Facemasks and similar barriers to prevent respiratory illness such as COVID-19: A rapid systematic review

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ABSTRACT

The current pandemic of COVID-19 has lead to conflicting opinions on whether wearing facemasks outside of health care facilities protects against the infection. To better understand the value of wearing facemasks we undertook a rapid systematic review of existing scientific evidence about development of respiratory illness, linked to use of facemasks in community settings.

Methods: We included all study designs. There were 31 eligible studies (including 12 RCTs). Narrative synthesis and random-effects meta-analysis of attack rates for primary and secondary prevention in 28 studies were performed. Results were reported by design, setting and type of face barrier in primary prevention, and by who wore the facemask (index patient or well contacts) in secondary prevention trials. The preferred outcome was influenza-like illness (ILI) but similar outcomes were pooled with ILI when ILI was unavailable. GRADE quality assessment was based on RCTs with support from observational studies.

Results: Where specific information was available, most studies reported about use of medical grade (surgical paper masks). In 3 RCTs, wearing a facemask may very slightly reduce the odds of developing ILI/respiratory symptoms, by around 6% (OR 0.94, 95% CI 0.75 to 1.19, I^2 29%, low-certainty evidence). Greater effectiveness was suggested by observational studies. When both house-mates and an infected household member wore facemasks the odds of further household members becoming ill may be modestly reduced by around 19% (OR 0.81, 95%CI 0.48 to 1.37, I^2 45%, 5 RCTs, low certainty evidence). The protective effect was very small if only the well person (OR 0.93, 95% CI 0.68 to 1.28, I^2 11%, 2 RCTs, low uncertainty evidence) or the infected person wore the facemask (very low certainty evidence).

Discussion: Based on the RCTs we would conclude that wearing facemasks can be very slightly protective against primary infection from casual community contact, and modestly protective against household infections when both infected and uninfected members wear facemasks. However, the RCTs often suffered from poor compliance and controls using facemasks. Across observational studies the evidence in favour of wearing facemasks was stronger. We expect RCTs to under-estimate the protective effect and observational studies to exaggerate it. The evidence is not sufficiently strong to support widespread use of facemasks as a protective measure against COVID-19. However, there is enough evidence to support the use of facemasks for short periods of time by particularly vulnerable individuals when in transient higher risk situations. Further high quality trials are needed to assess when wearing a facemask in the community is most likely to be protective.

INTRODUCTION

On 30 January 2020 the World Health Organisation (WHO) declared a Public Health Emergency of
International Concern (PHEIC) in response to the emergence of a novel coronavirus in Wuhan, China
(World Health Organization, 2020a). In the declaration, the WHO stated there had been 170 deaths
so far linked to the viral disease, later formally designated COVID-19. At the time of writing, more
than 4600 deaths have been linked to COVID-19 (John Hopkins University Coronavirus Resource
Centre, 2020) (accessed 12th March 2020, 9:46am). On the 11th March 2020 the WHO started
referring to the COVID-19 epidemic as a pandemic (World Health Organization, 2020b). It is not
clear when this outbreak will abate.

Amongst other advice widely sought by the public in response to this outbreak, was whether
wearing face coverings, especially medical-grade coverings (e.g. masks, goggles or similar) might
reduce the risk of catching or transmitting disease (Gajanan, 2020), particularly in domestic and
public places. Despite no support by WHO encouraging wearing facemasks in the community, sales
of inexpensive facemask products soared following the PHEIC declaration, leading to potential
shortages for health care workers (Asgari and Wells, 2020; Carter, 2020; O'Connor, 2020; Taylor,
2020; Wu *et al.*, 2020; US Surgeon General, 2020). Most previous similar systematic reviews
investigating the effect of facemask use either focused solely on facemask use in health care settings
or restricted study design to randomized controlled trials (RCTs), many of which were of low quality
(MacIntyre and Chughtai, 2015).

We responded to this information demand by undertaking a rapid systematic review of the existing
scientific evidence with regard to transmission of either respiratory disease or development of
respiratory symptoms, especially influenza-like illness (ILI), linked to use of face barriers by non-
health professionals and non-inpatients.

METHODS
Review question
Can wearing a face barrier (mask, goggles, shield, veil) in community settings prevent transmission of
respiratory illness, such as from coronaviruses, rhinoviruses, influenza viruses or tuberculosis? We
use the word 'facemask' as an umbrella term for diverse facial coverings that may cover any
combination of mouth, nose and/or eyes.

Search Strategy
Two recent literature reviews (MacIntyre and Chughtai, 2015; Jefferson *et al.*, 2008) were consulted,
to find eleven exemplar studies (Aiello *et al.*, 2010; Aiello *et al.*, 2012; Canini *et al.*, 2010; Cowling *et
al.*, 2009; Cowling *et al.*, 2008; Larson *et al.*, 2010; Lau *et al.*, 2004a; Lau *et al.*, 2004b; MacIntyre *et
al.*, 2009; Simmerman *et al.*, 2011; Suess *et al.*, 2012) that met our eligibility criteria. We designed
search strategies that were sensitive enough to find these exemplar studies and similar research, yet
specific enough exclude most irrelevant records. The bibliographic databases Scopus, Embase and
Medline were searched with the phrases in Box 1 on 31 Jan 2020. We also recent systematic
reviews (Barasheed *et al.*, 2016; Benkouiten *et al.*, 2014; Cowling *et al.*, 2010; MacIntyre and
Chughtai, 2015; bin-Reza *et al.*, 2012; Saunders-Hastings *et al.*, 2017; Jefferson *et al.*, 2008) on
similar non-pharmaceutical practices for any missing primary studies.

Assessment of inclusion
Two authors (JB and NJ) independently screened the retrieved titles and abstracts. Disagreements
were resolved by discussion with other authors. The inclusion criteria were:

- Original research (not a review, guidelines, discussion, regulations, debate or commentary) published in English since January 1980
- The research needed to describe facemask use that might prevent disease transmission or symptom development among people in the community (rather than prevent transmission to or from clinically trained persons)
- The study described an observed relationship between facemask use and respiratory symptoms or infection by respiratory pathogens: (e.g. influenza, coronavirus, TB).
- There was a comparator or control group (non-barrier users, other barrier users or non-cases)
- Any study design in any country

The full text of each article that passed screening was retrieved and eligibility verified as part of data extraction.

BOX 1 Bibliographic database search phrases

SCOPUS
TITLE-ABS-KEY (
(facemask? OR "facemasks?" OR mask? OR goggle? OR faceshield? OR respirator OR respirators)
AND
(influenza OR flu OR sars OR tuberculosis or mers OR coronav* OR "cov" OR respiratory-syndrome OR wuhan or "ncov")
)
AND
(LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "NURS") OR LIMIT-TO (SUBJAREA , "IMMU"))

EMBASE & Medline via the OVID portal
((facemask? or "face-masks?" or mask? or goggle? or face-shield? or respirator or respirators).ti.
or (facemask? or "face-masks?" or mask? or goggle? or face-shield? or respirator or respirators).ab.
or (facemask? or "face-masks?" or mask? or goggle? or face-shield? or respirator or respirators).kw.)
and
((influenza or flu or sars or tuberculosis or mers or coronav* or "cov" or respiratory-syndrome or "ncov" or wuhan).kw.
 or
(influenza or flu or sars or tuberculosis or mers or coronav* or "cov" or respiratory-syndrome or "ncov" or wuhan).ti.
or
(influenza or flu or sars or tuberculosis or mers or coronav* or "cov" or respiratory-syndrome or "ncov" or wuhan).ab.)

