

MASKS

Effectiveness of masks at preventing transmission of respiratory pathogens:

1 T Jefferson, M Jones, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses. MedRxiv. 2020 Apr 7.

<https://www.medrxiv.org/content/10.1101/2020.03.30.20047217v2>

Meta-analysis – face masks were found to have no detectable effect against transmission of viral infections. “Compared to no masks, there was no reduction of influenza-like illness cases or influenza for masks in the general population, nor in healthcare workers.”

2 J Xiao, E Shiu, et al. Nonpharmaceutical measures for pandemic influenza in non-healthcare settings – personal protective and environmental measures. Centers for Disease Control. 26(5); 2020 May.

https://wwwnc.cdc.gov/eid/article/26/5/19-0994_article

Meta-analysis – evidence from randomised controlled trials of face masks did not support a substantial effect on transmission of laboratory-confirmed influenza, either when worn by infected persons (source control) or by persons in the general community to reduce their susceptibility.

3 J Brainard, N Jones, et al. Facemasks and similar barriers to prevent respiratory illness such as COVID19: A rapid systematic review. MedRxiv. 2020 Apr 1.

<https://www.medrxiv.org/content/10.1101/2020.04.01.20049528v1.full.pdf>

Systematic review: masks had no effect specifically against Covid-19, although facemask use seemed linked to 3 in 31 of studies “very slightly reduced” odds of developing influenza-like illness.”

4 L Radonovich M Simberkoff, et al. N95 respirators vs medical masks for preventing influenza among health care personnel: a randomized clinic trial. JAMA. 2019 Sep 3. 322(9): 824-833.

<https://jamanetwork.com/journals/jama/fullarticle/2749214>

Randomised clinical trial – 2019 – 2862 participants showed that both N95 respirators and surgical masks “resulted in no significant difference in the incidence of laboratory confirmed influenza.”

5 J Smith, C MacDougall. CMAJ. 2016 May 17. 188(8); 567-574.

<https://www.cmaj.ca/content/188/8/567>

Meta-analysis – both randomised controlled trials and observational studies of N95 respirators and surgical masks used by healthcare workers did not show benefit against transmission of acute respiratory infections. Acute respiratory transmission “may have occurred via contamination of provided respiratory protective equipment during storage and reuse of masks and respirators throughout the workday.”

6 F bin-Reza, V Lopez, et al. The use of masks and respirators to prevent transmission of influenza: a systematic review of the scientific evidence. 2012 Jul; 6(4): 257-267.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5779801/>

Meta-analysis – 17 studies regarding masks and effect on transmission of influenza found that “none of the studies established a conclusive relationship between mask/respirator use and protection against influenza action.” However, authors speculated that effectiveness of masks may be linked to early, consistent and correct usage.

7 J Jacobs, S Ohde, et al. Use of surgical face masks to reduce the incidence of the common cold among health care workers in Japan: a randomized controlled trial. Am J Infect Control. 2009 Jun; 37(5): 417-419.

<https://pubmed.ncbi.nlm.nih.gov/19216002/>

Randomised controlled trial – face mask use was found to not be protective against the common cold, compared to controls without face masks among healthcare workers.

Airflow around masks:

8 M Viola, B Peterson, et al. Face coverings, aerosol dispersion and mitigation of virus transmission risk. <https://arxiv.org/abs/2005.10720>, <https://arxiv.org/ftp/arxiv/papers/2005/2005.10720.pdf>

Original article – masks assumed to be effective in obstructing forward travel of viral particles. Those positioned next to or behind a mask wearer received farther transmission of virus-laden fluid particles from masked individuals than from unmasked individuals by means of “several leakage jets, including intense backward and downwards jets that may present major hazards,” and a “potentially dangerous leakage jet of up to several metres.” All masks were thought to reduce forward airflow by 90% or more over wearing no mask. However Schlieren imaging showed that both surgical masks and cloth masks had farther brow jets (unfiltered upward airflow past eyebrows) than not wearing any mask at all, 182mm and 203mm respectively vs none discernible with no mask. Backward unfiltered airflow was found to be strong with all masks compared to not masking.

