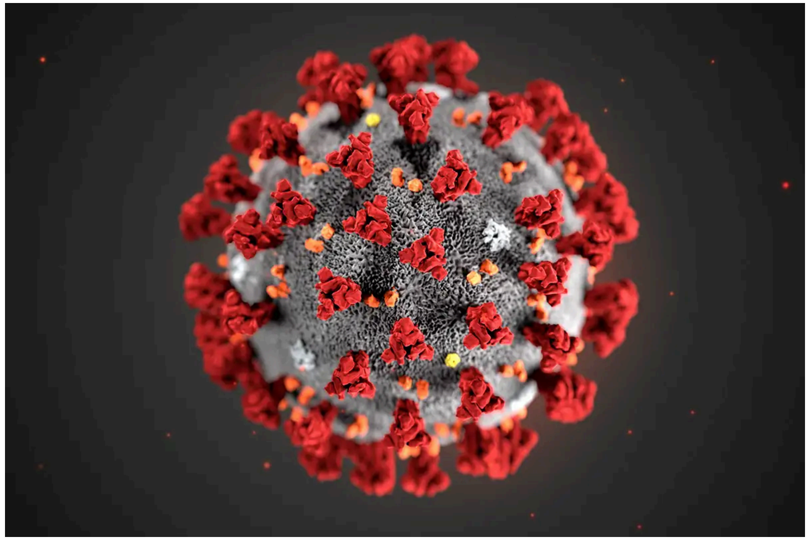
Evidence for using face masks to prevent SARS-CoV-2 transmission in the community



Sam Bailin, PGY-5

6/9/2020

DISCLOSURES

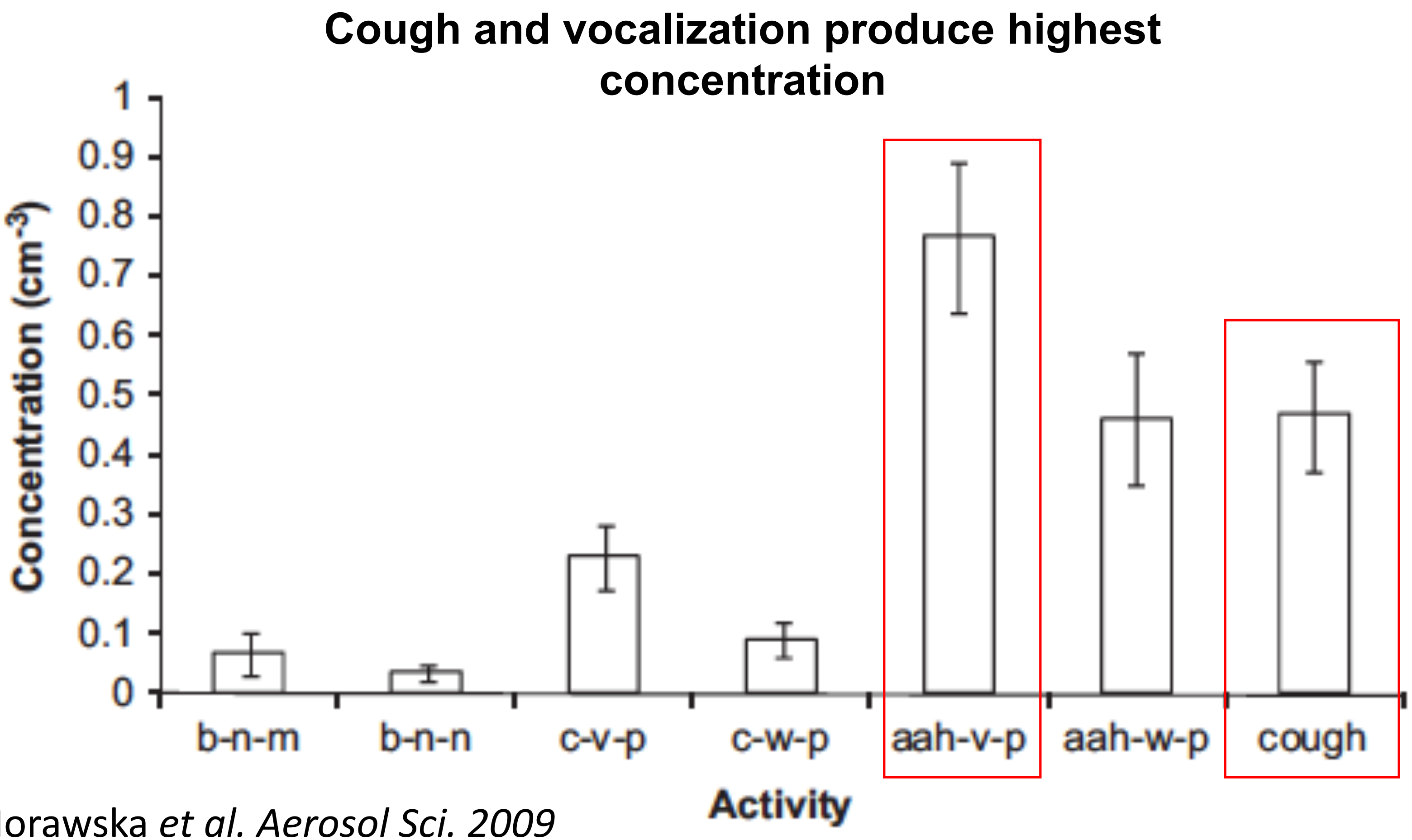
- I have no conflicts of interest
- I will only review data that has been peer reviewed

OBJECTIVES

- Review what is known about the production of respiratory particles
- Review existing evidence for the efficacy of face masks in filtering particles
- Discuss the use of masks in both the hospital setting and community setting
- Go over guidelines from major public health organizations

Respiratory Particle Production

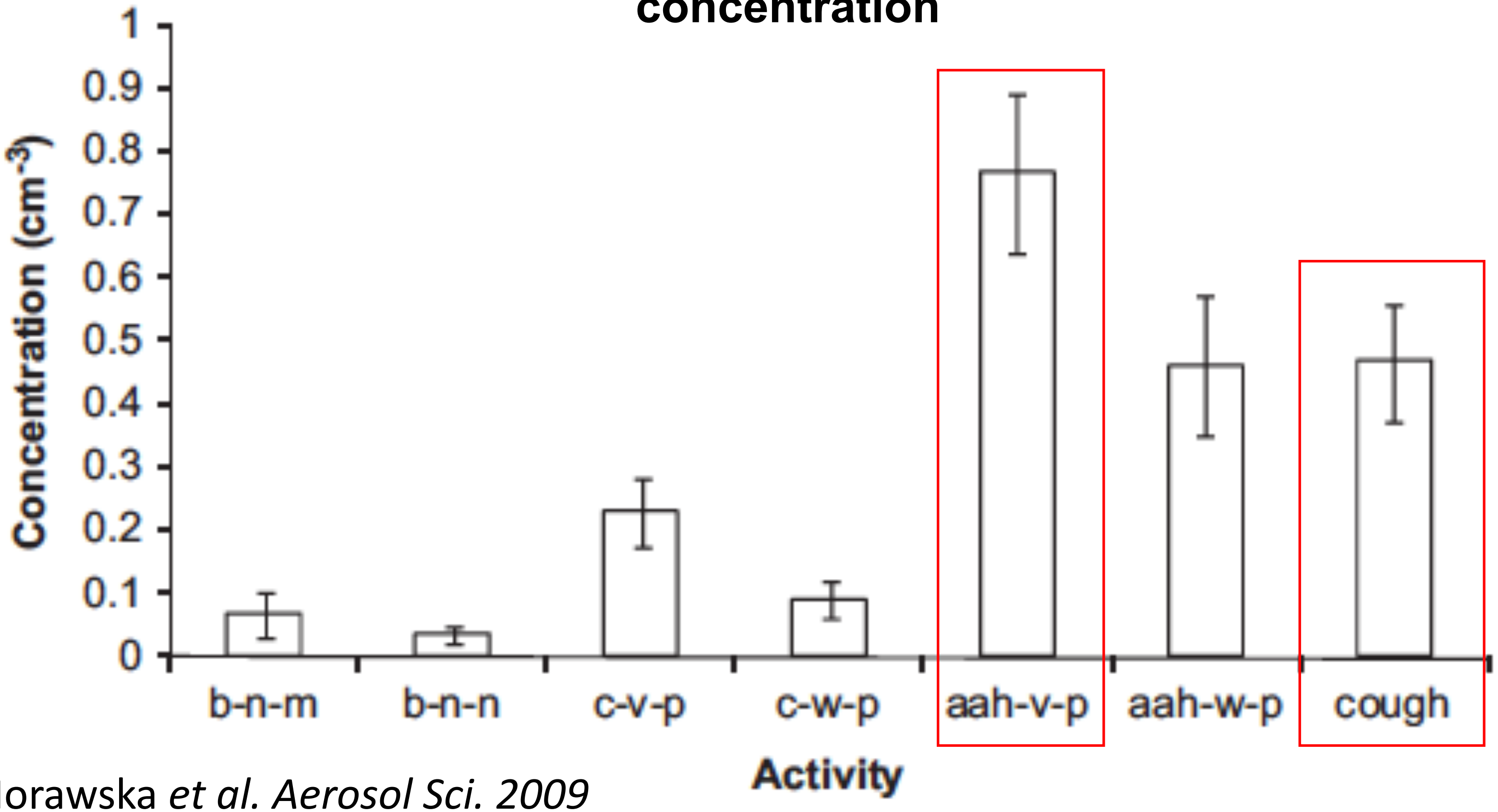
Respiratory droplet production increases with cough and vocalization



