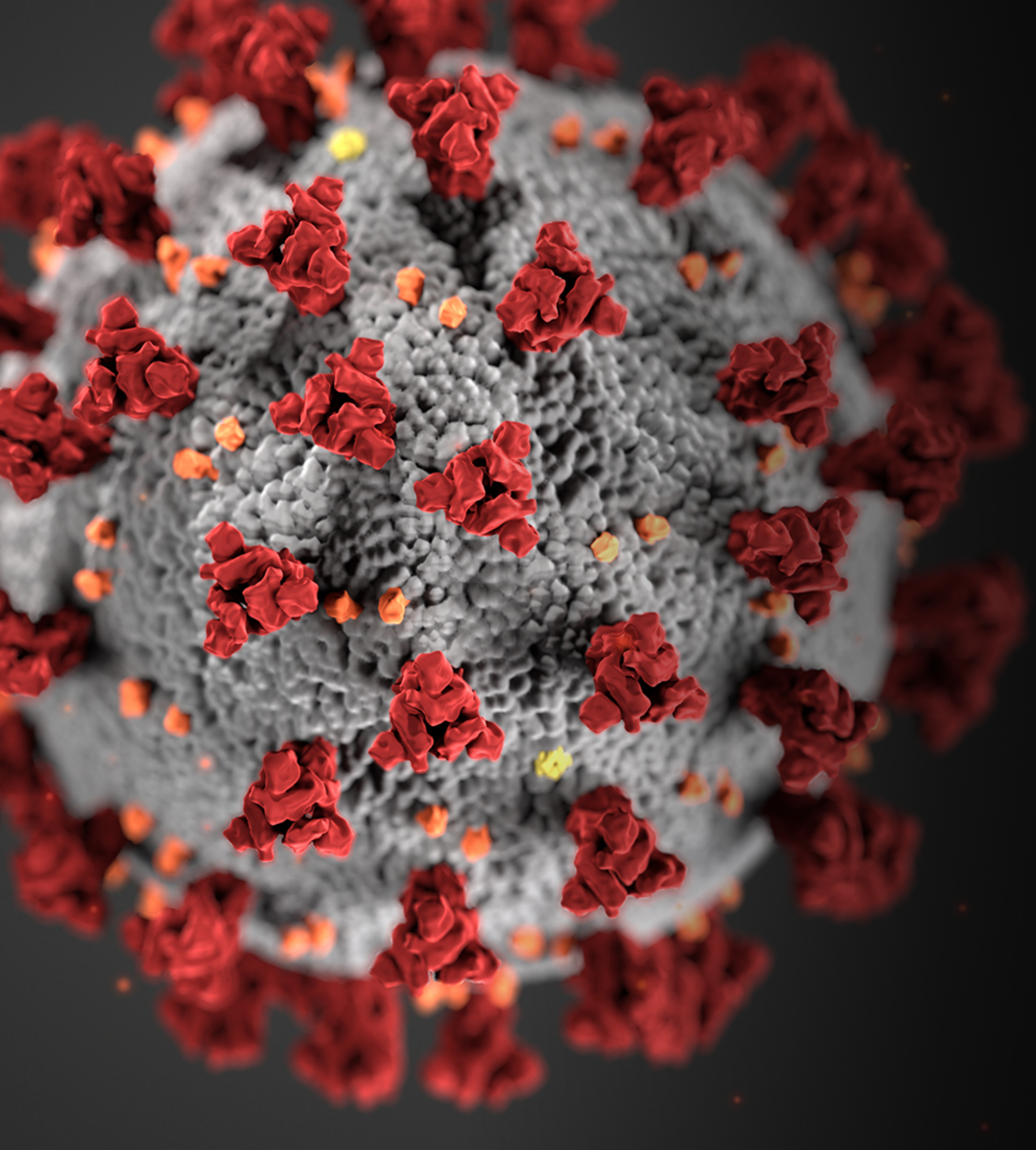

COVID-19 Update: How two years has shaped our understanding of respiratory virus infection control

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Infectious Diseases and Medical Microbiology

Infection Prevention and Control

McGill University – Jewish General Hospital

November 30, 2021

Disclosures

NO FINANCIAL DISCLOSURES

NO CONFLICTS OF INTERESTS WITH THE PRESENTED MATERIAL

Objectives

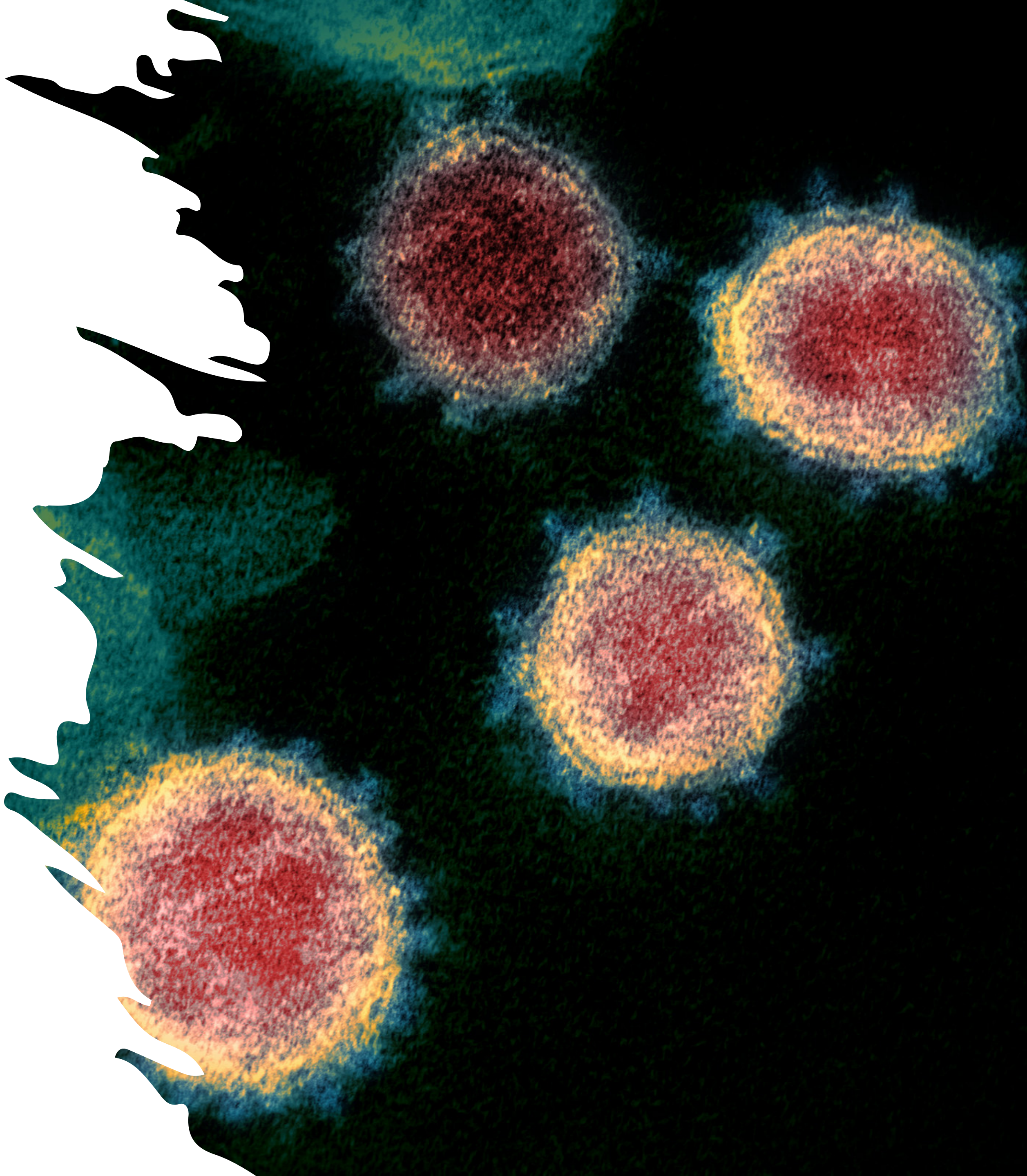
1. Describe key epidemiological features of SARS-CoV-2, including:
   - incubation period
   - serial interval
   - communicability period
   - secondary attack rate
2. Describe the primary routes of transmission of SARS-CoV-2
3. Describe the means by which relevant routes of transmission may be interrupted

Omissions in the interest of time…

1. Less common routes of transmission
2. Variants of concern, other than B.1.617.2
3. Role of vaccination
4. Animal studies

SARS-CoV-2

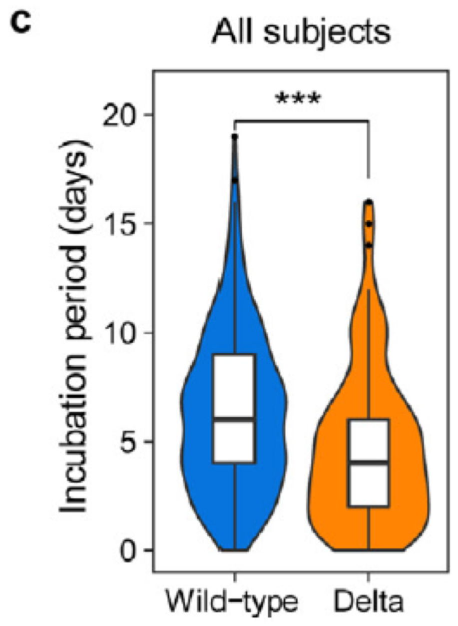
- Spike (S) protein to enter host cells + binds with high affinity to hACE2-receptor
- B.1.617.2 (Delta lineages) identified as variant of concern
  - Several salient spike protein changes enhance transmissibility and infectivity

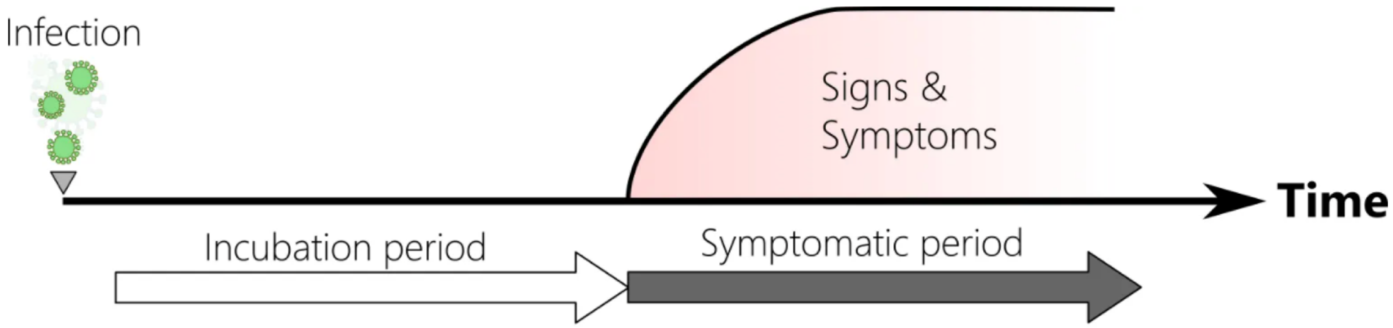


- 97.5% of those who develop symptoms will do so within 11.5 days (95% CI; 8.2 to 15.6 days) to 16.5 days

Mean incubation Period is
4.2 to 6.7 days

Delta = 4.0 days



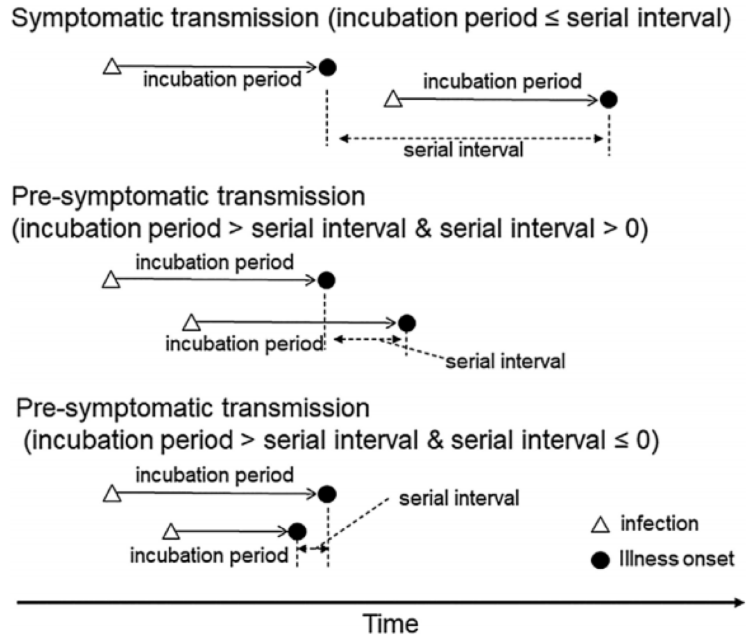


Lauer SA, et al. Ann Intern Med 2020; 172:577-582.
Wang Y, et al. EClinicalMedicine 2021; 40;101129.

Mean serial interval is 4.5 to 5.4 days

Delta = 2.3 days (95% CI 1.4 to 3.3)

- Nishiura H et al. analysis of 18 transmission pairs - median **serial interval 4.6 days** - shorter than mean incubation period 5 days
  - If serial interval < incubation period = some *transmission is likely occurring in incubation period*



Li Q, et al. N Engl J Med 2020; 382:1199-1207.
Nishiura H et al, International J Infect Dis. 2020; 93: 284–286.
Pung R et al. Lancet 2021, DOI:10.1016/ S0140-6736(21)01808-0.
Zhang M, et al. CCDC Weekly 2021; 3(27): 584-86.

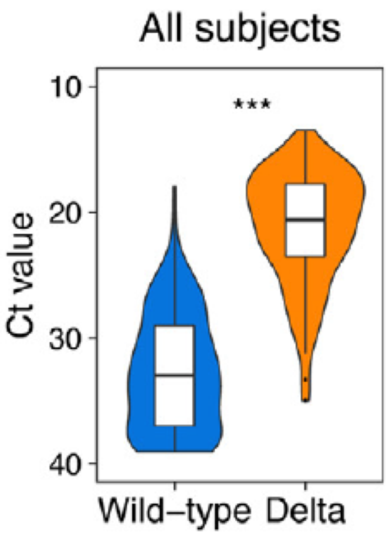
Communicability Period

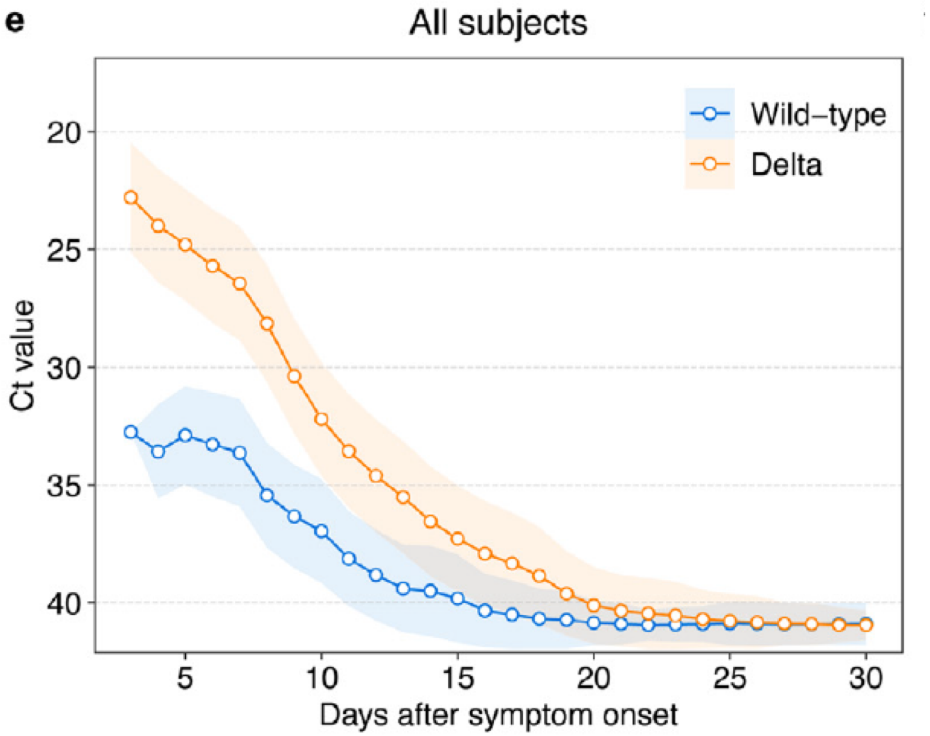
- Infectious dose is not known
- Detection of replication competent virus has been reported:
  - 6-days prior to symptom onset
  - 32-days after symptom onset
- Culture positivity at:
  - 7-days after symptom onset 40.1% (95% CI: 22.8–60.4)
  - 10-days after symptom onset 6.0% (95% CI: 0.9–31.2)
  - 14-days after symptom onset 0.03% (95% CI: 0.0–9.4)

Cevik M, et al. Lancet Microbe. 2021;2(1):e13-22.
Walsh KA, et al. J Infect. 2020;86(6):847-56
Jefferson T, et al. Clin Microbiol Infect. 2021. PMID:34757116.

