

Preventing Viral Transmission in the Workplace

Occupational Health Clinics for Ontario Workers October 7, 2022

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Disclosures

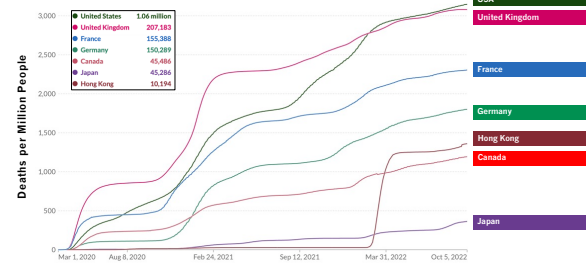
- **Grant funding**
 - Centers for Disease Control and Prevention
 - Massachusetts Department of Public Health
 - Agency for Healthcare Research and Quality
- **Royalties**
 - UpToDate Inc.

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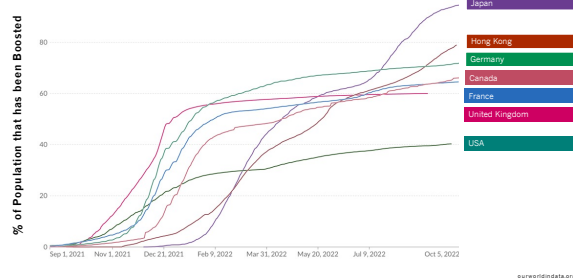
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Cumulative Deaths per Million People



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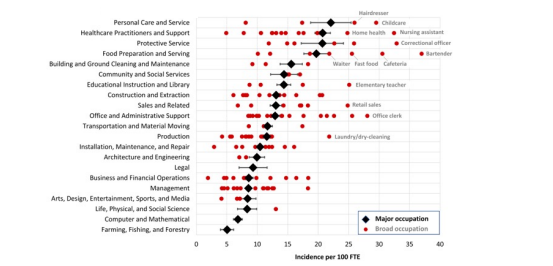
Covid Booster Rates by Country



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Covid risk by Occupation

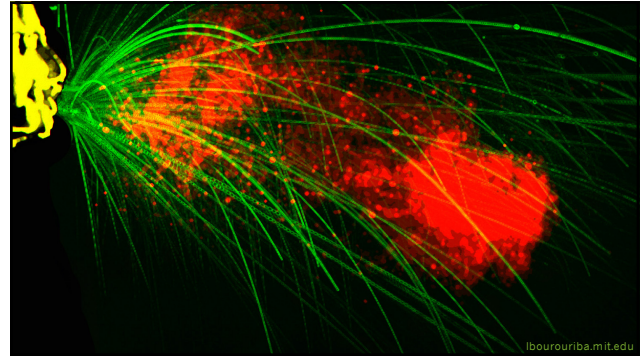
Wisconsin Department of Health analysis of 347,013 adults with SARS-CoV-2, Sept 2020 – May 2021



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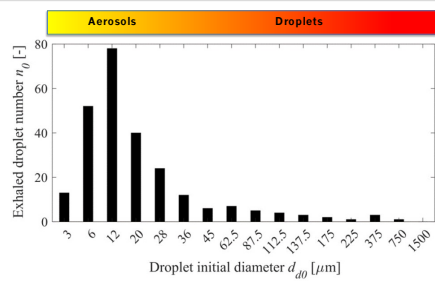
Is SARS-CoV-2 spread by droplets or aerosols?

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People Produce Respiratory Particles in a Range of Sizes

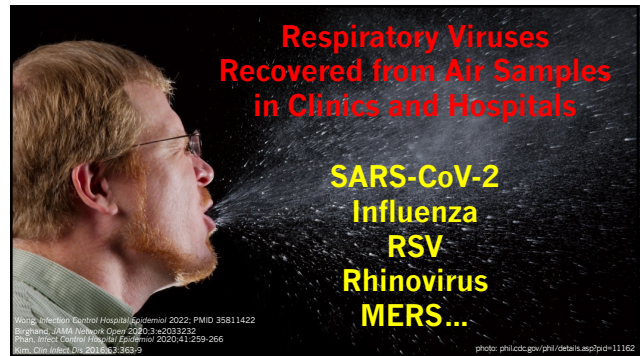


Chen, Building and Environment 2020;176:106859

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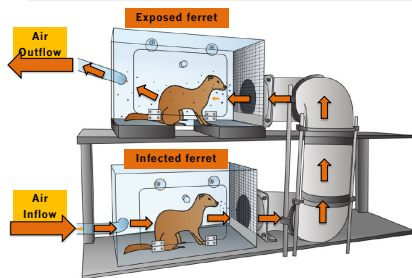
Respiratory Viruses Recovered from Air Samples in Clinics and Hospitals

SARS-CoV-2
Influenza
RSV
Rhinovirus
MERS...



