Are cloth masks effective in preventing COVID-19 infections?

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This rapid review summarizes the available evidence on the efficacy and safety of cloth masks/ non-medical masks in preventing COVID-19 infection. This may change as new evidence emerges.

KEY FINDINGS

There is no direct evidence on the effectiveness of cloth masks in preventing COVID-19 infections among healthcare workers or the general public. Indirect evidence suggest that although cloth masks may be as effective as medical masks in containing droplets, they have poor filtration efficiencies and are associated with higher risks for developing respiratory infections.

- Wearing non-medical masks or cloth face coverings appear to be one pragmatic method to protect the public against respiratory infections, but its effectiveness in preventing COVID-19 remains unclear.
- We found no clinical trials or observational studies directly evaluating the effectiveness of cloth masks in preventing COVID-19 infection among healthcare workers or the general public.
- Indirect evidence from one cluster randomized controlled trial with fair methodological quality showed that wearing two-layered cotton masks compared to medical masks increased the risk of developing influenza-like illness and rhinoviruses among healthcare workers.
- There is also indirect evidence from mechanistic studies that cloth masks, especially if double-layered, may be at least as effective as medical masks in preventing environmental droplet contamination and reducing ejection of micro-droplets.
- Although generally not effective in blocking aerosols, cloth masks offered some protection against larger particles. Filtration efficiencies were higher in cloth masks that are non-woven, well-fit, double-layered (or with multiple layers of kitchen paper).
- WHO had no specific recommendations on the use of non-medical masks for the general public while USA, Canada, some European and Asian countries advised the public to wear cloth face coverings in public settings where social distancing measures are difficult to maintain.

RESULTS

We found no completed or on-going clinical trials specifically assessing the efficacy of cloth masks in preventing COVID-19 infection. In this rapid review, **all included studies [5-12]** to determine its effectiveness **were considered indirect evidence** because they were not done for COVID-19. Therefore, the results should be taken with caution.

A cluster randomized controlled trial **[5]** with fair methodological quality showed that wearing two-layered cotton masks compared to medical masks increased the risk of developing influenza-like illness and rhinoviruses among healthcare workers in Vietnam. Those in the cloth mask group received 5 pieces of 2-layer cotton masks that were washed with soap and water daily and reused. In the medical mask group, HCWs were given 2 pieces of 3-layer, non-woven masks daily per 8 hour shift. It is important to note that the control group represented standard and ethical practice in Vietnamese hospitals and was not a no-mask control group. Participants were followed up for four (4) weeks for the development of the following primary outcomes: (a) clinical respiratory illness (CRI), (b) influenza-like illness (ILI; fever > 38ºC plus 1 respiratory symptom), and (c) RT-PCR confirmed viral respiratory infection (including SARS-CoV and 16 other viruses). The rate of influenza-like illness (ILI) was higher in participants who wore cloth masks (2.14%) than medical masks (0.27%) (adjusted relative risk: 6.64, 95% CI 1.45–28.65) **[5]**. Cloth masks were associated with a higher rate (5.6% vs 2.9%) of laboratory-confirmed rhinoviruses (adjusted RR: 1.72 95% CI 1.01-2.94). No substantial differences between medical and cloth mask use in terms of CRI and compliance rate (~56%). General discomfort (397/1130, 35.1%) and breathing problems (207/1130, 18.3%) were the most common adverse events reported **[5]**.

Mechanistic studies exhibited that cloth masks, especially if double-layered, may be at least as effective as medical masks in preventing environmental droplet contamination and reducing ejection of micro-droplets. Textiles prevented environmental droplet contamination (EnDC) by 75.1% if single-layered and 100% if double-layered, with an EnDC radius similar to that of medical masks (<10cm). Among the tested textiles, 100% combed cotton (T-shirt) and 100% polyester (dry-fit, jersey material) offered the best droplet protection **[9].** Although generally not effective in blocking aerosols, cloth masks offered some protection against larger particles (diameter > 200nm). In terms of filtration efficiencies, certain cloth materials (i.e. 100% cotton with two layers **[6]**, a layer of polyester with four layers of kitchen paper **[7]**, tea cloth with two layers **[8]**) offered some protective function, especially in experiments involving larger particle sizes and lower flow rates. Non-woven and multiple-layered cloth masks appeared to have better filtration efficiency than cotton masks with lower pressure drop or good breathability **[10].** As expected, surgical and N95 masks had far more superior filtration than cloth masks across studies **[12]**.