Delta has significantly higher peak virus loads

- Median Ct: 20.6 vs 34.0; p < 0.001





Wang Y, et al. EClinicalMedicine 2021; 40;101129.
Kang M, et al. medRxiv 2021; 21261991 [Preprint].
Bolze A, et al. medRxiv 2021; 21259195 [Preprint].
Williams GH, et al. EClinicalMedicine 2021; Jul 14 [Epub ahead of print].

Following onset of symptoms, there is a rapid decline in SARS-CoV-2 RNA measured in the upper respiratory tract

- Viral replication peaked at day 4
  - Infectivity **beyond 8 days** was not demonstrated (Wolfel R, et al.)

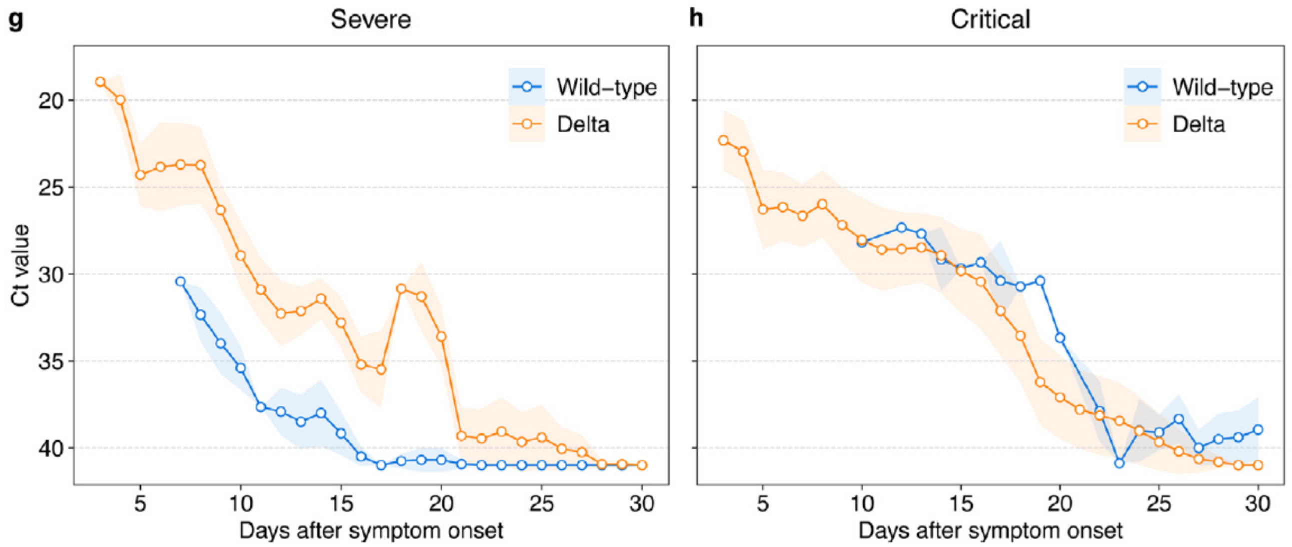
- Replication-competent virus only if **<8 days after symptom onset or CT<24 (**Bullard J, et al.)

- 852 high-risk contacts of 100 cases, **no secondary cases if exposed ≥ 6 days** from symptom onset (Cheng HW et al.)

Bullard J, et al. Clin Infect Dis 2020 May 22.
Cheng HW, et al. *JAMA Intern Med* 2020 May 1.
Wölfel R, et al. *Nature* 2020 May;581(7809):465-469.

This might not be generalizable to those with severe disease

- Replication competent virus detected between 10 to 20-days after onset of symptoms
- Probability of detecting infectious virus <5% after 15.2-days



van Kampen J, et al. (Pre-print) Medrxiv. 2020
Wang Y, et al. EClinicalMedicine 2021; 40;101129.
Longtin Y, et al. Pre-published data, 2021.
Ladhani SN, et al. EclinicalMedicine. 2020; 26:100533.

This might not be generalizable to the elderly

- Average or median age ranges from 33 to 57-years in most studies
- UK nursing home, virus detected up to 13-days after symptom onset
- Montreal patients ≥79 years of age, 10/22 samples (45%) at 10-days after symptom onset

van Kampen J, et al. (Pre-print) Medrxiv. 2020
Wang Y, et al. EClinicalMedicine 2021; 40;101129.
Longtin Y, et al. Pre-published data, 2021.
Ladhani SN, et al. EclinicalMedicine. 2020; 26:100533.

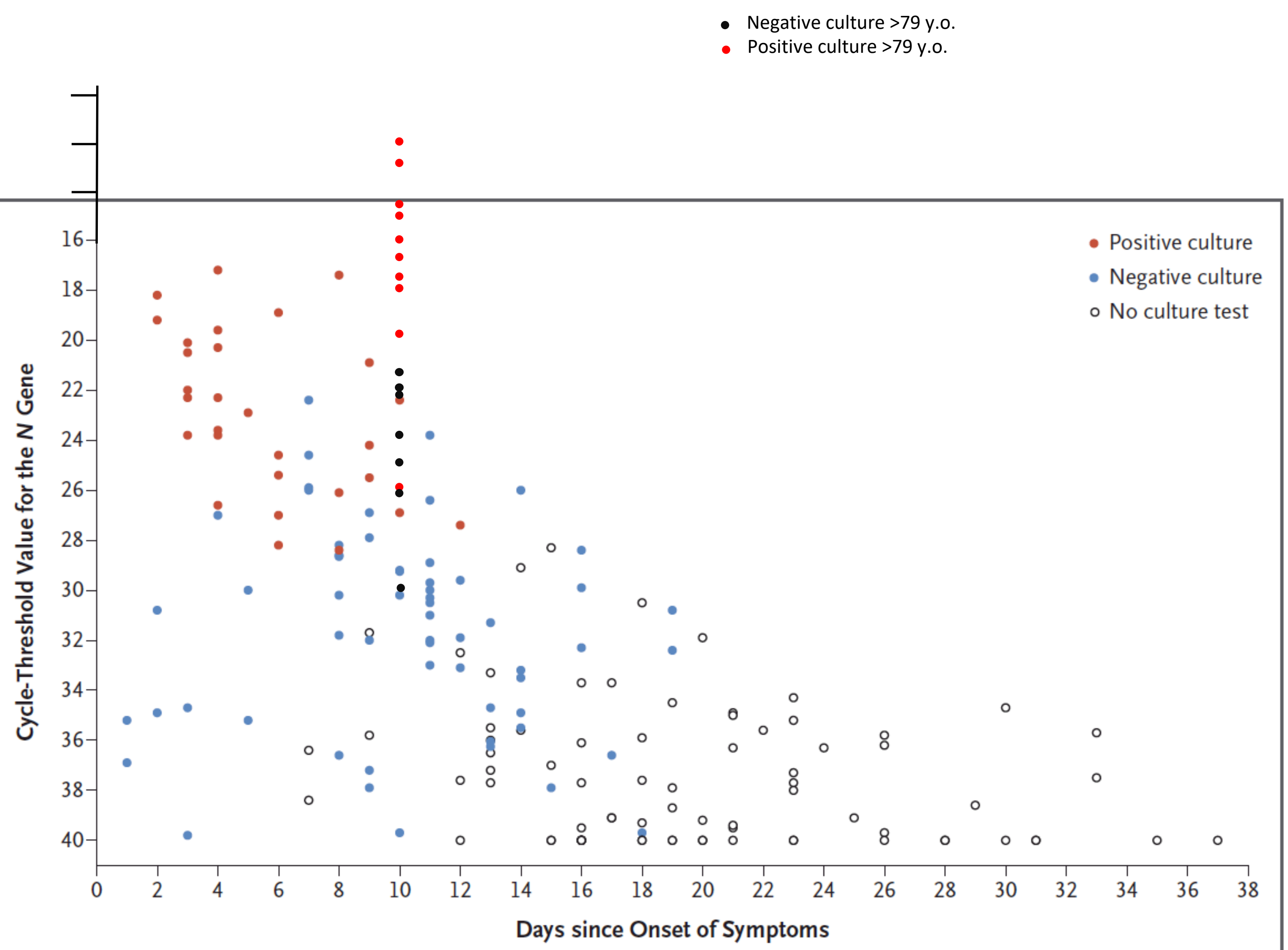


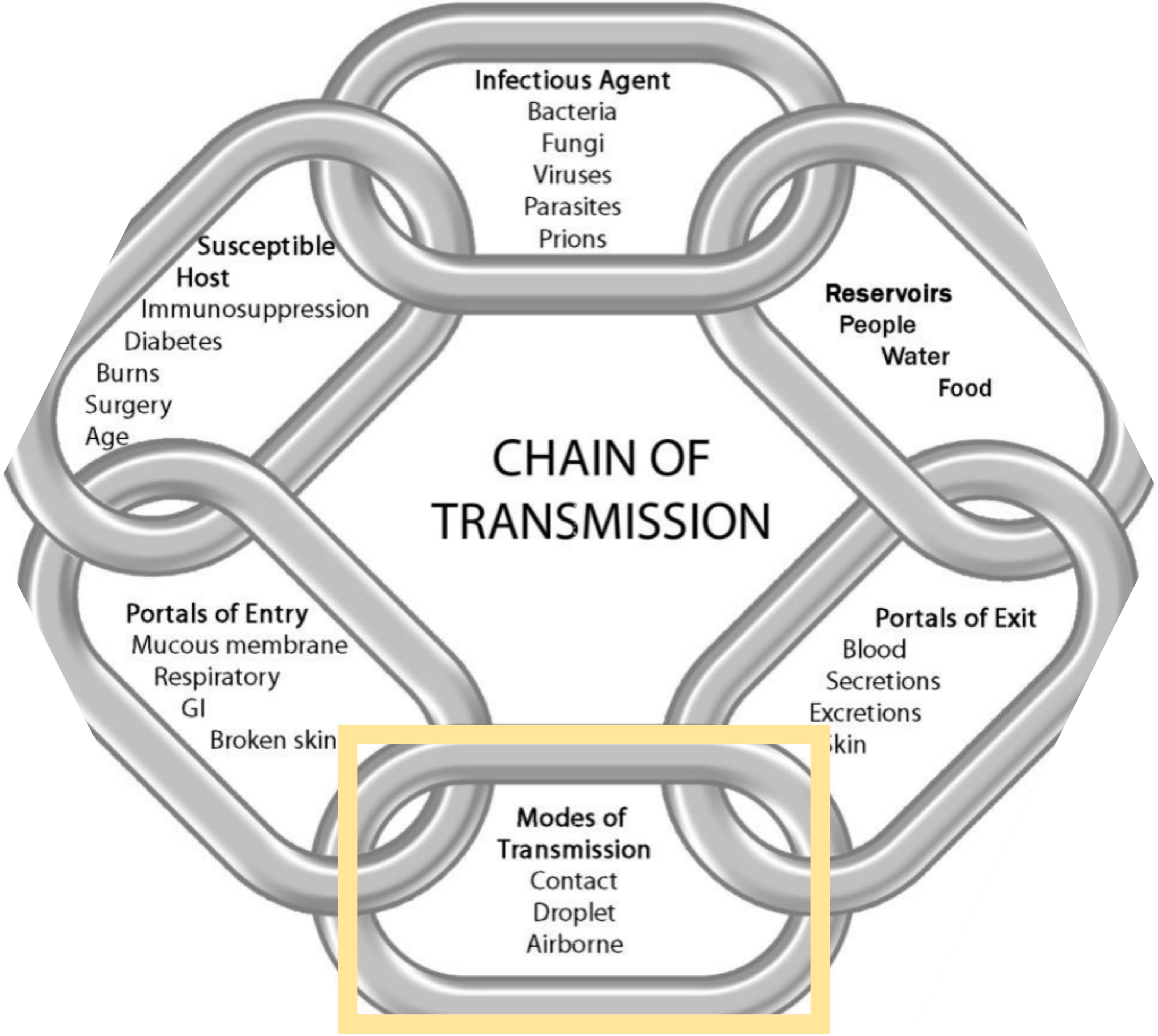
Figure 1. Timing of Presence or Absence of Viable SARS-CoV-2 on Viral Culture and Cycle-Threshold Values for 165 Serial Samples Obtained from 21 Consecutive Patients Hospitalized with Covid-19.

Viral loads were determined with the cycle-threshold value for the *N* gene of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[4] Sampling intervals ranged from 1 to 5 days (median, 2). Each circle represents a sample obtained on the specified day. Viral culture was positive only in samples with a cycle-threshold value of 28.4 or less and in those that were obtained as long as 12 days after symptom onset. Covid-19 denotes coronavirus disease 2019.

Chung JW. N Engl J Med. 2021 Feb 18;384(7):671-673.

TRANSMISSION

- Transmission <u>only</u> if all six links in chain present



Routine Practices and Additional Precautions in All Health Care Settings. 3rd edition. Toronto, ON: Queen's Printer for Ontario; November 2012.

Transmission based precautions have evolved

- CDC 1970 – seven categories of isolation
- CDC 1983 – expanded to include:
    - Tuberculosis (Acid-Fast Bacilli) isolation
    - Drainage/secretion precautions
    - Blood and bodily fluids precautions
- HIV pandemic
    - CDC 1985 – ‘*universal precautions*’ strategy
    - Jackson et al. 1987 – *’body substance isolation*’
        - All body fluids/tissues and feces

Table 1. Categories of isolation

Precautions	Disease
Strict isolation	Anthrax
Respiratory isolation	Tuberculosis
Enteric	Salmonella
Wound and skin	Scabies
Discharge	Infected abscess
Blood	Hepatitis B
Protective	Neutropenic patients

Adapted from CDC (1970)

Gammon J. Br J Nursing. 1998; 7(6):307-10.

TABLE 1
SYNOPSIS OF TYPES OF PRECAUTIONS AND PATIENTS REQUIRING THE PRECAUTIONS*

Standard Precautions

Use Standard Precautions for the care of all patients

Airborne Precautions

In addition to Standard Precautions, use Airborne Precautions for patients known or suspected to have serious illnesses transmitted by airborne droplet nuclei. Examples of such illnesses include:

- Measles
- Varicella (including disseminated zoster)†
- Tuberculosis*

Droplet Precautions

In addition to Standard Precautions, use Droplet Precautions for patients known or suspected to have serious illnesses transmitted by large particle droplets. Examples of such illnesses include:

- Invasive *Haemophilus influenzae type* b disease, including meningitis, pneumonia, epiglottitis, and sepsis
- Invasive *Neisseria meningitidis* disease, including meningitis, pneumonia, and sepsis
- Other serious bacterial respiratory infections spread by droplet transmission, including:
  - Diphtheria (pharyngeal)
  - Mycoplasma pneumonia
  - Pertussis
  - Pneumonic plague
  - Streptococcal pharyngitis, pneumonia, or scarlet fever in infants and young children
- Serious viral infections spread by droplet transmission, including:
  - Adenovirus†
  - Influenza
  - Mumps
  - Parvovirus B19
  - Rubella

Contact Precautions

In addition to Standard Precautions, use Contact Precautions for patients known or suspected to have serious illnesses easily transmitted by direct patient contact or by contact with items in the patient's environment. Examples of such illnesses include:

- Gastrointestinal, respiratory, skin, or wound infections or colonization with multidrug-resistant bacteria judged by the infection control program, based on current state, regional, or national recommendations, to be of special clinical and epidemiologic significance
- Enteric infections with a low infectious dose or prolonged environmental survival, including:
  - *Clostridium difficile*
  - For diapered or incontinent patients: enterohemorrhagic *Escherichia coli* O157:H7, *Shigella,* hepatitis A, or rotavirus
- Respiratory syncytial virus, parainfluenza virus, or enteroviral infections in infants and young children
- Skin infections that are highly contagious or that may occur on dry skin, including:
  - Diphtheria (cutaneous)
  - Herpes simplex virus (neonatal or mucocutaneous)
  - Impetigo
  - Major (noncontained) abscesses, cellulitis, or decubiti
  - Pediculosis
  - Scabies
  - Staphylococcal furunculosis in infants and young children
  - Zoster (disseminated or in the immunocompromised host)+
- Viral/hemorrhagic conjunctivitis
- Viral hemorrhagic infections (Ebola, Lassa, or Marburg) *

Because gaps existed in the knowledge of the epidemiologic patterns of some diseases, disagreement was expected, and occurred, regarding the placement of individual diseases within given categories, especially diseases with a respiratory component of transmission.[14] Placing measles in Respiratory Isolation (designed to prevent transmission of large-particle droplets) rather than in a category that had provisions for preventing transmission by airborne droplet nuclei and placing rubella and respiratory syncytial virus (RSV) infection in Contact Isolation were controversial.[15] There was also disagreement about the lack

Garner JS. Infect Control Hosp Epidemiol. 1996 Jan; 17(1):53-80.