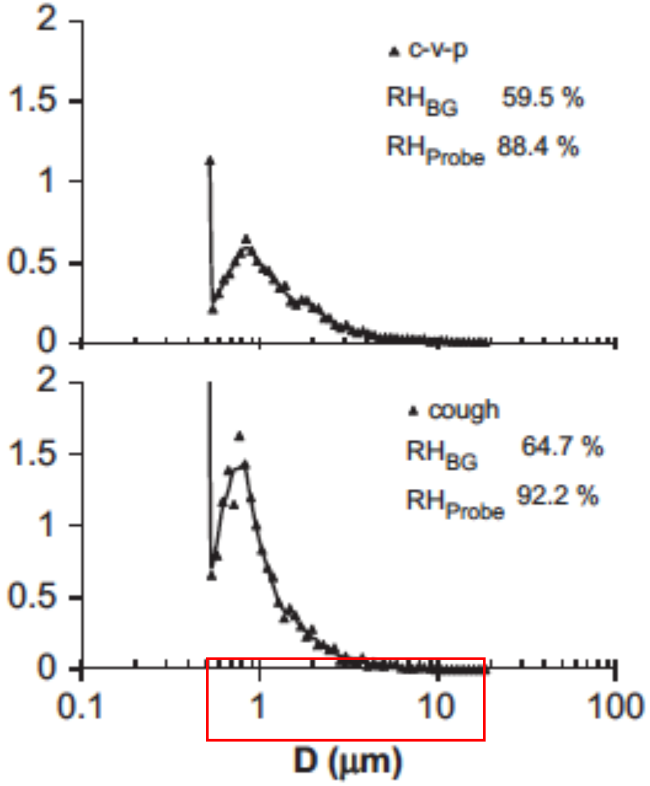
Morawska *et al. Aerosol Sci. 2009*

Respiratory droplet production increases with cough and vocalization

Cough and vocalization produce highest concentration

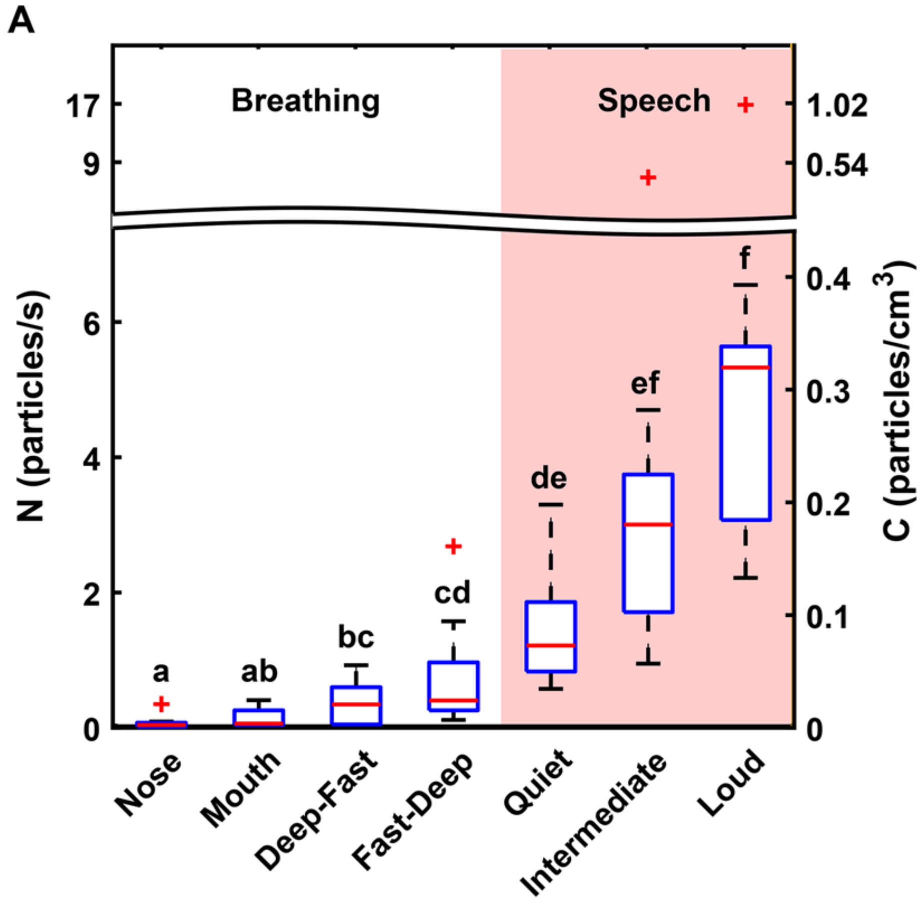


Particle Size ranged from 0.3µm to 20µm



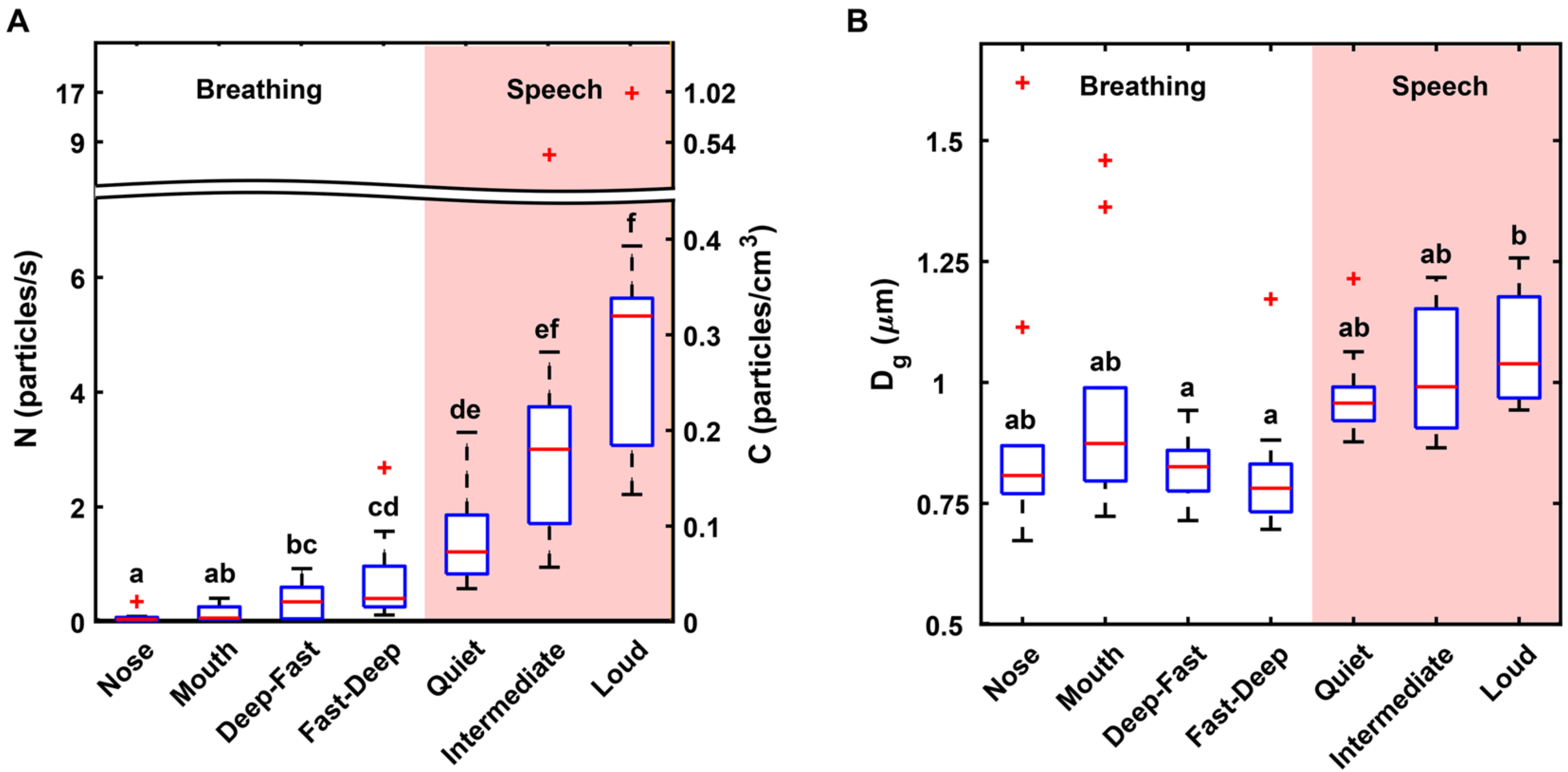
Morawska *et al. Aerosol Sci. 2009*

Particle emission increases with amplitude



Asadi *et al. Scien Reports. 2019*

Particle emission increases with amplitude



Asadi *et al. Scien Reports. 2019*

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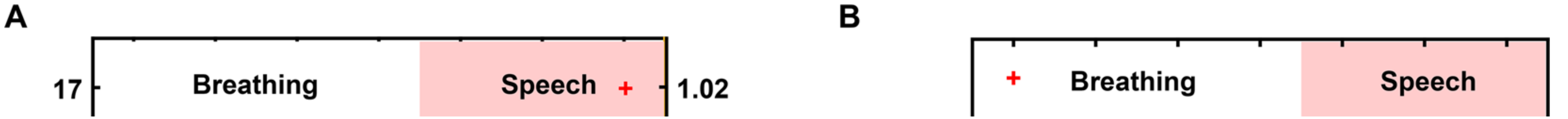
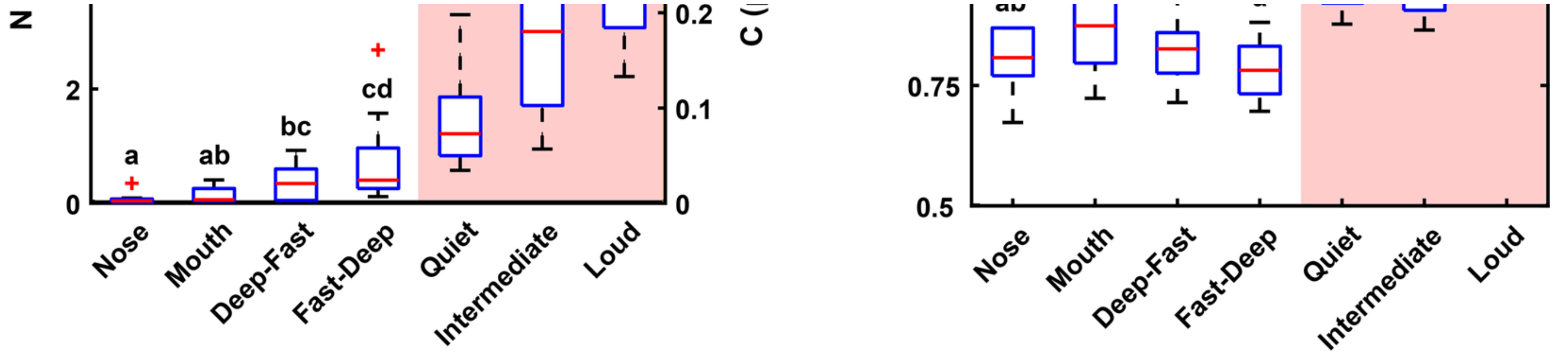