Recommendations from Other Guidelines

In contrast to the WHO guidelines **[13]**, wearing non-medical masks in public areas where physical distancing is not possible has been recommended in US **[14]**, Canada **[20]**, and in some European **[21]** and Asian **[22-24]** countries.

CONCLUSION

There is no direct evidence that evaluated the effectiveness of cloth masks in preventing COVID-19 infection among healthcare workers or in the general public.

Indirect evidence from a large cluster-RCT with fair methodological quality showed that wearing two-layered cotton masks instead of medical masks increased the risk of developing influenza-like illness and rhinoviruses among healthcare workers. Mechanistic studies, on the other hand, reported that cloth masks, especially if double-layered, may be at least as effective as medical masks in preventing environmental droplet contamination and reducing ejection of micro-droplets. Although generally not effective in blocking aerosols, cloth masks offered some protection against larger particles. Masks that are nonwoven, double-layered, and well-fit show potential as cheap and effective source control method.

Wearing non-medical masks for the general public is recommended in most countries despite the lack of clear guidance from the WHO.

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Appendix 1. Characteristics of the indirect evidence (cluster RCT)

No.	Title/Author	Study design	Country	Population	Intervention Group(s)	Comparison Group(s)	Outcomes	Key findings
1	A cluster randomized trial of cloth masks compared with medical masks in healthcare workers MacIntyre CR, Seale H, Dung TC, Hien NT, Nga PT, et al. (2015) *BMJ Open*	Cluster-randomized trial	Hanoi, Vietnam	Healthcare workers (nurses & doctors) ≥ 18 years old (1607 participants) Working in 15 high risk hospitals (ER, infectious, ICU, pediatrics)	**Cloth masks** (n = 569) - 5 masks for entire 4 wks, washed w/ soap & water every day and reused - 2-layer, cotton - locally manufactured **Medical masks** (n = 580) - 2 masks daily per 8h shift - 3-layer, non-woven material - locally manufactured	**Control group** (n = 458) - standard practice, which may or may not include mask use - n = 245 used both types of masks - n = 3 used N95 - n = 2 exclude	**1) Clinical respiratory illness (CRI)** - 2 or > respiratory symptoms OR 1 respiratory + 1 systemic symptom **2) Influenza-like illness** - fever > 38C + 1 respiratory symptom **3) lab-confirmed viral respiratory infection** - RT-PCR for 17 resp viruses, including SARS-CoV and coronaviruses 229E **4) compliance with mask use** - using mask during shift for 70% or more of work shift hours - validated self-reporting mechanism **Other outcomes:** **5) no. & type of aerosol-generating procedures (AGPs) conducted** **6) cleaning process used by HCWs** **7) filtration performance** - AS/NZS1716 standard; TSI 8110 Filter tester) against sodium chloride particles w/ known sizes; compared against N95 (3M 9320, 3M Vflex 9105)	**1) CRI** - Highest rate in cloth mask group (not significant) **2) ILI** - Higher rate in cloth vs medical mask group (Adjusted RR = 6.64 [1.45, 28.65]) - Higher rate in cloth mask vs control group - No significant difference between medical mask vs control grp **3) Lab-confirmed cases** - Higher rate in cloth vs medical mask group (Adjusted RR = 1.72 [1.01, 2.94]) - types: 58/68 (85%) rhinoviruses, 10/68 (15%) others – influenza B, hMPV, no influenza A or RSV **4) Compliance with mask use** - Higher in cloth mask group vs controls - Higher in medical mask grp vs. controls (RR = 2.40 [2.00, 2.87]) **5) No. and type of AGPs** - Not reported **6) Cleaning process used** - self-washing (80%) - self-washing + hospital laundry (16%) - hospital laundry only (4%) - handwashing significantly protective against lab-confirmed viral infection (RR 0.66 [0.44, 0.97]) **7) Filtration performance** - cloth masks (97%) – *very high* - medical masks (44%) - N95 3M 9320 (<0.01%) - N95 3M Vlfex 9105 (0.1%) **8) Adverse events** - general discomfort (397/1130, 35.1%), breathing problems (207/1130, 18.3% - no significant difference between medical mask group (222/562, 40.4%) vs. cloth mask group (242/568, 42.6%) Participation rate 86% (1607/1868) Average of 36 patient contact per day