Data Extraction & risk of bias assessment
Qualitative data and numbers of participants who developed respiratory outcomes in relevant study arms were extracted. The preferred specific outcome was ILI, defined as fever $\geq$ 38 C° with cough and onset $\leq$ 10 days previous (World Health Organization, 2014). Where a WHO-definition was unavailable, we accepted other similar case definitions (e.g. cold symptoms, acute respiratory infections, clinical cases of influenza or SARS). Where studies reported three arms we extracted data for arms where the only difference was whether a facemask was worn (e.g. hand hygiene vs. hand hygiene + facemasks). Risk of bias in included RCTs was assessed (by LH) using the Cochrane risk of

bias tool (Atkins *et al.*, 2004), and biases and limitations identified by primary study authors of observational studies were noted. We assessed the quality of evidence using the GRADE framework, based on the RCT data and supported or contradicted by observational data (Atkins *et al.*, 2004).

Synthesis

All characteristics of included studies were tabulated. Numbers of infections and numbers of people at risk in each study arm were input to Review Manager 5.3 (The Cochrane Collaboration, 2014) for meta-analysis by JB, verified by NJ or LH. We calculated pooled odds ratios using Mantel-Haenszel random effects meta-analysis (due to expected high heterogeneity) separately for primary prevention (when no cases were yet been identified) and prevention of secondary cases (when an individual was diagnosed with an infection and the aim was to prevent contacts from getting disease). We subgrouped by study design (RCT, pre/post, cohort, case-control or cross-sectional), and presented these subgroups in forest plots without global pooling to understand consistency of evidence across study designs. We also showed the trend of evidence within settings (subgrouping by setting). For secondary transmission (in RCTs) we subgrouped by who wore the facemask: index case, well contacts of the index case, or both. Outcomes after wearing faceveils were also presented where evidence was available.

A prospective patient (a mature adult living with many chronic health conditions including reduced lung function) commented on the draft manuscript and how the results could be made meaningful to laypeople.

RESULTS

Altogether, 979 titles and abstracts were retrieved from Scopus, and 1443 from Embase and Medline combined. Our search located all 11 exemplar articles. Combining and deduplicating left 1725 articles. Of these 233 were not written in English and 81 were published before 1980, so were removed. This left 1458 titles and abstracts to screen, of which 46 were selected to be collected in full text. Full text review identified 26 eligible studies. Checking previous systematic reviews on protective effects of facemask use in the community identified a further five studies (all in the Hajj setting). Of the 31 included studies, 12 were cluster-RCTs, three were cohort studies, five were case-control and ten were cross-sectional, of which 28 reported data suitable for meta-analysis. Settings included schools, university residences, visits to health care providers, family households, the Hajj mass gathering, and non-specific community settings. Most studies reported on influenza-like illness (ILI) as an outcome (n=19), but fever with respiratory symptoms, upper respiratory tract infection, lab-confirmed or clinical influenza, toxic pneumonitis, common colds and other respiratory symptoms were used when ILI was unavailable. All mass gathering studies were associated with the Hajj pilgrimage. Table S1 lists the characteristics of the included studies.

Prevention of primary infection

GRADE assessment suggested that wearing a facemask may very slightly reduce the odds of developing ILI/respiratory symptoms, by around 6% (OR 0.94, 95% CI 0.75 to 1.19, I^2 29%, low-certainty evidence, downgraded once each for risk of bias and imprecision). Figure 1 shows grouping of results by study design. Pooled data are presented to calculate a single odds ratio to compare and contrast study designs. Risk of biases for RCTs are also presented.

Prevention of primary infection, subgrouping by study design

The three RCTs which measured the prevention of primary infection, indicated a slight, non-significant, reduction in the odds of primary infection with ILI (OR 0.94, 95%CI 0.75-1.19) (Figure 1, Comparison 1.1; Table 1). Heterogeneity was low (I^2 29%). Protection appeared greater in observational studies. Pre/post facemask wearing by visitors to hospital (Sung et al 2012) suggested

a strong, significant reduction in infections among inpatient stem cell recipients (OR 0.30, 95%CI 0.17-0.52) (Figure 1, Comparison 1.2), but this finding is interpreted with caution because of likely changes in hygiene practices in the pre/post periods.

Evidence from the six cohort studies suggested facemasks provided some protection (OR 0.71, 95%CI 0.24-2.05), although, these findings were not significant (Figure 1, Comparison 1.3). Heterogeneity was very high (I^2 = 96%) and the men-only cohort from Choudhry *et al.* (2006) was a noticeable outlier. This set of studies included observational data based on actual facemask wearing habits from one RCT (Alfelali *et al.* (2019)).

Among case-control (OR 0.39, 95%CI 0.18-0.84, I^2 77%) (Figure 1, Comparison 1.4) and cross-sectional studies (OR 0.61, 95%CI 0.45-0.85, I^2 95%) (Figure 1, Comparison 1.5), pooled data suggested that facemask wearing was protective, but effects were highly heterogeneous. Of the cross-sectional studies, Tahir *et al.* (2019) and Zein (2002) were noticeable outliers. Removal of these outliers still indicates facemask wearing as protective, although no longer significant, and heterogeneity falls slightly (OR 0.89, 95%CI 0.78-1.01, I^2 = 64%) (data not shown).

Two further studies did not provide suitable data for pooling but reported that they had done analysis supporting their conclusions to comment narratively that facemasks were not protective (Hashim *et al.*, 2016; Gautret *et al.*, 2011). A third study without estimable data, Hashim *et al.* 2016 concluded that respirators were not effective protection against ILI.

Prevention of primary infection by exposure setting
Figure 2 groups results by exposure setting. Pooling of data from different study designs is not appropriate to calculate a single odds ratio statistic. Most results favoured facemask wearing.

Facemask wearing was consistently protective (the point-estimates of all included studies favoured facemask wearing) in the general community (2 cohort and 1 case-control; 1 significant protective finding) (Figure 2, Comparison 2.1), schools and universities (2 cluster-randomised RCTs and 2 cross-sectional; 1 significant protective finding) (Figure 2, Comparison 2.2), and for visits to health care clinics (1 pre/post and 2 case-control; 3 significant protective findings) (Figure 2, Comparison 2.3).

The results were less consistent (the point-estimates showed both protective and non-protective relationships) for animal contact (2 cross-sectional studies; 1 significant protective finding) (Figure 2, Comparison 2.4) and mass gatherings (all Hajj pilgrims; 1 cluster-randomised RCT, 2 cohort, 1 case-control and 3 cross-sectional; 3 significant protective findings) (Figure 2, Comparison 2.5).

One case-control study on air travel suggested a protective but non-significant relationship (Figure 2, Comparison 2.6).