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Transmission via Aerosols

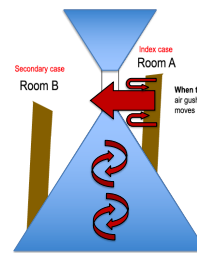


- Ferret model used to assess aerosol transmission
- 4 uninfected ferrets exposed to ferrets infected with SARS-CoV-2 and influenza
- Airflow between cages via closed pipe, 1.1m long, 4 right-angle turns
- 2/4 ferrets exposed to SARS-CoV-2 infected
- 4/4 ferrets exposed to influenza infected

Kutter, Nature Communications 2021;12:1653

12

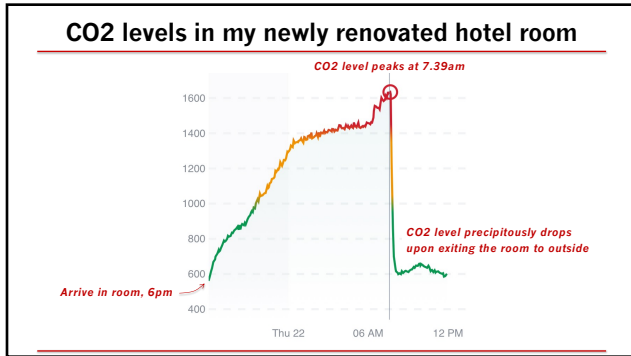
Aerosol Transmission in Humans: Quarantine Hotels



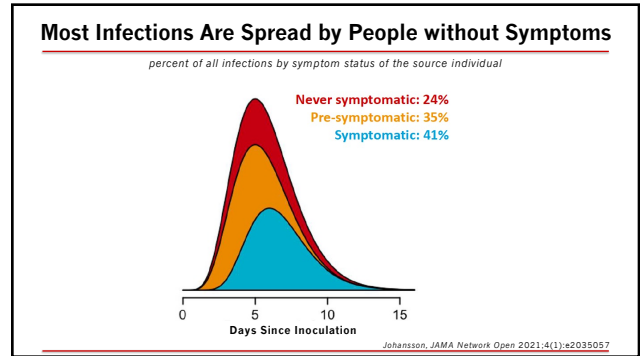
- Multiple case reports of transmission between unrelated travelers staying in quarantine hotels in Hong Kong, Singapore, New Zealand...
- Quarantine hotels have very strict rules in hotels requiring guests to stay in their own room at all times (video monitoring)
- Transmission presumed due to
 - Prolonged dwell time in poorly ventilated room leading to high concentration of virus in the air
 - Escape of virus laden air into stagnant corridors when room door is opened
 - Entry of virus laden air into nearby rooms when their residents subsequently open their doors

