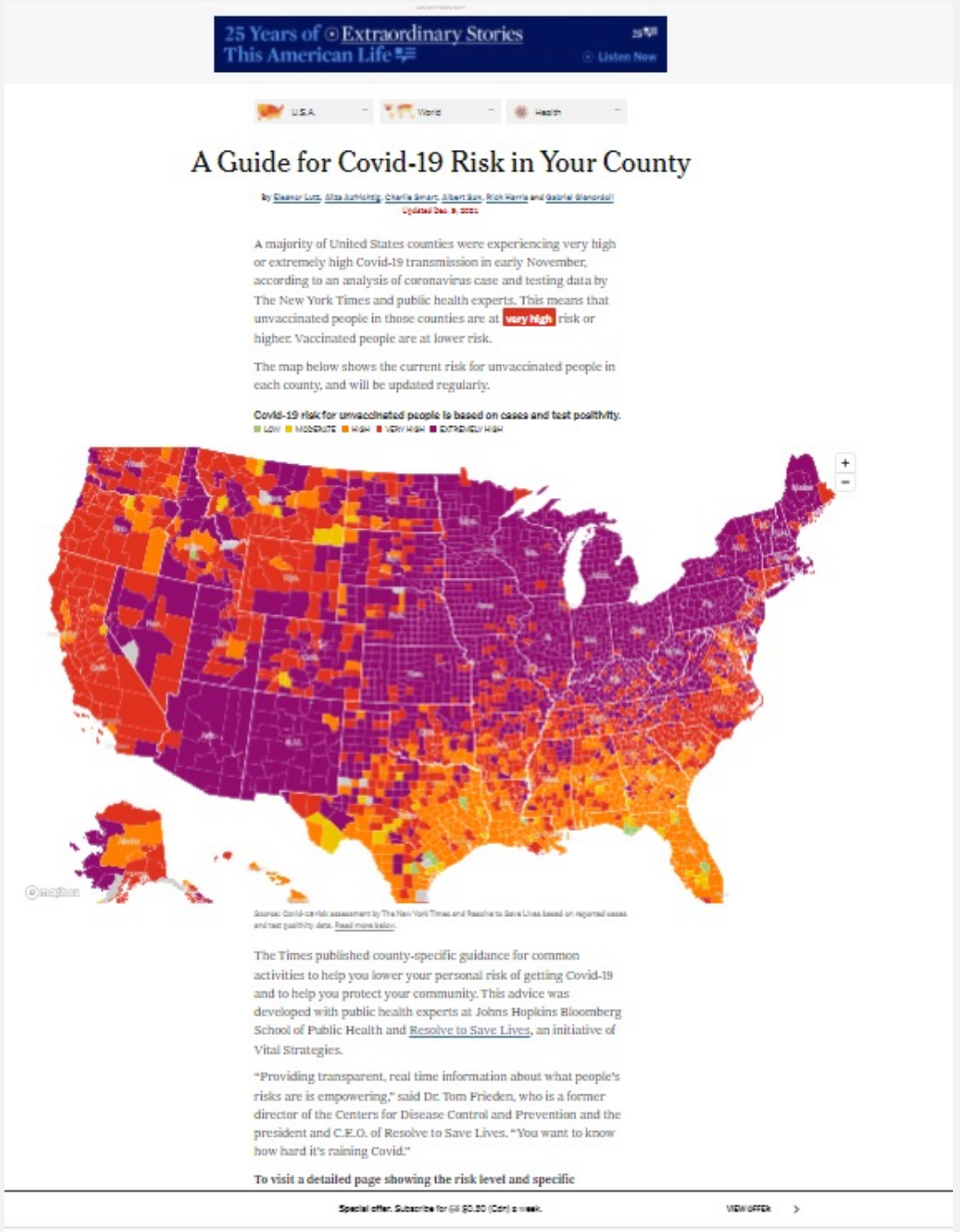
Select the options to see how particle levels change as you adjust ventilation settings.

https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/interactive-ventilation-tool.html