Respiratory Droplets + Direct Contact

- Dichotomy of droplet vs. airborne
- Relative role of droplet size in short-range transmission
- Close and prolonged contact with <u>symptomatic</u> and <u>asymptomatic</u> individuals

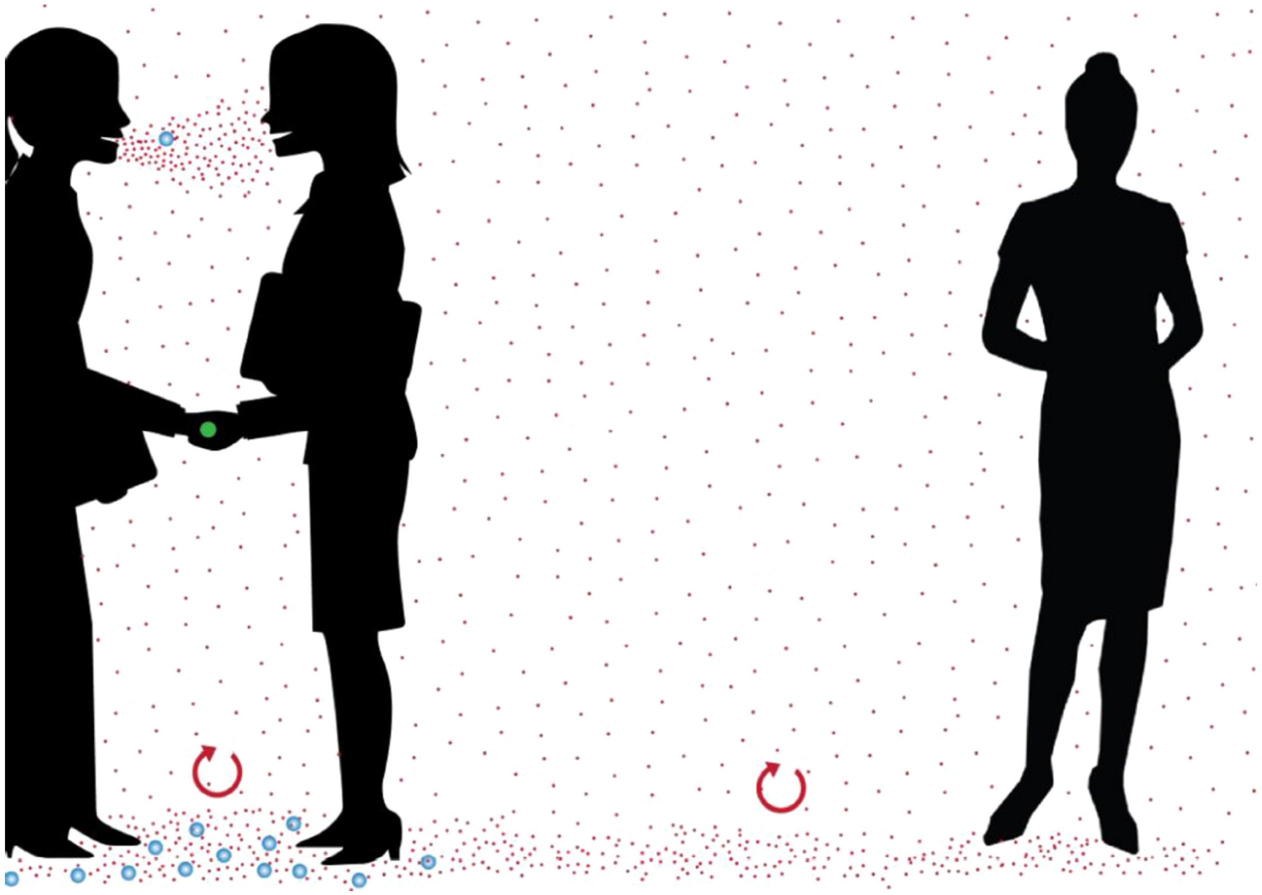


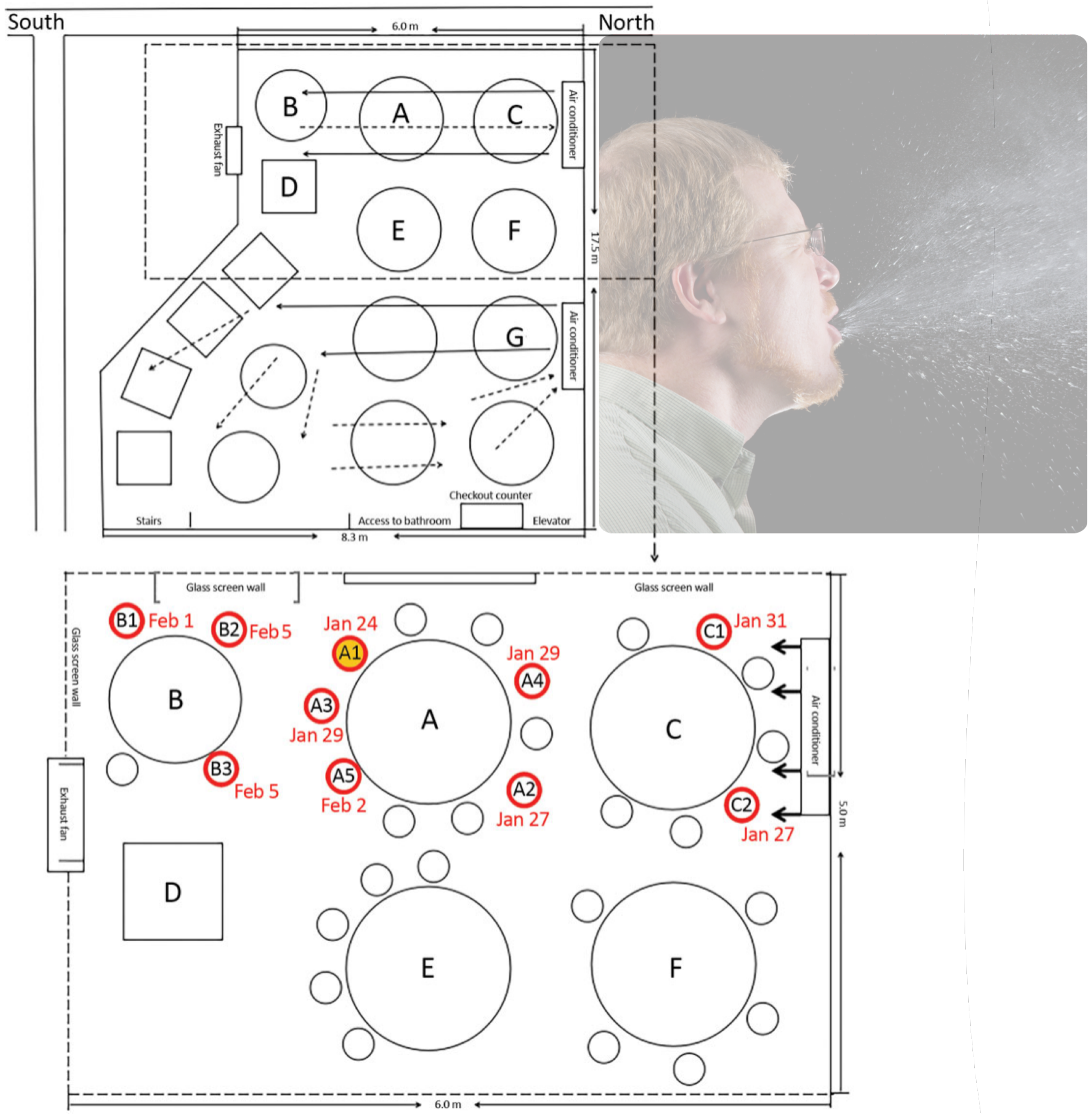
Image from: Tang JW, et al. J Hosp Infect. 2021; 110: 89-96.

Volume 26, Number 7—July 2020

Research Letter

COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020

Figure



Indoor, poor ventilation, close-proximity

- Households
- Family gatherings
- Schools
- Workplaces
  - Meat-processing plants
- Restaurants

Burke RM, et al. Morb Mortal Wkly Rep. 2020;69(9):245-6.
Chan JFW, et al. Lancet. 2020;395(10223):514-23.
Pung R, et al. Lancet. 2020;395(10229):1039-46.
Cheng HY, et al. JAMA Intern Med 2020.
Danis K, et al. Clin Infect Dis, ciaa424.
Ghinai I, et al. Morb Mortal Wkly Rep 2020;69:446–450.

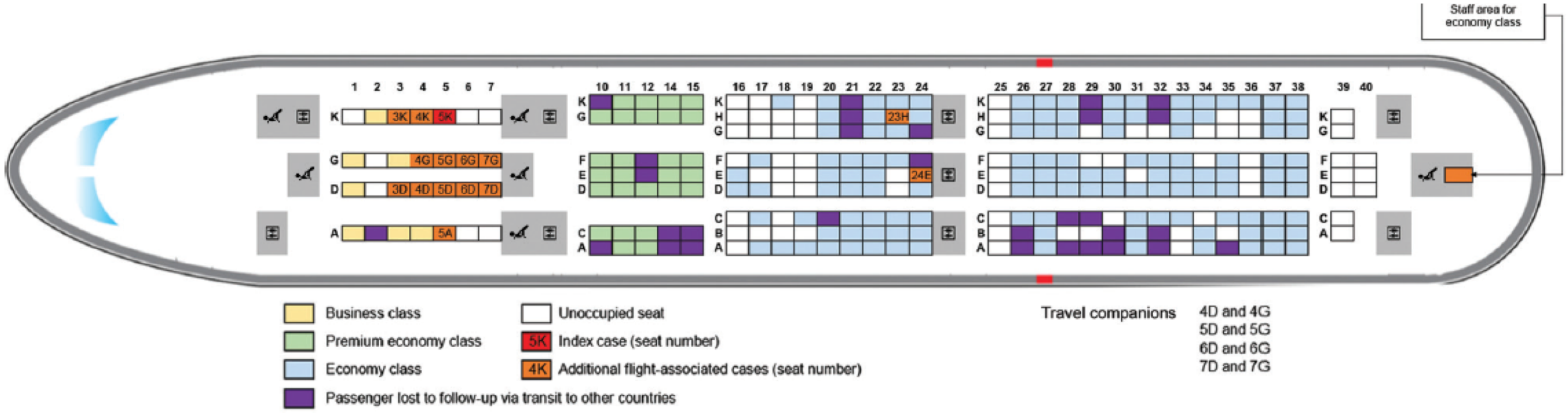
Aircraft transmission demonstrates the importance of proximity

- Attack rate for those < 2 seats away: 3.8% vs. 0.2%

Table 2. Risk for SARS-CoV-2 infection by seating location among business class passengers on Vietnam Airlines flight 54 from London, UK, to Hanoi, Vietnam, March 2, 2020*

Seating location in relation to index case	Positive for SARS-CoV-2 by PCR, no. (%)†	Negative for SARS-CoV-2 by PCR, no. (%)	Relative risk	Risk ratio (95% CI)
≤2 seats away	11 (92)	1 (13)	0.9	7.3 (1.2–46.2)
>2 seats away	1 (8)	7 (88)	0.1	

*SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
†Excluding the index case.



Khanh NC, et al. Emerg Infect Dis. 2020; 26(11): 2617-24.
Blomquist PB, et al. Influenza Other Respir Viruses. 2021;15(3):336-44.

Secondary attack rate is higher with frequent daily close contact

	Setting	Secondary attack rate	
Thompson et al. (2021)	Household Social setting close contact Travel Health care Casual contact Workplace	21.1% (95% CI: 17.4–24.8) 5.9% (95% CI: 0.3–9.8) 5.0% (95% CI: 0.3–9.8) 3.6% (95% CI: 1.0–6.9) 1.2% (95% CI: 0.3–2.1) 1.9% (95% CI: 0.0–3.9)	
Ng et al. (2021)	Household	25.8% (95% CI: 20.6-31.5)	Delta
Lei et al. (2020)	Household	27% (95% CI: 21−32)	
Madewell et al. (2020)	Household	16.6% (95% CI: 14.0–19.3)	
Koh et al. (2020)	Household Health care	18.1% (95% CI: 15.7–20.6) 0.7% (95% CI: 0.4–1.0)	

- Settings with casual contact **0% to 7%**
- Within household **17% to 27%**

Thompson HA, et al. Clin Infect Dis. 2021 Feb 09.
Ng OT, et al. Lancet Reg Health West Pac. 2021 Dec; 17:100299.
Lei H, et al. J Infect. 2020;81(6):979-97.
Madewell ZJ, et al. JAMA Netw Open. 2020;3(12):e2031756.
Koh WC, et al. PLoS One. 2020;15(10):e0240205.

Clusters of Coronavirus Disease in Communities, Japan, January–April 2020

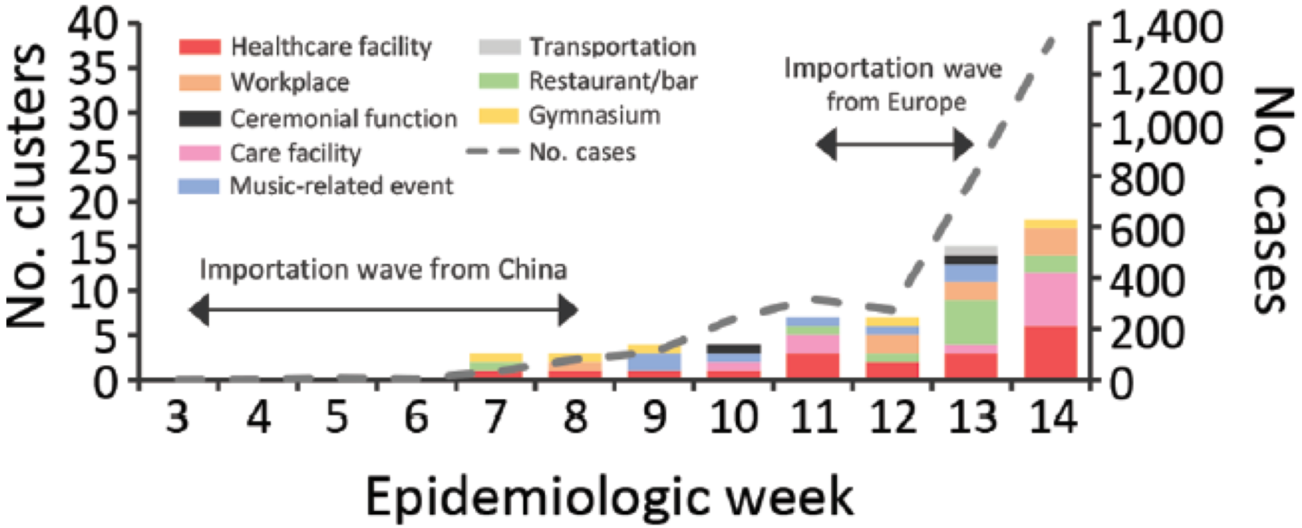
Yuki Furuse,[1] Eiichiro Sando,[1] Naho Tsuchiya,[1] Reiko Miyahara,[1] Ikkoh Yasuda,[1] Yura K. Ko,[1]
Mayuko Saito, Konosuke Morimoto, Takeaki Imamura, Yugo Shobugawa, Shohei Nagata, Kazuaki Jindai,
Tadatsugu Imamura, Tomimasa Sunagawa, Motoi Suzuki, Hiroshi Nishiura, Hitoshi Oshitani

Clusters associated with:

- Heavy breathing in close proximity (singing at karaoke parties, cheering in clubs, close conversations in bars, exercising in gyms)

THREE C'S:
Closed spaces with poor ventilation
Crowded places
Close-contact settings

Healthcare and care facilities located at the end of local transmission chains -> several weeks after persistent community transmission



Community and Close Contact Exposures Associated with COVID-19 Among Symptomatic Adults ≥18 Years in 11 Outpatient Health Care Facilities — United States, July 2020