Wong, Lancet Regional Health - Western Pacific 2022;18:100360

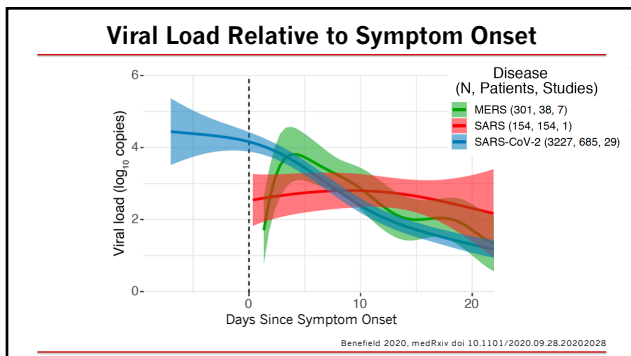
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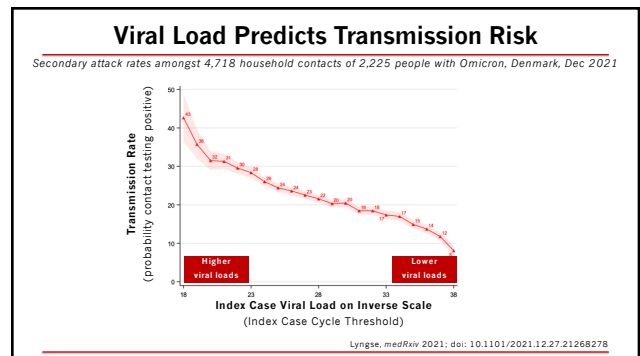
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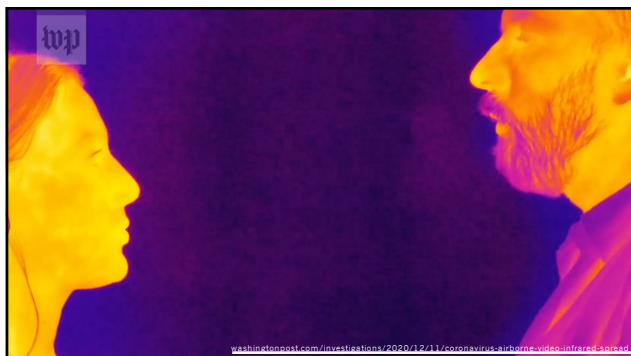
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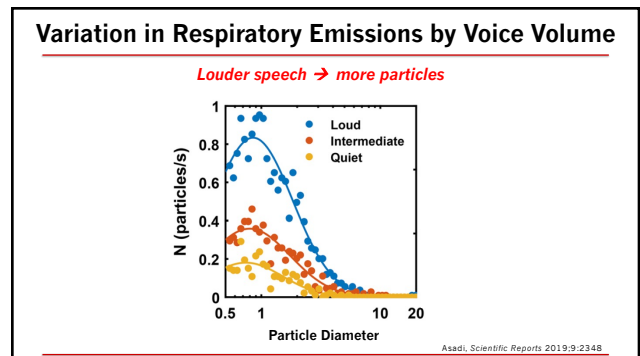
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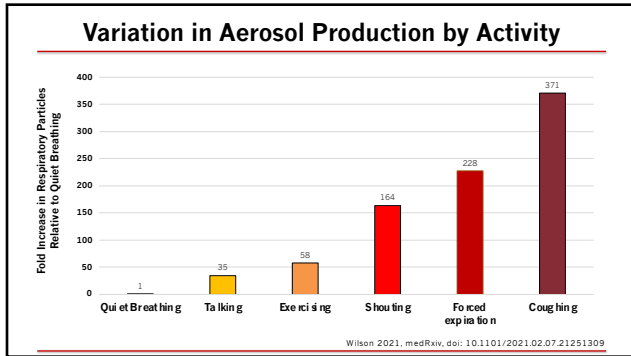
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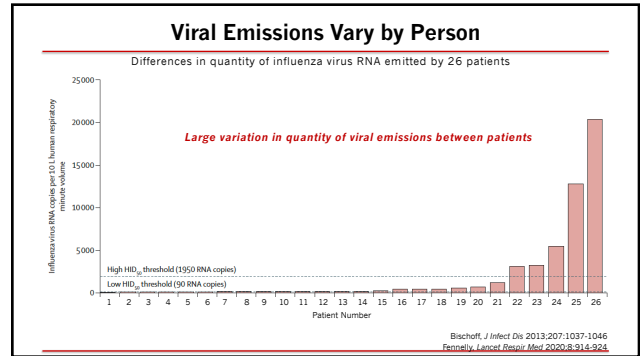
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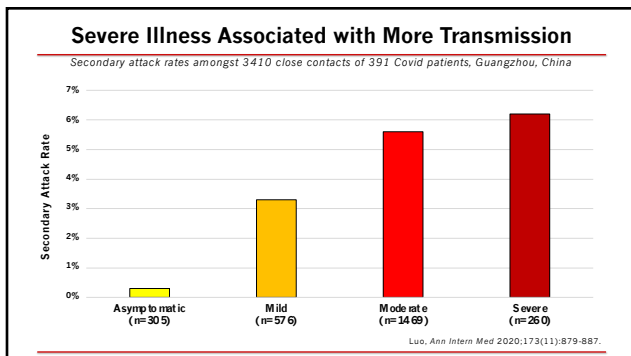
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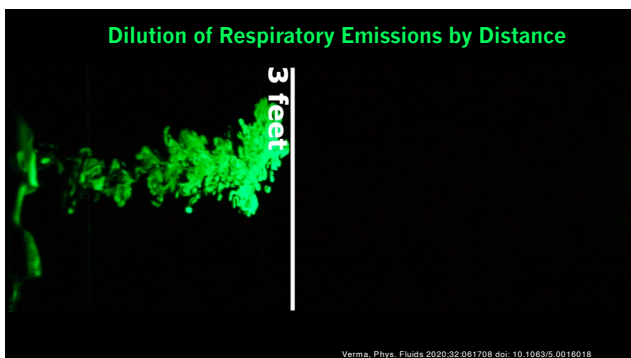
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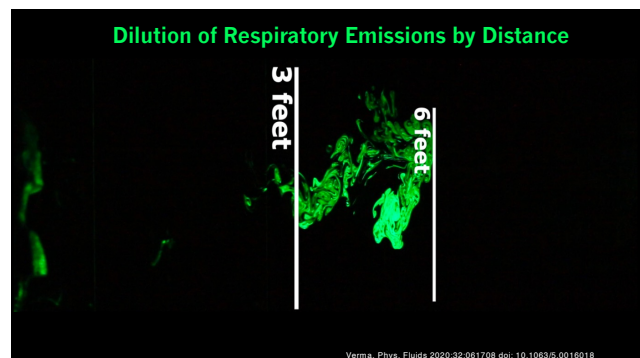
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If SARS-CoV-2 is spread by aerosols, how come we aren't seeing widescale, long distance transmission?