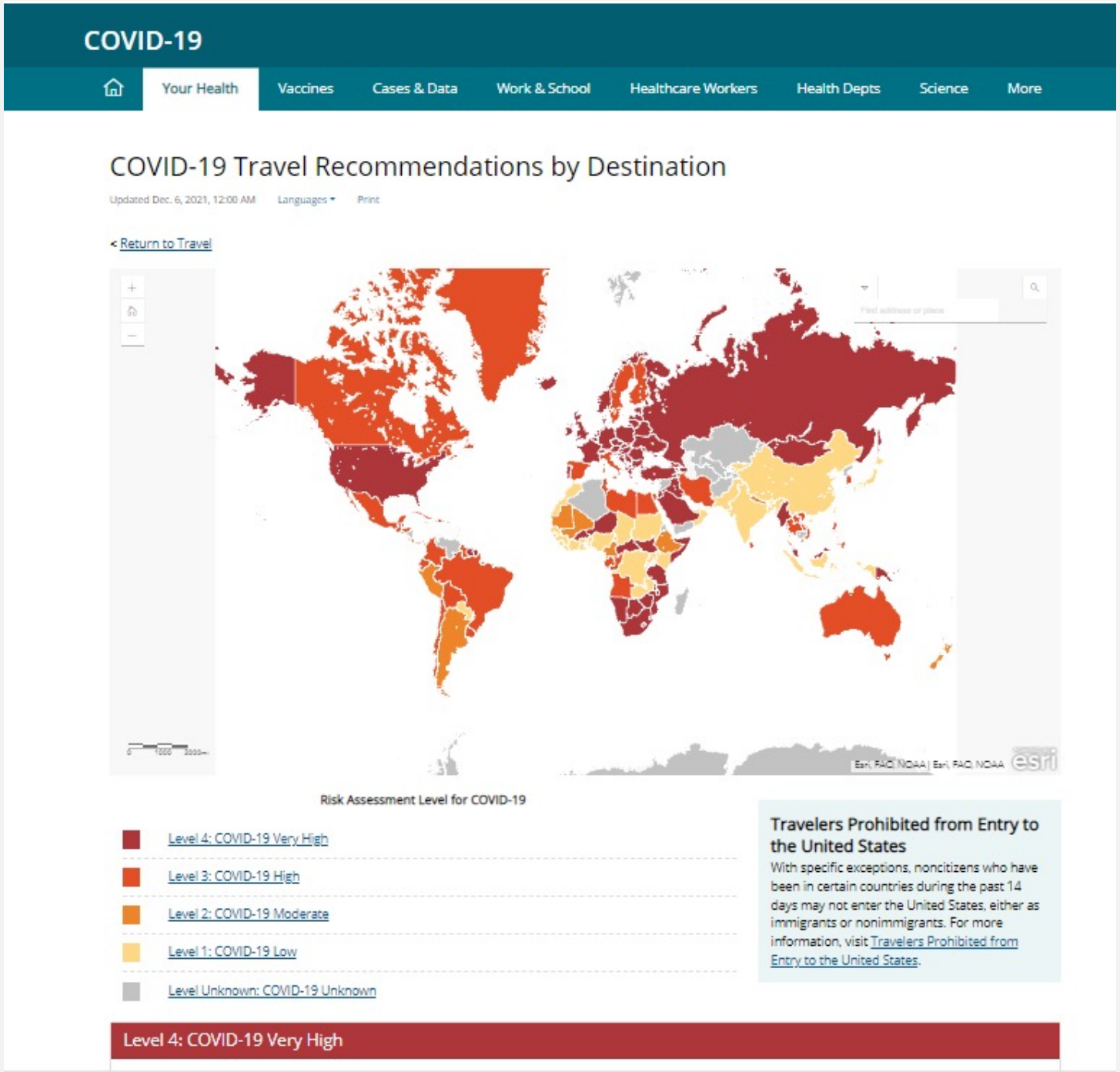


https://covidvisitrisk.com/riskscore-english.html?utm_source=sudbury.com&utm_campaign=sudbury.com%3A%20outbound&utm_medium=referral

https://www.nist.gov/services-resources/software/viper-virus-particle-exposure-residences



https://www.nytimes.com/interactive/2021/us/covid-risk-map.html



https://www.cdc.gov/coronavirus/2019-ncov/travelers/map-and-travel-notices.html

Opinion: How to assess the covid-19 risk from holiday gatherings? Here are four things to consider.

Turkeys on a farm in Orefield, Pa., on Nov. 10. (Hannah Beier/Bloomberg News)

By Leana S. Wen
Contributing columnist

November 30, 2021 at 1:54 p.m. EST

MOST READ OPINIONS ›

1. Vaccination status of attendees. The main reason this holiday season is dramatically different from last year's is the availability of coronavirus vaccines. A vaccinated person is six times less likely to be infected with covid-19 compared with an unvaccinated individual. Events with only vaccinated people will have lower risk than those with attendees of mixed vaccination status.