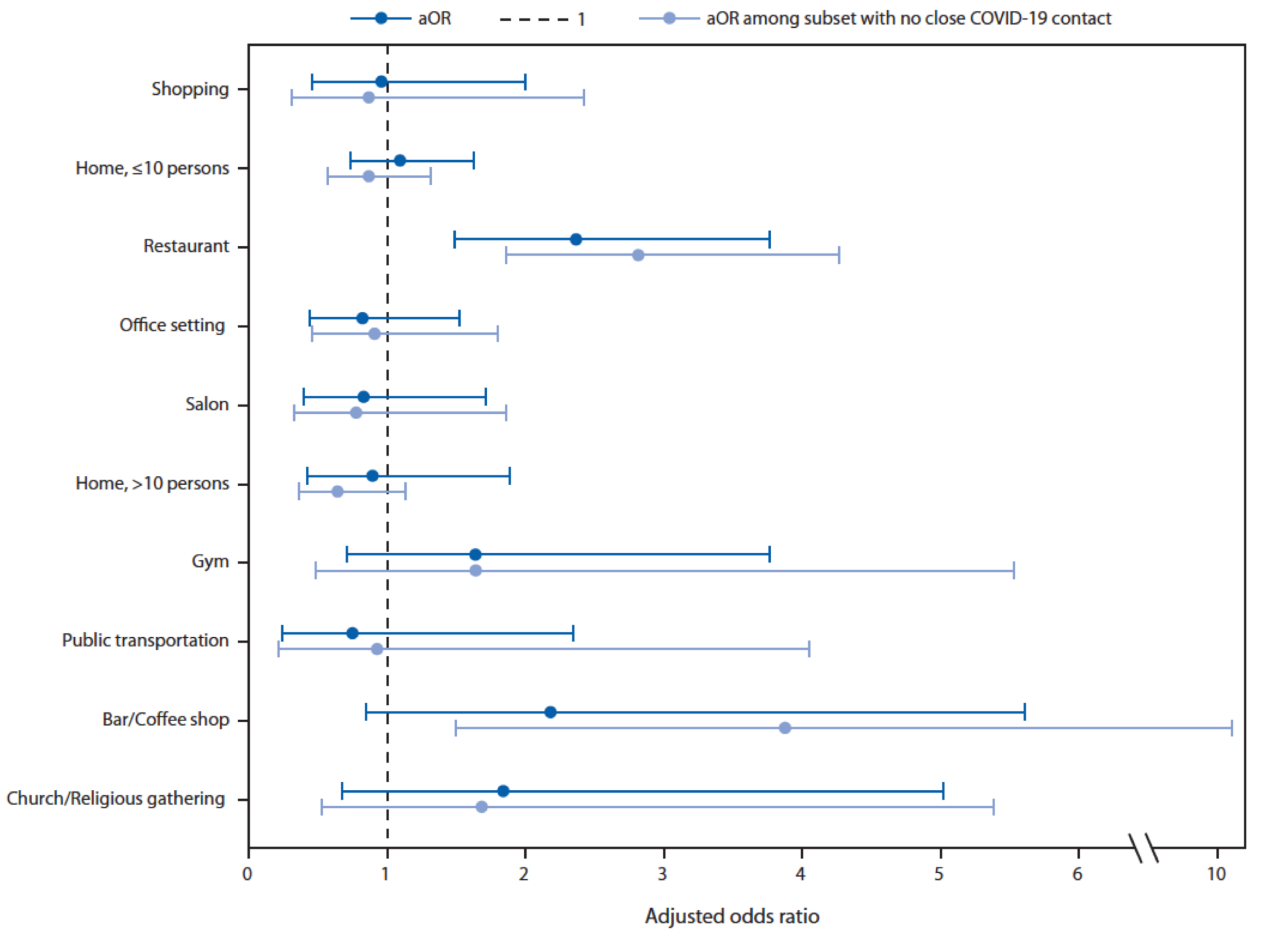
Kiva A. Fisher, PhD[1]; Mark W. Tenforde, MD, PhD[1,2]; Leora R. Feldstein, PhD[1]; Christopher J. Lindsell, PhD[3,4]; Nathan I. Shapiro, MD[3,5]; D. Clark Files, MD[3,6]; Kevin W. Gibbs, MD[3,6]; Heidi L. Erickson, MD[3,7]; Matthew E. Prekker, MD[3,7]; Jay S. Steingrub, MD[3,8]; Matthew C. Exline, MD[3,9]; Daniel J. Henning, MD[3,10]; Jennifer G. Wilson, MD[3,11]; Samuel M. Brown, MD[3,12]; Ithan D. Peltan, MD[3,12]; Todd W. Rice, MD[3,4]; David N. Hager, MD, PhD[3,13]; Adit A. Ginde, MD[3,14]; H. Keipp Talbot, MD[3,4]; Jonathan D. Casey, MD[3,4]; Carlos G. Grijalva, MD[3,4]; Brendan Flannery, PhD[1]; Manish M. Patel, MD[1]; Wesley H. Self, MD[3,4];
IVY Network Investigators; CDC COVID-19 Response Team

COVID-19 + more likely to have gone to locations with <u>on-site eating and drinking options</u>

…where masks cannot be effectively worn

42% reported close contact with a person with COVID-19

FIGURE. Adjusted odds ratio (aOR)* and 95% confidence intervals for community exposures† associated with confirmed COVID-19 among symptomatic adults aged ≥18 years (N = 314) — United States, July 1–29, 2020



Indoor settings are a predominant risk factor for transmission

Table 1. Comparison of Respiratory Virus Transmission Outdoors Compared to Indoors Ordered by Virus Studied

Outcome	Virus Studied	Estimate of Effect: Outdoor	Estimate of Effect: Indoor	Relative Estimate of Effect	Number of Participants in the Study
Number of cases [14]	SARS-CoV-2	2/7324 cases	7322/7324 cases	<1% of transmissions happened outdoors	7324 cases, totaling 318 outbreaks
Number of cases [15]	SARS-CoV-2	4/103 cases	99/103 cases	5% of work-related cases occurred outdoors	103 possible work-related cases among a total of 690 local transmissions
Odds of transmission [16]	SARS-CoV-2	Raw data not available	Raw data not available	Odds of transmission in closed environments 18.7 (95% CI, 6.0–57.9) times greater than in open air	110 cases: 27 primary cases and 83 secondary cases
Number of super-spreading events and odds of transmission[a] [16]	SARS-CoV-2	1/7 super-spreading events	6/7 super-spreading events	Odds ratio of super-spreading in closed environments: 32.6 (95% CI, 3.7–289.5)	110 cases: 27 primary cases and 83 secondary cases
Number of cases [17]	SARS-CoV-2	95/10 926 cases	10 831/10 926 cases	<1% of transmissions happened outdoors	10 926 cases, totaling 201 events of transmission

Bulfone TC, et al. J Infect Dis. 2021;223(4):550-62.

- Majority of clusters (90%) are indoor settings

RESEARCH ARTICLE

REVISED **What settings have been linked to SARS-CoV-2 transmission clusters?** [version 2; peer review: 2 approved]

Quentin J. Leclerc [1,2], Naomi M. Fuller [1,2], Lisa E. Knight[3],
CMMID COVID-19 Working Group, Sebastian Funk [1,2], Gwenan M. Knight [1,2]

Setting type	Number of reported events	Secondary cases Min	Secondary cases Median	Secondary cases Max	Total cluster size Min	Total cluster size Median	Total cluster size Max	Total number of cases across all clusters	Countries	Indoor / outdoor
Bar	12	2	9	16	3	13	80	319	Germany, Austria, Italy, Singapore, Japan, USA, Australia, New Zealand, Brazil	Indoor / outdoor
Building site	4	/	/	/	5	20.5	49	95	Singapore	Outdoor
Conference	5	/	/	/	3	10	89	148	Canada, Singapore, Japan, USA, New Zealand	Indoor / outdoor
Elderly care	17	/	/	/	5	19	167	638	UK, Canada, Scotland, France, Germany, Italy, USA, Japan, New Zealand, Luxembourg	Indoor
Food processing plant	9	2	2	2	3	84	518	1207	USA, Germany, Canada, Netherlands	Indoor
Funeral	1	3	3	3	4	4	4	4	USA	Indoor / outdoor
Hospital	9	1	3	14	2	10	118	224	China, Singapore, Italy, Taiwan, South Korea, Japan	Indoor
Hotel	2	/	/	/	3	5	7	10	Singapore	Indoor
Household	36	1	3	11	2	4	12	168	China, Italy, Vietnam, Taiwan, South Korea, Hong Kong, France	Indoor
Meal	17	1	3	10	2	5	47	134	Singapore, USA, Vietnam, China, South Korea, Japan	Indoor
Prison	4	351	351	351	66	226	353	871	USA, Ethiopia	Indoor
Public	4	/	/	/	10	10	27	57	China, Japan	Indoor / outdoor
Religious	15	1	18	52	2	23	130	570	USA, Singapore, South Korea, US, China, India, Netherlands, Germany	Indoor / outdoor
School	8	1	1	131	2	22	133	349	Singapore, France, USA, New Zealand, Australia, Sweden	Indoor / outdoor
Ship	5	619	619	619	78	662	1156	3597	Grand Princess, Diamond Princess, Ruby Princess, USS Theodore Roosevelt, Charles de Gaulle aircraft carrier	Indoor
Shipyard	1	/	/	/	22	22	22	22	Singapore	Indoor / outdoor
Shopping	9	5	10	19	7	20	163	361	China, Singapore, Peru, Mexico	Indoor / outdoor
Sport	6	1	1	1	2	7.5	65	95	South Korea, Singapore, Italy, Japan	Indoor / outdoor
Transport	1	1	1	1	3	3	3	3	China	Indoor
Wedding	3	/	/	/	13	43	98	154	Australia, New Zealand	Indoor / outdoor
Work	12	6	7	11	4	8.5	97	198	China, Singapore, South Korea, Germany	Indoor
Worker dormitories	21	/	/	/	3	24	797	1702	Singapore	Indoor

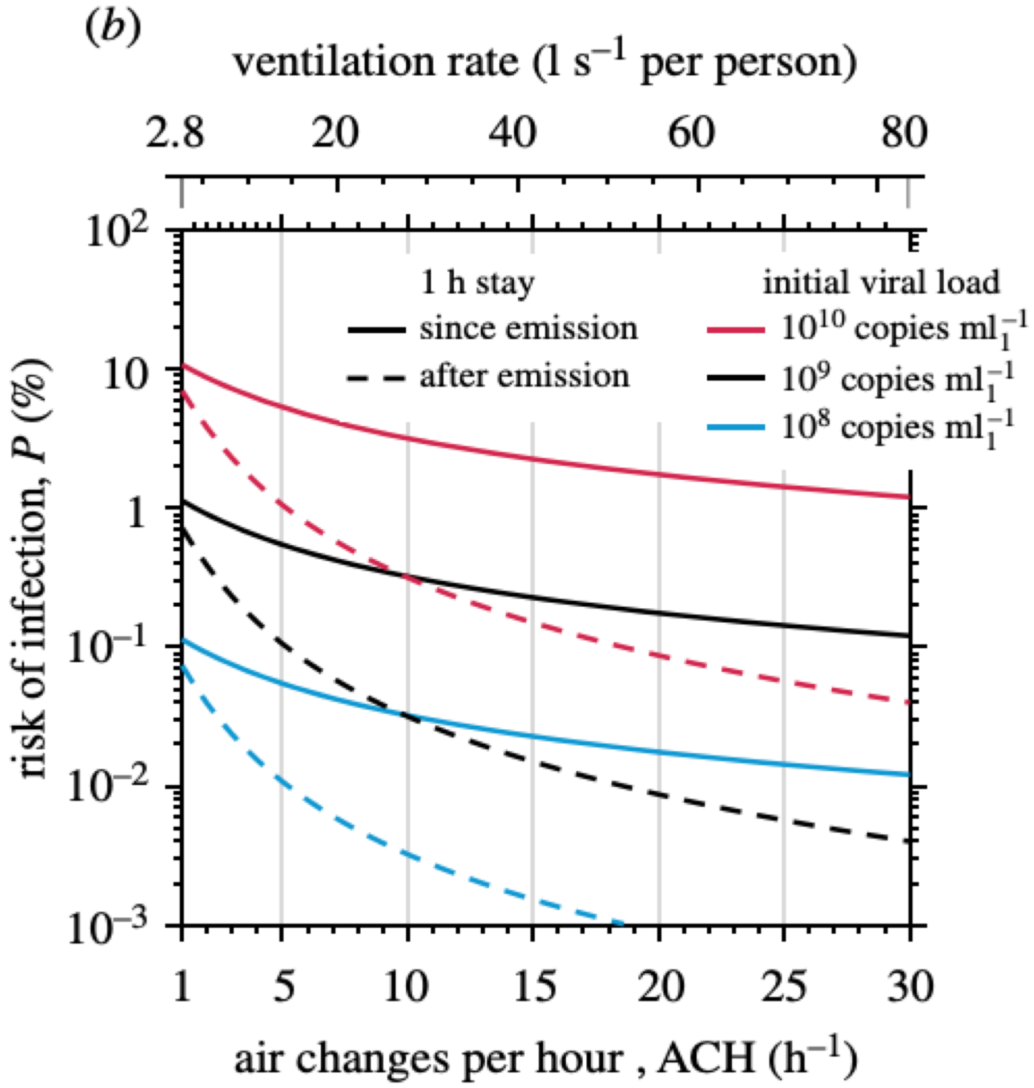
Research paper

Transmission, viral kinetics and clinical characteristics of the emergent SARS-CoV-2 Delta VOC in Guangzhou, China

Yaping Wang[a,1], Ruchong Chen[b,c,1], Fengyu Hu[a,1], Yun Lan[a,1], Zhaowei Yang[b,c,1], Chen Zhan[b,c,1], Jingrong Shi[a], Xizi Deng[a], Mei Jiang[b], Shuxin Zhong[b], Baolin Liao[a], Kai Deng[a], Jingyan Tang[a], Liliangzi Guo[a], Mengling Jiang[a], Qinghong Fan[a], Meiyu Li[a], Jinxin Liu[a], Yaling Shi[a], Xilong Deng[a], Xincai Xiao[d], Min Kang[e], Yan Li[e], Weijie Guan[b], Yimin Li[b], Shiyue Li[b], Feng Li[a,1,*], Nanshan Zhong[b,f,1,**], Xiaoping Tang[a,f,1,**]

Dining = 30.8%
Household = 29.6%
Community = 18.2%

Ventilation can affect short-range transmission

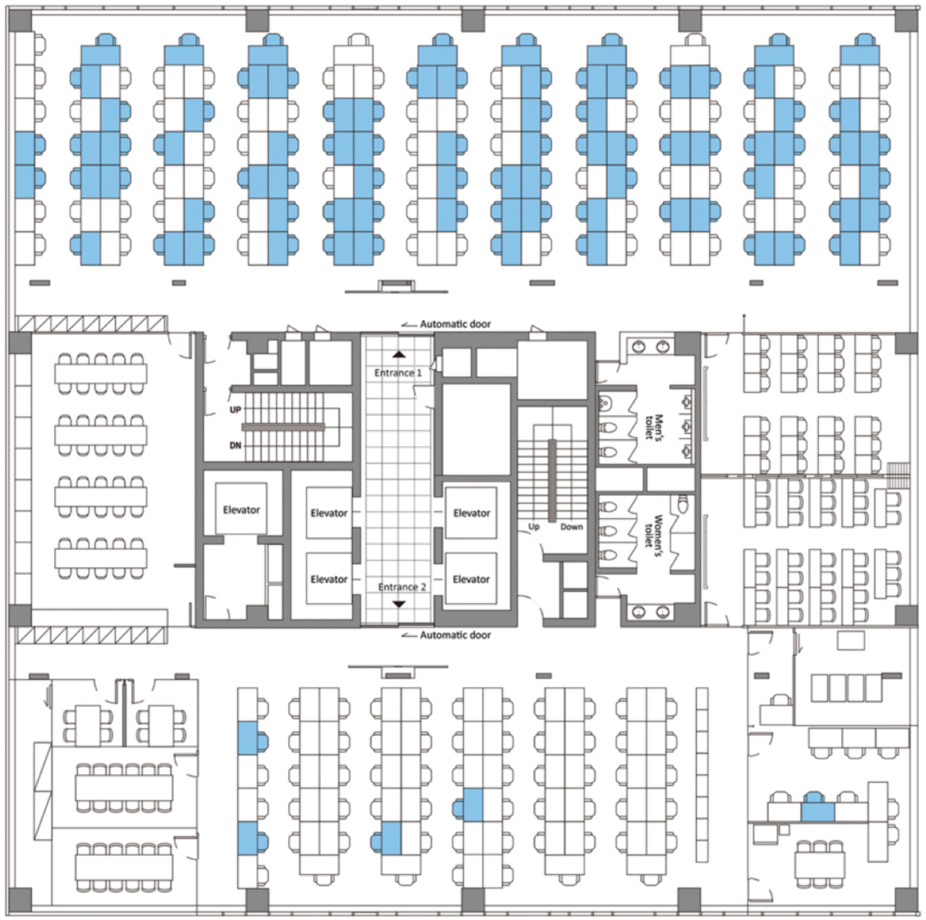


de Oliveira PM, et al. Proc R Soc A. 2021 Jan 20 [Epub ahead of print].