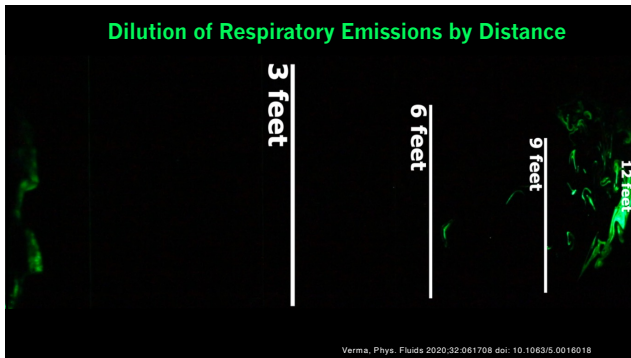
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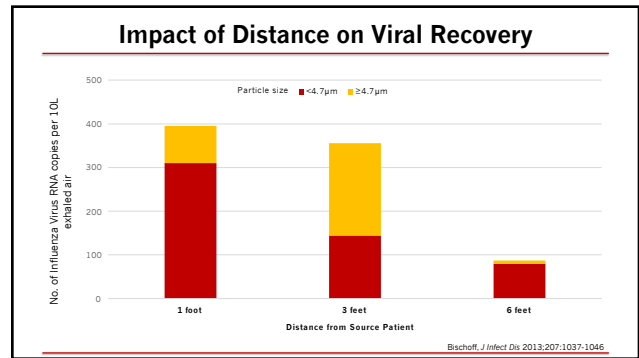
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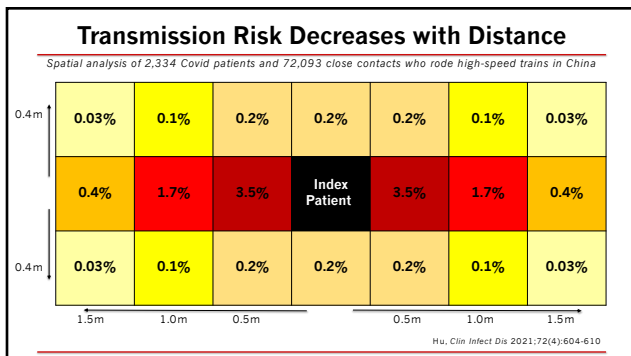
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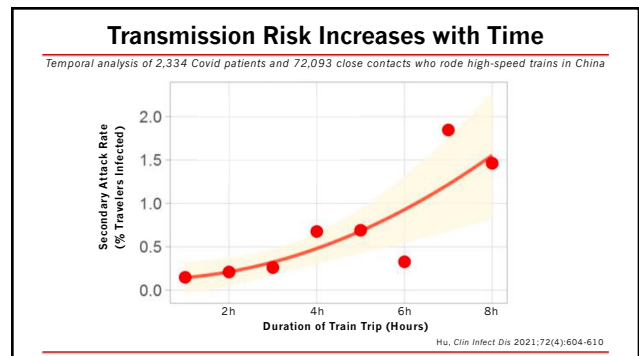
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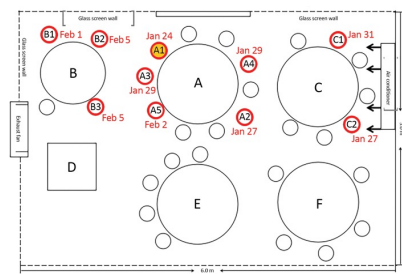
Skagit Valley Choir Outbreak

- 61 members of the choir attended practice together (March 10, 2020)
 - 53 developed Covid-19 (87% attack)
 - 3 hospitalized, 2 died
- Investigation
 - One member tested positive for SARS-CoV-2
 - 2.5 hour practice; no masking
 - Cases spread broadly throughout the room
 - Air change rate estimated to have been 0.7 changes per hour

Hammer, MMWR 2020;69:606-610
Miller, Indoor Air 2021;31(2):314-323

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Restaurant Cluster Associated with Air Conditioning, Guangzhou, China

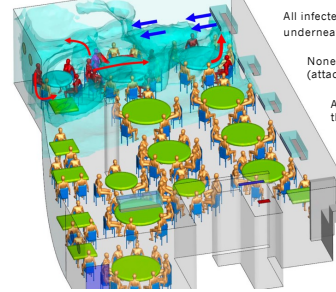


- Well documented cluster in a restaurant in Guangzhou
- One pre-symptomatic diner infected 9 other diners (4 at own table, 5 at other tables)
- Some of the infected diners up to 4 meters (12 feet) away from the index case
- Air conditioner and lack of ventilation likely contributory

Lu, Emerging Infectious Diseases 2020;26:1628-31

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Air Flow Modeling



All infected diners were in one area of the restaurant underneath an air conditioner (attack rate 9/20, 45%)

None of the 68 diners in other areas were infected (attack rate 0/68). None of the 8 waiters infected.

Air conditioner was recirculating "old" air rather than fresh (exhaust vents were closed)

Tracer gas studies confirmed VERY poor ventilation in the affected area of the restaurant (0.7 air changes/hour; hospital standard is ≥ 6 air changes/hour)

Take home: poor ventilation facilitates longer range aerosol transmission

Li 2020, medRxiv preprint, doi: 10.1101/2020.04.16.20067728 and Li, Build Environments 2021;196:107788

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Cluster of Infections on Poorly Ventilated Bus

- Cluster of 31 infections amongst 300 people who attended an outdoor Buddhist ceremony and lunch in Eastern China. Traced to one pre-symptomatic attendee.
- Two groups traveled to the ceremony by bus. Others travelled via private transport
- 100 mins travel time. 150 mins ceremony time. Ceremony Outdoors.