Level of vaccination also matters. Children 5 to 11 years old are newly eligible to get their shots. Unless they participated in clinical trials, younger kids are unlikely to have received both doses before Thanksgiving. Those with partial vaccination have inadequate immunity and should be considered at similar risk as the unvaccinated. On the other end of the spectrum, people who have received boosters are even better protected than those who were inoculated more than six months ago. I'd feel more comfortable gathering with individuals who are not only vaccinated but also boosted.

[Sign up for The Checkup With Dr. Wen, a newsletter on how to navigate the pandemic and other public health challenges]

2. Level of community transmission. Most of the United States is awash in the coronavirus, though there are major differences across regions. Parts of the South and Southeast that were hit particularly hard by the delta wave are experiencing a respite, while covid-19 is surging in areas such as the Mountain West. In Montana, 44 percent of intensive-care beds are filled with covid-19 patients, and Colorado has reactivated its crisis standards of care.

I've likened the vaccine to a good raincoat. It will keep you dry in a drizzle, but in a downpour, you could get wet unless you also have an umbrella. The higher the rate of infection in your community, the more likely you will encounter covid-19. Just as you would consult the weather forecast with your exact location, you should also look to the CDC's website for updated information on local infection levels. If your county's rates are low, you could attend a large gathering with few precautions; if they are high, you might not go without more layers of protection, such as masking and testing.

3. Medical risk of household. If everyone in your household is vaccinated and generally healthy, the risk is relatively low. But living with immunocompromised family members or unvaccinated young children is a very different situation. Because the vaccines provide such excellent protection against severe disease, many who are inoculated and in good health can reasonably decide that they don't want to limit social interactions. Others will make more conservative choices to protect medically frail loved ones.

4. Setting of the gathering. Outdoor settings remain by far the safest option. Indoor masking is an effective protective measure, too. If it's unclear from the invitation, I would ask about the proportion of indoor vs. outdoor activities. This is particularly important when food and drink are involved. An event that supposedly requires masks but also has people eating and drinking indoors is not as safe as one where food and drink are served outdoors only.

Ontario COVID-19 Regional Risk Tool:

Risk Legend

Minimal risk – low to absent community transmission

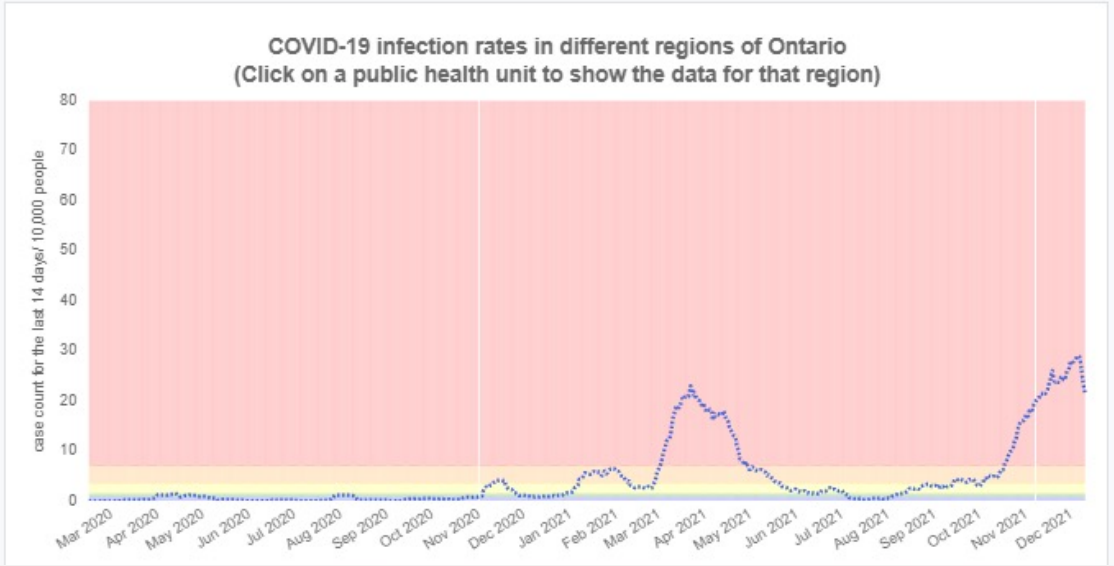
Controlled risk – some sporadic community activity – controlled occasional minor outbreaks