Volume 26, Number 8—August 2020

Synopsis

Coronavirus Disease Outbreak in Call Center, South Korea



97/1143 (8.5%) confirmed cases

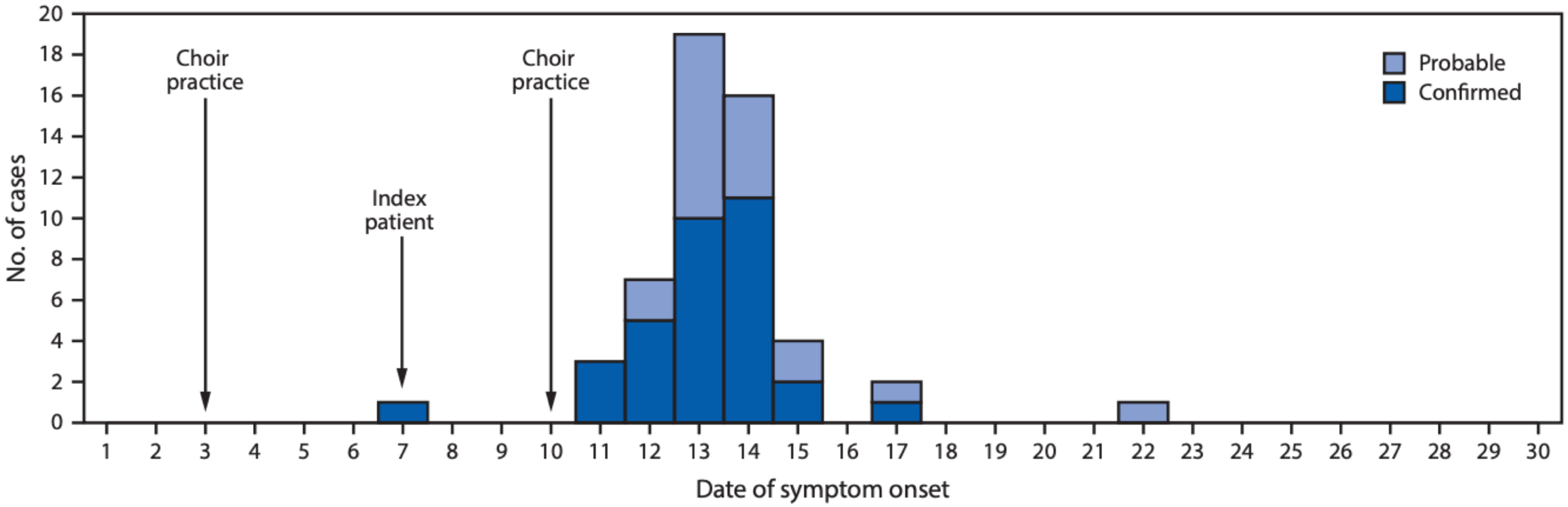
94 were working in an 11th-floor call center with 216 employees, translating to an attack rate of 43.5%

The household secondary attack rate among symptomatic case-patients was 16.2%

Morbidity and Mortality Weekly Report

High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice — Skagit County, Washington, March 2020

FIGURE. Confirmed* and probable† cases of COVID-19 associated with two choir practices, by date of symptom onset (N = 53) — Skagit County, Washington, March 2020



Estimated attack rates of 53.3% amongst confirmed cases

86.7% among all cases

51% (533/1,038) cases linked to one of 137 clusters

Largest cluster accounted for 10.2% of all cases and 32.5% of locally acquired cases

17-19% of SARS-CoV-2 infections were responsible for 80% of all transmission events, **while 69% of cases did not infect anyone**

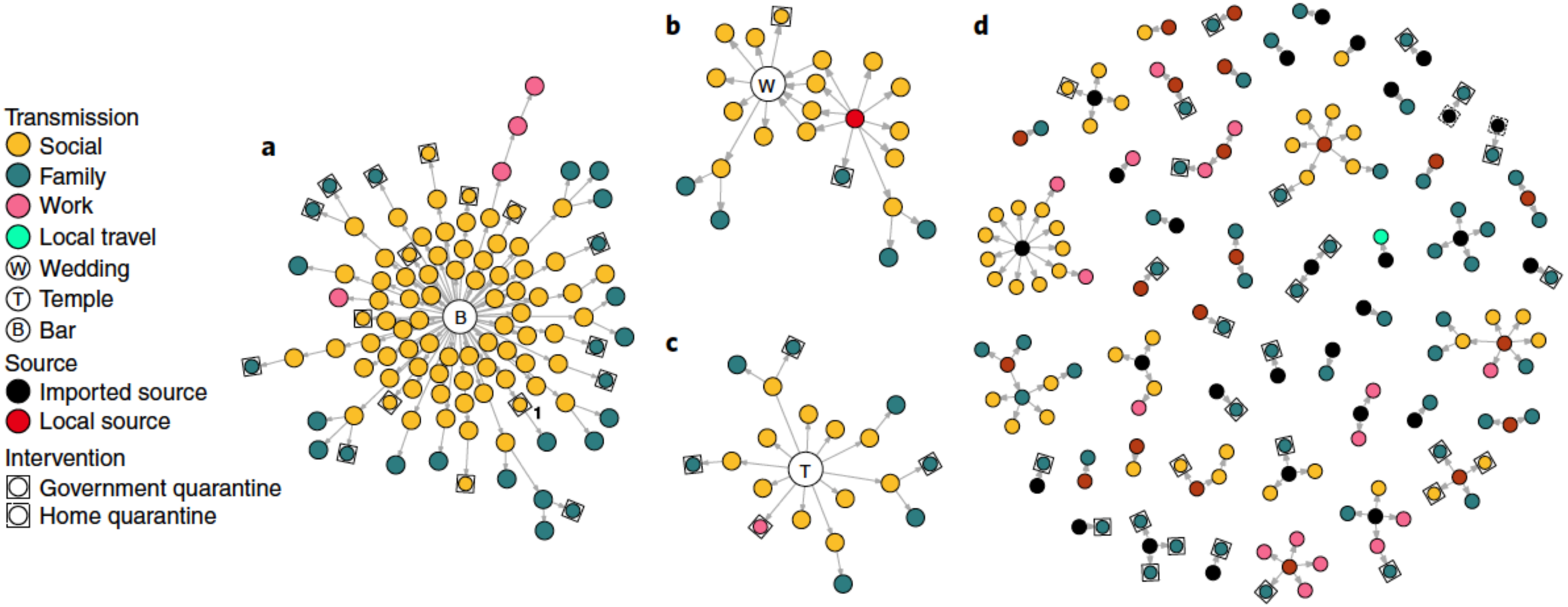
High potential for superspreading -> 19% of cases responsible for 80% of all transmission

Clustering and superspreading potential of SARS-CoV-2 infections in Hong Kong

Dillon C. Adam[1,2], Peng Wu[1]✉, Jessica Y. Wong[1], Eric H. Y. Lau[1], Tim K. Tsang[1], Simon Cauchemez[3], Gabriel M. Leung[1,4] and Benjamin J. Cowling[1,4]

Transmission within:

- Households 54.4%
- Social setting 33.1%
- Work setting 11.8%



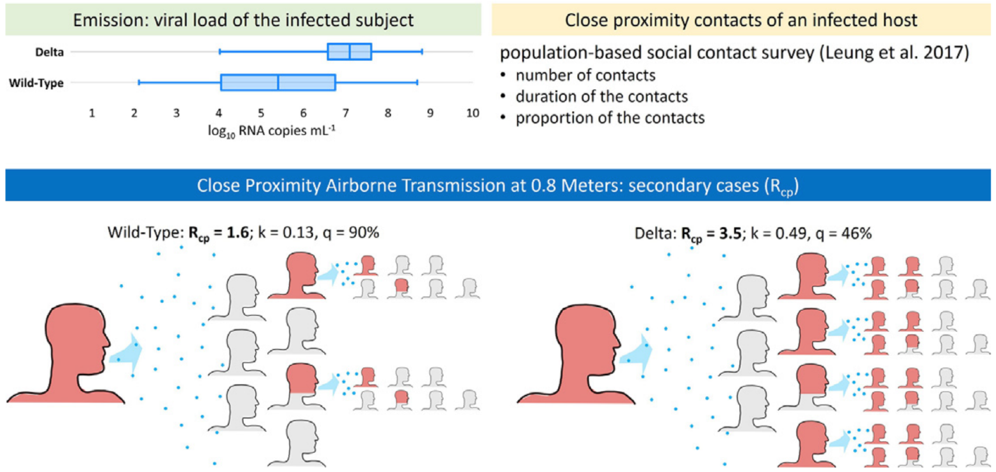
Overdispersion of basic reproductive number (R_0)

- Consensus **between 2 and 3**
- *Diamond Princess* **14.8**

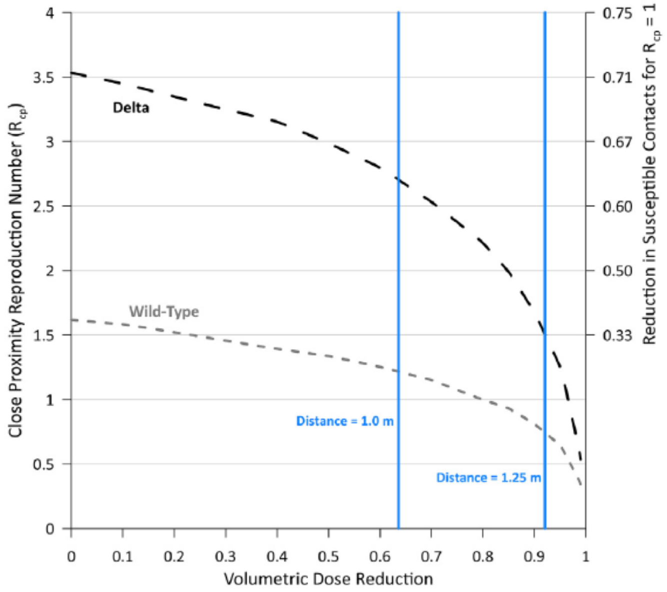
Date	Location	Setting	*Z*
SARS-CoV-2			
Mar., 2020	Washington, US	Choir practice	52
Feb., 2020	Gyeonggi, S. Korea	Social contact	51
Feb., 2020	Chungcheongnam, S. Korea	Social contact	27
Jan., 2020	Ningbo, China	Social contact	25
May 2020	Incheon, S. Korea	Social contact	24
Mar., 2020	Arkansas, US	Religious gathering	17.5*
Feb., 2020	Chongqing, China	Family	13
Feb., 2020	Munich, Germany	Seminar	11
Jan., 2020	Alps, France	Ski resort	11
Feb., 2020	Chicago, US	Family gathering	10

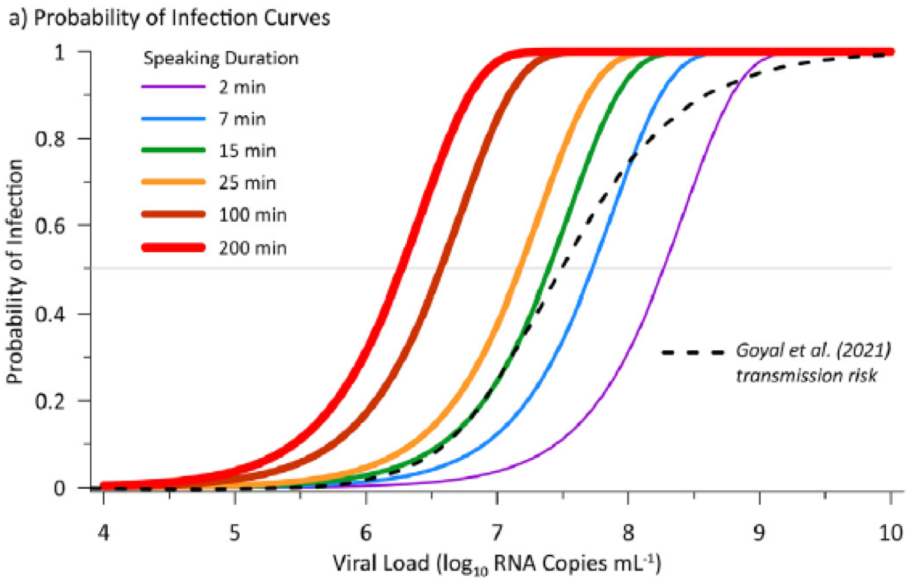
- Is this epidemiological evidence of long-range transmission?

Overdispersion of basic reproductive number (R_0)

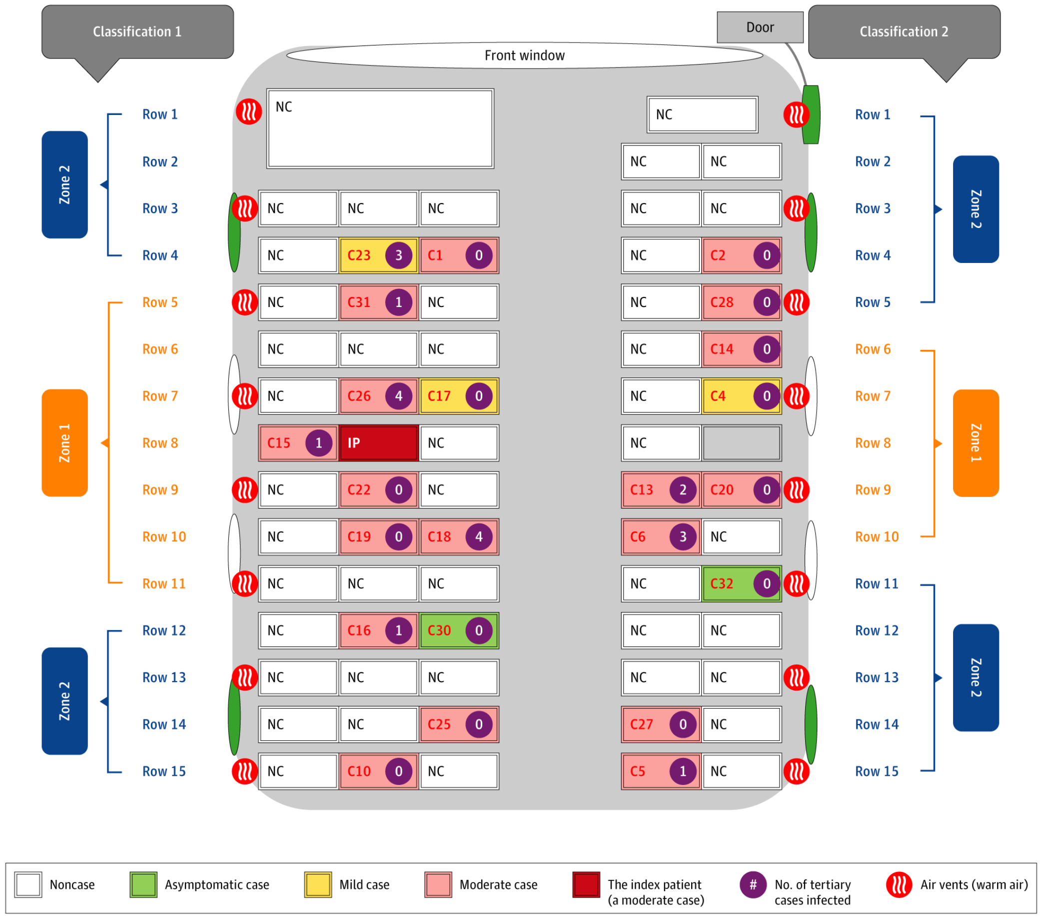


- 64% Delta cases versus 29% wild-type will reproduce infection in close proximity contacts
- Delta less overdispersed
    - SSE of less importance
- In a fully susceptible population - maintaining at least 1.5m of separation drives close proximity reproductive number < 1



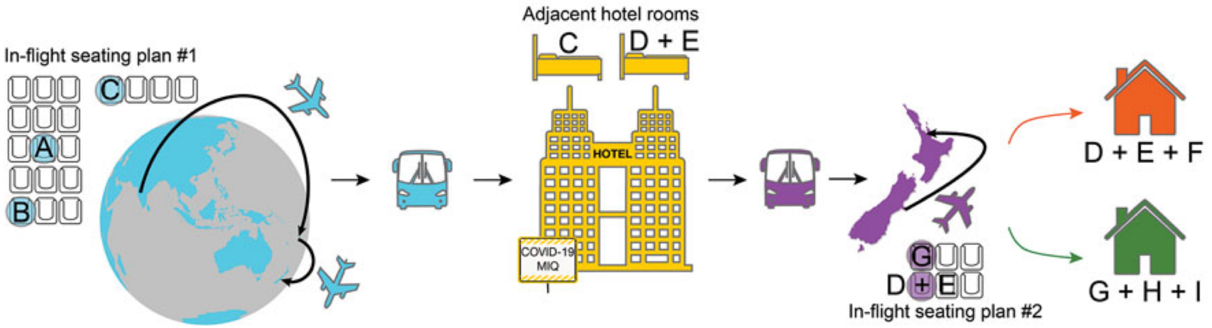


Mikszewski A, et al. Sci Tot Environ. 2021 Nov 6; 151499.