Prevention of primary infection among face veil wearers
Figure 3 shows data from two studies (cross-sectional and cohort) examining case incidence among women who wore face veils often/always while on Hajj pilgrimage. Both studies indicate a protective but non-significant relationship.

Secondary transmission
GRADE assessment suggested that when both house-mates and an infected household member wore facemasks the odds of further household members becoming ill may be modestly reduced by around 19% (OR 0.81, 95%CI 0.48 to 1.37, I^2 45%, 5 RCTs, low certainty evidence, downgraded twice overall for risk of bias, imprecision and inconsistency). The protective effect was very small if only the well people wore facemasks (OR 0.93, 95% CI 0.68 to 1.28, I^2 11%, 2 RCTs, low uncertainty

evidence, downgraded twice overall for risk of bias, imprecision and inconsistency) and unclear due to very low certainty evidence when only the infected person wore a facemask (downgraded once for risk of bias, twice for imprecision).

Figure 4 shows results for secondary transmission subdivided by study design and who wore the facemask (index patient, well contacts or both). Presented are pooled data to calculate a single odds ratio and risk of biases for RCTs. Findings from the two RCTs when only infected persons wore a facemask, suggested a very small, non-significant protective effect (OR 0.95, 95%CI 0.53 to 1.72, I^2 0%) (Figure 4, Comparison 4.1; Table 1). The evidence of a very small protective effect was stronger in the 2 RCTs where only well people wore facemasks (OR 0.93, 95%CI 0.68 to 1.28, I^2 11%) (Figure 4, Comparison 4.2; Table 1).

Pooled data from five RCTs where both infected and non-infected household members wore facemasks showed the odds of infection fell modestly and not significantly (OR 0.81, 95%CI 0.48 to 1.37, I^2 45%) (Figure 4, Comparison 4.3, Table 1). Findings from the one case-control study where both infected and non-infected household members wore facemasks indicated a similar relationship (OR 0.45, 95%CI 0.18 to 1.10) (Figure 4, Comparison 4.4).

Secondary transmission and commencement of facemask wearing
Figure 5 shows results for the four secondary transmission RCT studies providing data for attack rates when facemask wearing started < 36 hours after index patient became symptomatic. A single odds ratio statistic and risk of biases for RCTs are presented.

Facemask wearing was not protective in this subgroup analysis OR 1.36, 0.66-2.79, I^2 0%). Some of the original investigators in these studies undertook logistic regression to adjust their findings for other confounders and found evidence that early facemask wearing (< 36 hours after symptom onset) could be protective, but acknowledged that their models were underpowered.

DISCUSSION
In this study we have undertaken a rapid review to examine whether the use of facemasks impacts on the transmission of respiratory symptoms. Evidence based on RCTs suggests that wearing a facemask may very slightly reduce the odds of primary infection with ILI by around 6% (low-certainty evidence). Observational studies suggested greater effectiveness. In households where infected people were grouped with uninfected people, if both house-mates and the infected household member wore facemasks the odds of further household members becoming ill were reduced by around 19% (low certainty evidence). Where only the uninfected people wore facemasks the effect was very small (reducing the odds of infection by 7%, low certainty evidence). The evidence is similar where only the infected household members wore facemasks (reducing the odds of infection by 5%, very low certainty evidence). However, due to controls wearing facemasks when they shouldn't and poor compliance (intervention participants not wearing facemasks when they should) we expect that RCT evidence under-estimated efficacy. In contrast, we expect observational studies, especially those based on self-reported symptoms, have over-estimated how protective facemask wearing can be because of confounding. Therefore, specific accurate estimates of the degree of protectiveness of facemasks are not feasible from the currently available evidence base.

Facemasks appear be most effective when worn to prevent primary respiratory illness in relatively low risk situations: community settings where contact may be casual and relatively brief, such as on public transport, in shops, in workplaces and perhaps in university residences or schools with limited shared public spaces. Facemask wearing is probably not protective during mass gatherings, but evidence on use during mass gatherings is inconsistent. All studies focussed on Hajj pilgrimage

which may not be a typical mass gathering event (especially large and prolonged). Facemask
wearing within households where infection was already present was modestly effective in the
included studies, and this evidence was fairly consistent (low-medium heterogeneity, I^2 from 0% to
45%). Limited effectiveness of primary prevention at Hajj or secondary prevention within households
may be because of the multiplicity of transmission pathways within these settings and high level of
recurring contact. It may also be due to the late use of facemasks, usually > 24 hours after a
household or group member became symptomatic which could be 48 hours after they became
infectious (Centers for Disease Control, 2018).

That facemasks might protect wearers has been cast in doubt during the COVID-19 outbreak (eg.,
Abramson, 2020; Geggel, 2020; Harris, 2020), often supported by the observation that surgical
facemasks were designed (originally) to protect patients from the wearers, and that facemasks soon
become very moist with condensation from wearer's breath (facilitating microbial ingress and
growth). Nevertheless, worn correctly for brief periods, wearing surgical masks have been shown to
provide an average 6-fold reduction in exposure to aerosolized influenza virus (Booth *et al.*, 2013),
so it is unsurprising that facemask wearing was linked to fewer cases in our synthesis, especially
primary observational studies in community settings. With regard to secondary attack rates,
whether the ill or the initially well people in a household wore facemasks (or both, or neither wore
facemasks) did not seem to matter: attack rates were similar in household-setting RCTs. These
details suggest that other factors (not who wore the facemask, but rather duration and type of
contact) also matter greatly to disease transmission. Many barriers exist that can make it difficult for
individuals to wear facemasks correctly for hours over a multi-day period, including perceived
breathing impairment and other discomforts (Sim *et al.*, 2014; Suess *et al.*, 2011). Facemasks are
perceived to or genuinely do interfere with ordinary physical activities such as heavy exertion, sleep,
oral hygiene and eating. Facemasks can be uncomfortable, hot, cause skin rashes or simply feel anti-
social (Al Badri, 2017; Donovan *et al.*, 2007).

Previous systematic literature reviews on the efficacy of using facemasks in community settings are
often combined with other personal protection measures (Saunders-Hastings *et al.*, 2017; Jefferson
et al., 2008; Wong *et al.*, 2014) or mixed health care workers with non-health care workers
(Jefferson *et al.*, 2008; bin-Reza *et al.*, 2012; Wang *et al.*, 2015). Those that have looked specifically
at community use have focused only on RCTs (Cowling *et al.*, 2010; MacIntyre and Chughtai, 2015).
Overall, the reviews had mixed conclusions about community settings: that facemasks were highly
effective (Jefferson *et al.*, 2008), definitely effective (Barasheed *et al.*, 2016; bin-Reza *et al.*, 2012),
may be effective for protection (Benkouiten *et al.*, 2014; Cowling *et al.*, 2010; MacIntyre and
Chughtai, 2015) or had a not statistically significant protective effect (Saunders-Hastings *et al.*,
2017). There was near consensus that the evidence base was inadequate (Cowling *et al.*, 2010; bin-
Reza *et al.*, 2012; Barasheed *et al.*, 2016; MacIntyre and Chughtai, 2015; Saunders-Hastings *et al.*,
2017; Benkouiten *et al.*, 2014).