Appendix 2. Characteristics of the indirect evidence (mechanistic studies)

<table>
<tr><th>No.</th><th>Title/Author</th><th>Study Aims</th><th>Cloth mask tested</th><th>Experimental details</th><th>Outcomes and key findings</th></tr>
<tr>
<td>1</td>
<td>Effectiveness of surgical and cotton masks in blocking SARS-CoV-2: a controlled comparison in 4 patients

Bae et al. (2020)</td>
<td>To evaluate the effectiveness of surgical and cotton masks in filtering SARS-CoV-2</td>
<td>1) 100% cotton masks
(160 mm x 135 mm, 2 layers, individually packaged in plastic; Seoulsa)

Comparison:
2) Surgical masks
(180 mm x 90 mm, 3 layers, pleated; KM Dental Mask, KM Healthcare Corp)

3) No mask</td>
<td>- pathogen: SARS-CoV-2

- form: aerosol or droplet

- procedure: 4 patients with COVID-19 coughed 5 times under different conditions (no mask, + surgical mask, + cotton mask) on a petri dish placed 20 cm from patients' mouths; viral loads were measured on the petri dish and on the inner and outer mask surfaces of the masks worn.</td>
<td>Median viral load (log copies, [range])
- nasopharyngeal: 5.66 [3.57, 7.68]
- saliva: 3.9 [2.59, 5.91]

<table>
<tr><th></th><th>No mask</th><th>Surgical mask</th><th>Cotton mask</th></tr>
<tr><td>Petri dish</td><td>2.54 [0, 3.23]</td><td>2.33 [0, 3.26]</td><td>1.85 [0, 3.23]</td></tr>
<tr><td>Inner surface</td><td>N/A</td><td>0 [0, 2.00]</td><td>0 [0, 3.70]</td></tr>
<tr><td>Outer surface</td><td>N/A</td><td>2.4 [2.11, 2.63]</td><td>2.71 [2.58, 3.61]</td></tr>
</table>

Inner vs. outer surface contamination
- outer mask surface had greater contamination vs. inner surface
- outer surface contamination may be due to small aerosols ejected during cough OR air leakage around mask edge</td>
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<tr>
<td>2</td>
<td>Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2

Ma et al. (2020)</td>
<td>To evaluate efficacy of 3 types of masks in blocking avian influenza virus (AIV) in aerosols

To evaluate efficacy of hand wiping in removing AIV from hands</td>
<td>1) Homemade, 1-layer polyester cloth
2) Homemade, 1-layer polyester cloth + 4-layer kitchen paper (each with 3 thin layers)

Comparison:
3) Medical mask (AMMEX, Shanghai, China)
4) N95 mask (New 2001, Jiande Chaomei Daily Chemical Company, Zhejiang, China)</td>
<td>- pathogen: asian influenza virus (A/chicken/Qingdao/211/2019 – enveloped, pleomorphic spherical virus with 80-120 nm diameter)

- form: aerosols (median diameter 3.9 μm, with at least 65% of particles < 5 μm diameter)

- procedure: aerosols produced using nebulizer, collected in a seamless plastic bag; test masks were wrapped around 60-mL syringes, inhaled 100x to simulate human breathing; repeated 4x

- detection: RT-PCR (TaqMan)