Some community risk – regular sporadic activity – controlled occasional larger outbreaks

Wider community risk – regular activity – periodic outbreaks

High risk – uncontrolled community transmission &/or outbreaks

Minimal risk	Controlled risk	Some community risk	Wider community risk	High risk
low to absent community transmission	some sporadic community activity	regular sporadic activity	regular activity outbreaks	uncontrolled community outbreaks
0-0.7 cases in the last 14 days per 10,000 people	0.7-1.4 cases in the last 14 days per 10,000 people	1.4-3.5 cases in the last 14 days per 10,000 people	3.5-7 cases in the last 14 days per 10,000 people	7+ cases in the last 14 days per 10,000 people



Regional Risk Table At A Glance

Rank	Region Public Health Unit (PHU)	Regional Infection Risk Level*	ON Framework Categories**
1	Algoma Public Health Unit	High risk	CONTROL
2	Sudbury & District Health Unit	High risk	CONTROL
3	Timiskaming Health Unit	High risk	CONTROL
4	Windsor-Essex County Health Unit	High risk	CONTROL
5	Kingston, Frontenac and Lennox & Addington Public Health	High risk	CONTROL
6	Simcoe Muskoka District Health Unit	High risk	CONTROL
7	Chatham-Kent Health Unit	High risk	CONTROL
8	Haldimand-Norfolk Health Unit	High risk	CONTROL
9	Southwestern Public Health	High risk	CONTROL
10	Brant County Health Unit	High risk	CONTROL
11	Hastings and Prince Edward Counties Health Unit	High risk	CONTROL
12	Thunder Bay District Health Unit	High risk	CONTROL
13	Lambton Public Health	High risk	CONTROL
14	Huron Perth District Health Unit	High risk	RESTRICT
15	Eastern Ontario Health Unit	High risk	RESTRICT
16	Region of Waterloo, Public Health	Wider community risk	RESTRICT
17	Niagara Region Public Health Department	Wider community risk	RESTRICT
18	Halton Region Health Department	Wider community risk	RESTRICT
19	Middlesex-London Health Unit	Wider community risk	CONTROL
20	Wellington-Dufferin-Guelph Public Health	Wider community risk	RESTRICT
21	Renfrew County and District Health Unit	Wider community risk	RESTRICT
22	Ottawa Public Health	Wider community risk	RESTRICT
23	Hamilton Public Health Services	Wider community risk	RESTRICT
24	York Region Public Health Services	Wider community risk	RESTRICT
25	Durham Region Health Department	Wider community risk	PROTECT
26	Grey Bruce Health Unit	Wider community risk	PROTECT
27	Toronto Public Health	Wider community risk	RESTRICT
28	Peterborough Public Health	Wider community risk	PROTECT
29	Peel Public Health	Wider community risk	PROTECT
30	Leeds, Grenville and Lanark District Health Unit	Wider community risk	PROTECT
31	Haliburton, Kawartha, Pine Ridge District Health Unit	Some community risk	PROTECT
32	Northwestern Health Unit	Some community risk	PROTECT
33	North Bay Parry Sound District Health Unit	Some community risk	PROTECT
34	Porcupine Health Unit	Some community risk	PREVENT

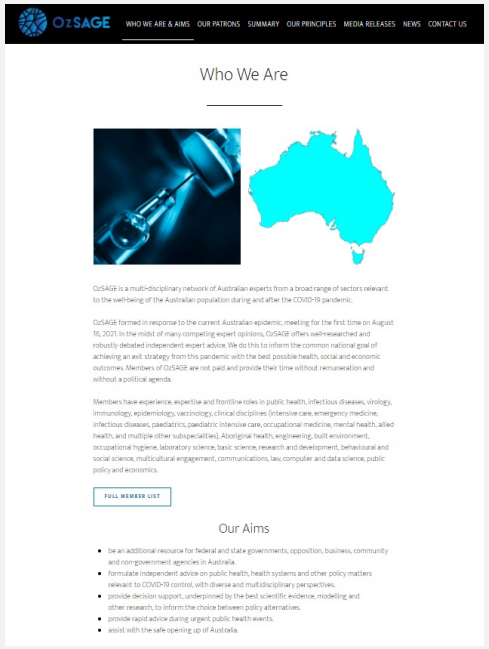
* These tools translate Reported case data published by Public Health Ontario as a 14 day rolling count (divided by population to create a rate per 10 000 people) to understand and compare Ontario regional SARS CoV2 transmission risk. Recent numbers can be delayed and are less reliable, particularly over weekends, so risk may be underestimated.