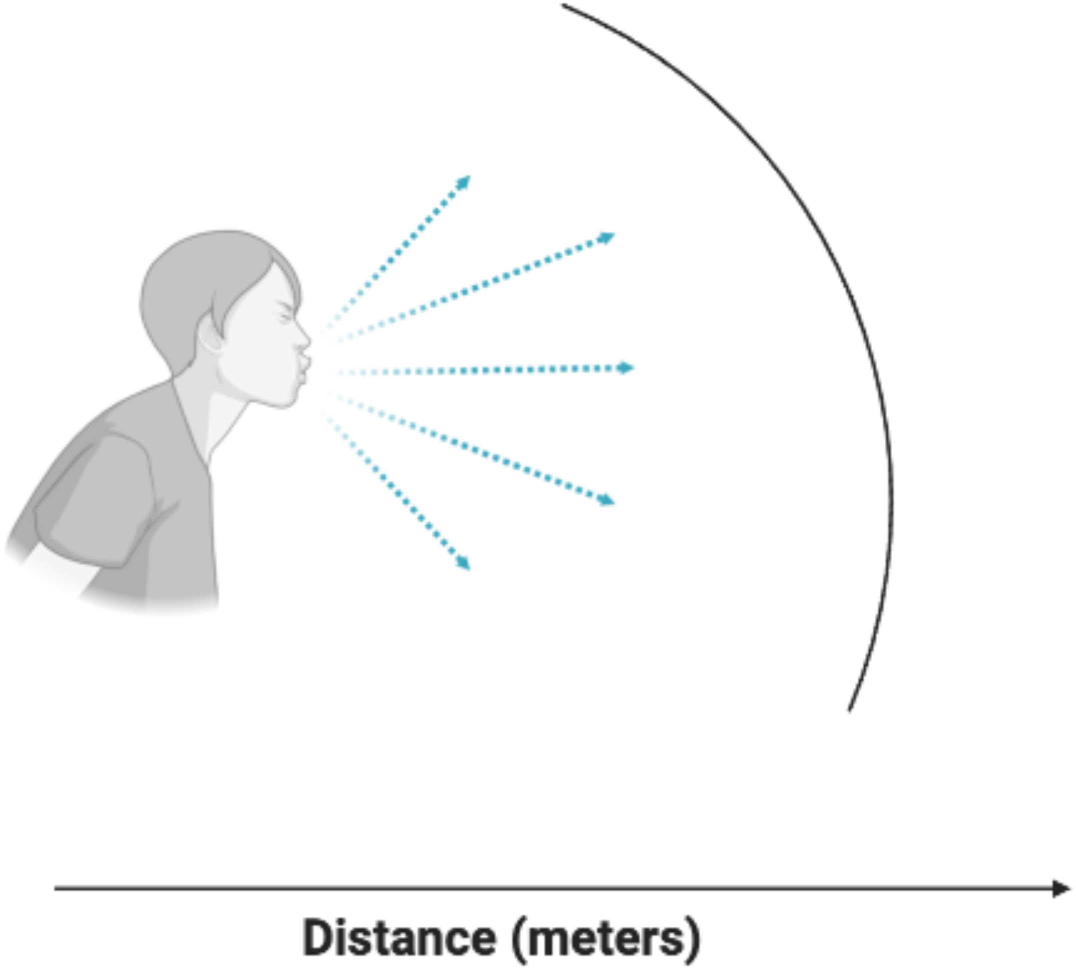
High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice — Skagit County, Washington, March 2020

Lea Hamner, MPH[1]; Polly Dubbel, MPH[1]; Ian Capron[1]; Andy Ross, MPH[1]; Amber Jordan, MPH[1]; Jaxon Lee, MPH[1]; Joanne Lynn[1]; Amelia Ball[1]; Simranjit Narwal, MSc[1]; Sam Russell[1]; Dale Patrick[1]; Howard Leibrand, MD[1]



Asadi *et al. Scien Reports. 2019*

Transmission of SARS-CoV-2



- Believed to be primarily through droplets
- May be on fomites
- Up to 86% of cases were undocumented initially[1]

[1]Li R, *et al. Science. 2020*
Image made in Biorender

Summary: Respiratory Particles

- All expiratory activity produces respiratory particles, but vocalizations and cough produce more
- The size of respiratory particles is small (~ 1μm) but wide range
- The implications are that transmission can occur without coughing or sneezing
- Droplets are thought to be the primary mode of transmission of SARS-CoV-2

Mask Filtration of Particles

Respirators and surgical masks are defined by particle size filtration

Respirators: filter 0.075µm solid particles and measured across entire mask

Respirators and surgical masks are defined by particle size filtration

Respirators: filter 0.075µm solid particles and measured across entire mask

Medical: filter 3µm droplets and measured in cross section

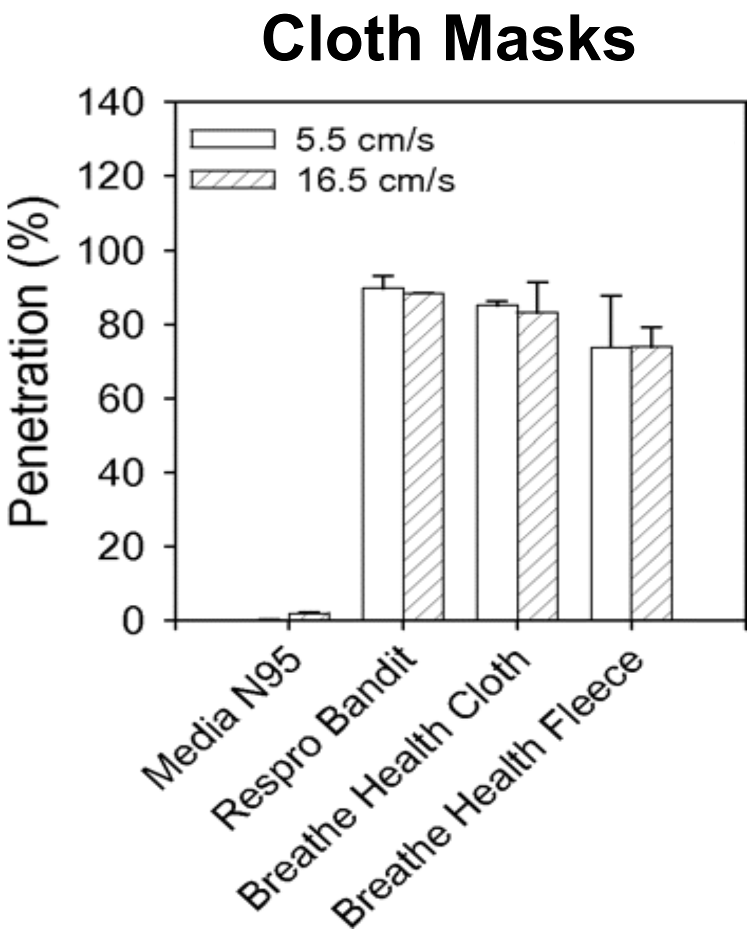
Mask type determines efficacy of particle filtration

Mask Type	Penetration (%)
Respirator (e.g. N95)	0.87%
Medical Mask (Cotton)	44.695%
General Mask (Cotton)	62.4%
Handkerchief (gauze, cotton)	97.56%

- Respiratory masks had superior protection
- Inward and outward protection was similar
- The number of layers of cotton significantly changed penetration

Jung *et al. Aeorosol and Air Quality Research.* 2014

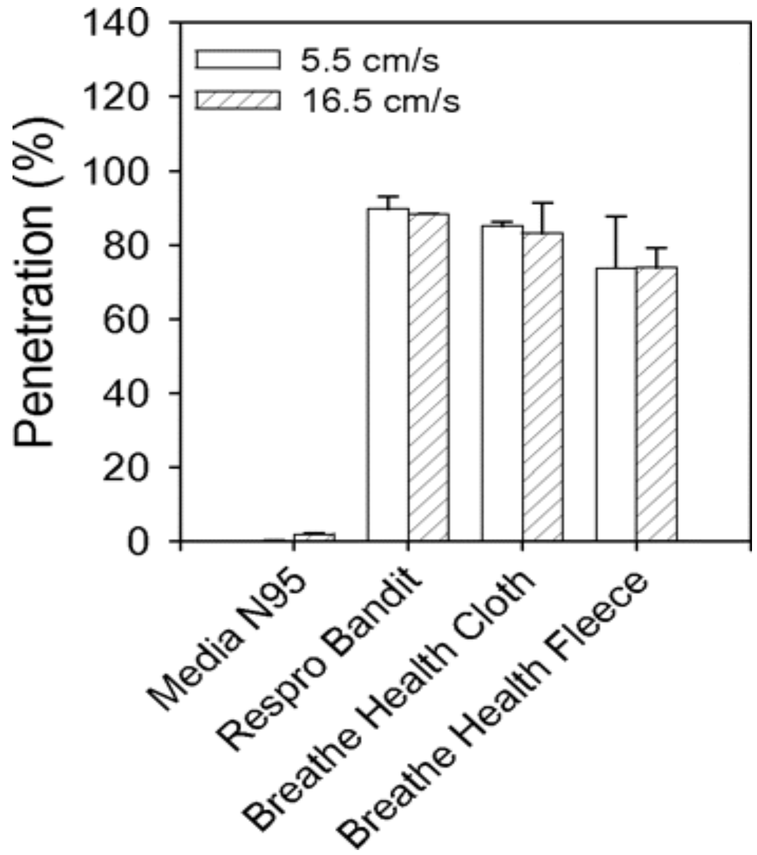
Type of material also determines efficacy of particle filtration



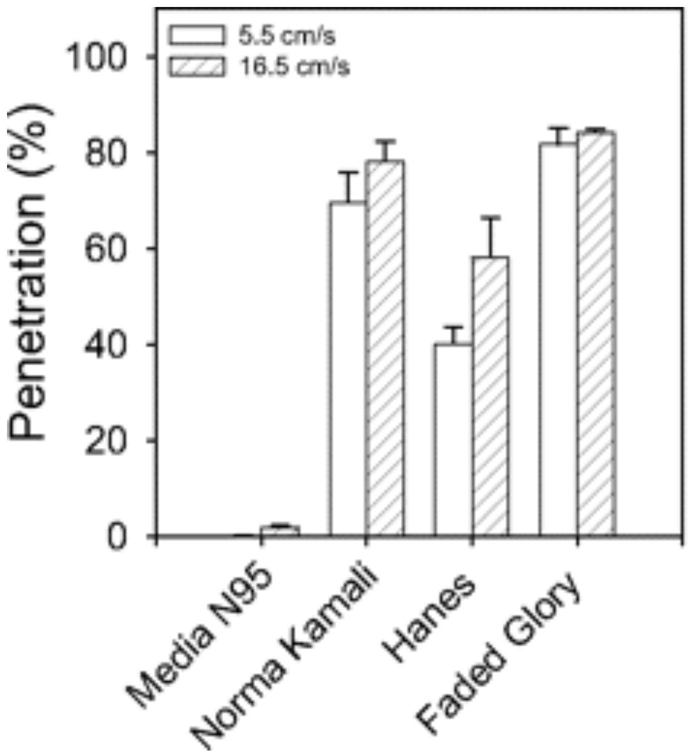
Rengasamy S, *et al. Ann Occup Hyg. 2009*