RCTs may not be the best quality evidence to evaluate a population behaviour like facemask use that
is likely to be imperfectly implemented. Many of the included RCTs reported that participants did
not follow instructions (Alfelali *et al.*, 2019; Barasheed *et al.*, 2016; Cowling *et al.*, 2009; Cowling *et
al.*, 2008; MacIntyre *et al.*, 2009; MacIntyre *et al.*, 2016). In these RCTs, large proportions of controls
wore facemasks during the monitoring period (Simmerman *et al.*, 2011; MacIntyre *et al.*, 2016;
Cowling *et al.*, 2008), while intervention participants did not wear facemasks the majority of the
time (MacIntyre *et al.*, 2009; MacIntyre *et al.*, 2016; Larson *et al.*, 2010; Cowling *et al.*, 2009; Cowling
et al., 2008). Compared to RCTs, observational data (cohort and case-control studies) may give
superior quality evidence for efficacy of facemask wearing to avoid ILI, given they are trying to relate
actual behaviour to outcomes. Of course, observational data are subject to recall bias and other
confounding factors that RCTs may obviate. For expediency, we have not undertaken formal quality

assessment on the diverse observational studies included in this review: we expect that the
observational evidence would be found to have many potential sources of bias that RCT designs are
intended to avoid. We found original study authors gave many informative comments on their own
study limitations (Supplemental Table 1). We argue that there is merit in combining study types to
generate a full view of existing evidence.

A difficulty with previous reviews and also in our own review, is the mix of facial barrier used. All of
the RCTs included in our review provided specific facemasks (usually surgical grade, rarely P2 or
equivalent grade respirator) with instructions how to wear the facemask, as well as told users the
frequency facemasks should be changed and how to hygienically dispose of used facemasks.
Information was not reported about the types of facemasks that (contrary to protocol) some
controls in RCTs used. Only a few of the observational studies collected specific information about
what type of face covering was used.

We assume that where not explicitly stated, most facemasks worn were surgical grade in the
included observational studies. This view concords with survey of facemasks visible in recent street
scene photography of Hong Kong, Korean, Chinese and Japanese cities where facemask wearing is
common: most of the evident facemasks resemble surgical styles and is somewhat supported by
surveys and discussions of habitual facemask users, usually in Far East countries (Wada *et al.*, 2012;
Shirai, 2019; Hung, 2018; Burgess and Horii, 2012).

Future investigations should collect information about what facemasks people had, how the
facemasks were worn, whether they were reused and how they were prepared for reuse, as well as
duration of facemask wear. The impact of the timing of intervention is worth analysing further
especially if studies can be fully powered to produce more definitive results, or if evidence should
emerge about facemask use within homes before symptom onset or within a very short period
(perhaps 4-12 hours) after symptom onset.

Limitations

The search strategy tried to include all 'respiratory' illnesses. However, actual transmission risks vary
with the type of pathogen: adequate protection for one germ may be unsafe against others. All of
the articles we found related to viruses, most typically influenza but also SARS coronavirus. The lack
of tuberculosis studies included in this review may relate to the date cut off we imposed (we
omitted studies published before 1980 for expediency). If the evidence base were larger then we
could meaningfully subset the studies by the types of pathogen studied: e.g. coronaviruses vs.
influenza. Similarly, although we preferred clinical case definitions of ILI or respiratory illness (based
on symptoms), where only lab-confirmed case definitions were available, we grouped these with
clinical cases. The case definitions were also based mostly on self-report. These pathogens,
outcomes and reporting origins could be meaningfully separated with a larger evidence base.

Due to the rapidity of this review we did not consider other article archives or databases such as
Google Scholar, CINAHL and MedRXiv. We did not undertake quality assessment of observational
studies, although we have provided the authors own assessments of their study limitations which
highlight many potential issues. We did not classify outcomes by severity of symptoms or other
clinical outcomes (Paulo *et al.*, 2010). It is possible that facemask wearing reduced duration or
severity of symptoms experienced due to reducing infectious dose received, although not actual
disease. Severity or duration of symptoms and other specific clinical outcomes are important to
patients and this is an area which requires further research. We also didn't separate results by
duration that facemasks were worn; some studies did subgroup analysis that found this influenced
attack rates.

The only mass-gathering setting where facemask wearing evidence has been gathered and published is the Hajj. This event may not be comparable to many smaller mass-gatherings and the Hajj is exceptional for high contact levels (Zein, 2002; Deris *et al.*, 2010; Shirah *et al.*, 2017; Hashim *et al.*, 2016; Gautret *et al.*, 2011).

We have not undertaken a full cost-benefit analysis. The sudden emergence of COVID-19 led to high community demand for face barriers and raised valid concerns that insufficient supplies of facemasks were available for health care workers (Wu *et al.*, 2020; US Surgeon General, 2020). The environmental and economic costs of regularly using facemasks are notable, and only partly abated by reuse. Wearing facemasks consistently and correctly for long periods may not be easy for many people. There is a need to calculate where the balance of benefits and costs lie in facemask wearing for disease prevention (Baracco *et al.*, 2015; Rivera *et al.*, 1997; McGain *et al.*, 2017; Coulter, 2017).

We make no comment on the relative utility of other proposed protective measures compared to facemask wearing, such as self-isolation or frequent handwashing: we have not undertaken research on those measures for comparison. We did not formally assess likelihood of publication bias in the primary research evidence base, due to this being a rapid review.

CONCLUSIONS
Our study was a rapid review of the literature on the impact of the use of facemasks on the transmission of respiratory symptoms. Based on randomized trial data, wearing a facemask may very slightly reduce the odds of primary infection with influenza-like illness (ILI). However, included trials generally had very low compliance and comparisons undermined by some controls also wearing facemasks. Considering both experimental and observational studies, we consider that the balance of evidence is that facemasks may offer some protection against primary respiratory virus infection when used in community settings outside the home. We surmise that this relates to relatively short exposure windows, brief duration of wear and casual contact, while noting that existing evidence is prone to recall bias and lack of information about what kind of facemasks were worn or if they were worn correctly. Facemasks appear to be slightly effective for preventing secondary infection within household settings, but the certainty of this evidence is low. Facemasks used in the Hajj-related multi-day mass gatherings (which typically involve 2-6 weeks of inter-related activities) have not consistently prevented respiratory symptoms from developing. We do not consider that the balance of evidence across all available studies supports routine and widespread use of facemasks in the community. However, using a mask for short periods of time by particularly vulnerable individuals during transient exposure events may be justified.

SUPPLEMENTAL See Table S1 for full list of included studies.