** The Ontario Framework Category is an estimation of the official provincial colour-coding as explained in COVID-19 Response Framework: Keeping Ontario Safe and Open (see slide 9) based only on the weekly incidence rate per 100,000, but absent the other factors considered locally (e.g. % positivity of daily tests, the reproductive number (Rt = the number of new cases traced from each known case), the number and status of outbreaks, trend in cases without an epi connection, hospital and ICU capacities, and, PHU capacity for contact tracing). We are also not able to assign "Grey = Lockdown" since this category is based on a judgement call by local authorities. Therefore, the ON categories assigned in this table may not necessarily align with the official version but are provided for translation and reconciliation with Prevention Tips below.

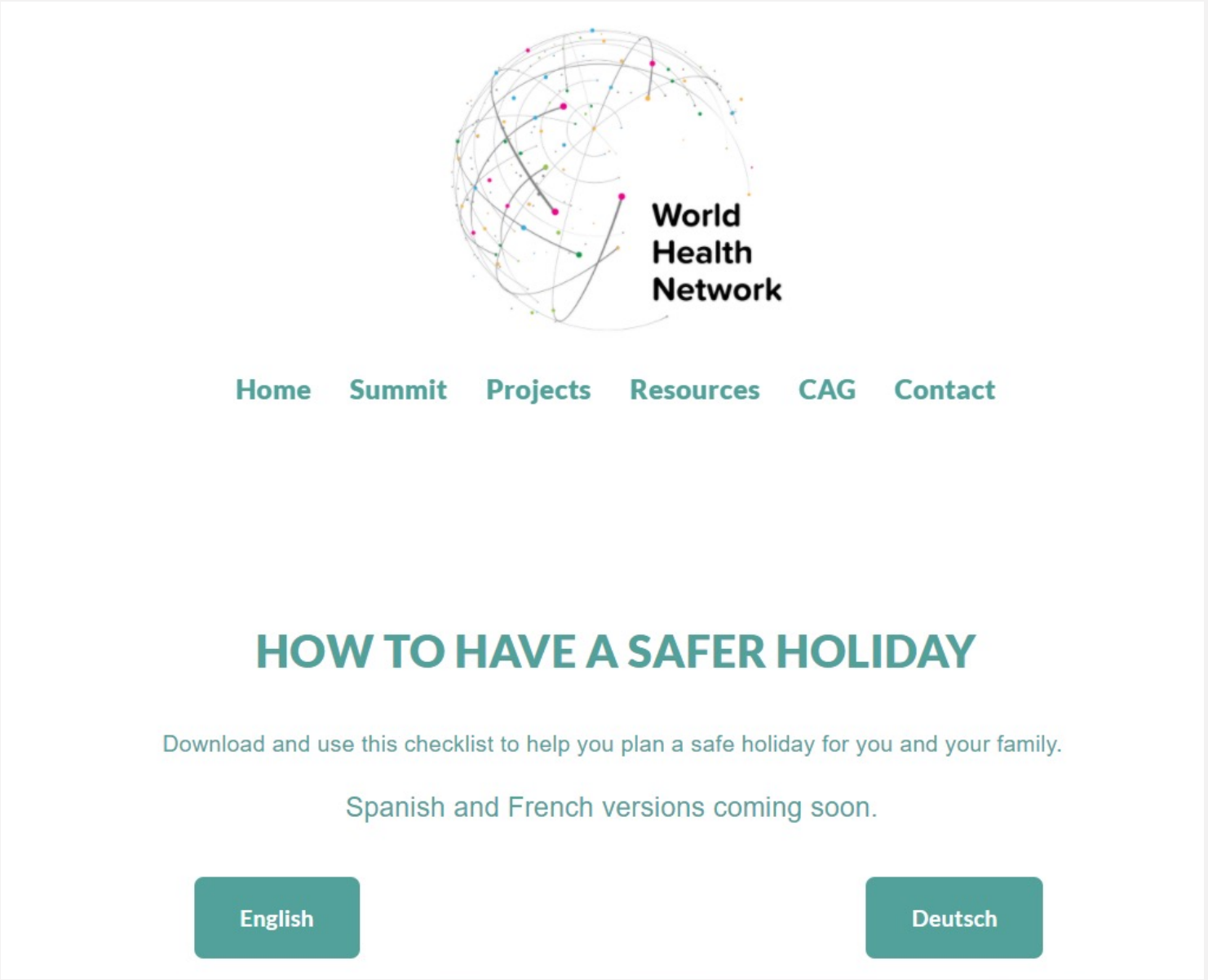
Sudbury & District Health Unit

https://www.ohcow.on.ca/covid-19/regional-risk-tool-tips/#risktable

International good practices

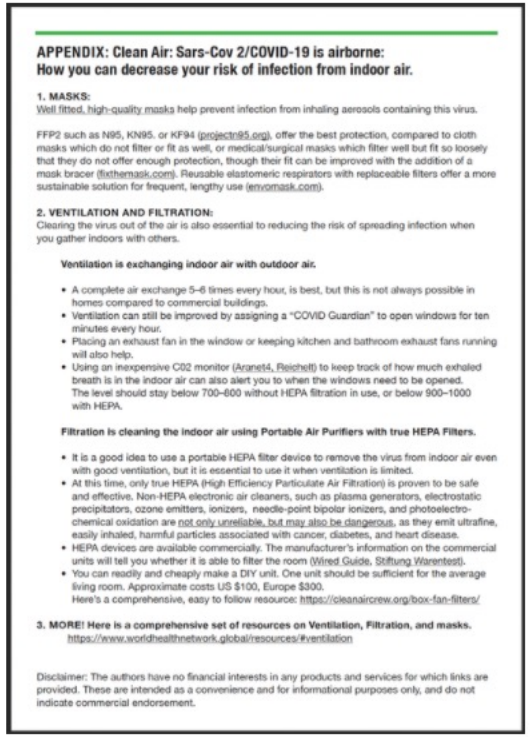


https://ozsage.org/who-we-are/



https://www.worldhealthnetwork.global/holiday-flyer/

HOW TO HAVE A SAFER HOLIDAY



APPENDIX: Clean Air: Sars-Cov 2/COVID-19 is airborne: How you can decrease your risk of infection from indoor air.

1. MASKS:
Well fitted, high-quality masks help prevent infection from inhaling aerosols containing this virus.