Type of material also determines efficacy of particle filtration

Cloth Masks



Sweatshirt



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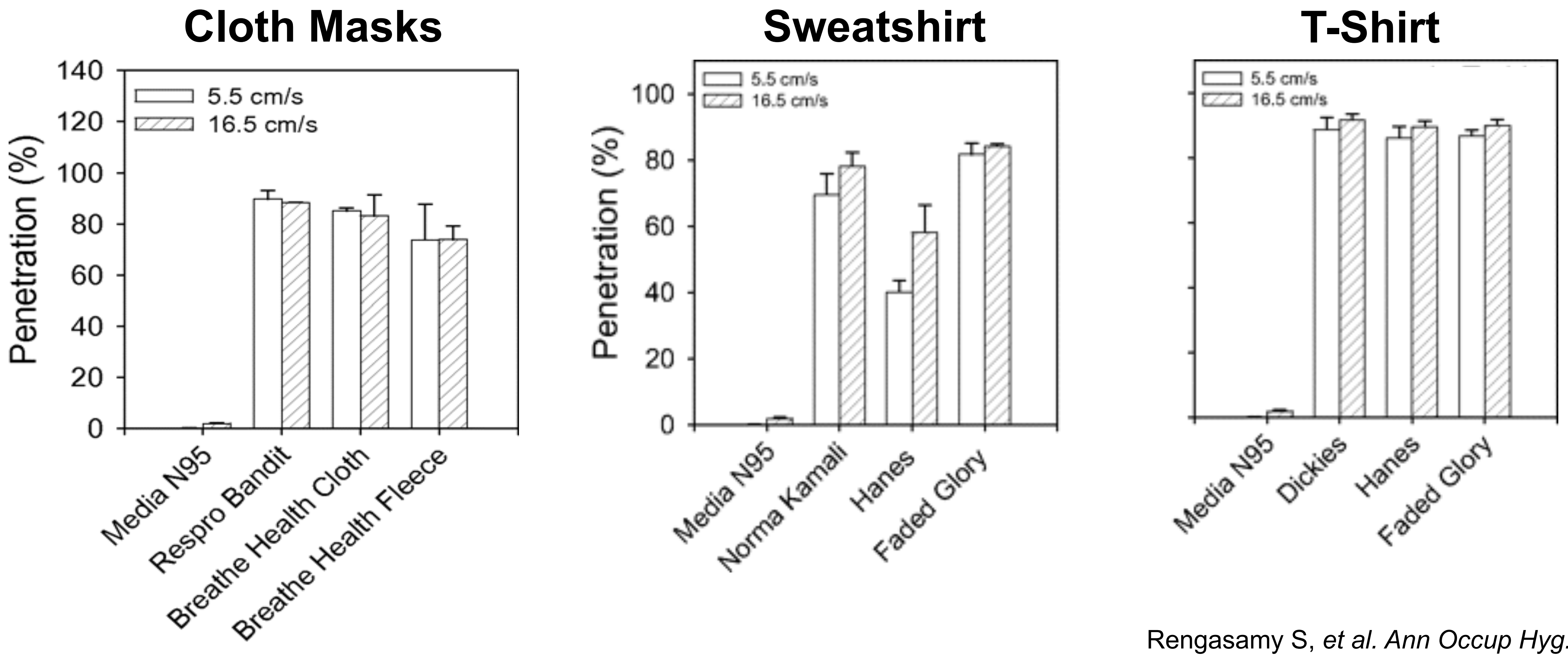
Type of material also determines efficacy of particle filtration



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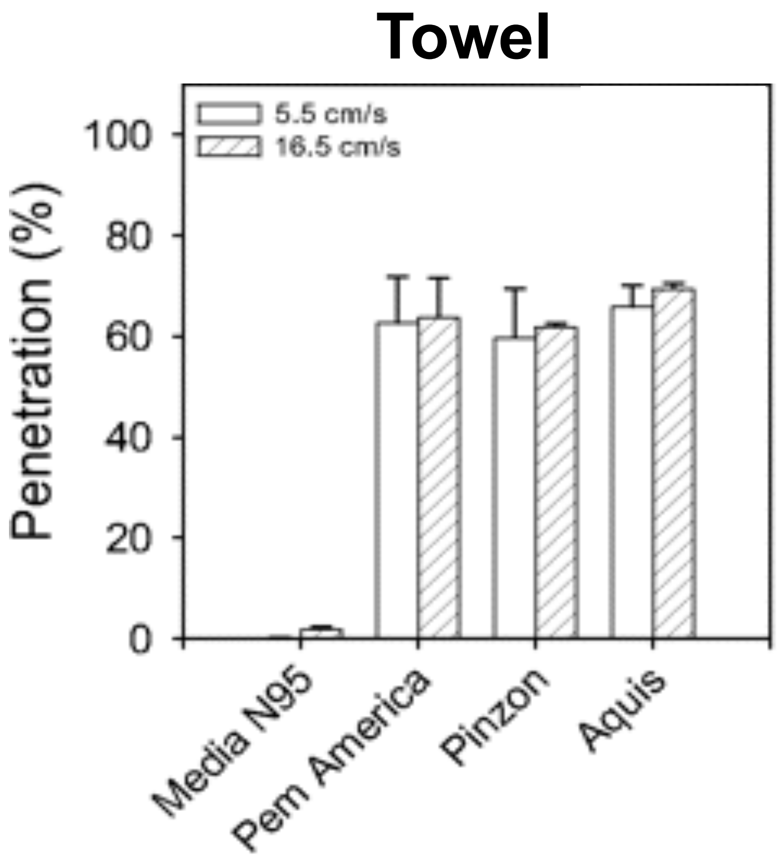
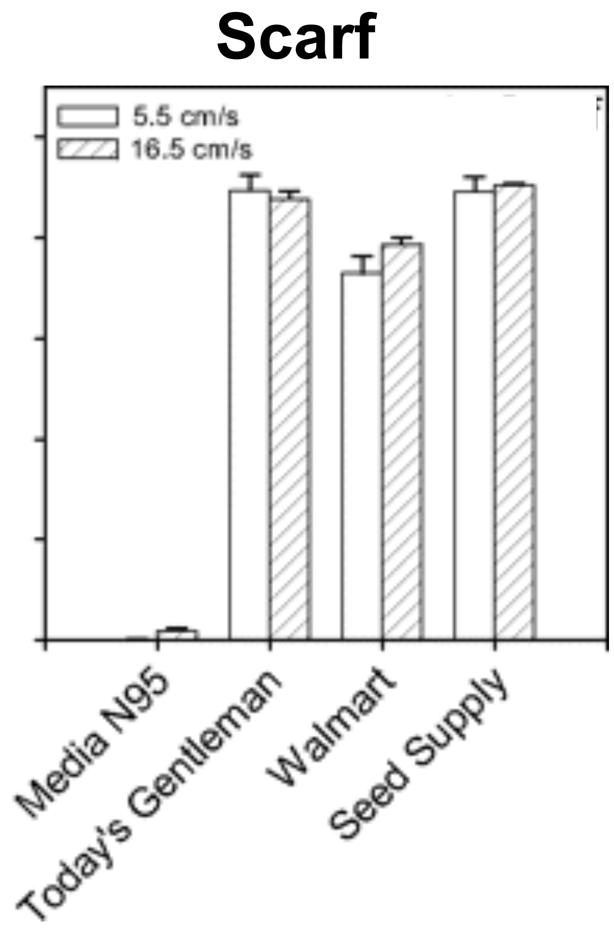




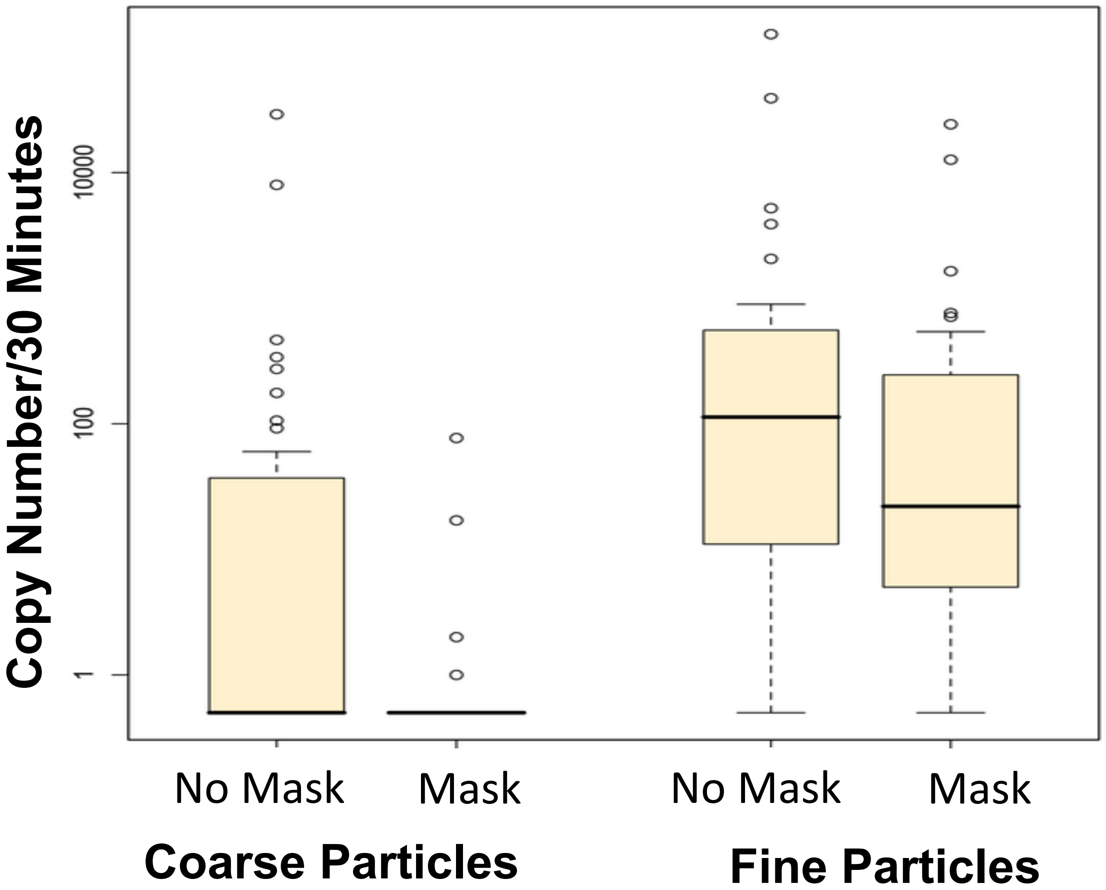
Rengasamy S, *et al. Ann Occup Hyg. 2009*

Summary: Efficacy of particle filtration

- Respirator (N95) masks offer the highest protection against particles around the size produced by respiratory exhalation
- Two important factors that influence filtration efficacy:
  - Type of material
  - Number of layers