- Bus #1 (indoor exposure)**
- Pre-symptomatic patient onboard
 - 24/68 people on bus infected
- 35% infected**



- Bus #2 (outdoor exposure)**
- 0/60 infected despite attending the same ceremony as passengers on Bus #1
- 0% infected**

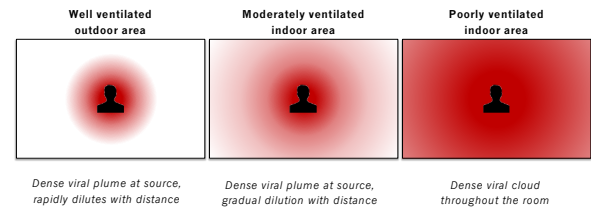


- Private transport**
- 7/172 infected.
 - All 7 had close contact with the index patient at ceremony
- 4% infected**

Shen, JAMA Intern Med 2020;180(12):1665-1671

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Impact of Ventilation on Viral Exposure



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Transmission Risk in Shared Hospital Rooms

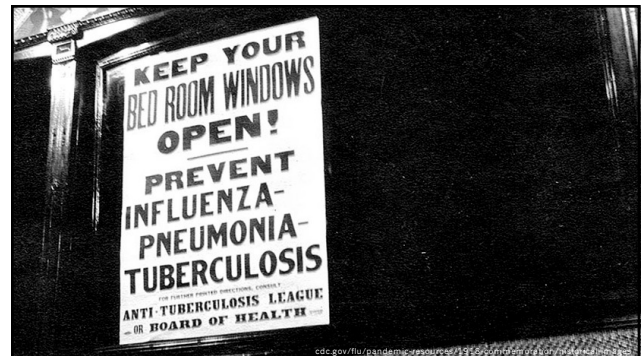


39% of exposed roommates were infected

- Brigham & Women's Hospital, Sept 2020 - April 2021
- 25 patients diagnosed with SARS-CoV-2 after admission to a shared room
- 31 potentially exposed roommates
- Roommates ~7 feet apart and separated by a curtain
- ≥ 6 air changes per hour
- Median duration of exposure: 18 hours (IQR 12-47 hours)
- 12/31 (39%) roommates infected

Karan, Clinical Infectious Diseases 2021; doi: 10.1093/cid/ciab564

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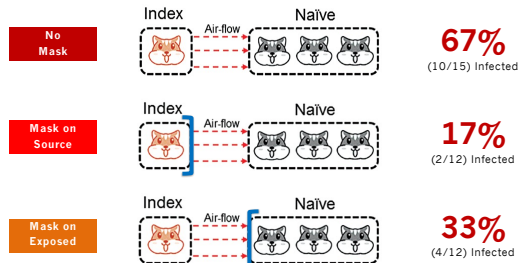
How good is your mask?



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Medical Masks are Good! ... But Not Perfect

Transmission study using Golden Syrian Hamsters in adjacent cages with and without tightly fixed surgical masks between cages

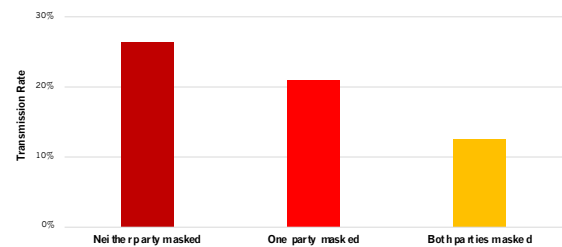


Chan, Clin Infect Dis 2020;71:2139-2149

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Masking Effectiveness in Practice

Transmission rates amongst 969 close contacts of 431 people with Covid-19, Johnson County Public Health, Iowa

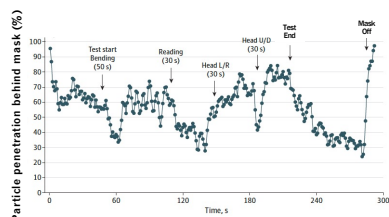


Riley, Emerging Infectious Disease 2021; doi: 10.3201/eid2801.211591

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Mask Filtration Efficiency in Practice

Medical Masks' Overall Efficiency: 38%



Overall % FFE
Mean (SD) over all tests,
38.5% (11.2%)

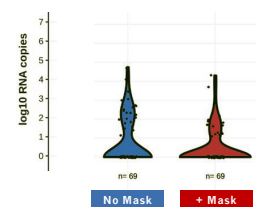
Clapp, JAMA Intern Med 2020; doi: 10.1001/jamainternmed.2020.8168

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Impact of masks on viral emissions

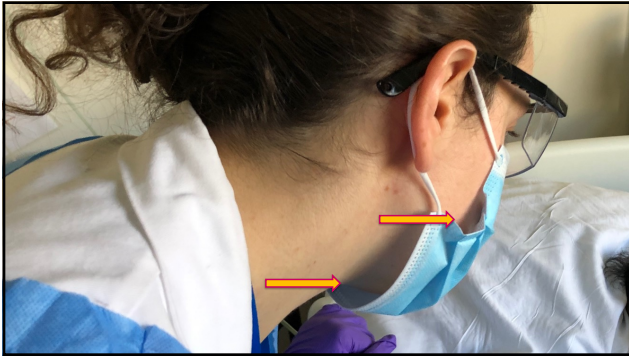
Analysis of 30-minute breath samples from 49 people infected SARS-CoV-2