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Figure 1. Mask wearing to prevent primary infection, by study design

Study or Subgroup	wore masks Events	Total	no masks Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
5.1.1 RCTs						
Aiello 2010 pilot (1)	44	378	80	552	25.6%	0.78 [0.52, 1.15]
Aiello 2012 (2)	46	392	51	370	22.6%	0.83 [0.54, 1.27]
Alfelali 2019 (3)	152	1531	179	1960	51.8%	1.10 [0.87, 1.38]
Subtotal (95% CI)		2301		2882	100.0%	0.94 [0.75, 1.19]
Total events	242		310			

Heterogeneity: Tau² = 0.01; Chi² = 2.84, df = 2 (P = 0.24); I² = 29%
Test for overall effect: Z = 0.50 (P = 0.62)

5.1.2 Pre/post						
Sung 2012 (4)	15	454	95	920	100.0%	0.30 [0.17, 0.52]
Subtotal (95% CI)		454		920	100.0%	0.30 [0.17, 0.52]
Total events	15		95			

Heterogeneity: Not applicable
Test for overall effect: Z = 4.28 (P < 0.0001)

5.1.3 Cohort studies						
Alfelali 2019 (5)	135	1291	196	2200	17.7%	1.19 [0.95, 1.50]
Balaban 2012 (6)	37	89	18	54	16.6%	1.42 [0.70, 2.88]
Choudhry 2006 (7)	43	319	260	431	17.5%	0.10 [0.07, 0.15]
Choudhry 2006 (8)	8	21	98	256	15.8%	0.99 [0.40, 2.48]
Shin 2018 intvn arm (9)	11	35	33	94	16.1%	0.85 [0.37, 1.94]
Shin control arm (10)	14	40	35	96	16.3%	0.94 [0.43, 2.03]
Subtotal (95% CI)		1795		3131	100.0%	0.71 [0.24, 2.05]
Total events	248		640			

Heterogeneity: Tau² = 1.65; Chi² = 127.93, df = 5 (P < 0.00001); I² = 96%
Test for overall effect: Z = 0.64 (P = 0.52)

5.1.5 Case-control						
Emanian 2013 (11)	21	57	11	38	25.8%	1.43 [0.59, 3.47]
Lau 2004a (12)	92	479	238	511	36.9%	0.27 [0.20, 0.36]
Wu 2004 (13)	15	146	69	229	31.4%	0.27 [0.15, 0.49]
Zhang 2013 (14)	0	12	9	29	5.9%	0.09 [0.00, 1.62]
Subtotal (95% CI)		694		807	100.0%	0.39 [0.18, 0.84]
Total events	128		327			

Heterogeneity: Tau² = 0.40; Chi² = 13.26, df = 3 (P = 0.004); I² = 77%
Test for overall effect: Z = 2.40 (P = 0.02)

5.1.6 Cross-sectional						
Al-Jasser 2012 (15)	98	216	702	1291	13.5%	0.70 [0.52, 0.93]
Deris 2010 (16)	121	282	34	105	11.4%	1.57 [0.98, 2.52]
Jolie 1998 (17)	63	86	30	46	8.1%	1.46 [0.67, 3.16]
Kim 2012 (18)	178	3285	239	4163	14.3%	0.94 [0.77, 1.15]
Tahir 2019 (19)	41	131	123	170	11.1%	0.17 [0.11, 0.29]
Uchida 2017 (20)	1069	5474	1080	5050	14.9%	0.89 [0.81, 0.98]
Wu 2016 (21)	1154	2728	4911	10298	15.0%	0.80 [0.74, 0.88]
Zein 2002 (22)	47	216	168	230	11.8%	0.10 [0.07, 0.16]
Subtotal (95% CI)		12418		21353	100.0%	0.61 [0.45, 0.85]
Total events	2771		7287			

Heterogeneity: Tau² = 0.18; Chi² = 140.07, df = 7 (P < 0.00001); I² = 95%
Test for overall effect: Z = 2.98 (P = 0.003)

Test for subgroup differences: Chi² = 18.51, df = 4 (P = 0.0010), I² = 78.4%

Risk of Bias: A B C D E F G

Odds Ratio M-H, Random, 95% CI — 0.05 0.2 1 5 20 — Favours mask wearing   Favours no masks

Footnotes
(1) Setting University residences, Design cluster RCT, Outcome 'fever' symptoms
(2) Setting University residences, Design cluster RCT, Outcome ILI symptoms
(3) Setting Hajj pilgrims, Design cluster RCT, Outcome respiratory illness
(4) Setting stem-cell recipients in hospital, Design pre-post study, Outcome respiratory...
(5) Setting Hajj pilgrims, Design cohort (was cluster RCT but badly contaminated), Outcome...
(6) Setting Hajj pilgrims, Design retrospective cohort, Outcome respiratory illness
(7) Setting male Hajj pilgrims, Design prospective cohort, Outcome respiratory illness, Details.
(8) Setting female Hajj pilgrims, Design prospective cohort, Outcome respiratory illness,...
(9) Setting community, Design cohort, Outcome common cold symptoms
(10) Setting community, Design cohort, Outcome common cold symptoms
(11) Setting Hajj pilgrims, Design nested case control, Outcome respiratory illness (not colds)
(12) Setting visiting index patients, Design case control, Outcome SARS (WHO definition),...
(13) Setting community, Design case control, Outcome SARS (WHO definition)
(14) Setting long-haul flights, Design case-control, Outcome ILI linked to H1N1 (WHO definition)
(15) Setting Hajj pilgrims, Design cross sectional, Outcome respiratory illness, Details Most of...
(16) Setting Hajj pilgrims, Design cross-sectional, Outcome ILI
(17) Setting students on pig farm, Design cross-sectional, Outcome respiratory symptoms
(18) Setting schools, Design cross-sectional, Outcome rt-PCR tested, Continuous or irregular'...
(19) Setting poultry workers, Design cross-sectional, Outcome serological tests for A(H9N2)...
(20) Setting schools, Design cross-sectional, Outcome rapid diagnostic kit, Issues...
(21) Setting hospital visitors, Design cross sectional, Outcome ILI
(22) Setting Hajj pilgrims (masks supplied), Design cross-sectional, Outcome URTI symptoms

Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Figure 2. Mask wearing to prevent primary infection, by exposure setting

Study or Subgroup	wore masks Events	Total	no masks Events	Total	Odds Ratio M-H, Random, 95% CI	Odds Ratio M-H, Random, 95% CI
1.2.1 general community						
Shin 2018 intvn arm (1)	11	35	33	94	0.85 [0.37, 1.94]	
Shin control arm (2)	14	40	35	96	0.94 [0.43, 2.03]	
Wu 2004 (3)	15	146	69	229	0.27 [0.15, 0.49]	
1.2.2 schools & universities						
Aiello 2010 pilot (4)	44	378	80	552	0.78 [0.52, 1.15]	
Aiello 2012 (5)	46	392	51	370	0.83 [0.54, 1.27]	
Kim 2012 (6)	178	3285	239	4163	0.94 [0.77, 1.15]	
Uchida 2017 (7)	1069	5474	1080	5050	0.89 [0.81, 0.98]	
1.2.3 health care settings (well person wears mask)						
Lau 2004a (8)	92	479	238	511	0.27 [0.20, 0.36]	
Sung 2012 (9)	15	454	95	920	0.30 [0.17, 0.52]	
Wu 2016 (10)	1154	2728	4911	10298	0.80 [0.74, 0.88]	
1.2.4 Animal contact						
Jolie 1998 (11)	63	86	30	46	1.46 [0.67, 3.16]	
Tahir 2019 (12)	41	131	123	170	0.17 [0.11, 0.29]	
1.2.5 Mass gatherings (Hajj)						
Al-Jasser 2012 (13)	98	216	702	1291	0.70 [0.52, 0.93]	
Alfelali 2019 (14)	152	1531	179	1960	1.10 [0.87, 1.38]	
Balaban 2012 (15)	37	89	18	54	1.42 [0.70, 2.88]	
Choudhry 2006 (16)	43	319	260	431	0.10 [0.07, 0.15]	
Choudhry 2006 (17)	8	21	98	256	0.99 [0.40, 2.48]	
Deris 2010 (18)	121	282	34	105	1.57 [0.98, 2.52]	
Emanian 2013 (19)	21	57	11	38	1.43 [0.59, 3.47]	
Zein 2002 (20)	47	216	168	230	0.10 [0.07, 0.16]	
1.2.6 Air travel						
Zhang 2013 (21)	0	12	9	29	0.09 [0.00, 1.62]	