9 S Grinshpun, H Haruta, et al. Performance of an N95 filtering facepiece particular respirator and a surgical mask during human breathing: two pathways for particle penetration. *J Occup Env Hygiene*. 2009; 6(10):593-603.

<https://www.tandfonline.com/doi/pdf/10.1080/15459620903120086>

Original article – both N95 and surgical masks, it was found that expelled particles from 0.03 to 1 micron were deflected around the edge of each mask, and that there was measurable penetration of particles through the filter of each mask.

Penetration through masks:

10 H Jung, J Kim, et al. Comparison of filtration efficiency and pressure drop in anti-yellow sand masks, quarantine masks, medical masks, general masks, and handkerchiefs. *Aerosol Air Qual Res*. 2013 Jun. 14:991-1002.

<https://aaqr.org/articles/aaqr-13-06-0a-0201.pdf>

Original study – study of 44 mask brands found mean 35.6% penetration (+34.7%). Most medical masks had over 20% penetration while “general masks and handkerchiefs had no protective function in terms of the aerosol filtration efficiency.” Findings – “medical masks, general masks and handkerchiefs were found to provide little protection against respiratory aerosols.”

11 C MacIntyre, H Seale, et al. A cluster randomized trial of cloth masks compared with medical masks in healthcare workers. *BMJ Open*. 2015; 5(4)

<https://bmjopen.bmj.com/content/5/4/e006577.long>

Randomised control trial – penetration of cloth masks by particles was almost 97% and medical masks 44%.

N95 masks:

12 N95 masks explained. <https://www.honeywell.com/us/en/news/2020/03/n95-masks-explained>

Honeywell manufactures N95 respirators. They are made with 0.3 micron filter. They are named N95 because 95% of particles having a diameter of 0.3 microns are filtered by the mask forward to the wearer by use of an electrostatic mechanism. Coronaviruses are approximately 0.125 microns in diameter. <https://pubmed.ncbi.nlm.nih.gov/32342926/>

13 V Offeddu, C Yung, et al. Effectiveness of masks and respirators against infections in healthcare workers: A systematic review and meta-analysis. *Clin Inf Dis*. 65(11), 2017 Dec 1; 1934-1942.

<https://academic.oup.com/cid/article/65/11/1934/4068747>

Meta-analysis – found that N95 respirators did not provide superior protection to facemasks against viral infections or influenza-like infections.

14 C MacIntyre, Q Wang, et al. A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers. *Influenza J*. 2010 Dec 3.

[https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1750-2659.2011.00198.x?](https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1750-2659.2011.00198.x?fbclid=IwAR3kRYVYDKb0aR-su9_me9_vY6a8KVR4HZ17J2A_80f_fxUABROdhOlc8Wo)

[fbclid=IwAR3kRYVYDKb0aR-su9_me9_vY6a8KVR4HZ17J2A_80f_fxUABROdhOlc8Wo](https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1750-2659.2011.00198.x?fbclid=IwAR3kRYVYDKb0aR-su9_me9_vY6a8KVR4HZ17J2A_80f_fxUABROdhOlc8Wo)

Randomised clinical trial – this study did find superior protection by N95 respirators when they were properly fitted (fit-tested) compared to surgical masks.

15 M Walker. Study casts doubt on N95 masks for the public. MedPage Today. 2020 May 20.
<https://www.medpagetoday.com/infectiousdisease/publichealth/86601>

Original study found that 624 out of 714 people wearing N95 masks left visible gaps when putting on their own masks. <https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2766070>

Surgical masks:

16 C MacIntyre, Q Wang, et al. A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers. Influenza J. 2010 Dec 3.

https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1750-2659.2011.00198.x?fbclid=IwAR3kRYVYDKb0aR-su9_me9_vY6a8KVR4HZ17J2A_80f_fXUABROdhOlc8Wo

Randomised clinical trial – study found that surgical masks offered no protection at all against influenza.