- outcome: % virus blocked, C_t
(virus amount declines by 50% if C_t increased by 1; declines by (100*(1−1/(2^Y)))% if the Ct value increases by Y)</td>
<td>Efficacy / percentage of virus blocked:

<table>
<tr><th></th><th>C_t increase (mean±SD)</th><th>% virus blocked (95% CI)</th></tr>
<tr><td>N95 ask</td><td>12.49±0.33</td><td>99.98% (99.98-99.99)</td></tr>
<tr><td>Medical</td><td>5.13±0.98</td><td>97.14% (94.36-98.55)</td></tr>
<tr><td>Homemade +4 layers</td><td>4.37±0.90</td><td>95.15% (90.97-97.39)</td></tr>
<tr><td>Homemade 1 layer</td><td>Not reported</td><td>Not reported</td></tr>
</table>

- homemade masks with 4 layers of kitchen paper and 1 layer of polyester cloth can be used should be helpful especially when supply of medical masks are short
- probably effective because of its non-woven structure, multiple layers, virus-absorbing property
- other types of cloth masks made of cloth alone may be unable to block the virus</td>
</tr>
<tr>
<td>3</td>
<td>Textile masks and surface covers - a 'universal droplet reduction model' against respiratory pandemics.

Rodriguez-Palacios et al. (2020)</td>
<td>To assess the potential of household textiles (facemasks/covers/ scarfs/surface covers) as effective environmental droplet barriers (EDBs)</td>
<td>1) 100% combed cotton (T-shirt material)
2) 100% polyester microfiber 300-thread count fabric (pillow case)
3) 100% cotton fabric ("homespun", 140 GSM, 60x60-thread count)
4) 100% cotton fabric (115 GSM, 52x48-thread count)
5) 100% polyester (dry fit, sport jerseys)

Comparison:
6) No textile barrier / mask
7) Medical mask
8) Surgical cloth material</td>
<td>- pathogen: 12 bacteria (Lactobacillus lactis, L. rhamnosus, L. plantarum, L. casei, L. acidophilus, Leuconostoc cremoris, Bifidobacterium longum, B. breve, B. lactis, Streptococcus diacetylactis, Sccharomyces florentinus)

- form: droplet

- procedure: aqueous suspension (75mL; $3x10^{6-7}$ cfu/mL in 1000mL PBS (Fisher BP-399-1), dispersed using household spray bottles to simulate droplets produced by a sneeze

- detection: quantification of droplets reaching 7 agar plates (10mm-Petri dishes with tryptic soy agar</td>
<td>Distance covered by droplets
1) no textile barrier
- macro-droplets – 180cm or greater
- micro-droplets – 120 cm
2) all types of textiles, single-layers
- macro-droplets – none
- micro-droplets – 25.5-34cm

Environmental droplet contamination (EnDC) prevention
1) 100% combed cotton/T-shirt, 100% polyster/dry-fit
- single-layer: 75.1% prevention of EnDC
- two-layers: 100% prevention of EnDC
- EnDC radius reduced to <10cm (similar to medical mask)

Micro-droplet reduction</td>
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<td>(56.75cm^2 surface area/dish), 5% defibrinated sheep blood spaced in 30 cm intervals between 0-1.8 m); incubated 24h to enable colony-forming-droplet-unit (CFDU) formation</td>
<td>2) all types of textiles
- single layer: 97.2% reduction
- two-layers: 99.7%

Absorption
1) all textiles equally effective at absorbing humidity – even after 3 sprays
2) medical/surgical mask – condensate after 1 spray</td>
</tr>
<tr>
<td>4</td>
<td>Comparison of filtration efficiency and pressure drop in anti-yellow sand masks, quarantine masks, medical masks, general masks, and handkerchiefs.