0.01 0.1 1 10 100
Favours mask wearing   Favours no masks

Footnotes
(1) Setting community, Design cohort, Outcome common cold symptoms
(2) Setting community, Design cohort, Outcome common cold symptoms
(3) Setting community, Design case control, Outcome SARS (WHO definition)
(4) Setting University residences, Design cluster RCT, Outcome 'fever' symptoms
(5) Setting University residences, Design cluster RCT, Outcome ILI symptoms
(6) Setting schools, Design cross-sectional, Outcome rt-PCR tested, Continuous or irregular' vs. non-users; school pupils,
(7) Setting schools, Design cross-sectional, Outcome rapid diagnostic kit, Issues denominators add up to > total respondents
(8) Setting visiting index patients, Design case control, Outcome SARS (WHO definition), Comparison 'frequently vs. seldom/no
(9) Setting stem-cell recipients in hospital, Design pre-post design, Outcome respiratory infections (various), lab-confirmed
(10) Setting hospital visitors, Design case control, Outcome ILI
(11) Setting students on pig farm, Design cross-sectional, Outcome respiratory symptoms
(12) Setting poultry workers, Design cross-sectional, Outcome serological tests for A(H9N2) influenza, Comparison Always vs....
(13) Setting Hajj pilgrims, Design cross sectional, Outcome respiratory illness, Details Most of the time vs. sometimes/never
(14) Setting Hajj pilgrims, Design cluster RCT, Outcome respiratory illness
(15) Setting Hajj pilgrims, Design retrospective cohort, Outcome respiratory illness
(16) Setting male Hajj pilgrims, Design prospective cohort, Outcome respiratory illness, Details most of time vs. sometimes/never
(17) Setting female Hajj pilgrims, Design prospective cohort, Outcome respiratory illness, Details most of time vs. sometimes/never
(18) Setting Hajj pilgrims, Design cross-sectional, Outcome ILI
(19) Setting Hajj pilgrims, Design nested case control, Outcome respiratory illness (not colds)
(20) Setting Hajj pilgrims (masks supplied), Design cross-sectional, Outcome URTI symptoms
(21) Setting long-haul flights, Design case-control, Outcome ILI linked to H1N1 (WHO definition)

Figure 3. Faceveil wearing to prevent primary infection

Study or Subgroup	wore veils Events	Total	no veils Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
1.3.7 Hajj setting: Women wearing faceveils or not, cohort respTIs						
Al-Jasser 2012 (1)	164	300	153	277	72.2%	0.98 [0.70, 1.36]
Choudhry 2006 (2)	71	197	35	80	27.8%	0.72 [0.43, 1.23]
Subtotal (95% CI)		497		357	100.0%	**0.90 [0.68, 1.19]**
Total events	235		188			

Heterogeneity: Tau² = 0.00; Chi² = 0.89, df = 1 (P = 0.35); I² = 0%
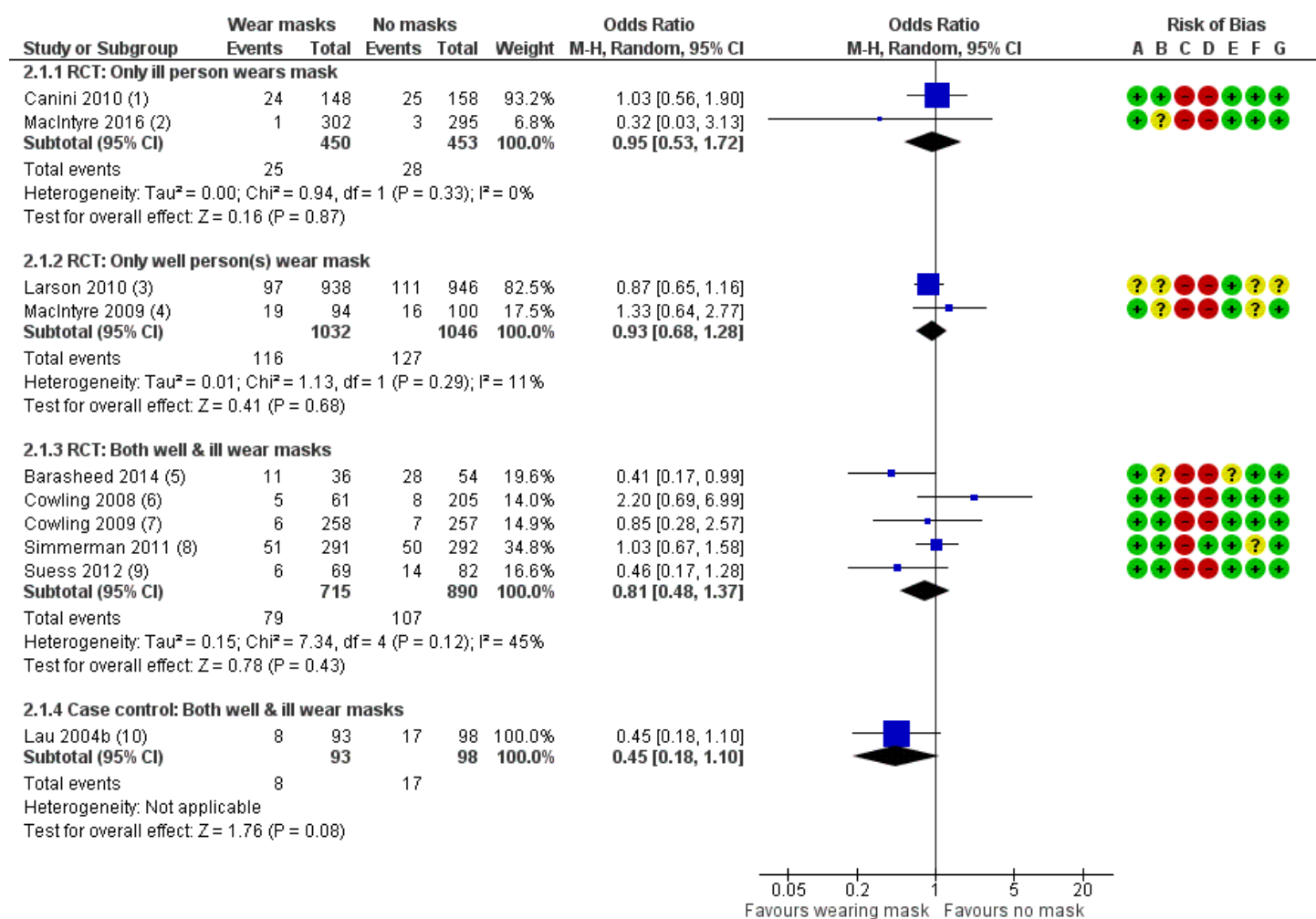Test for overall effect: Z = 0.75 (P = 0.46)
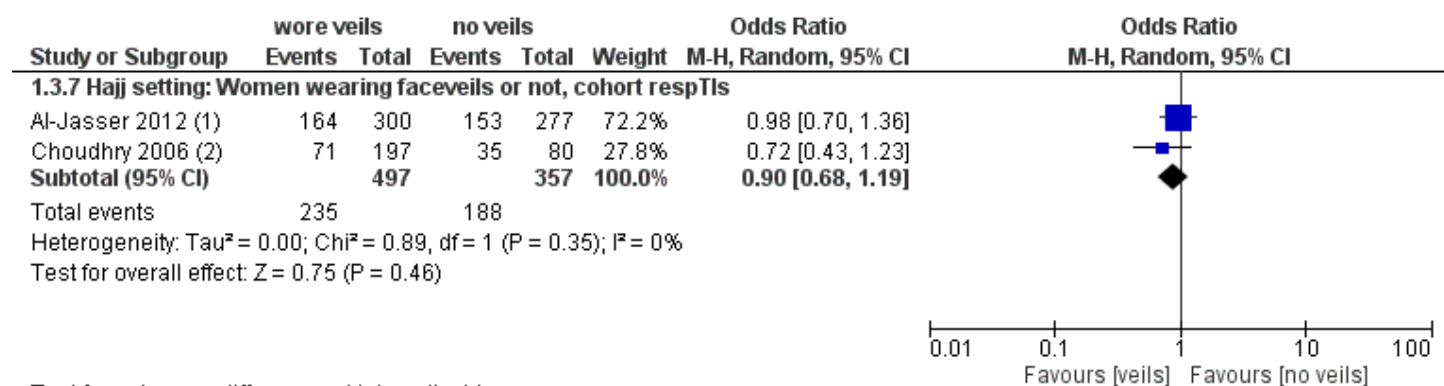
Test for subgroup differences: Not applicable