17 N Shimasaki, A Okaue, et al. Comparison of the filter efficiency of medical nonwoven fabrics against three different microbe aerosols. Biocontrol Sci. 2018; 23(2). 61-69.

https://www.jstage.jst.go.jp/article/bio/23/2/23_61/_pdf-char/en

Original article – surgical masks had about 85% penetration ratio of aerosolised inactivated influenza particles and about 90% of *Staphylococcus aureus* bacterial although the *S. aureus* particles were about 6x the diameter of influenza particles.

18 T Tunevall. Postoperative wound infections and surgical face masks: A controlled study. World J Surg. 1991 May; 15: 383-387.

<https://link.springer.com/article/10.1007%2FBF01658736>

Original article – use of masks in surgery were found to slightly INCREASE incidence of infection over not masking in a study of 3088 surgeries. The surgeons' masks were found to give no protective effect to the patients.

19 N Orr. Is a mask necessary in the operating theatre? Ann Royal Coll Surg Eng 1981; 63: 390-392.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2493952/pdf/annrcse01509-0009.pdf>

Original article – no difference in wound infection rates with and without surgical masks.

20 N Mitchell, S Hunt. Surgical face masks in modern operating rooms – a costly and unnecessary ritual? J Hosp Infection. 18(3); 1991 Jul 1. 239-242.

[https://www.journalofhospitalinfection.com/article/0195-6701\(91\)90148-2/pdf](https://www.journalofhospitalinfection.com/article/0195-6701(91)90148-2/pdf)

Original article – no difference in wound infection rates with and without surgical masks.

21 C DaZhou, P Sivathondan, et al. Unmasking the surgeons: the evidence base behind the use of facemasks in surgery. JR Soc Med. 2015 Jun; 108(6): 223-228.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4480558/>

Systematic review – “there is a lack of substantial evidence to support claims that facemasks protect either the patient or surgeon from infectious contamination.”

22 L Brosseau, M Sietsema. Commentary: Masks for all for Covid-19 not based on sound data. U Minn Ctr Inf Dis Res Pol. 2020 Apr 1.

<https://www.cidrap.umn.edu/news-perspective/2020/04/commentary-masks-all-covid-19-not-based-sound-data>

Comentary – medical masks have a wide range of filtration efficiency, with most showing a 30% to 50% efficiency.

23 N Leung, D Chu, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks Nature Research. 2020 Mar 7. 26,676-680 (2020).

<https://www.researchsquare.com/article/rs-16836/v1>

Original article – both experimental and control groups, masked and unmasked respectively, were found to “not shed detectable virus in respiratory droplets or aerosols.” The study “did not confirm the infectivity of coronavirus” as found in exhaled breath.

24 S Rengasamy, B Eimer, et al. Simple respiratory protection – evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles. Ann Occup Hyg. 2010 Oct; 54(7): 789-798.

<https://academic.oup.com/annweh/article/54/7/789/202744>

Original article – study of aerosol penetration showed that two of the five surgical masks studied had 51% to 89% penetration of polydisperse aerosols.

25 S Bae, M Kim, et al. Effectiveness of surgical and cotton masks in blocking SARS-CoV-2: A controlled comparison in 4 patients. Ann Int Med. 2020 Apr 6.

<https://www.acpjournals.org/doi/10.7326/M20-1342>

Original article – observed subjects while coughing, “neither surgical nor cotton masks effectively filtered SARS-CoV-2 during coughs by infected patients.” More viral particles were found on the outside than on the inside of masks tested.

Cloth masks:

26 S Rengasamy, B Eimer, et al. Simple respiratory protection – evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles. Ann Occup Hyg. 2010 Oct; 54(7): 789-798.