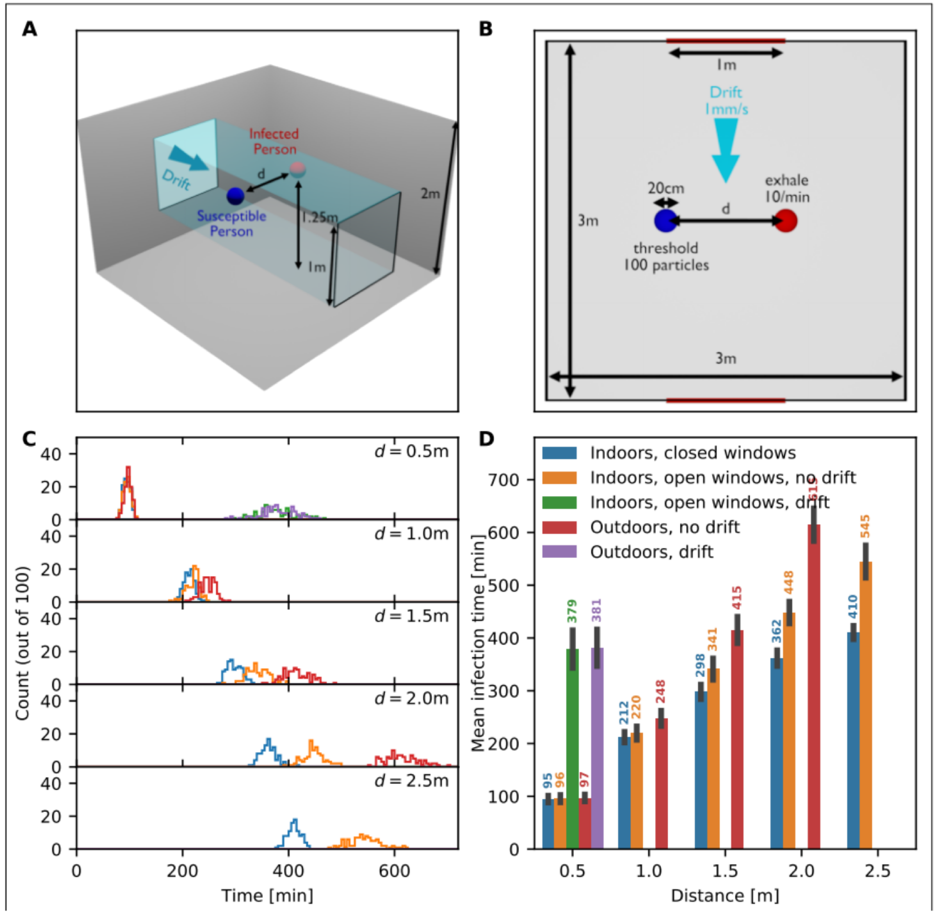
Possible indirect transmission of COVID-19 at a squash court, Slovenia, March 2020: case report

A. Brlek, Š. Vidovič, S. Vuzem, K. Turk and Z. Simonović

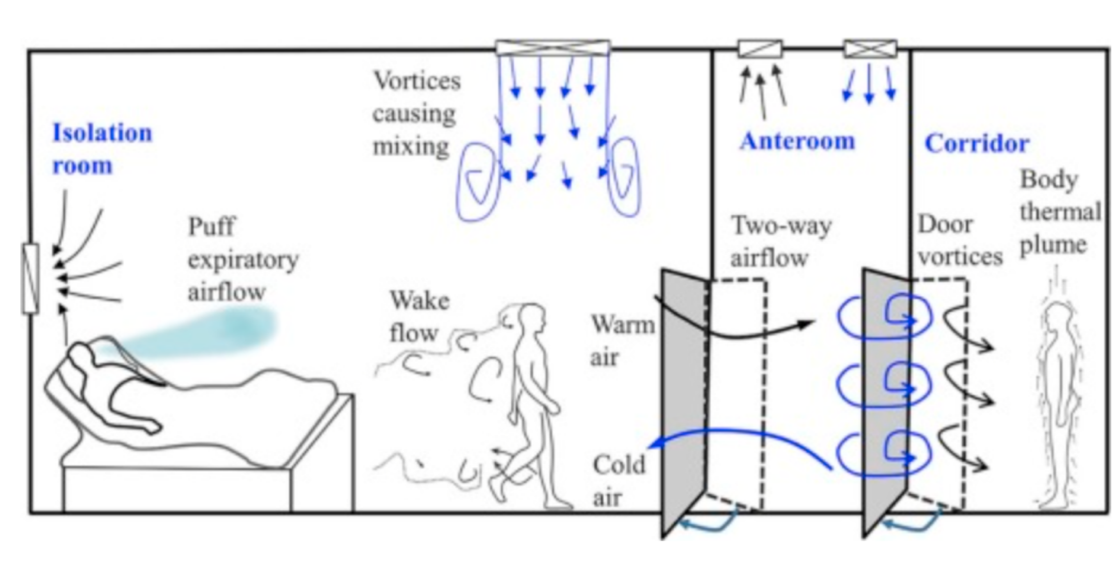


Brlek A, et al. Epidemiol Infect. 2020 Jun 19
Eichler N, et al. Emerg Infect Dis. 2021;27(5):1274-8.
Shen Y, et al. JAMA Intern Med. 2020;180(12):1665-71.

Long-range transmission occurs under favourable conditions



1. Prolonged exposure time
2. Inadequate ventilation
3. Environmental factors (temperature, UV-light)
4. High viral load
5. Specific human behaviours (singing, shouting, exercise)
6. Lack of source control (masking of source)



Wei J, Li Y. Am J Infect Control. 2016;44(9 Suppl):S102-8
Sen N. Phys Fluids. 2021 Mar 12.
Dobramysl U, et. al. medRxiv 21254802 [Preprint]. 2021 Apr 07.

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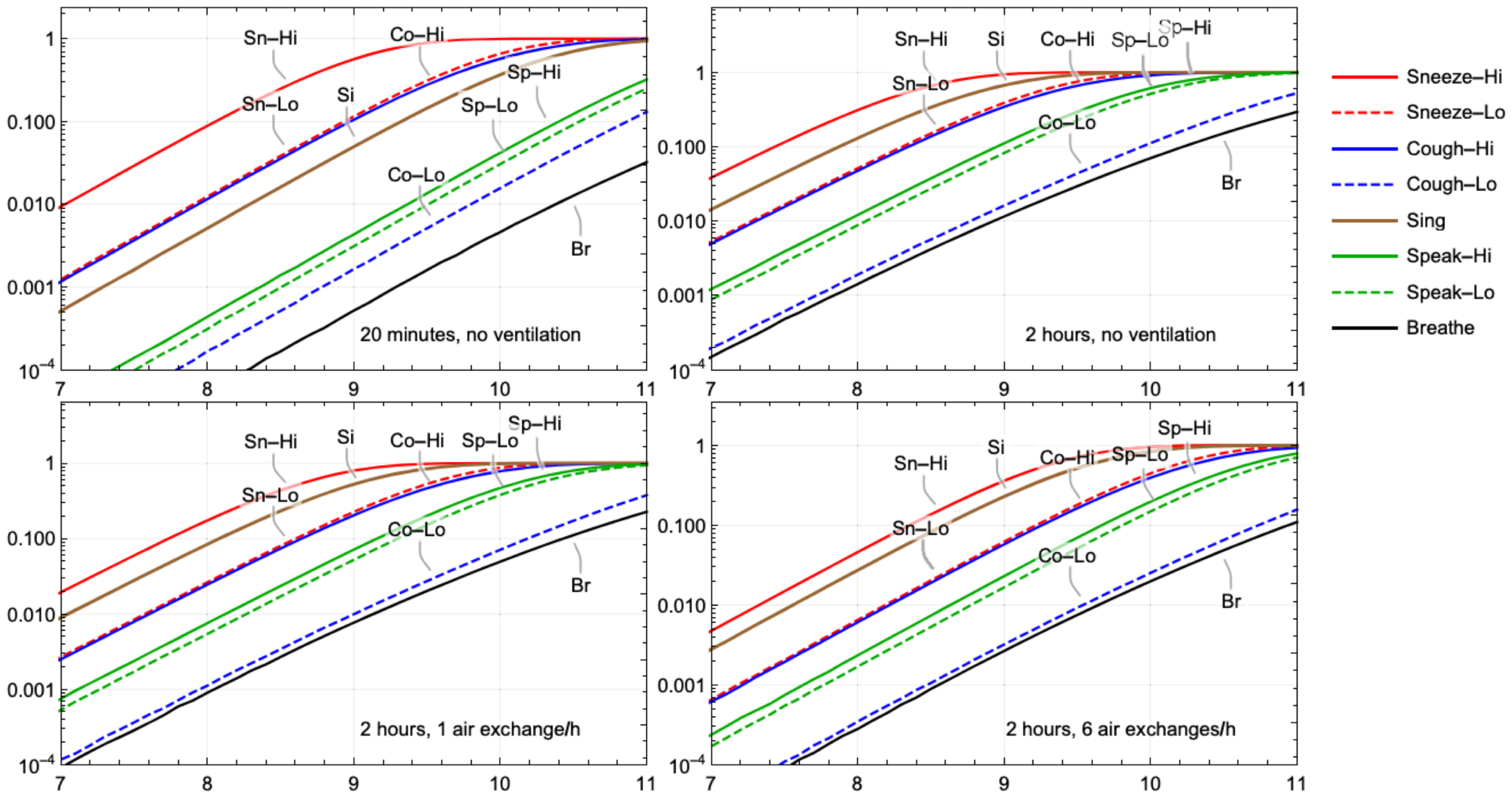
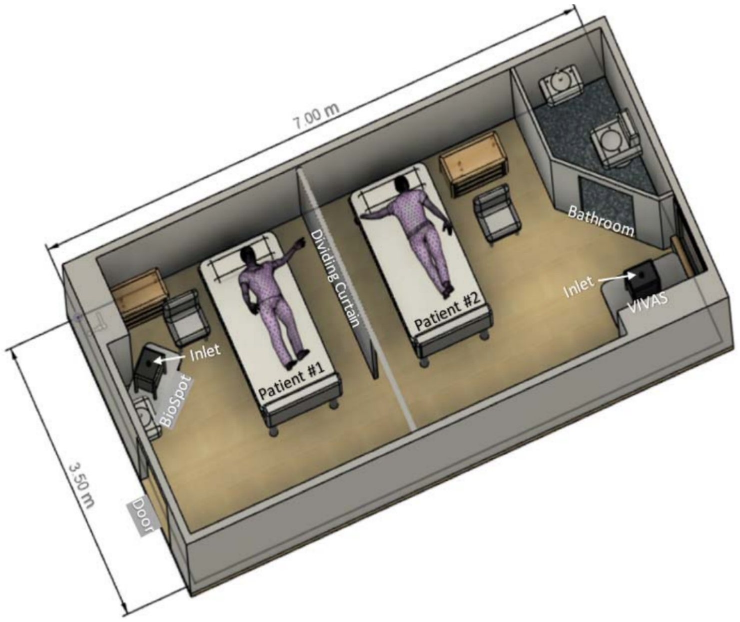


Schijven J, et al. Environ Health Perspect. 2021 Apr 01.

Studies have inconsistently detected virus in air sampling

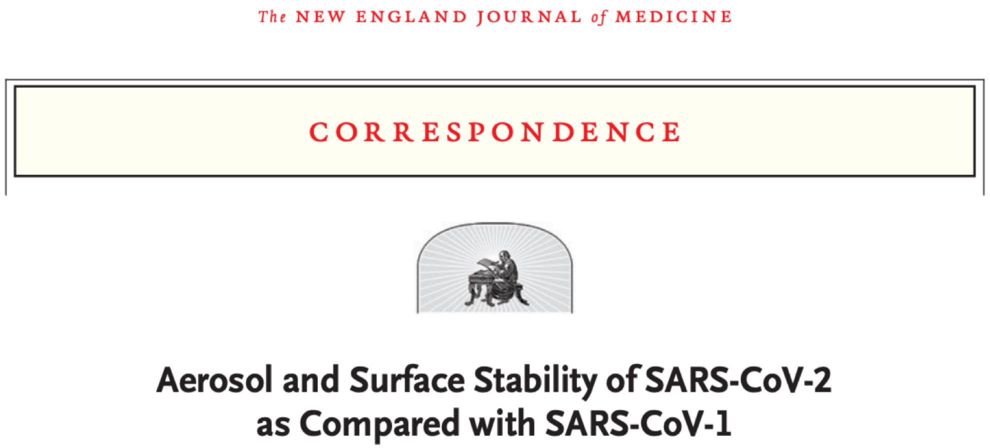
- In some studies, air sampling has failed to detect RNA or viable virus (Cheng et al., Ong et al. and Lebreil et al.)
- Others detected RNA < 2 m from patients, with 1/8 samples positive at 4 m (Guo et al.)
  - RNA detected 35% (14/40) air samples in the ICU and 12.5% (2/16) air samples on the general ward
  - Gregorio et al. importance of exposure time (16h versus 2h) in detection of RNA in air samples; Fawcett S et al. found <1% transmission rate following unprotected AGMP
- One study has detected viable virus at >2 m from patient (Lednicky J, et al.)
  - But in actuality <2 m from a positive patient
  - Concentration step
- Canadian study concluded that air and surfaces may pose a limited risk (Kotwa JD, et al.)
  - RNA detected from 125/474 surface samples and 3/146 air samples
  - 6/42 (14%) surface samples viable virus
- Local air sampling has similarly yielded negative results



Cheng V, et al. Infect Control Hosp Epidemiol. 2020;41(5);493-8.
Guo ZD, et al. Emerg Infect Dis. 2020;26(7):1583-91.
Lebreil AL, et al. J Infect Dis. 2021 Nov 12:jiab564.
Gregorio PHP, et al. JOEM. 2021; 63(11): 956-62)
Ong SW, et al.. JAMA. 2020;323(16):1610-2.
Lednicky J, et al. medRxiv [Pre-print]. 4 Aug 2020.
Kotwa JD, et al. medRxiv (Pre-print). 20 May 2021.

Controlled studies demonstrate stability of SARS-CoV-2 in the environment

- Viable in/on:
  - aerosols for 3 hours
  - plastic/stainless steel for up to 72 hours
  - copper up to 4 hours
  - cardboard up to 24 hours


The NEW ENGLAND JOURNAL *of* MEDICINE

CORRESPONDENCE

Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1

van Doremalen N, et al. N Engl J Med. 2020;382(16):1564-7
Ong S, et al JAMA. 2020;323(16):1610-1612..

Surface persistence studies lack generalizability to real-world situations

- Infectivity preserved in the presence of proteins
- Mimics respiratory fluids, but more complex with mucins/enzymes

RESEARCH LETTERS

Prolonged Infectivity of SARS-CoV-2 in Fomites

Boris Pastorino, Franck Touret, Magali Gilles,

Table. SARS-CoV-2 titer values for different materials*

	Material						
	Glass		Aluminum		Plastic		SARS-CoV-2 in suspension
Time, h	No BSA	BSA 10 g/L	No BSA	BSA 10 g/L	No BSA	BSA 10 g/L	
0				6 ± 0.2			
2	3.7 ± 0.5	5.1 ± 0.1	4 ± 0.1	4.8 ± 0.2	5.1 ± 0.1	5.4 ± 0.3	
4	3.5 ± 0.5	5.1 ± 0.4	ND	4.8 ± 0.5	4.8 ± 0.4	5.2 ± 0.4	
8	3.4 ± 0.2	4.9 ± 0.2	ND	4.9 ± 0.1	4.2 ± 0.5	4.6 ± 0.5	
24	2.7 ± 0.5	4.7 ± 0.3	ND	4.9 ± 0.1	3.8 ± 0.1	4.5 ± 0.1	5.99
48	ND	4.8 ± 0.1	ND	4.4 ± 0.4	3.7 ± 0.1	4.3 ± 0.2	4.99
72	ND	4.1 ± 0.2	ND	3.4 ± 0.3	3.6 ± 0.3	4.3 ± 0.4	3.99
96	ND	3.9 ± 0.3	ND	3.6 ± 0.3	3.3 ± 0.3	4.1 ± 0.2	3.99
Half-life	17	>96	2.5	>96	>96	>96	>96

*Values are mean value of 3 replicates ± SD. BSA, bovine serum albumin; ND, not detectable; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

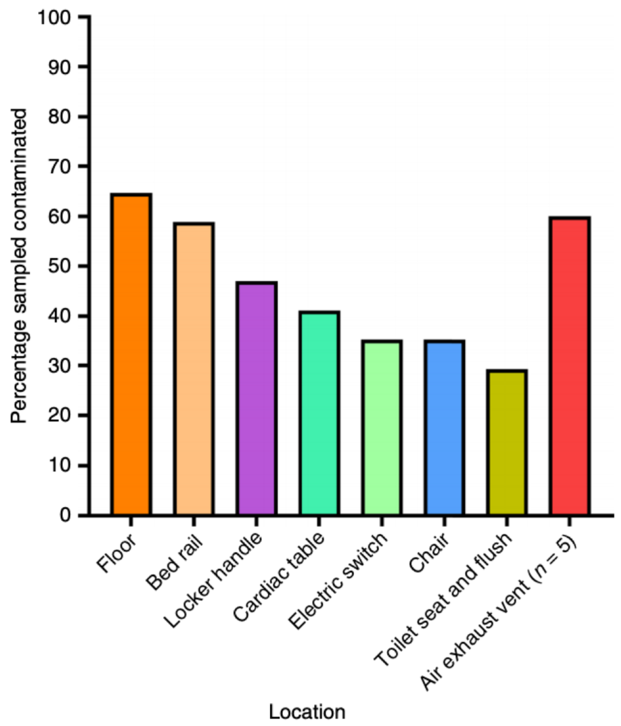

ARTICLE

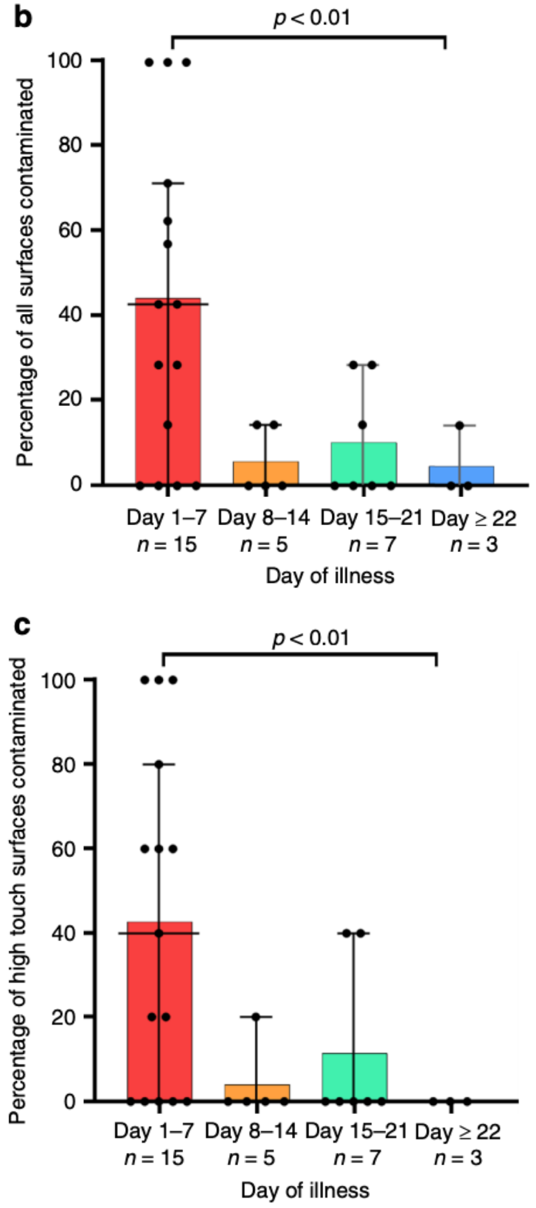
Check for updates

https://doi.org/10.1038/s41467-020-16670-2 OPEN

Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients

Po Ying Chia[1,2,3,11], Kristen Kelli Coleman[4,11], Yian Kim Tan[5,11], Sean Wei Xiang Ong[1,2,11], Marcus Gum[5], Sok Kiang Lau[5], Xiao Fang Lim[5], Ai Sim Lim[5], Stephanie Sutjipto[1,2], Pei Hua Lee[1,2], Than The Son[4], Barnaby Edward Young[1,2,3], Donald K. Milton[6], Gregory C. Gray[4,7,8], Stephan Schuster[9], Timothy Barkham[2,10], Partha Pratim De[2,3], Shawn Vasoo[1,2,3], Monica Chan[1,2], Brenda Sze Peng Ang[1,2,3,10], Boon Huan Tan[5], Yee-Sin Leo[1,2,3,10], Oon-Tek Ng[1,2,3,12✉], Michelle Su Yen Wong[5,12], Kalisvar Marimuthu[1,2,10,12✉] & for the Singapore 2019 Novel Coronavirus Outbreak Research Team*





56.7% of rooms have at least one environmental surface contaminated

High touch surface contamination in 66.7% patient rooms in the **first week of illness**, and 20% beyond the first week of illness ($p = 0.01$)

Zhang et al. no significant association between surface contamination and staff infection

Chia PY, et al. Nat Commun. 2020;11(1):2800.
Zhang HL, et al. Infect Control Hosp Epidemiol. 2021 Nov 15;1-10.