FFP2 such as N95, KN95. or KF94 (projectn95.org), offer the best protection, compared to cloth masks which do not filter or fit as well, or medical/surgical masks which filter well but fit so loosely that they do not offer enough protection, though their fit can be improved with the addition of a mask bracer (fixthemask.com). Reusable elastomeric respirators with replaceable filters offer a more sustainable solution for frequent, lengthy use (envomask.com).

2. VENTILATION AND FILTRATION:
Clearing the virus out of the air is also essential to reducing the risk of spreading infection when you gather indoors with others.

Ventilation is exchanging indoor air with outdoor air.

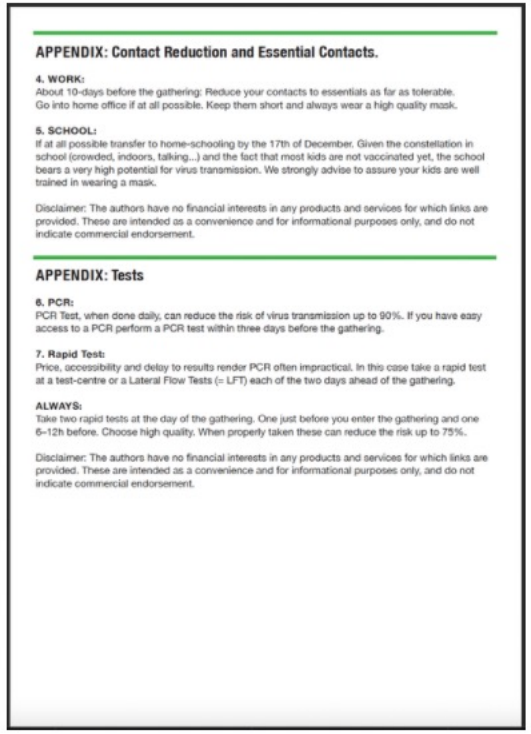
- A complete air exchange 5–6 times every hour, is best, but this is not always possible in homes compared to commercial buildings.
- Ventilation can still be improved by assigning a "COVID Guardian" to open windows for ten minutes every hour.
- Placing an exhaust fan in the window or keeping kitchen and bathroom exhaust fans running will also help.
- Using an inexpensive C02 monitor (Aranet4, Reichelt) to keep track of how much exhaled breath is in the indoor air can also alert you to when the windows need to be opened. The level should stay below 700–800 without HEPA filtration in use, or below 900–1000 with HEPA.