Masks reduce SARS-CoV-2 emissions by ~48%



Adenaiye, Clin Infect Dis 2022;75:e241-248

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Transmission To and From HCWs Despite Masks

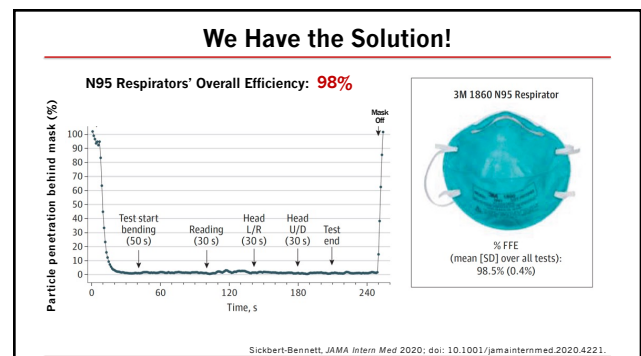
- Multiple instances of transmission to and from healthcare workers despite masks & eye protection
- All transmissions confirmed by whole genome sequencing (0 SNP differences)
 - Patient to CT tech (10 min interaction)
 - Patient to video swallow technician (45 mins)
 - Asymptomatic inpatient to two patient care assistants (4-8 hours)
 - Presymptomatic nurse to patient (2 shifts)
 - Presymptomatic outpatient to physician (45 mins, both parties masked)

Klompas, Ann Intern Med 2021;174:794-802 doi.org/10.7326/M20-7567
 Klompas, Clin Infect Dis 2021;73:1693-5 doi.org/10.1093/cid/ciab218

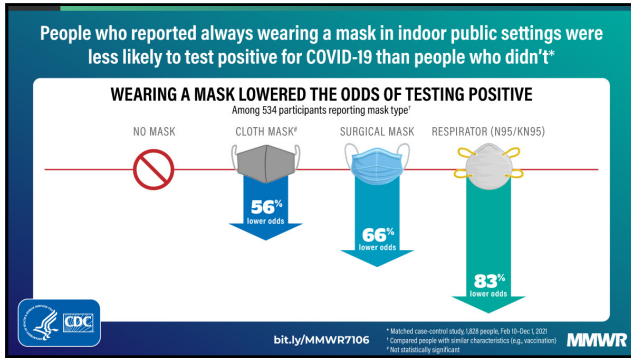
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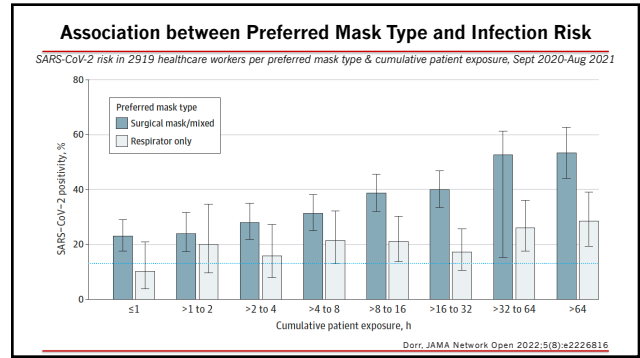
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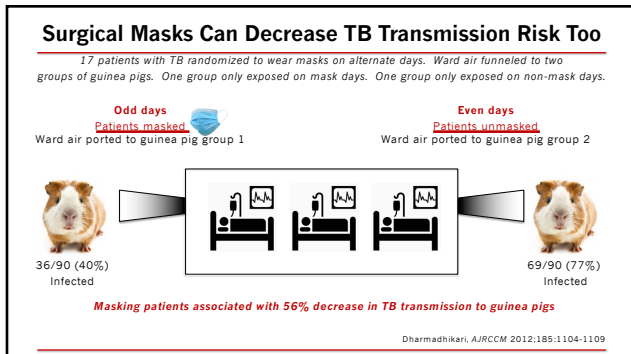
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Association between Mask Type and Protection

		Person 2				
		Nothing	Cloth Mask	Surgical Mask	KN95	N95
Person 1	Nothing	15min	20min	30min	2.5h	25h
	Cloth Mask	20min	27min	40min	3.3h	33h
	Surgical Mask	30min	40min	60min	5h	50h
	KN95	2.5h	3.3h	5h	25h	10 days
	N95	25h	33h	50h	10 days	100 days

American Conference of Governmental Industrial Hygienists

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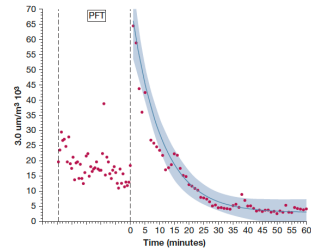
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Aerosols Rapidly Dissipate in Well Ventilated Spaces