Footnotes
(1) Setting Hajj pilgrims, Design cross sectional, Outcome respiratory illness, Most of the time vs. sometimes/never Table 5
(2) Setting female Hajj pilgrims, Design prospective cohort, Outcome respiratory illness, Most of the time vs. sometimes/never, Table 3

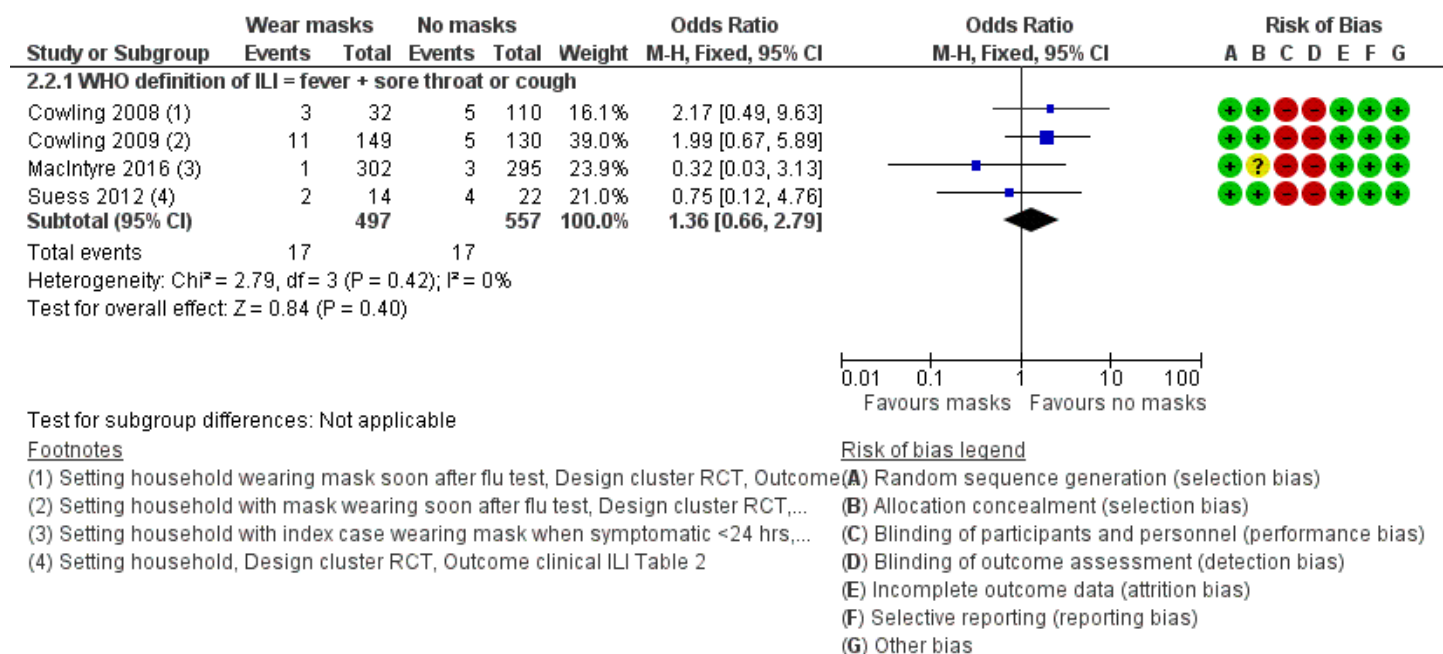## Figure 4. Mask wearing to prevent secondary infection, households