Filtration is cleaning the indoor air using Portable Air Purifiers with true HEPA Filters.

- It is a good idea to use a portable HEPA filter device to remove the virus from indoor air even with good ventilation, but it is essential to use it when ventilation is limited.
- At this time, only true HEPA (High Efficiency Particulate Air Filtration) is proven to be safe and effective. Non-HEPA electronic air cleaners, such as plasma generators, electrostatic precipitators, ozone emitters, ionizers, needle-point bipolar ionizers, and photoelectro-chemical oxidation are not only unreliable, but may also be dangerous, as they emit ultrafine, easily inhaled, harmful particles associated with cancer, diabetes, and heart disease.
- HEPA devices are available commercially. The manufacturer's information on the commercial units will tell you whether it is able to filter the room (Wired Guide, Stiftung Warentest).
- You can readily and cheaply make a DIY unit. One unit should be sufficient for the average living room. Approximate costs US $100, Europe $300.
  Here's a comprehensive, easy to follow resource: https://cleanaircrew.org/box-fan-filters/

3. MORE! Here is a comprehensive set of resources on Ventilation, Filtration, and masks.
https://www.worldhealthnetwork.global/resources/#ventilation

Disclaimer: The authors have no financial interests in any products and services for which links are provided. These are intended as a convenience and for informational purposes only, and do not indicate commercial endorsement.



APPENDIX: Contact Reduction and Essential Contacts.

4. WORK:
About 10-days before the gathering: Reduce your contacts to essentials as far as tolerable. Go into home office if at all possible. Keep them short and always wear a high quality mask.

5. SCHOOL:
If at all possible transfer to home-schooling by the 17th of December. Given the constellation in school (crowded, indoors, talking...) and the fact that most kids are not vaccinated yet, the school bears a very high potential for virus transmission. We strongly advise to assure your kids are well trained in wearing a mask.

Disclaimer: The authors have no financial interests in any products and services for which links are provided. These are intended as a convenience and for informational purposes only, and do not indicate commercial endorsement.

APPENDIX: Tests

6. PCR:
PCR Test, when done daily, can reduce the risk of virus transmission up to 90%. If you have easy access to a PCR perform a PCR test within three days before the gathering.

7. Rapid Test:
Price, accessibility and delay to results render PCR often impractical. In this case take a rapid test at a test-centre or a Lateral Flow Tests (= LFT) each of the two days ahead of the gathering.

ALWAYS:
Take two rapid tests at the day of the gathering. One just before you enter the gathering and one 6–12h before. Choose high quality. When properly taken these can reduce the risk up to 75%.

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https://www.worldhealthnetwork.global/holiday-flyer/#English

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Ventilation is exchanging indoor air with outdoor air.

- A complete air exchange 5–6 times every hour, is best, but this is not always possible in homes compared to commercial buildings.
- Ventilation can still be improved by assigning a "COVID Guardian" to open windows for ten minutes every hour.
- Placing an exhaust fan in the window or keeping kitchen and bathroom exhaust fans running will also help.
- Using an inexpensive C02 monitor (Aranet4, Reichelt) to keep track of how much exhaled breath is in the indoor air can also alert you to when the windows need to be opened. The level should stay below 700–800 without HEPA filtration in use, or below 900–1000 with HEPA.

Filtration is cleaning the indoor air using Portable Air Purifiers with true HEPA Filters.

- It is a good idea to use a portable HEPA filter device to remove the virus from indoor air even with good ventilation, but it is essential to use it when ventilation is limited.
- At this time, only true HEPA (High Efficiency Particulate Air Filtration) is proven to be safe and effective. Non-HEPA electronic air cleaners, such as plasma generators, electrostatic precipitators, ozone emitters, ionizers, needle-point bipolar ionizers, and photoelectro-chemical oxidation are not only unreliable, but may also be dangerous, as they emit ultrafine, easily inhaled, harmful particles associated with cancer, diabetes, and heart disease.
- HEPA devices are available commercially. The manufacturer's information on the commercial units will tell you whether it is able to filter the room (Wired Guide, Stiftung Warentest).
- You can readily and cheaply make a DIY unit. One unit should be sufficient for the average living room. Approximate costs US $100, Europe $300.
  Here's a comprehensive, easy to follow resource: https://cleanaircrew.org/box-fan-filters/

3. MORE! Here is a comprehensive set of resources on Ventilation, Filtration, and masks.
https://www.worldhealthnetwork.global/resources/#ventilation

Disclaimer: The authors have no financial interests in any products and services for which links are provided. These are intended as a convenience and for informational purposes only, and do not indicate commercial endorsement.