<https://academic.oup.com/annweh/article/54/7/789/202744>

Original article – cloth masks were found to have low efficiency for blocking particles of 0.3 microns and smaller. Aerosol penetration through the various cloth masks examined in the study were between 74 and 90%. Likewise, the filtration efficiency of fabric materials was 3% to 33%.

27 C MacIntyre, H Seale, et al. A cluster randomized trial of cloth masks compared with medical masks in healthcare workers. BMJ Open. 2015; 5(4)

<https://bmjopen.bmj.com/content/5/4/e006577.long>

Randomised controlled trial – healthcare workers wearing cloth masks were found to have 13 times the risk of influenza-like illness than those wearing medical masks.

28 W Kellogg. An experimental study of the efficacy of gauze face masks. Am J Pub Health. 1920. 34-42.

<https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.10.1.34>

Original article – 1920 – analysis of cloth mask use during the 1918 pandemic examines the failure of masks to impede or stop flu transmission at that time. Concluded that the number of layers of fabric required to prevent pathogen penetration would have required a suffocating number of layers, and could not be used for that reason, as well as the problem of leakage vents around the edges of cloth masks.

Masks against Covid-19:

29 M Klompas, C Morris, et al. Universal masking in hospitals in the Covid-19 era. N Eng J Med. 2020; 382 e63.

<https://www.nejm.org/doi/full/10.1056/NEJMp2006372>

Editorial New England Journal of Medicine – “we know that wearing a mask outside health care facilities offers little, if any, protection from infection. Public health authorities define a significant exposure to Covid-19 as face-to-face contact within 6 feet with a patient with symptomatic Covid-19 that is sustained for at least a few minutes (and some say more than 10 minutes or even 20 minutes). The chance of catching Covid-19 from a passing interaction in a public space therefore is minimal. In many cases, the desire for widespread masking is a reflexive reaction to anxiety over the pandemic.”

SAFETY OF MASKS

During walking or other exercise

30 E Person, C Lemercier et al. Effect of a surgical mask on six minute walking distance. *Rev Mal Respir.* 2018 Mar; 35(3):264-268.

<https://pubmed.ncbi.nlm.nih.gov/29395560/>

Randomised controlled trial – surgical mask wearers had significantly increased dyspnea after a 6 minute walk than non-mask wearers.

31 B Chandrasekaran, S Fernandes. Exercise with facemask; are we handling a devil's sword – a physiological hypothesis. *Med Hypotheses.* 2020 Jun 22. 144:110002.

<https://pubmed.ncbi.nlm.nih.gov/32590322/>

Physiological Hypothesis – concern about possible burden of facemasks during physical activity on pulmonary, circulatory and immune systems, due to oxygen reduction and air trapping reducing substantial carbon dioxide exchange. As a result of hypercapnia, there may be a cardiac overload, renal overload and a shift to metabolic acidosis.

Risks of N95 respirators:

32 P Shuang Ye Tong, A Sugam Kale, et al. Respiratory consequences of N95-type mask usage in pregnant healthcare workers – A controlled clinical study. *Antimicrob Resist Infect Control.* 2015 Nov 16; 4:48.

<https://pubmed.ncbi.nlm.nih.gov/26579222/>

Controlled clinical trial – Pregnant healthcare workers were found to have a loss in volume of oxygen consumption by 13.8% compared to controls when wearing N95 respirators. 17.7% less carbon dioxide was inhaled.

33 T Kao, K Huang, et al. The physiological impact of wearing an N95 mask during hemodialysis as a precaution against SARS in patients with end-stage renal disease. *J Formos Med Assoc.* 2004 Aug; 103(8):624-628.

<https://pubmed.ncbi.nlm.nih.gov/15340662/>

Original article – patients with end stage renal disease were studied during use of N95 respirators. Their partial pressure of oxygen (PaO₂) decreased significantly compared to controls and increased respiratory adverse effects. 19% of the patients developed various degrees of hypoxemia while wearing the masks.