Efficacy of masks in stopping virus particles

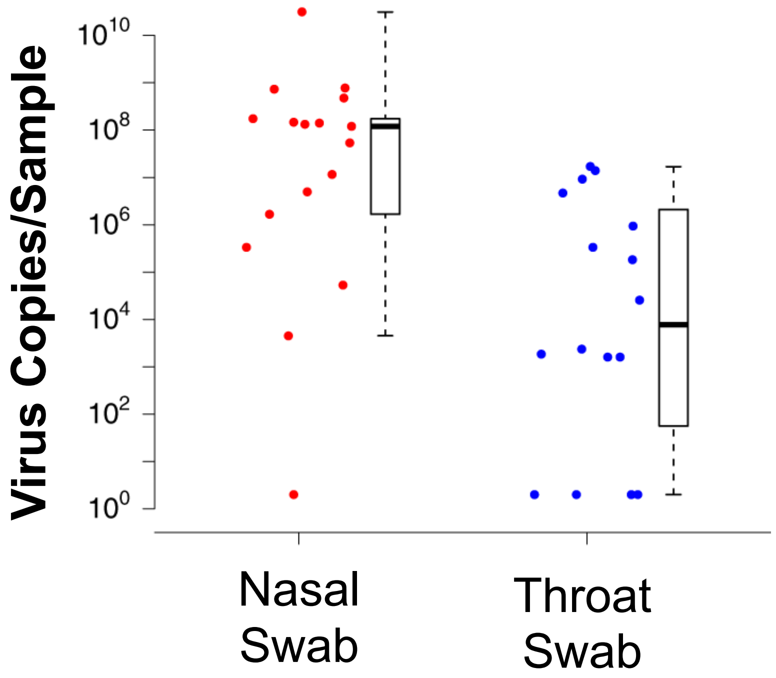
Surgical masks reduce the amount of Influenza RNA detected



- ➤ Mask use may prevent spread of Influenza

Milton *et al. PLoS Pathog. 2013*

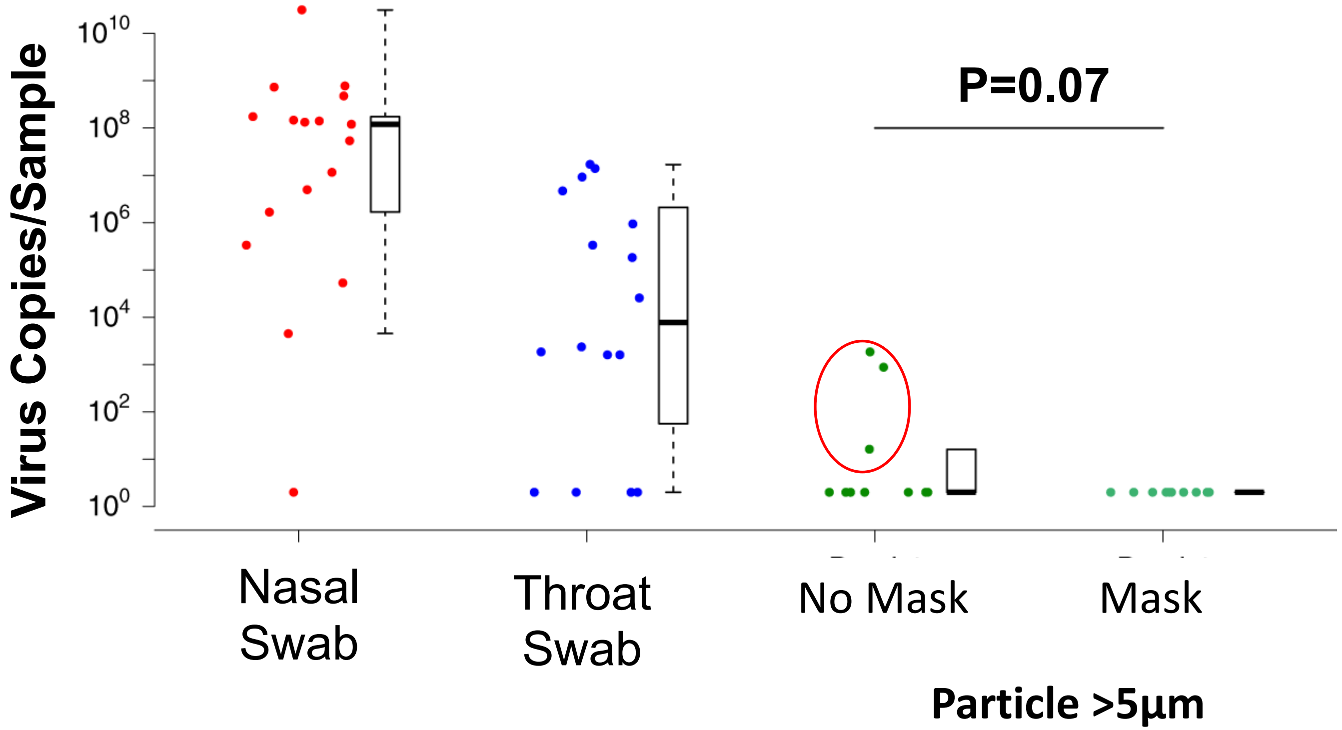
Surgical mask significantly reduced shedding of virus in coronavirus



- Viral shedding higher in nasal compared to throat swabs.

Leung *et al*. *Nat Med*. 2020

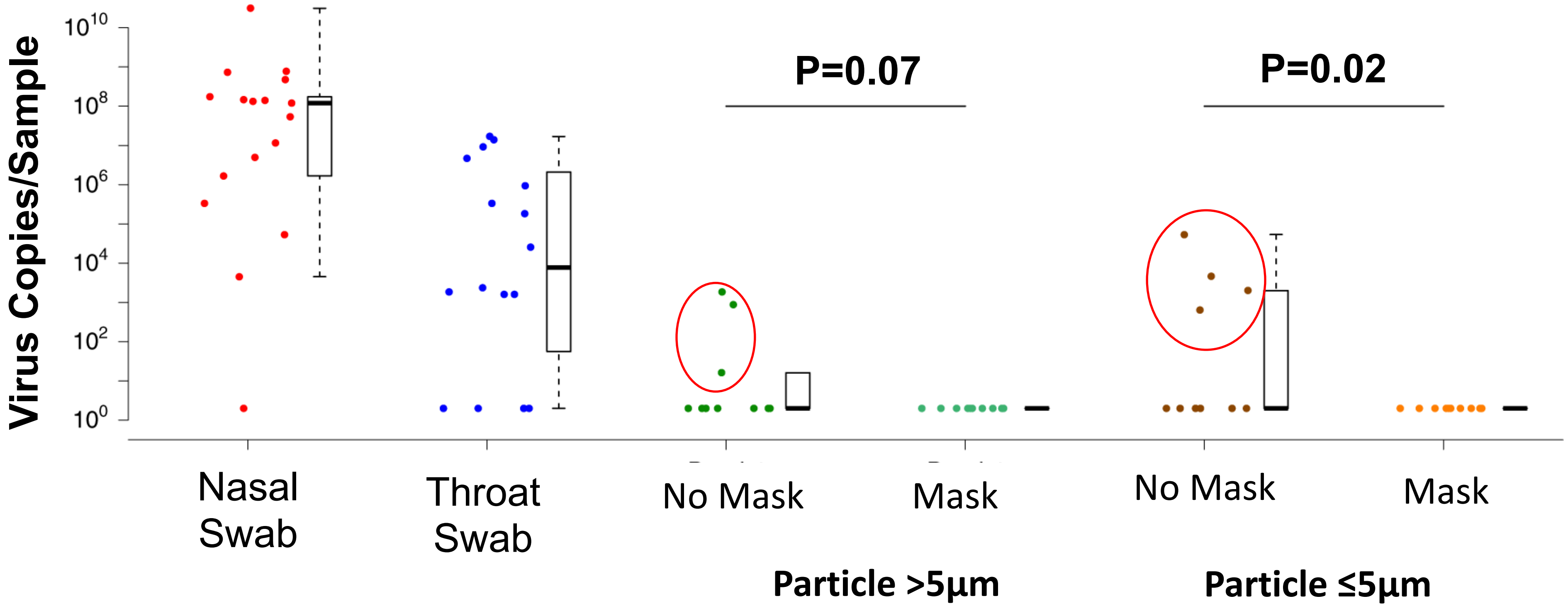
Surgical mask significantly reduced shedding of virus in coronavirus



- Masks reduce the number of samples with detectable virus in droplets

Leung *et al*. *Nat Med*. 2020

Surgical mask significantly reduced shedding of virus in coronavirus



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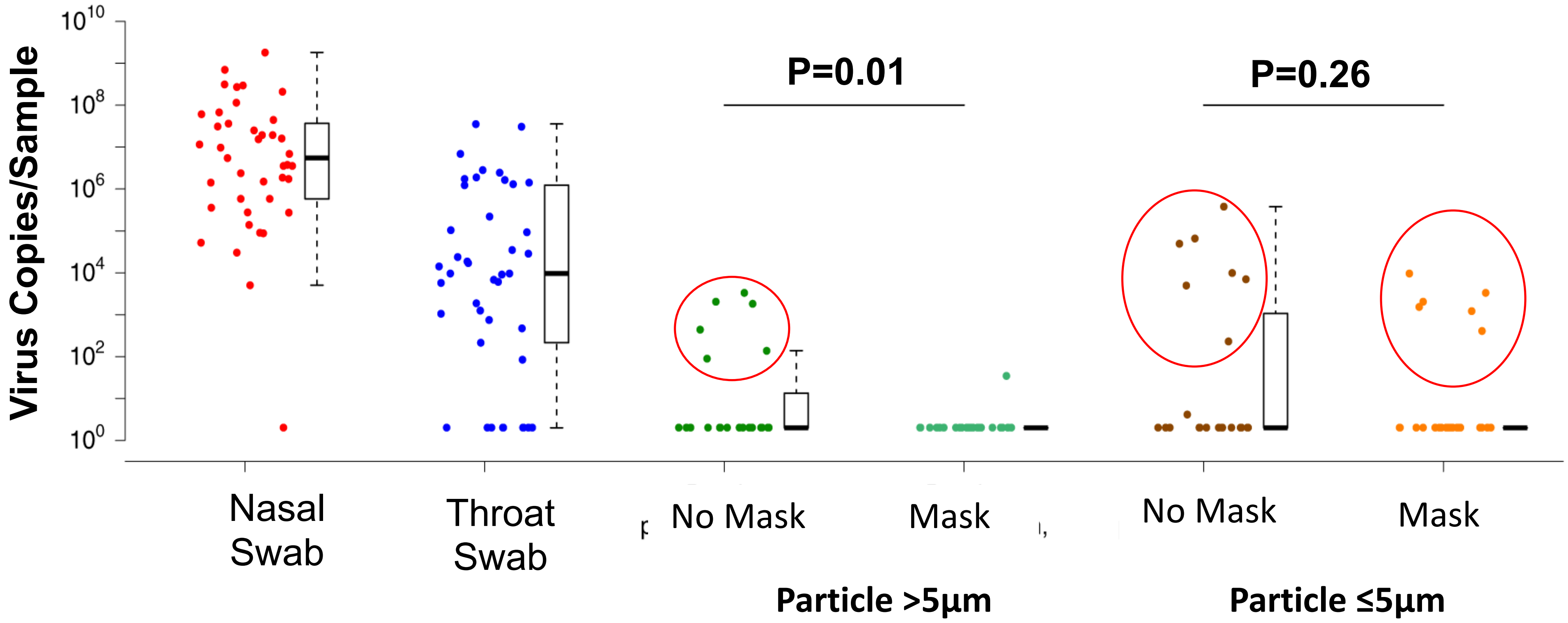
Leung *et al*. *Nat Med*. 2020