Aerosol quantification before, during, and after forced expiration, clinic with 5 air changes per hour

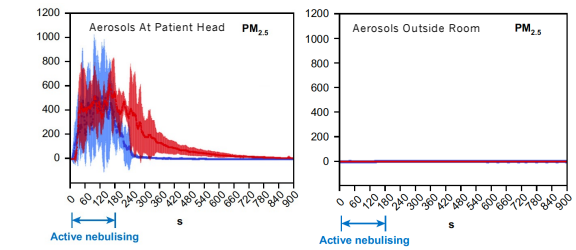


Li, Chest 2021;159:1570-1574

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Aerosol Clearance in Well Ventilated Hospital Rooms

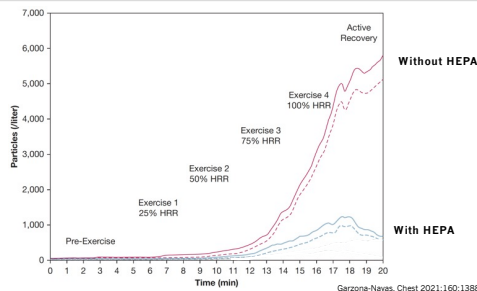
◆ Negative Pressure Room, 12 air changes/hour ◆ Operating Room, Pos Pressure, 27 air changes/hour



Tsui, Br J Anaesthesia 2020; doi: 10.1016/j.bja.2020.09.011

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HEPA Filters Can Effectively Reduce Aerosol Counts



Garzone-Navas, Chest 2021;160:1388-1396

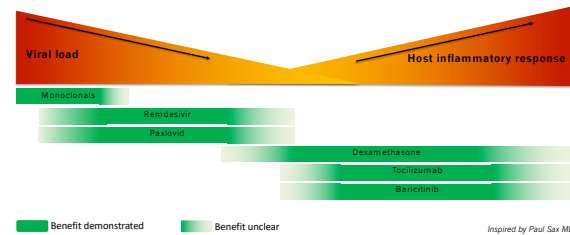
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The Sickest are Sometimes the Least Contagious

Early Infection
Fever, myalgia, fatigue

Pulmonary Phase
Shortness of breath, cough, hypoxia

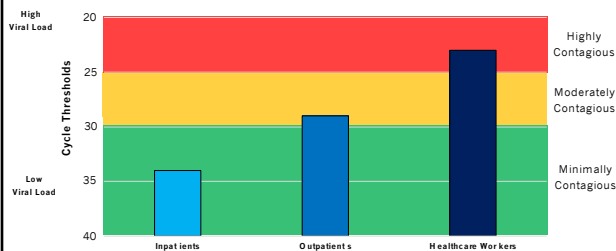
Hyperinflammatory Phase
ARDS, myocarditis, renal failure, neuro syndromes



Inspired by Paul Sax MD

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Average Viral Loads in Covid+ Inpatients vs Others

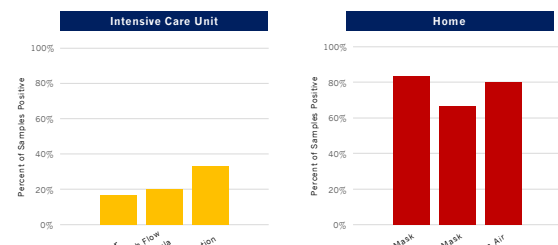


McElisliem, PLoS ONE 2021; 16(3): e0248347

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SARS-CoV-2 Air Sampling: ICU vs Home

Air sampling for SARS-CoV-2 RNA in rooms of Covid positive patients in ICU vs home

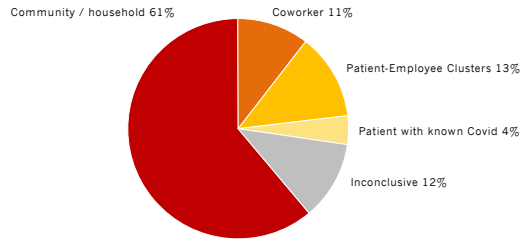


de Man, J Hospital Infection 2021; doi: 10.1016/j.jhin.2021.10.018

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Where Do Healthcare Workers Get Infected?

Sequencing of SARS-CoV-2 clusters, 95 HCWs & 137 possible patient contacts, University of Wisconsin

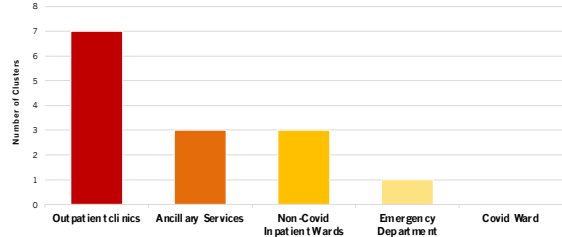


Braun, Clin Infect Dis 2021; 73: e1329-e1336

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Where do hospital Covid clusters occur?

Whole genome sequencing analysis of 14 clusters, 117 infections (112 HCWs, 5 patients), VA Northeast Ohio
Cluster defined as ≥ 3 potentially-related infections



Jimadatha, Open Forum Infect Dis 2021; doi.org/10.1093/ofid/ofab328

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Does vaccination prevent transmission?