34 F Blachere, W Lindsley et al. Assessment of influenza virus exposure and recovery from contaminated surgical masks and N95 respirators. *J Viro Methods.* 2018 Oct; 260:98-106.

<https://pubmed.ncbi.nlm.nih.gov/30029810/>

Original article – healthcare workers' N95 respirators were measured by personal bioaerosol samplers to harbour influenza virus.

35 A Rule, O Apau, et al. Healthcare personnel exposure in an emergency department during influenza season. *PLoS One.* 2018 Aug 31; 13(8): e0203223.

<https://pubmed.ncbi.nlm.nih.gov/30169507/>

Original article – 25% of healthcare workers' facepiece respirators were found to contain influenza in an emergency department during the 2015 flu season.

Risk of surgical masks:

36 F Blachere, W Lindsley et al. Assessment of influenza virus exposure and recovery from contaminated surgical masks and N95 respirators. *J Viro Methods*. 2018 Oct; 260:98-106.
<https://pubmed.ncbi.nlm.nih.gov/30029810/>

Original article – healthcare workers’ surgical masks were measured by personal bioaerosol samplers to harbour for influenza virus.

37 A Chughtai, S Stelzer-Braid, et al. Contamination by respiratory viruses on our surface of medical masks used by hospital healthcare workers. *BMC Infect Dis*. 2019 Jun 3; 19(1): 491.
<https://pubmed.ncbi.nlm.nih.gov/31159777/>

Original clinical study – various respiratory pathogens were found on the outer surface of used medical masks, which could result in self-contamination. The risk was found to be higher with the longer duration of mask use.

38 L Zhiqing, C Yongyun, et al. *J Orthop Translat*. 2018 Jun 27; 14:57-62.
<https://pubmed.ncbi.nlm.nih.gov/30035033/>

Original article – surgical masks were found to be a repository of bacterial contamination. The source of the bacterial was determined to be the body surface of the surgeons, rather than the operating room environment. Given that surgeons are gowned from head to foot for surgery, this finding should be especially concerning for the general public who wear masks. Without the protective outfits of surgeons, the general public have even more exposed body surface to serve as a source for bacteria to collect on their masks.

Risks of cloth masks:

39 C MacIntyre, H Seale, et al. A cluster randomized trial of cloth masks compared with medical masks in healthcare workers. *BMJ Open*. 2015; 5(4)
<https://bmjopen.bmj.com/content/5/4/e006577>

Randomised controlled trial – healthcare workers wearing cloth masks had significantly higher rates of influenza-like illness after four weeks of continuous on-the-job use, when compared to controls (medical masks)

40 A Beder, U Buyukkocak, et al. Preliminary report on surgical mask induced deoxygenation during major surgery. *Neurocirugia*. 2008; 19: 121-126.
<https://scielo.isciii.es/pdf/neuro/v19n2/3.pdf>

Longitudinal and observational study – increased rate of infection in mask-wearers may be due to a weakening of immune function during mask use. Surgeons were found to have lower oxygen saturation after surgeries even as short as 30 minutes.

41 D Lukashev, B Klebanov, et al. Cutting edge: Hypoxia-inducible factor 1-alpha and its activation-inducible short isoform negatively regulate functions of CD4+ and CD8+ T lymphocytes. *J Immunol*. 2006 Oct 15; 177(8) 4962-4965.
<https://www.jimmunol.org/content/177/8/4962>

Animal study – low oxygen induces hypoxia-inducible factor 1 alpha (HIF-1).

42 A Sant, A McMichael. Revealing the role of CD4+ T-cells in viral immunity. *J Exper Med*. 2012 Jun 30; 209(8):1391-1395.
<https://europepmc.org/article/PMC/3420330>

Review – low oxygen and induction of HIF-1 down regulates CD4+ T-cells. CD4+ T-cells are necessary for viral immunity.