Jung et al (2014)</td>
<td>To evaluate filtration efficiency and pressure drop of various types of Korean FDA-approved and non-approved masks</td>
<td>1) Handkerchief (cotton, gauze, towel; 1-4 layers)
2) General mask (nonwoven, cotton)

Comparison:
3) Yellow sand mask (adult)
4) Yellow sand mask (children)
5) Quarantine mask (N95)
6) Medical mask (surgical, dental)</td>
<td>- pathogen: none; NaCL (75±20 nm) and paraffin oil (224.9 nm) were used

- form: aerosol

- procedure: 2% NaCL and paraffin oil aerosol particles were generated at a flow rate of 95 L/min, then detected using scanning mobility particle sizer (SMPS, TSI-3910); pressure drops up to 150mmH_20 were measured; KFDA and NIOSH protocols were used

- outcome: penetration, pressure drop

$P (\%) = (C_{down} / C_{up}) \times 100$
Where:
C_{down} = aerosol concentration downstream
C_{up} = aerosol concentration upstream</td>
<td>Particle penetration (%, using NIOSH standards)
<table>
<tr><th></th><th>Penetration%</th><th>Pressure drop</th></tr>
<tr><td>Handkerchief, cotton, 1 layer</td><td>98.9 ± 0.66</td><td>1.00 ± 0.00</td></tr>
<tr><td>Handkerchief, cotton, 4 layers</td><td>96.2 ± 0.35</td><td>3.57 ± 0.25</td></tr>
<tr><td>Handkerchief, gauze, 1 layer</td><td>99.3 ± 0.30</td><td>0.67 ± 0.06</td></tr>
<tr><td>Handkerchief, gauze, 4 layers</td><td>96.4 ± 0.35</td><td>2.80 ± 0.17</td></tr>
<tr><td>General mask, cotton</td><td>77.4 ± 26.7</td><td>6.78 ± 3.51</td></tr>
<tr><td>General mask, nonwoven</td><td>45.3 ± 9.41</td><td>10.0 ± 5.11</td></tr>
<tr><td>Surgical mask (inward)</td><td>59.1 ± 36.7</td><td>9.28 ± 1.1</td></tr>
<tr><td>Surgical mask (outward)</td><td>57.7 ± 33.7</td><td>13.3 ± 4.5</td></tr>
<tr><td>Yellow sand mask, children</td><td>37.0 ± 25.5</td><td>12.1 ± 4.7</td></tr>
<tr><td>Yellow sand mask, adult</td><td>12.6 ± 14.5</td><td>13.7 ± 5.3</td></tr>
<tr><td>Quarantine/N95 mask</td><td>0.6 ± 0.5</td><td>12.5 ± 6.9</td></tr>
</table>
- handkerchiefs showed > 98% initial penetration regardless of material (cotton or gauze), 87-91% if folded; no protection against aerosols
- general masks with average 63.1% penetration; nonwoven material better than cotton
- filter efficiency of quarantine masks was the greatest, while that of handkerchiefs and general masks was the lowest</td>
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<tr>
<td>5</td>
<td>Testing the efficacy of homemade masks: would they protect in an influenza pandemic?

Davies et al. (2013)</td>
<td>To assess filtration efficiencies and pressure drop of improvised masks/homemade masks</td>
<td>1) homemade mask (100% cotton t-shirt fabric)
2) scarf
3) tea towel
4) pillowcase
5) antimicrobial pillowcase
6) vacuum cleaner bag
7) cotton mix
8) linen
9) silk

Comparison:
1) no mask
2) surgical mask (Mölnlyke Health Care Barrier face mask 4239, EN14683 class I)</td>
<td>- pathogen: Bacillus atrophaeus (0.95 – 1.25 μm) and Bacteriophage MS2 (MCIMB10108, 23 nm diameter); test organisms chosen to represent influenza virus

- form: aerosol

- procedure:
Experiment 1: aerosols produced from a Collison nebulizer at a controlled relative humidity; aerosols delivered across each material at 30L/min or 3-6x/min ventilation of human at rest but < 0.1 the flow of an average cough; test done 9x per material
Experiment 2: healthy volunteers coughed 2x on cough box, air sampled for 5 min, culture plates incubated for 48 hr at 37C then CFU counted