Surgical masks were maybe less effective in preventing spread of Influenza in aerosols



Leung *et al*. *Nat Med*. 2020

Key points: Mask efficacy and filtering viral RNA/DNA

- Surgical masks reduce viral RNA/DNA in larger droplets
- Masks may prevent coronavirus transmission in smaller particles as well

Evidence for mask use to prevent infections

Early use of surgical masks may reduce transmission of influenza

Study Group	Participants	RT-PCR Confirmed	Clinical
Control	279	1.00 (reference)	1.00 (reference)
Hand hygiene	257	0.57 (0.26-1.22)	0.92 (0.57-1.48)
Facemask + hand hygiene	258	0.77 (0.38-1.55)	1.25 (0.79-1.98)

- Face masks and hand hygiene interventions did not reduce rate of secondary attacks
- If intervention started < 36 hours, odd ratio of secondary attack with face mask and hand hygiene was 0.33

Cowling BJ, *et al*. *Ann Intern Med*. 2009

Face mask and hand hygiene reduced the incidence of influenza like illness

- 1,111 college students
- 1:1:1 Control, face mask, face mask + hand hygiene
- Wore face mask an average of 5 hours/day
- Did not reduce PCR proven influenza

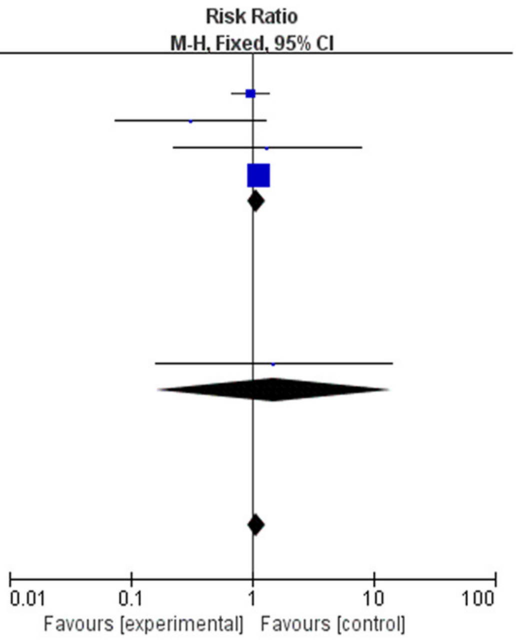
	Face Mask/Hand hygiene vs. Control			
1	0.16	0.85	(0.44–1.64)	0.62
2	0.15	0.66	(0.40–1.10)	0.11
3	0.23	0.52	(0.30–0.88)	0.02[e]
4	0.49	0.40	(0.20–0.83)	0.01[e]
5	0.82	0.32	(0.12–0.84)	0.02[e]
6	0.96	0.25	(0.07–0.87)	0.03[e]
Cumulative Rate Ratio[d]	0.42	0.78	(0.57–1.08)	0.13

Aiello AE, *et al. PLoS ONE. 2012*

There is no evidence to suggest N95 masks are better than surgical masks in preventing respiratory viral infections

…No significant difference with influenza

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 Hospital						
Loeb 2009	48	221	50	225	20.1%	0.98 [0.69, 1.39]
MacIntyre 2011	3	949	5	492	2.7%	0.31 [0.07, 1.30]
MacIntyre 2013	3	581	2	516	0.9%	1.33 [0.22, 7.94]
Radonovich 2019	207	2512	193	2668	75.9%	1.14 [0.94, 1.38]
Subtotal (95% CI)		**4263**		**3901**	**99.5%**	**1.09 [0.92, 1.28]**
Total events	261		250			
Heterogeneity: Chi² = 3.59, df = 3 (P = 0.31); I² = 17%						
Test for overall effect: Z = 0.99 (P = 0.32)						
1.1.2 Community						
MacIntyre 2009	3	186	1	94	0.5%	1.52 [0.16, 14.38]
Subtotal (95% CI)		**186**		**94**	**0.5%**	**1.52 [0.16, 14.38]**
Total events	3		1			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.36 (P = 0.72)						
Total (95% CI)		**4449**		**3995**	**100.0%**	**1.09 [0.92, 1.28]**
Total events	264		251			
Heterogeneity: Chi² = 3.68, df = 4 (P = 0.45); I² = 0%						
Test for overall effect: Z = 1.01 (P = 0.31)						
Test for subgroup differences: Chi² = 0.08, df = 1 (P = 0.77), I² = 0%						



Long Y, *et al. J Evidence-based Med.* 2020

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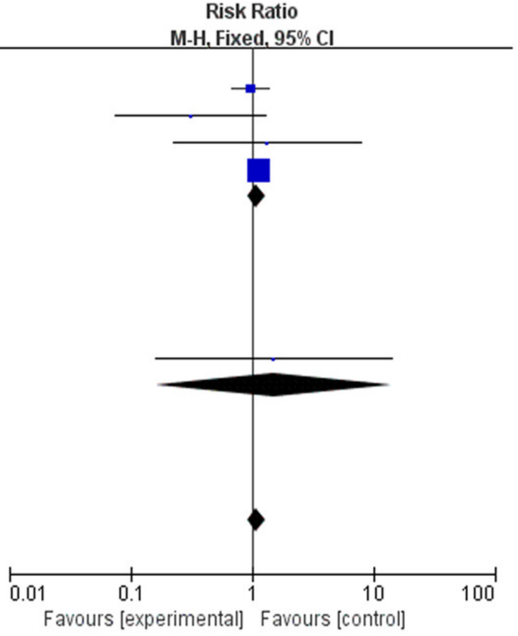
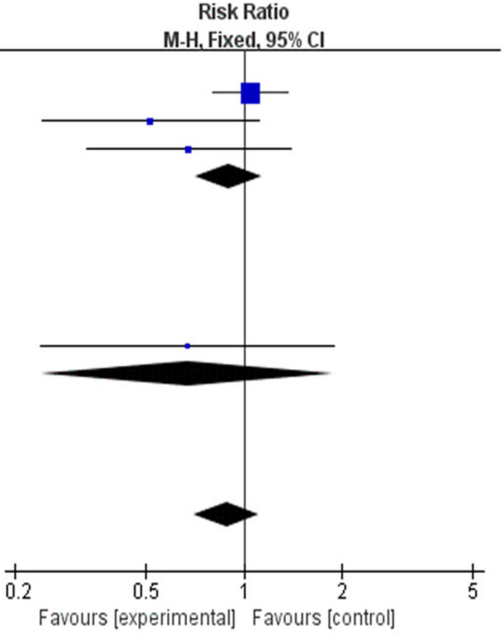


…No significant difference with respiratory viruses

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.2.1 Hospital						
Loeb 2009	76	221	74	225	63.0%	1.05 [0.81, 1.36]
MacIntyre 2011	13	949	13	492	14.7%	0.52 [0.24, 1.11]
MacIntyre 2013	13	581	17	516	15.5%	0.68 [0.33, 1.38]
Subtotal (95% CI)		**1751**		**1233**	**93.2%**	**0.90 [0.71, 1.14]**
Total events	102		104			
Heterogeneity: Chi² = 3.88, df = 2 (P = 0.14); I² = 48%						
Test for overall effect: Z = 0.87 (P = 0.39)						
1.2.2 Community						
MacIntyre 2009	8	186	6	94	6.8%	0.67 [0.24, 1.89]
Subtotal (95% CI)		**186**		**94**	**6.8%**	**0.67 [0.24, 1.89]**
Total events	8		6			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.75 (P = 0.45)						
Total (95% CI)		**1937**		**1327**	**100.0%**	**0.89 [0.70, 1.11]**
Total events	110		110			
Heterogeneity: Chi² = 4.26, df = 3 (P = 0.23); I² = 30%						
Test for overall effect: Z = 1.04 (P = 0.30)						
Test for subgroup differences: Chi² = 0.29, df = 1 (P = 0.59), I² = 0%						



Long Y, *et al. J Evidence-based Med.* 2020

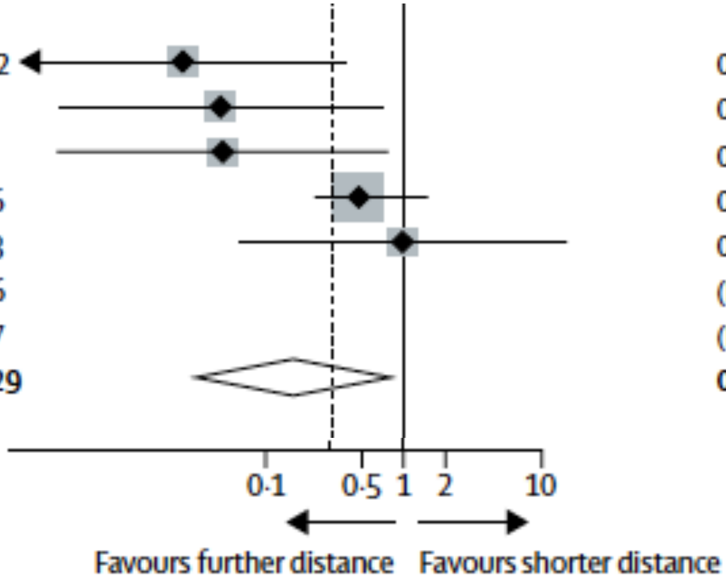
What about SARS-CoV-2?

Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis

*Derek K Chu, Elie A Akl, Stephanie Duda, Karla Solo, Sally Yaacoub, Holger J Schünemann, on behalf of the COVID-19 Systematic Urgent Review Group Effort (SURGE) study authors**

Physical distance ≥ 1 meter associated with decreased risk of transmission

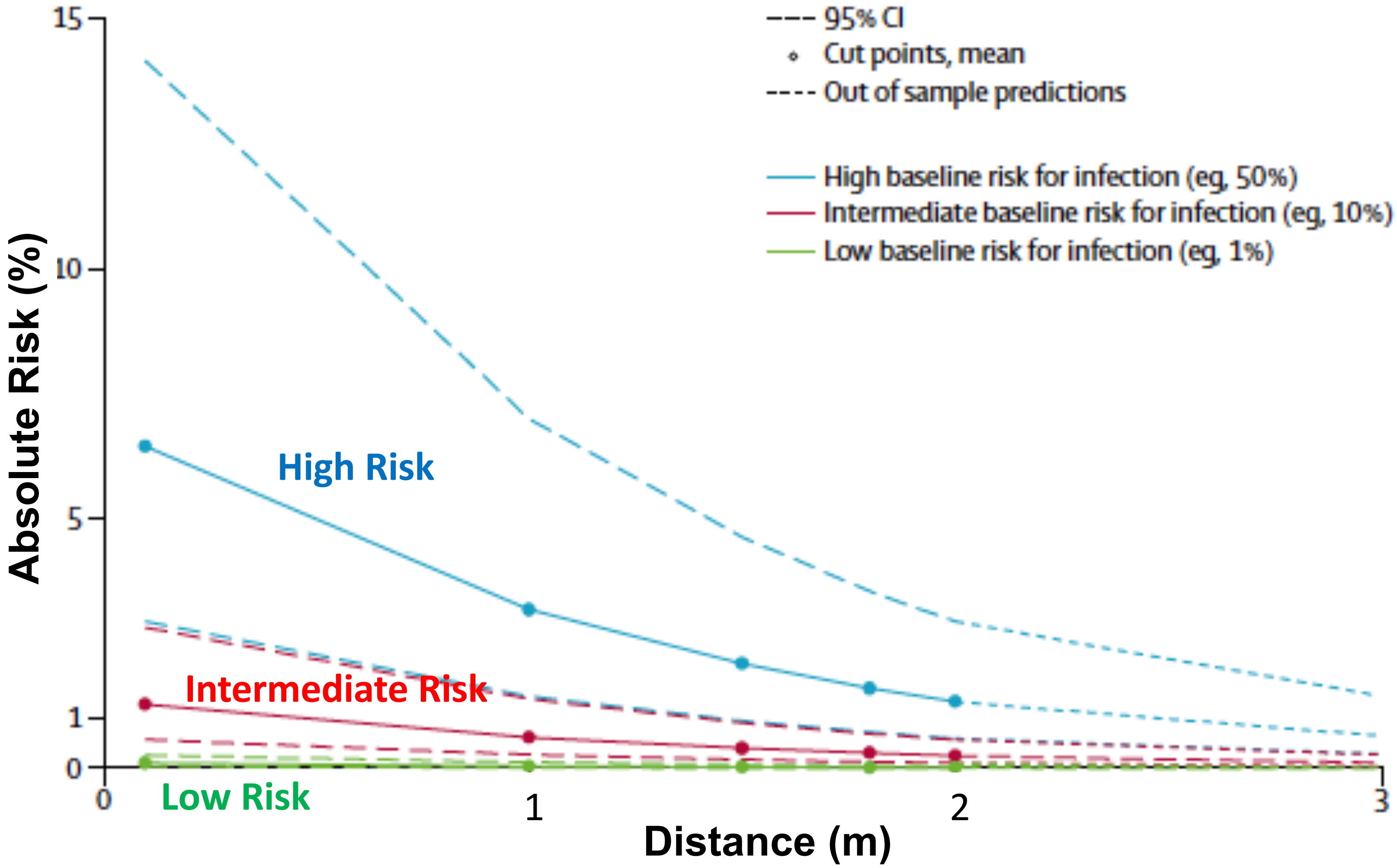
COVID-19							
Bai et al (2020)[36]	China	1	0	0/76	12/42	0·02 (0·001–0·37)	1·5
Burke et al (2020)[37]	USA	0	0	0/13	2/2	0·04 (0·003–0·68)	1·6
Liu et al (2020)[52]	China	0	1	0/17	2/3	0·04 (0·003–0·76)	1·5
Cheng et al (2020)[40]	Taiwan	0	1*	5/47	7/36	0·55 (0·19–1·58)	4·8
Heinzerling et al (2020)[44]	USA	0	1·8	0/4	3/33	0·97 (0·06–16·14)	1·5
Burke et al (2020)[37]	USA	1	0	0/50	0/76	(Not calculable)	0
Burke et al (2020)[37]	USA	0	2	0/41	0/37	(Not calculable)	0
Random, subtotal (I^2=59%)				**5/248**	**26/229**	**0·15 (0·03–0·73)**	**10·9**



- Physical distance of ≥ 1m vs < 1m had a relative risk of 0.15 (0.03-0.73)

Chu DK, *et al. Lancet.* 2020

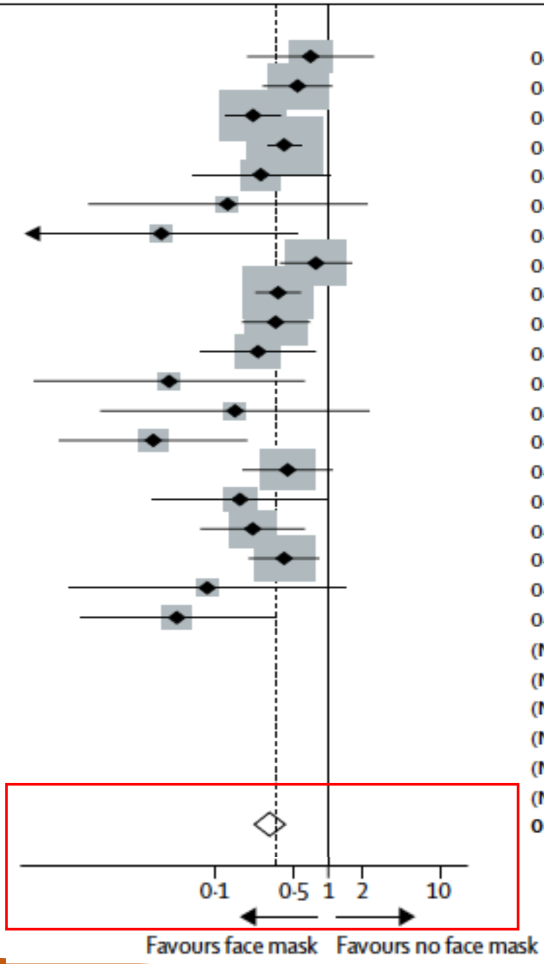
Physical distance ≥ 1 meter associated with decreased risk of transmission



Chu DK, *et al. Lancet.* 2020

Face masks prevented transmission of novel Coronavirus in healthcare settings

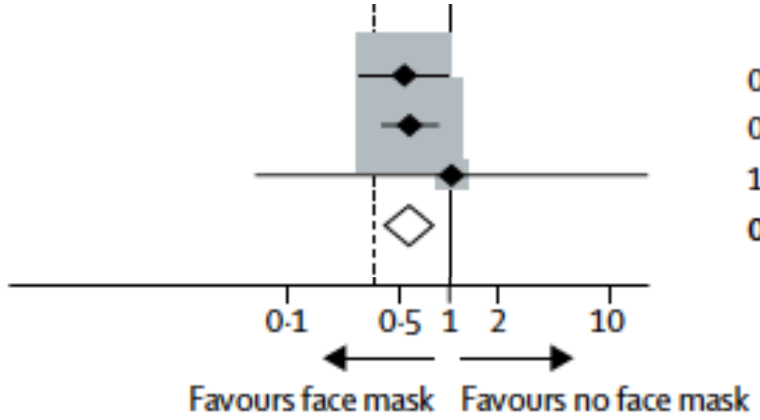
	Country	Respirator (0=no)	Infection	Events, face mask (n/N)	Events, no face mask (n/N)	RR (95% CI)
Health-care setting						
Scales et al (2003)[66]	Canada	0	SARS	3/16	4/15	0·70 (0·19–2·63)
Liu et al (2009)[51]	China	0	SARS	8/123	43/354	0·54 (0·26–1·11)
Pei et al (2006)[61]	China	0	SARS	11/98	61/115	0·21 (0·12–0·38)
Yin et al (2004)[75]	China	0	SARS	46/202	31/55	0·40 (0·29–0·57)
Park et al (2016)[59]	South Korea	0	MERS	3/24	2/4	0·25 (0·06–1·06)
Kim et al (2016)[48]	South Korea	0	MERS	0/7	1/2	0·13 (0·01–2·30)
Heinzerling et al (2020)[44]	USA	0	COVID-19	0/31	3/6	0·03 (0·002–0·54)
Nishiura et al (2005)[55]	Vietnam	0	SARS	8/43	17/72	0·79 (0·37–1·67)
Nishiyama et al (2008)[56]	Vietnam	0	SARS	17/61	14/18	0·36 (0·22–0·58)
Reynolds et al (2006)[64]	Vietnam	0	SARS	8/42	14/25	0·34 (0·17–0·69)
Loeb et al (2004)[53]	Canada	1	SARS	3/23	5/9	0·23 (0·07–0·78)
Wang et al (2020)[41]	China	1	COVID-19	0/278	10/215	0·04 (0·002–0·63)
Seto et al (2003)[67]	China	1	SARS	0/51	13/203	0·15 (0·01–2·40)
Wang et al (2020)[70]	China	1	COVID-19	1/1286	119/4036	0·03 (0·004–0·19)
Alraddadi et al (2016)[34]	Saudi Arabia	1	MERS	6/116	12/101	0·44 (0·17–1·12)
Ho et al (2004)[45]	Singapore	1	SARS	2/62	2/10	0·16 (0·03–1·02)
Teleman et al (2004)[68]	Singapore	1	SARS	3/26	33/60	0·21 (0·07–0·62)
Wilder-Smith et al (2005)[72]	Singapore	1	SARS	6/27	39/71	0·40 (0·19–0·84)
Ki et al (2019)[47]	South Korea	1	MERS	0/218	6/230	0·08 (0·005–1·43)
Kim et al (2016)[49]	South Korea	1	MERS	1/444	16/308	0·04 (0·01–0·33)
Hall et al (2014)[43]	Saudi Arabia	1	MERS	0/42	0/6	(Not calculable)
Ryu et al (2019)[65]	South Korea	1	MERS	0/24	0/10	(Not calculable)
Park et al (2004)[58]	USA	1	SARS	0/60	0/45	(Not calculable)
Peck et al (2004)[60]	USA	1	SARS	0/13	0/19	(Not calculable)
Burke et al (2020)[37]	USA	1	COVID-19	0/64	0/13	(Not calculable)
Ha et al (2004)[42]	Vietnam	1	SARS	0/61	0/1	(Not calculable)
Random subtotal (I^2=50%)				**126/3442**	**445/6003**	**0·30 (0·22–0·41)**



Chu DK, *et al. Lancet.* 2020

Face masks prevented transmission of novel Coronavirus in non-healthcare settings

Non-health-care setting						
Lau et al (2004)[50]	China	0	SARS	12/89	25/98	0·53 (0·28–0·99)
Wu et al (2004)[74]	China	0	SARS	25/146	69/229	0·57 (0·38–0·85)
Tuan et al (2007)[69]	Vietnam	0	SARS	0/9	7/154	1·03 (0·06–16·83)
Random subtotal (I^2=0%)				**37/244**	**101/481**	**0·56 (0·40–0·79)**