Modelling studies found that infection risk via fomites was much lower compared to droplet and aerosol transmission

- *Diamond Princess*:
  - Contact transmission = 30%
  - Short + long-range transmission = 70%

Relative contributions of transmission routes for COVID-19 among healthcare personnel providing patient care

Rachael M. Jones

Mean % contribution	Without PPE	With PPE
Fomite	6.9%	2.8%
Droplet/inhalation(sic)	93%	98%

Jones RM. J Occup Environ Hyg. 2020 Sep;17(9):408-15.
Azimi P, et al. Proc Nat Acad Sci USA. 2021;118(8):e2015482118.
Xiao S, et al. PLoS ONE. 2017;12(7):1-13.

Limited epidemiological evidence to support transmission via fomites, compared to droplet transmission

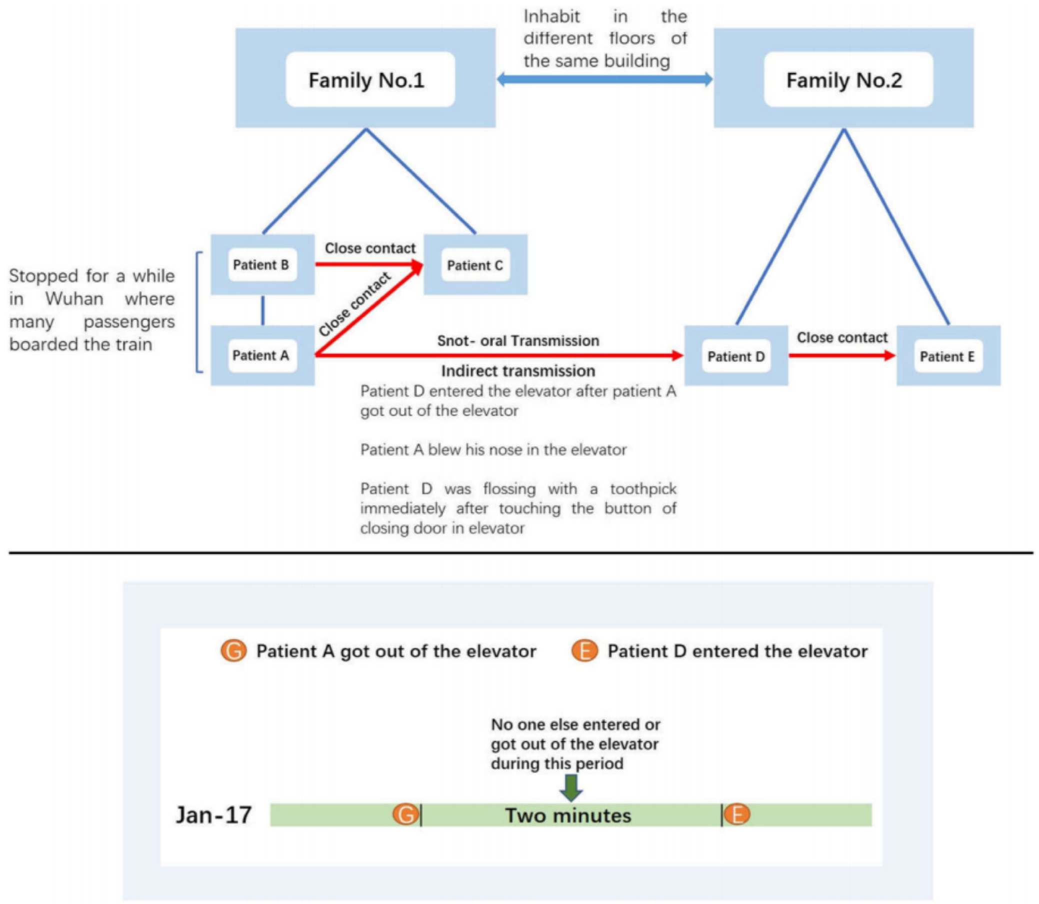
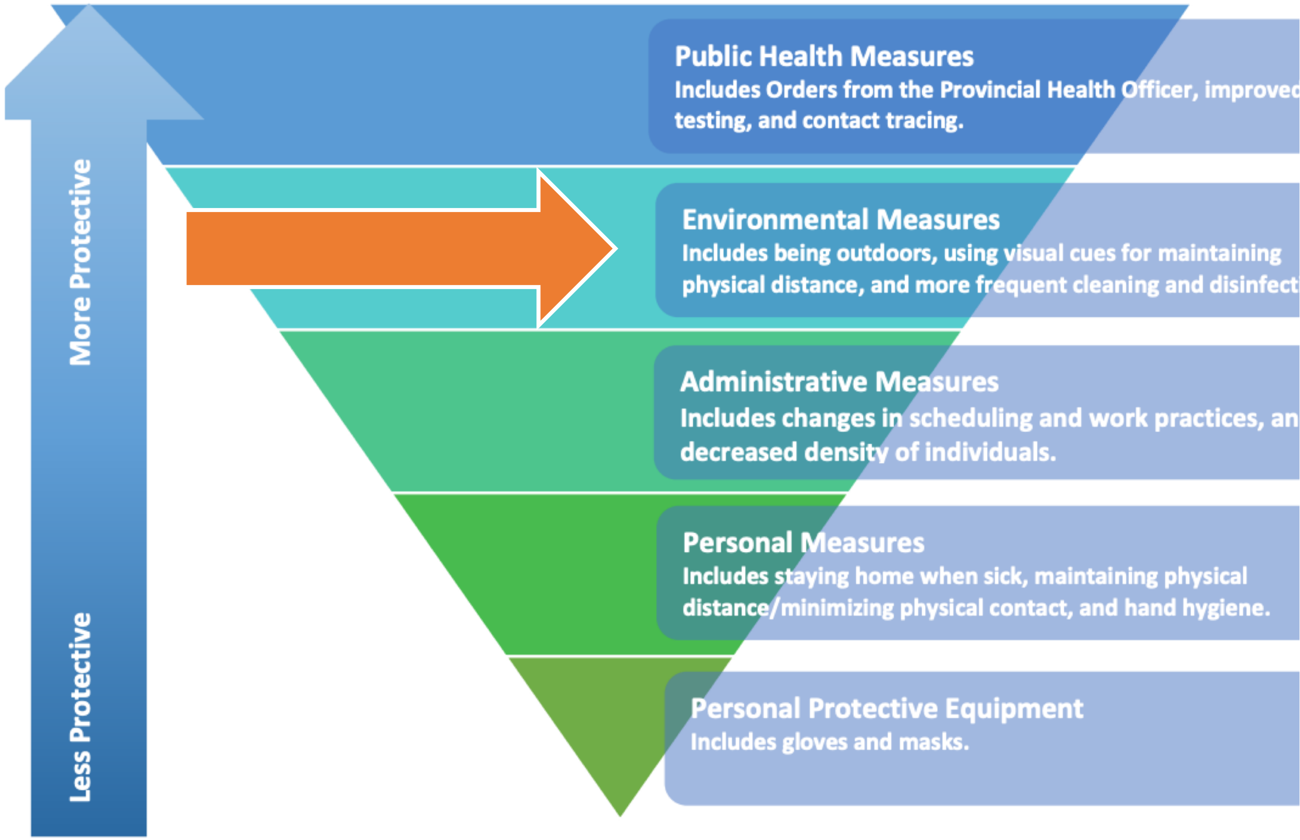


Fig. 5 The epidemiological investigation and their relationship between family No.1 and family No.2

Xie C, et al. BMC Public Health. 2020 Aug;20(1):1202.

Risk Mitigation Strategies

- **Environmental or engineering controls**
  - Re-imagine the clinic environment
    - Maximize social distancing in waiting room, exam rooms and break room
  - Optimize ventilation
  - Air filtration
    - Morris et al. Clin Infect Dis. 2021 Oct 30; ciab933.
  - Environmental cleaning
  - Infection isolation room



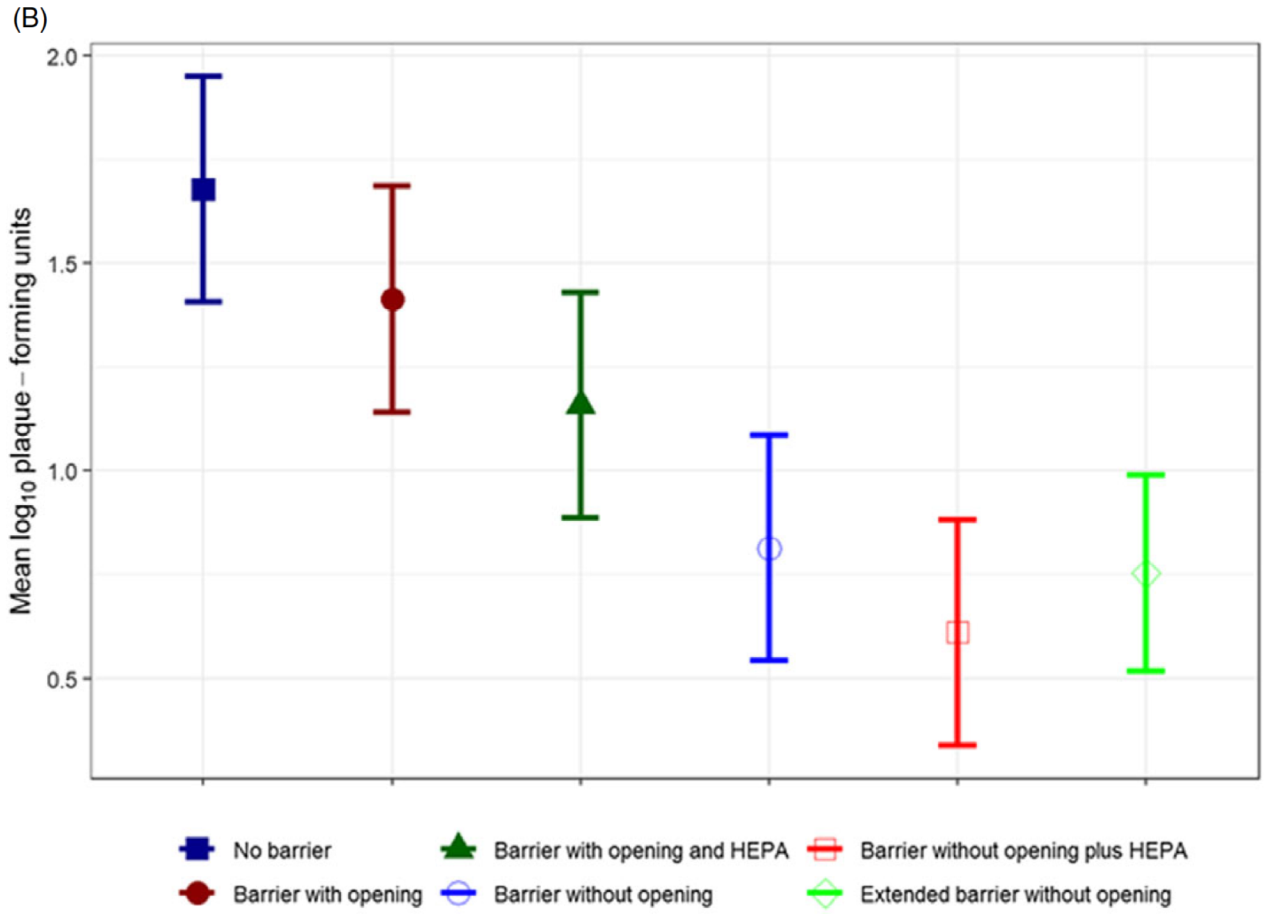
Risk Mitigation Strategies

- **Environmental or engineering controls**

Do plexiglass barriers reduce the risk for transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)?

Jennifer L. Cadnum BS[1], Annette L. Jencson CIC[1] and Curtis J. Donskey MD[2,3]

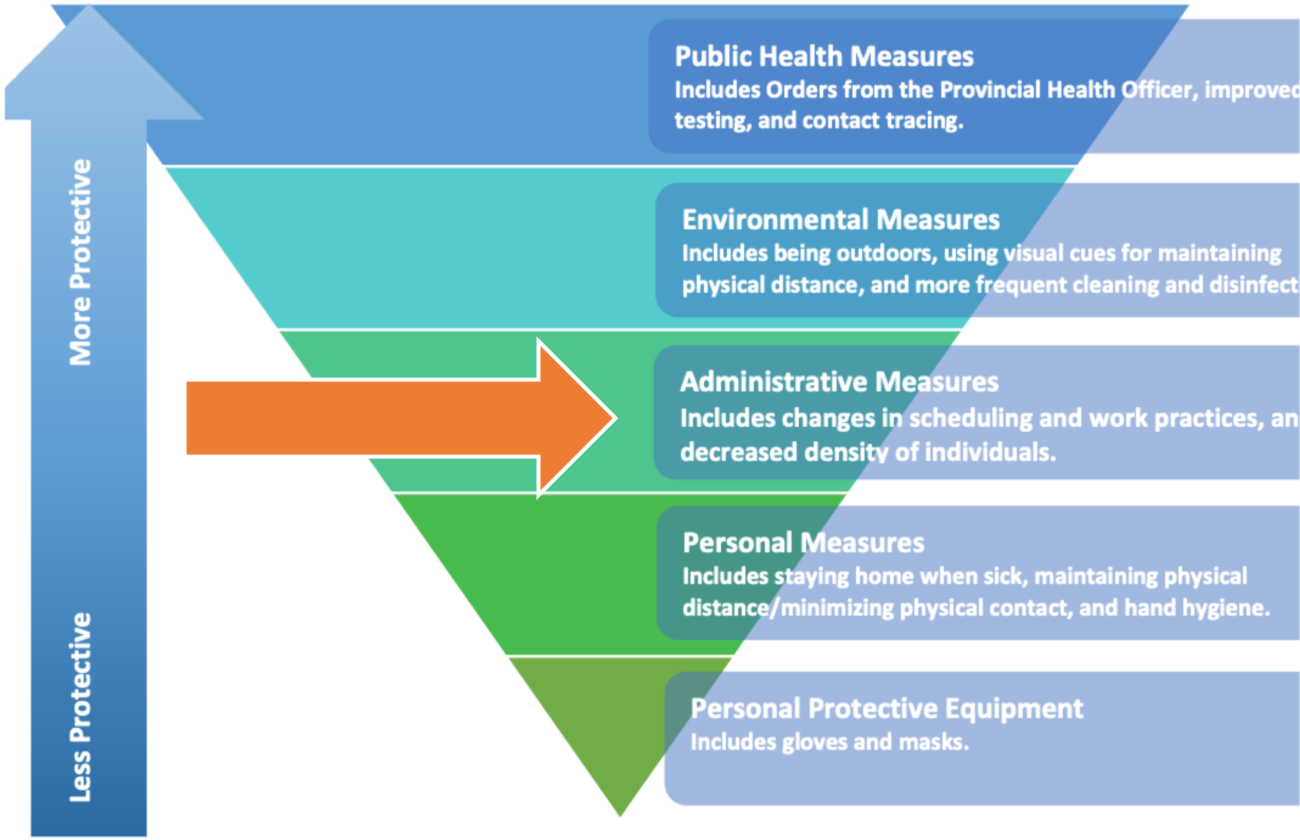
[1]Research Service, Louis Stokes Cleveland Vetarans' Affairs (VA) Medical Center, Cleveland, Ohio, [2]Geriatric Research, Education, and Clinical Center, Louis Stokes Cleveland VA Medical Center, Cleveland, Ohio and [3]Case Western Reserve University School of Medicine, Cleveland, Ohio



Doron S, et al. medRxiv. 2021; 21253976v1 [preprint].
Bagherirad M, et al. Med J of Australia. 2014; 200(3):177-79.
Bartels J, et al. medRxiv. 2021; 21261146v1 [preprint].
Gilkeson CA, et al. Building and Environment. 2013; 65:35-48.
Gettings J, et al. MMWR. 2021; 70(21):779-84.