Study or Subgroup	Wear masks Events	Total	No masks Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
2.1.1 RCT: Only ill person wears mask						
Canini 2010 (1)	24	148	25	158	93.2%	1.03 [0.56, 1.90]
MacIntyre 2016 (2)	1	302	3	295	6.8%	0.32 [0.03, 3.13]
Subtotal (95% CI)		**450**		**453**	**100.0%**	**0.95 [0.53, 1.72]**
Total events	25		28			
Heterogeneity: Tau² = 0.00; Chi² = 0.94, df = 1 (P = 0.33); I² = 0%						
Test for overall effect: Z = 0.16 (P = 0.87)						
2.1.2 RCT: Only well person(s) wear mask						
Larson 2010 (3)	97	938	111	946	82.5%	0.87 [0.65, 1.16]
MacIntyre 2009 (4)	19	94	16	100	17.5%	1.33 [0.64, 2.77]
Subtotal (95% CI)		**1032**		**1046**	**100.0%**	**0.93 [0.68, 1.28]**
Total events	116		127			
Heterogeneity: Tau² = 0.01; Chi² = 1.13, df = 1 (P = 0.29); I² = 11%						
Test for overall effect: Z = 0.41 (P = 0.68)						
2.1.3 RCT: Both well & ill wear masks						
Barasheed 2014 (5)	11	36	28	54	19.6%	0.41 [0.17, 0.99]
Cowling 2008 (6)	5	61	8	205	14.0%	2.20 [0.69, 6.99]
Cowling 2009 (7)	6	258	7	257	14.9%	0.85 [0.28, 2.57]
Simmerman 2011 (8)	51	291	50	292	34.8%	1.03 [0.67, 1.58]
Suess 2012 (9)	6	69	14	82	16.6%	0.46 [0.17, 1.28]
Subtotal (95% CI)		**715**		**890**	**100.0%**	**0.81 [0.48, 1.37]**
Total events	79		107			
Heterogeneity: Tau² = 0.15; Chi² = 7.34, df = 4 (P = 0.12); I² = 45%						
Test for overall effect: Z = 0.78 (P = 0.43)						
2.1.4 Case control: Both well & ill wear masks						
Lau 2004b (10)	8	93	17	98	100.0%	0.45 [0.18, 1.10]
Subtotal (95% CI)		**93**		**98**	**100.0%**	**0.45 [0.18, 1.10]**
Total events	8		17			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.76 (P = 0.08)						

Odds Ratio M-H, Random, 95% CI

0.05   0.2   1   5   20
Favours wearing mask   Favours no mask

Risk of Bias: A B C D E F G

Footnotes
(1) Setting household with index case wearing mask when symptomatic <48 hrs, Design...
(2) Setting household with index case wearing mask when symptomatic <24 hrs, Design...
(3) Setting carers, Design cluster RCT, Outcome ILI
(4) Setting household - adults wear mask caring for sick child, Design cluster RCT,...
(5) Setting Hajj pilgrims sleeping near index cases, Design cluster RCT, Outcome...
(6) Setting household wearing mask <36 hours after flu test, Design cluster RCT, Outcome...
(7) Setting household with mask wearing soon after flu test, Design cluster RCT, Outcome...
(8) Setting household, Design cluster RCT, Outcome ILI
(9) Setting household wearing masks when index case symptomatic <48 hrs, Design...
(10) Setting visitors to index cases (SARS), Design case control, Outcome ILI, mask worn...

Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Figure 5. Mask wearing to prevent secondary infection starting <36 hours after onset in index patient, households

Study or Subgroup	Wear masks Events	Total	No masks Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
2.2.1 WHO definition of ILI = fever + sore throat or cough						
Cowling 2008 (1)	3	32	5	110	16.1%	2.17 [0.49, 9.63]
Cowling 2009 (2)	11	149	5	130	39.0%	1.99 [0.67, 5.89]
MacIntyre 2016 (3)	1	302	3	295	23.9%	0.32 [0.03, 3.13]
Suess 2012 (4)	2	14	4	22	21.0%	0.75 [0.12, 4.76]
Subtotal (95% CI)		**497**		**557**	**100.0%**	**1.36 [0.66, 2.79]**
Total events	17		17			

Heterogeneity: Chi² = 2.79, df = 3 (P = 0.42); I² = 0%
Test for overall effect: Z = 0.84 (P = 0.40)

Test for subgroup differences: Not applicable

Footnotes
(1) Setting household wearing mask soon after flu test, Design cluster RCT, Outcome
(2) Setting household with mask wearing soon after flu test, Design cluster RCT,...
(3) Setting household with index case wearing mask when symptomatic <24 hrs,...
(4) Setting household, Design cluster RCT, Outcome clinical ILI Table 2

Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Table 1 Summary of GRADE findings

Masks compared to no masks for influenza-like-illness (ILI)

Patient or population: people without ILI, either in contact with a person with ILI (secondary transmission) or not (primary prevention)
Setting: Any
Intervention: Advice to wear a mask and/or provision of masks
Comparison: No advice to wear a mask

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk without masks	Risk with masks				
Primary prevention, well wear masks - RCT data - outcome ILI	108 per 1,000	**102 per 1,000** (83 to 125)	OR 0.94 (0.75 to 1.19)	5183 (3 RCTs)	⊕⊕◯◯ LOW [a,b,c,d,e]	Wearing a mask may very slightly reduce the odds of primary infection with influenza-like illness (ILI) by around 6%. Low-certainty evidence, downgraded once each for risk of bias and imprecision.
Secondary transmission, use of masks in homes, only ill person wears mask – RCT data – outcome ILI	68 per 1,000	**65 per 1,000** (38 to 108)	OR 0.95 (0.53 to 1.72)	903 (2 RCTs)	⊕◯◯◯ VERY LOW [f,g]	When one household member becomes ill with an ILI the effect of their wearing a mask on the odds of house-mates developing ILI is unclear, as the evidence is of very low certainty (downgraded once for risk of bias, twice for imprecision).
Secondary transmission, use of masks in homes, only well person(s) wears mask – RCT data – outcome ILI	121 per 1,000	**114 per 1,000** (86 to 150)	OR 0.93 (0.68 to 1.28)	2078 (2 RCTs)	⊕⊕◯◯ LOW [f,h]	Both house-mates and the infected household member wearing masks once one household member has contracted an infectious disease may modestly reduce the odds of further household members becoming ill by around 19%. Low certainty evidence (downgraded twice overall for risk of bias, imprecision and inconsistency).
Secondary transmission, use of masks in homes, both well and ill person(s) wear mask – RCT data – outcome ILI	192 per 1,000	**173 per 1,000** (121 to 242)	OR 0.81 (0.48 to 1.37)	1605 (5 RCTs)	⊕⊕◯◯ LOW [h,i,j]	Both house-mates and the infected household member wearing masks once one household member has contracted an infectious disease may modestly reduce the odds of further household members becoming ill by around 19%. Low certainty evidence (downgraded twice overall for risk of bias, imprecision and inconsistency).

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval; **OR:** Odds ratio

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations
a. Risk of bias: Outcome assessors were not blinded for ILI (as outcomes are self-reported and participants could not be blinded), but were for lab-based diagnoses (not shown). Allocation concealment often unclear. Downgraded once.
b. Inconsistency: I2 was 19%. Evidence from other study designs were roughly confirmatory of a small beneficial effect. Not downgraded.
c. Indirectness: measured exactly what we wanted to know re primary prevention. Not downgraded.

d. Imprecision: the 95% CIs included both benefits and harms. Downgraded once.

e. Publication bias: no suggestion of publication bias, not downgraded.

f. Risk of bias: In most trials outcome assessors were not blinded (as outcomes are self-reported and participants could not be blinded), and allocation concealment was often unclear. Downgraded once.

g. Imprecision: the 95% CIs included both big benefits and big harms. Downgraded twice.

h. Imprecision: the 95% CIs included both benefits and harms. Downgraded once.

i. Risk of bias: In most trials outcome assessors were not blinded (as outcomes were self-reported and participants could not be blinded). Downgraded once in conjunction with inconsistency.

j. Inconsistency: I2 was 53%. Downgraded in conjunction with Risk of Bias (downgraded once between both factors).