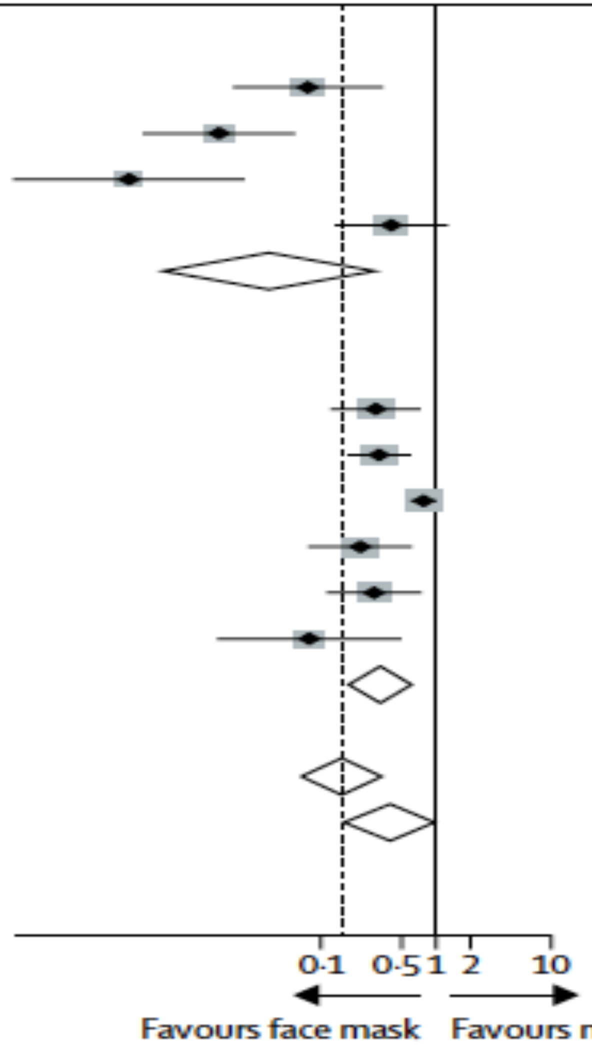
- The risk reduction was lower in non-healthcare settings compared to healthcare settings
- However, after adjustment for higher frequency of respirator use in healthcare settings, the risk reduction was similar

Chu DK, *et al. Lancet.* 2020

Respirators may be more effective than medical masks BUT more studies are needed

	Country	Virus	Setting	aOR (95% CI)	% weight (random)
N95 respirator or similar vs no face mask					
Seto et al (2003)[67]	China	SARS	Health care	0·08 (0·02–0·34)	9·0
Ma et al* (2004)[54]	China	SARS	Health care	0·01 (0·003–0·06)	8·9
Wang et al (2020)[41]	China	COVID-19	Health care	0·002 (0·000–0·02)	6·2
Alraddadi et al* (2016)[34]	Saudi Arabia	MERS	Health care	0·41 (0·13–1·26)	10·4
Random subtotal (I^2=87%)				**0·04 (0·004–0·30)**	**34·5**
Surgical face mask or similar (eg, 12–16-layer cotton) vs no face mask					
Wu et al (2004)[74]	China	SARS	Non-health care	0·30 (0·12–0·73)	11·2
Lau et al (2004)[50]	China	SARS	Non-health care	0·32 (0·17–0·61)	12·0
Yin et al (2004)[75]	China	SARS	Health care	0·78 (0·61–1·00)	12·8
Liu et al* (2009)[51]	China	SARS	Health care	0·22 (0·08–0·62)	10·8
Nishiura et al (2005)[55]	Vietnam	SARS	Health care	0·29 (0·11–0·75)	11·0
Nishiyama et al (2008)[56]	Vietnam	SARS	Health care	0·08 (0·01–0·50)	7·7
Random subtotal (I^2=76%)				**0·33 (0·17–0·61)**	**65·5**
Random overall (I^2=88%)				**0·15 (0·07–0·34)**	**100·0**
Bayesian overall (Jefferson[31] seasonal viruses)				**0·40 (0·16–0·97)**	

Interaction p=0·090; adjusted for setting, p=0·17; adjusted for AGP, p=0·048



Chu DK, *et al. Lancet.* 2020

Limitations to current studies

- Well-designed, high-quality randomized controlled trials evaluating the intervention of face masking in the community are lacking
- Most studies evaluated masking as a bundle
- Clinical vs laboratory confirmed infections may yield bias results
- Superiority of respirators contrasts to multiple previous findings of non-superiority and may be in part due to bias

Key points: Efficacy of face masks in preventing SARS-CoV-2

- There is a strong relationship between distance to infection source and risk of infection
- Face masks (both respirators and medical masks) are associated with significant reductions in risk of infection in both healthcare and non-healthcare settings
- Face masks do not replace social distancing

Government Agency Guidelines

Centers for Disease Control and Prevention

- Recommendations
  - General public over the age of 2 should wear cloth face coverings in public setting where other social distancing measures are difficult to maintain
  - Use cotton fabric (quilting, sheets, or T-shirt)

World Health Organization

- Healthcare Workers
  - Continuously wear medical masks in clinical areas when community spread is occurring
  - Respirator when performing aerosol generating procedures
- Community
  - Recommend taking into consideration the purpose of the mask, risk of COVID-19 exposure, vulnerability of population, setting, feasibility, and type of mask

World Health Organization

Situations/settings	Population	Purpose of mask use	Type of mask to consider wearing if recommended locally
Areas with known or suspected widespread transmission and limited or no capacity to implement other containment measures such as physical distancing, contact tracing, appropriate testing, isolation and care for suspected and confirmed cases.	General population in public settings, such as grocery stores, at work, social gatherings, mass gatherings, closed settings, including schools, churches, mosques, etc.	Potential benefit for source control	Non-medical mask
Settings with high population density where physical distancing cannot be achieved; surveillance and testing capacity, and isolation and quarantine facilities are limited	People living in cramped conditions, and specific settings such as refugee camps, camp-like settings, slums	Potential benefit for source control	Non-medical mask
Settings where a physical distancing cannot be achieved (close contact)	General public on transportation (e.g., on a bus, plane, trains) Specific working conditions which places the employee in close contact or potential close contact with others e.g., social workers, cashiers, servers	Potential benefit for source control	Non-medical mask

World Health Organization

Situations/settings	Population	Purpose of mask use	Type of mask to consider wearing if recommended locally
Settings where physical distancing cannot be achieved and increased risk of infection and/or negative outcomes	Vulnerable populations: • People aged ≥60 years • People with underlying comorbidities, such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease, immunosuppression	Protection	Medical mask
Any setting in the community*	Persons with any symptoms suggestive of COVID-19	Source control	Medical mask

World Health Organization

- Non-medical Masks Considerations
  - **Material type:** Polypropylene, cotton, nylon
  - **Number of layers:** minimum of 3 layers
  - **Combination of materials:** innermost (cotton) and outermost (polypropylene)
  - **Mask shape:** flat-fold or duckbill
  - **Mask Maintenance:** Worn by one person and not shared

Summary of Key Points

- Respiratory droplets are produced by all activities, but highest with vocalization, coughing, or sneezing
- Respirators have superior filtration of particles compared with surgical masks. Homemade materials (cotton e.g.) have lower filtration (0.7% to 60%)
- Face masks may stop transmission of coronavirus RNA in droplets and aerosols
- The use of face masks significantly reduced the risk of novel coronavirus infections in both health care and non-health care settings
- High-quality studies are needed

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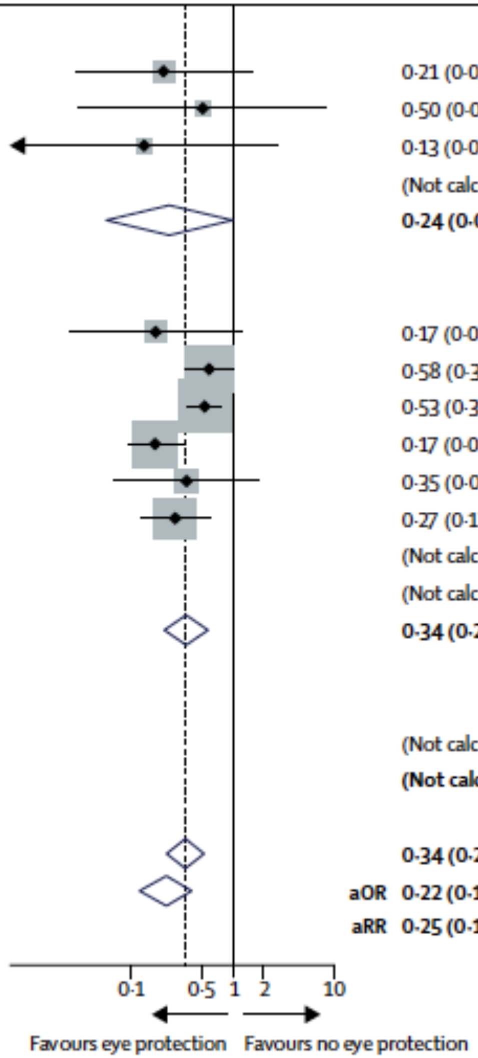
Eye protection prevented transmission of novel Coronavirus

	Country	Respirator (0=no)	Events, eye protection (n/N)	Events, no eye protection (n/N)	RR (95% CI)	% weight (random)
MERS						
Alraddadi et al (2016)[34]	Saudi Arabia	1	1/47	17/165	0·21 (0·03–1·51)	4·0
Ki et al (2019)[47]	South Korea	1	0/9	6/64	0·50 (0·03–8·21)	2·2
Kim et al (2016)[49]	South Korea	1	0/443	2/294	0·13 (0·01–2·76)	1·8
Ryu et al (2019)[65]	South Korea	1	0/24	0/10	(Not calculable)	0
Random subtotal (I^2=0%)			**1/523**	**25/533**	**0·24 (0·06–0·99)**	**8·0**
SARS						
Chen et al (2009)[39]	China	0	1/45	90/703	0·17 (0·02–1·22)	4·2
Liu et al (2009)[51]	China	0	17/221	34/256	0·58 (0·33–1·01)	21·2
Pei et al (2006)[61]	China	0	24/120	123/323	0·53 (0·36–0·77)	26·0
Yin et al (2004)[75]	China	0	10/120	67/137	0·17 (0·09–0·32)	19·4
Caputo et al (2006)[38]	Canada	1	2/46	4/32	0·35 (0·07–1·79)	5·6
Ma et al (2004)[54]	China	1	7/175	40/269	0·27 (0·12–0·59)	15·6
Park et al (2004)[58]	USA	1	0/30	0/72	(Not calculable)	0
Peck et al (2004)[60]	USA	1	0/13	0/19	(Not calculable)	0
Random subtotal (I^2=62%)			**61/770**	**358/1811**	**0·34 (0·21–0·56)**	**92·0**
COVID-19						
Burke et al (2020)[37]	USA	1	0/42	0/34	(Not calculable)	0
Random subtotal			**0/42**	**0/34**	**(Not calculable)**	**0**
Random overall (I^2=43%)			**62/1335**	**383/2378**	**0·34 (0·22–0·52)**	**100·0**
Adjusted estimates, overall (2 studies, Yin[75] and Ma[54])					**aOR 0·22 (0·12–0·39)**	
					aRR 0·25 (0·14–0·43)	

Interaction by virus, p=0·75



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