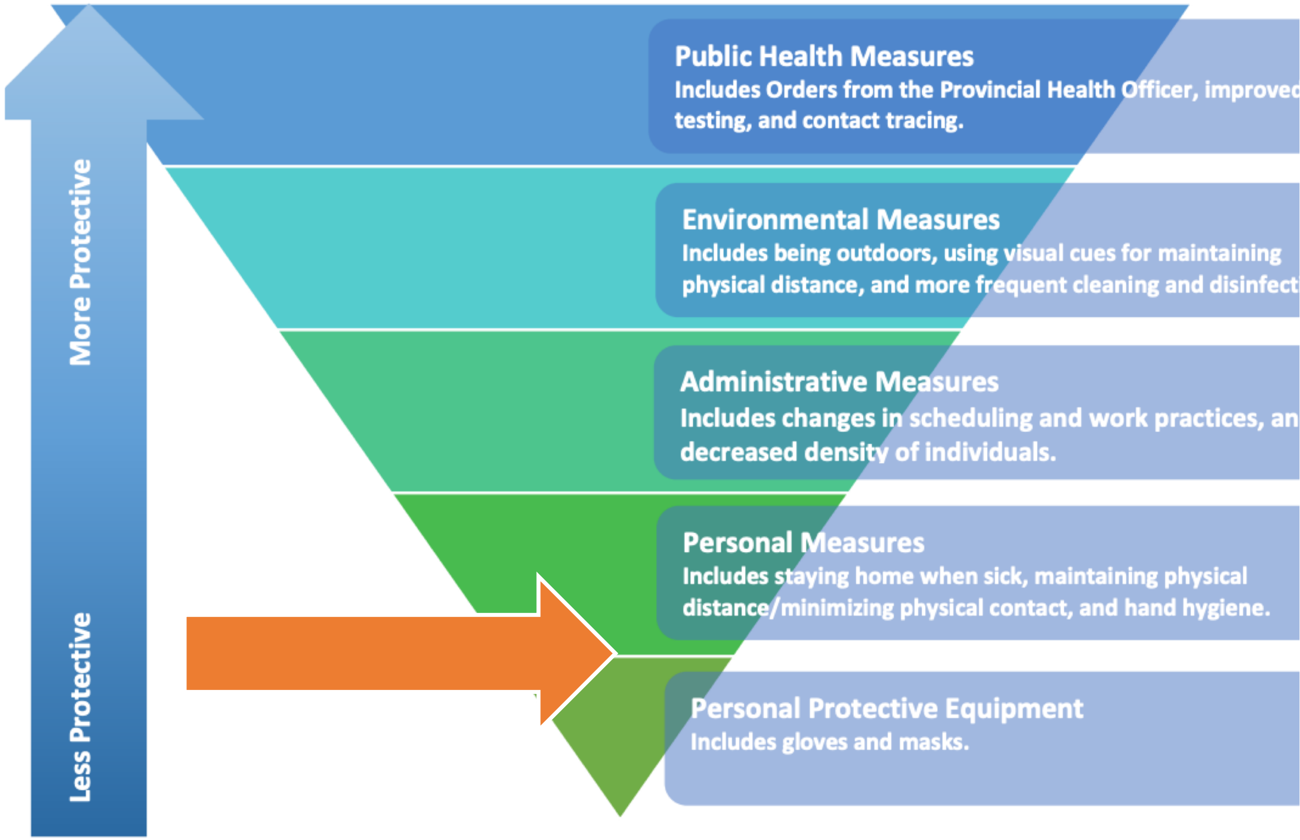
Risk Mitigation Strategies

- **Administrative controls**
  - Decrease density
    - Stagger appointment times
    - Stagger break times
    - Virtual visits
    - Creative use of technology – self check-in, BEAM robots
  - Maintain social distancing
    - Manage flow
  - Active surveillance
    - Pre-visit screening for symptoms



Risk Mitigation Strategies

- **Personal Controls**
  - Staff symptom surveillance
    - Furlough if sick
  - Hand hygiene
  - Respiratory hygiene
  - Maintain your bubble
- **Personal-Protective Equipment (PPE)**
  - Universal masking for staff and patients
  - Point-of-care risk assessment

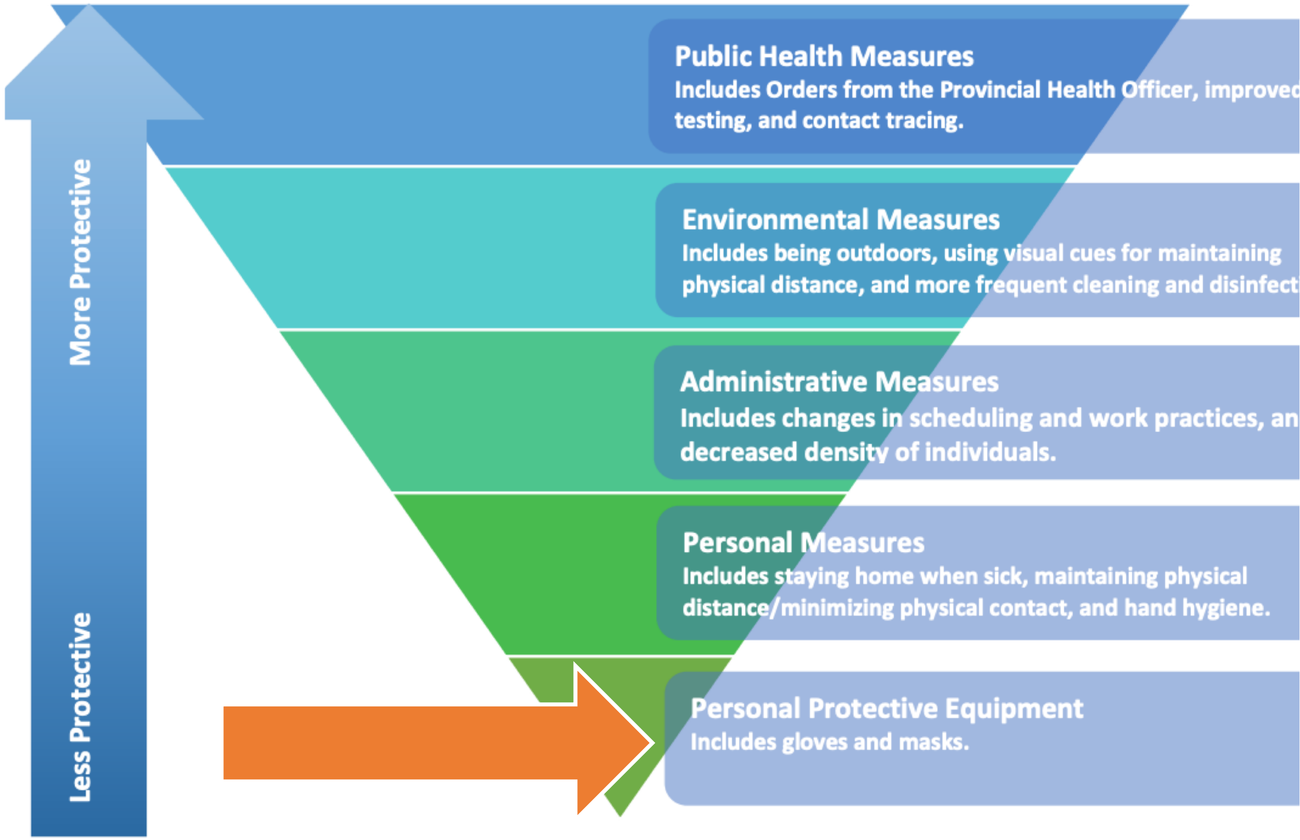


The Most Visible but Least Effective Measure

"PPEs occupy a precarious but fecund position between being tools, icons, and thresholds of humanity's wavering (if not altogether forlorn) self-realization in reason and its scientifically driven fight against invisible forces of existential risk"

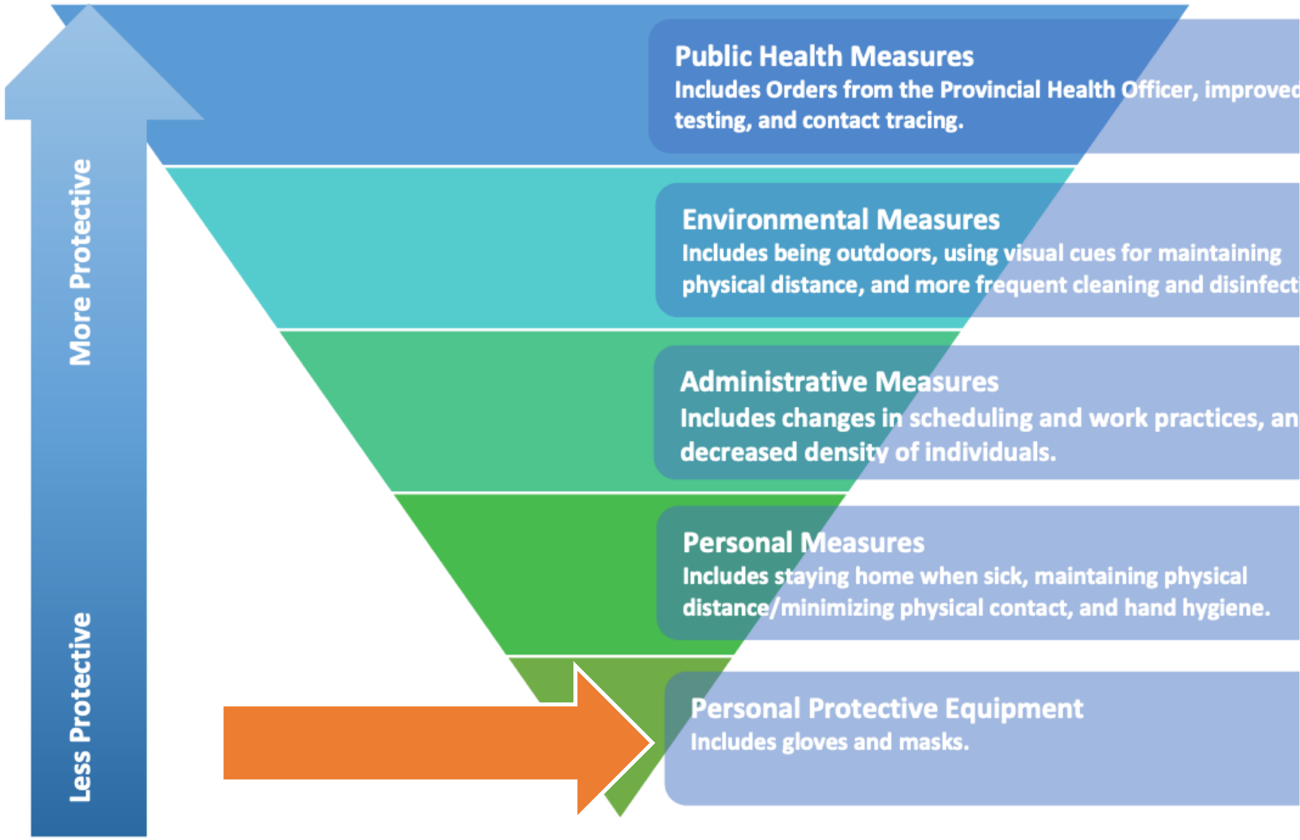
The Most Visible but Least Effective Measure

- Ocular protection statistically significant reduction in SARS-CoV-2
  - Byambasuren O, et al. Antimicrob Resist Infect Control 2021; 10:156.
- Mask better than no mask (0/278 vs. 10/213)
  - Wang X, et al. J Hosp Infect. 2020; 105:104-105.
- ‘Mask on Mask’ exposure in elementary school yielded no secondary transmission
  - Boutzoukas AE, et al. Pediatrics 2021; doi:10.1542/peds.2021-054268L.
- RCT demonstrating no significant difference in incidence of influenza
  - Radonovich LJ Jr, et al. JAMA 2019;322(9):824-33
  - Loeb M, et al. JAMA 2009; 302(17):1865-1871.



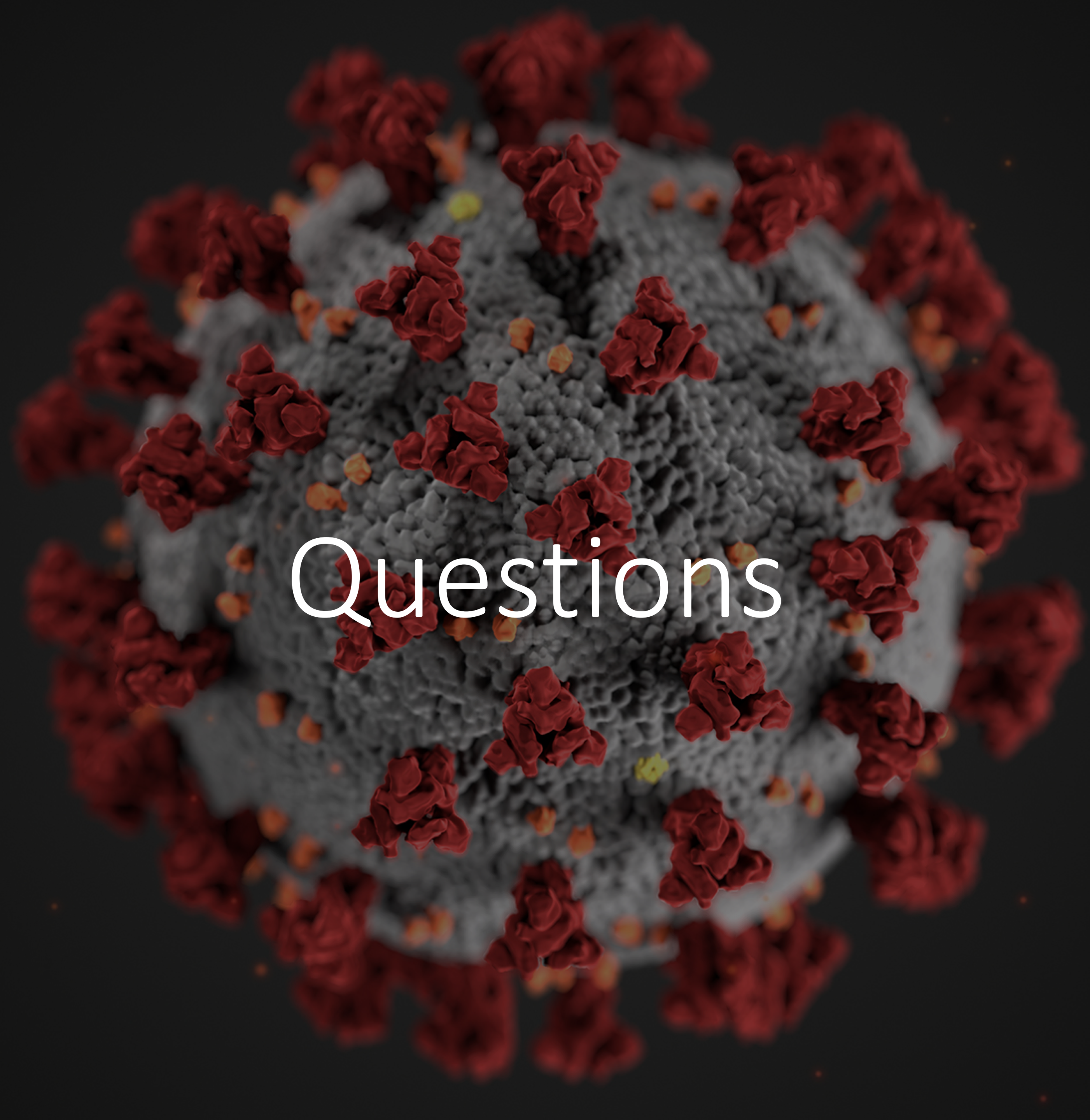
The Most Visible but Least Effective Measure

- Low certainty evidence suggests that medical masks and N95 respirators offer similar protection
  - Bartoszko JJ, et al. Influenza Other Resp Viruses. 2020;14:365-373.
- Non-significant difference between N95 respirators and face masks
  - Meta-analysis:
    - Chu DK, et al. Lancet. 2020 Jun 1.
    - Ocular protection significant effect
    - Strong association between proximity of exposed individual and risk of infection
  - Prospective cohort:
    - FFP2 use was non-significantly associated with decreased risk for SARS-CoV-2 positive swab or seroconversion
    - Haller S, et al. medRxiv [Preprint] 2021 Jun 1.



Summary

- Almost two years of epidemiological and clinical experience has shaped our understanding of the transmission of SARS-CoV-2 and its prevention
- Much of our knowledge is based on small datasets that are extrapolated to other populations
- There remain key unanswered questions:
  - Superspreader events
  - Infectious dose
  - Relative role of fomite transmission
  - Efficacy of PPE: Medical Mask versus N95 respirator
  - Efficacy of other infection control strategies
- With all novel or emerging infections our understanding and policies are bound to evolve



Questions