2. VENTILATION AND FILTRATION:
Clearing the virus out of the air is also essential to reducing the risk of spreading infection when you gather indoors with others.

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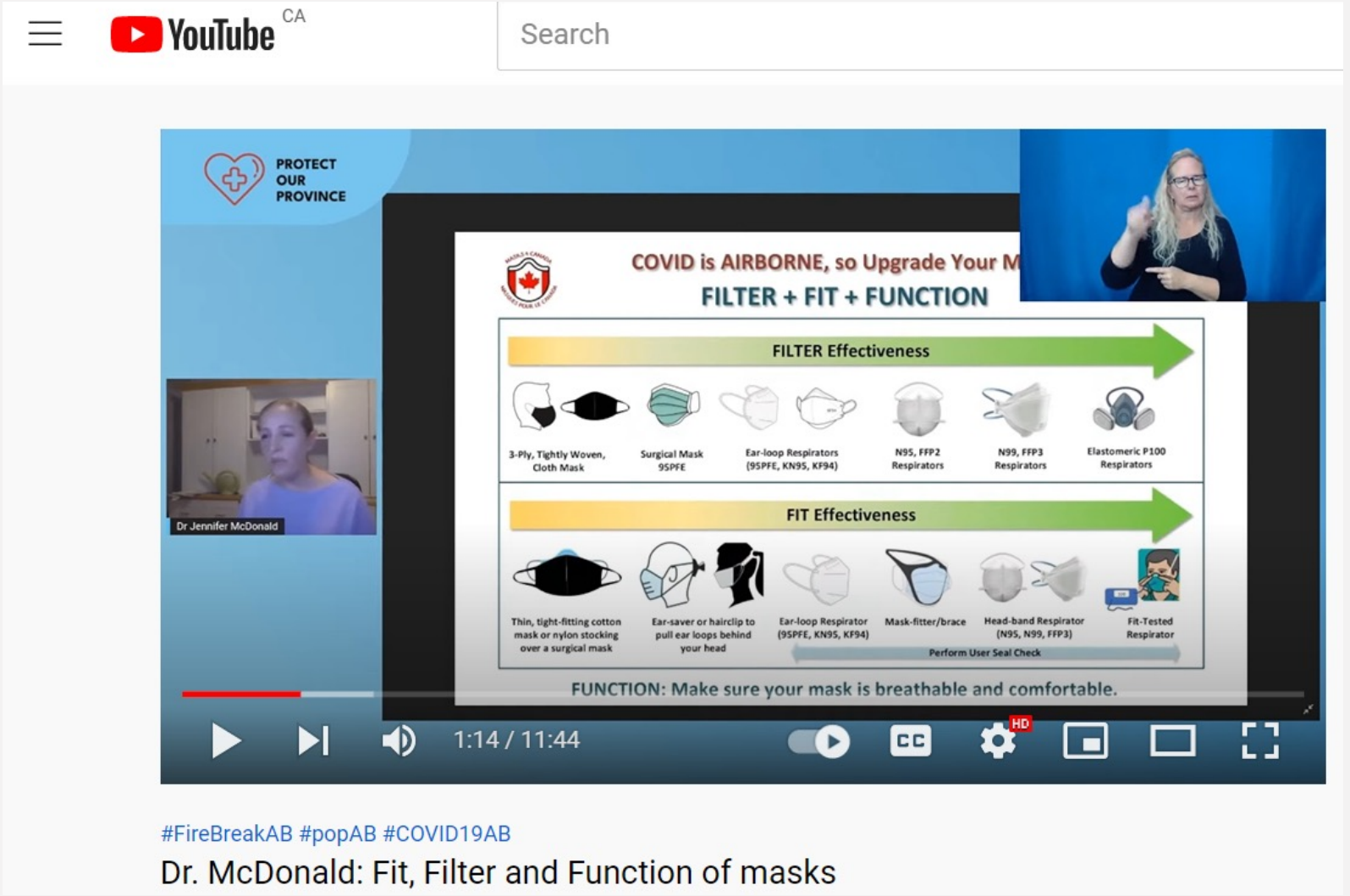
Simple Solutions for a “COVID-Safe” season – **Upgrade you mask to a respirator!**



https://www.youtube.com/watch?v=QHTK2yQidM8