- detection: total bacterial count (CFU) measured during coughing; downstream air sampled for 1 min into 10mL phosphate buffer manucol antifoam; pressure drop measured using manometer (P200UL, Digitron)</td>
<td>Filtration efficiency (FE), pressure drop
<table>
<tr><th rowspan="2">Material</th><th colspan="2">Mean % FE</th><th rowspan="2">Mean pressure drop</th></tr>
<tr><th>B atrophaeus (0.95-1.25 μm)</th><th>Bacteriophage MS2 (23 nm)</th></tr>
<tr><td>Surgical mask</td><td>96.4</td><td>89.5%</td><td>5.2</td></tr>
<tr><td>Vacuum cleaner bag</td><td>94.4%</td><td>85.9%</td><td>10.2</td></tr>
<tr><td>Tea towel</td><td>83.2% (96.7%)</td><td>72.5%</td><td>7.2 (12.1)</td></tr>
<tr><td>Cotton mix</td><td>74.6%</td><td>70.2%</td><td>6.2</td></tr>
<tr><td>100% cotton</td><td>69.4% (70.6%)</td><td>50.8%</td><td>4.3 (5.1)</td></tr>
<tr><td>Antimicrobial pillowcase</td><td>65.6%</td><td>68.9%</td><td>6.1</td></tr>
<tr><td>Scarf</td><td>62.3%</td><td>48.9%</td><td>4.4</td></tr>
<tr><td>Pillowcase</td><td>61.3% (62.4%)</td><td>57.1%</td><td>3.9 (5.5)</td></tr>
<tr><td>Linen</td><td>60%</td><td>61.7%</td><td>4.5</td></tr>
<tr><td>Silk</td><td>58%</td><td>54.3%</td><td>4.6</td></tr>
</table>
- surgical mask: highest FE for both test microbes, low pressure drop
- vacuum cleaner bag & tea towel: high FE, high pressure drop (unsuitable for mask)
- pillowcase & 100% cotton tshirt: lower FE, low pressure drop, better material for improvised face mask
- tea towel, 2 layers: significantly higher FE, increased pressure drop</td>
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<td>- outcome:

Filtration efficiency
(calculated using the following formula)
$FE = \frac{\text{Upstream cfu} - \text{Downstream cfu} \times 100}{\text{Upstream cfu}}$</td>
<td>Droplet prevention when coughing (number of CFU)
- surgical mask: 0.0 (0.0,3.0)
- homemade mask (100% cotton tshirt): 1.0 (0.0,3.0)
- no mask: 2.0 (0.0,1.0)

- surgical mask more effective than homemade mask, especially for lowest particle sizes
- homemade mask did not significantly reduce number of particles emitted, vs. surgical mask</td>
</tr>
<tr>
<td>6</td>
<td>Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles

Rengasamy et al. (2010)</td>
<td>To assess filtration performance of cloth masks and fabric materials against a wide range of particle sizes</td>
<td>1) cloth mask (unclear fiber composition)
2) sweatshirt (mixed cotton (60-85%) and polyester (15-40%))
3) t-shirt (mixed cotton (60-100%) and polyester (1-40%))
4) towel (100% cotton or 80/20% polyester/nylon)
5) scarf (100% cotton or 100% polyester)

Comparison:
6) N95 respirator filter media</td>
<td>- pathogen: none, NaCL

- form: aerosol (variable diameter from 20 to 1000nm)

- procedure: NaCL polydisperse aerosol particles were generated at two flow rates (33 and 99 L/min), then detected using TSI 8130 Automated Filter Tester; initial penetration levels measured for 1 min with no loading; monodisperse aerosol test was also done using TSI 3160 tester, at same flow rates for 10 different sizes of particles (20 to 1000nm)

- outcome: % penetration (ratio of particle concentration downstream to upstread X 100)</td>
<td>Penetration level (%)