Vaccinated People are 2/3 Less Likely to Carry Virus

National random sample of 98,233 UK residents, June 24-July 12, 2021
(during the height of UK's Delta wave)

1.21%
unvaccinated
people
tested
positive

0.40%
vaccinated
people
tested
positive

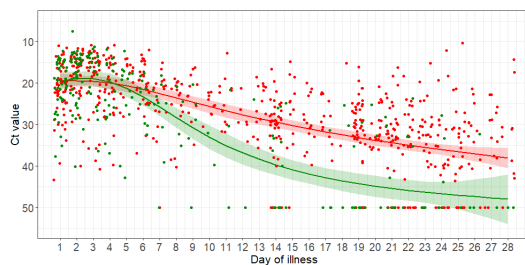
Elliott 2021, REACT-1 round 13 final report
<https://spiral.imperial.ac.uk/handle/10044/1/90800>

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Vaccinated People Clear Virus Faster

Unvaccinated Vaccine-breakthrough

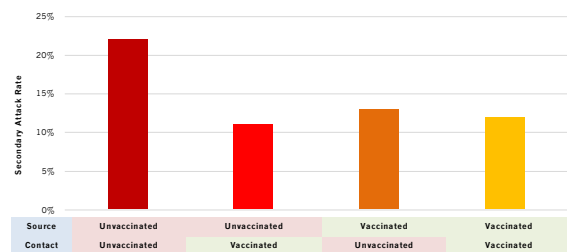


Chia 2021, medRxiv, doi: 10.1101/2021.07.28.21261295

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Secondary Attack Rates by Vaccination Status

Analysis of 7,771 household contacts of 4,921 people positive for SARS-CoV-2, Netherlands, Aug 9 – Sept 24, 2021 (97% Delta)

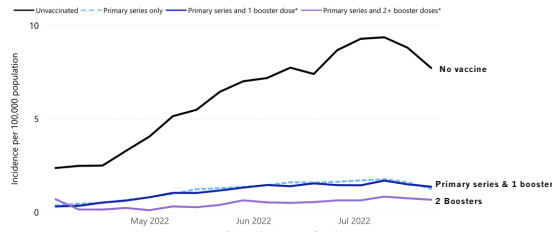


de Gier, Euro Surveill, 2021 Nov;26(44). doi: 10.2807/1560-7917.ES.2021.26.44.2100977 PMID: 34738514

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Covid 2022 is not the same as Covid 2020

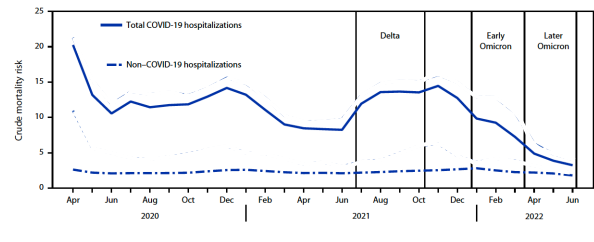
Rates of COVID-19 Deaths by Vaccination Status and 2+ Booster Doses* in Ages 50+ Years
April 03, 2022–July 30, 2022 (27 U.S. jurisdictions)



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Covid 2022 is not the same as Covid 2020

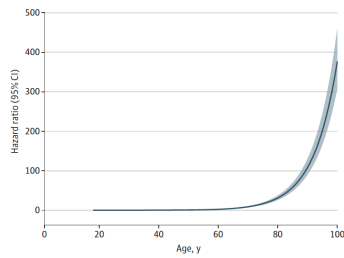
Crude mortality rates for people hospitalized with Covid-19, 678 US hospitals



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Who is at Risk of Dying from Covid Despite a Booster?

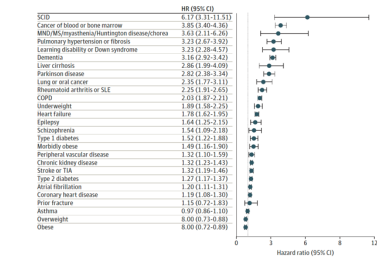
Analysis of risk factors for death due to Omicron despite full vaccination + booster, UK Office of National Statistics



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Who is at Risk of Dying from Covid Despite a Booster?

Analysis of risk factors for death due to Omicron despite full vaccination + booster, UK Office of National Statistics



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Risk & Protection Exists on a Continuum

Factors That Increase Risk

- High community incidence
- Higher viral load
- Symptoms
- Proximity
- Longer exposure
- Poor ventilation
- Lack of masking
- Lack of vaccination

Factors That Decrease Risk

- Low community incidence
- Lower viral load
- Lack of symptoms
- Distance
- Brevity
- Good ventilation
- Mask on patient
- Mask on provider
 - N95 > KN95 > facemask
- Vaccination

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Thank You!

For all the lives we touch

Clean hands protect our patients. Always perform hand hygiene and help others do the same.

BRIGHAM HEALTH
BRIGHAM AND WOMEN'S HOSPITAL

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LIVES TOUCH

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