<table>
<tr><td></td><td>Polydisperse</td><td colspan="2">Monodisperse</td></tr>
<tr><td>Activity</td><td>75 ± 20 nm</td><td>20 nm</td><td>1000 nm</td></tr>
<tr><td>Cloth mask</td><td>74-90%</td><td>35-68%</td><td>73-82%</td></tr>
<tr><td>Sweatshirt</td><td>40-82%</td><td>30-61%</td><td>80-93%</td></tr>
<tr><td>T-shirt</td><td>86-90%</td><td>56-79%</td><td>89-97%</td></tr>
<tr><td>Towel</td><td>60-66%</td><td>18-31%</td><td>62-73%</td></tr>
<tr><td>Scarf</td><td>73-89%</td><td>9-74%</td><td>73-97%</td></tr>
<tr><td>N95</td><td>0.12%</td><td><1%</td><td>0%</td></tr>
</table>

- cloth masks and fabric materials had 40-90% penetration levels in polydisperse aerosols at 33 L/min flow rate; at monodisperse tests, had 9-98% penetration.
- filtration efficiency of improvised fabric comparable to surgical masks and dust masks resistance levels were less than or comparable to N95
- fabric materials provide only minimal levels or protection against virus-size submicron aerosol particles
- filtration performance of towels against <100nm better than other fabrics</td>
</tr>
<tr>
<td>7</td>
<td>Professional and home-made face masks reduce exposure to respiratory infections among the general population

van der Sande et al. (2008)</td>
<td>To assess levels of protection offered by wearing professional and homemade masks in different activities, in both inward and outward conditions</td>
<td>1) N95/FFP-2 mask 3M 1872®
2) Surgical mask (3M 1818 Tie-On®)
3) teacloth (TD Cerise Multi®, Blokker)</td>
<td>- pathogen: none, respiratory droplets

- form: aerosol

- procedure:
Experiment 1: 28 volunteers performed different activities: (1) none/sit still, (2) nod yead, (3) shake head, (4) read aloud a standard text, (5) stationary walk; Experiment 2: 22 volunteers performed same activities as in exp#1, measurements taken after 10-15 minutes and after 3 hrs
Experiment 3: artificial head / PC-driven respirator simulated 3 breathing flow conditions (30, 50, 80L/min) correlated with light, medium, strenuous activities

- detection: concentration of aerosol particles (up to 20 nm - 1 μm) measured on both sides of mask using receptor connected to electrostatic particle classifer and counter (Portacount®)</td>
<td>Inward protection

Short term (<15 min):
- surgical masks: 2x more protection than homemade masks; more marked with adults
- N95 masks: 50x more protection than homemade masks, 25x more protection than surgical masks
- increase in protection less marked in children (10x in N95 vs homemade, 6x surgical vs. homemade)
- no significant activity effect

<table>
<tr><td>Activity</td><td>Tea cloth</td><td>Surgical</td><td>N95</td></tr>
<tr><td>At rest</td><td>2.5 [2.1,2.9]</td><td>4.1 [3.1,7.2]</td><td>113 [26,210]</td></tr>
<tr><td>Walking</td><td>2.4 [2.1,3.3]</td><td>4.2 [3.1,5.7]</td><td>99 [19,169]</td></tr>
<tr><td>Speaking</td><td>3.2 [2.5,3.9]</td><td>5.3 [4.3,8.0]</td><td>66 [29,107]</td></tr>
</table>

Long term (after 3 hrs):
- stable PF over time (trends all non-significant): increased protection for homemade masks; decreased in N95 masks; no consistent pattern for surgical masks
- still higher protection in N95 > surgical > homemade mask</td>
</tr>
</table>

				- outcome: **Protection factor (PF)** (defined as the inverse of the total inward leakage (TIL)%, calculated as follows: TIL = (concentration inside / outside x 100) PF = $(TIL/100)^{-1}$) *where: PF = 1 means no protection; higher PF values greater protection TIL = probability that any particle leaks through the mask	- no significant effect of activity on PF **Outward protection** - homemade mask PF only provided marginal protection (PF = 1.2) - lower PF in outward compared to inward conditions - PF in homemade mask lower than surgical or N95 - no difference in PF between surgical and N95 mask - no effect of breath flow on PF