

The effectiveness of PPE in reducing the transmission of COVID-19 in health and social care settings: December 2021 update

Effectiveness of PPE in protection against COVID-19 transmission

In September 2020, we performed a rapid literature search to investigate the effectiveness of PPE in reducing the transmission of COVID-19 initially for unpaid carers¹. In May 2021 we updated this to consider people working in health and social care settings as part of a fuller paper on mitigations for residential care in the post vaccination risk landscape². Here we update that paper to bring it up to date for December 2021 in the light of the identification of the Omicron variant. It should be noted that all literature reported below predates identification of this variant of concern. Whilst our previous searches found no direct evidence regarding the use of PPE directly related to residential social care in our most recent search we did find reviews related to IPC measure in residential care setting. Nonetheless because of the focus, and quality, of that work we still depend primarily on literature about the effectiveness of PPE when used by healthcare workers. Our updated rapid literature search (Appendix A) reveals that studies reporting on PPE in health care workers are predominantly based in hospital settings with a focus on nurses and physicians. We have now also identified research on mask use in the general population and have drawn on the UK Health Security Agency (UKHSA) October 2021 review of the effectiveness of face coverings in reducing community transmission of COVID-19³. In addition the living review on coronavirus infection epidemiology and risk factors in health care workers based on cross-sectional, cohort, and case series studies and first published in 2020⁴ has been updated twice since we used update 8 (118 studies) in our May 2021 version of this briefing. Update 9⁵ adds 21 new studies & update 10⁶ has 20 new studies. Data from these two updates are thus included herein^a. To date no meta-analysis of results has been undertaken because of heterogeneity of outcomes and continued methodological differences and limitations in the included studies. Update 10 presents a summary evidence table of risk factors and mitigations for COVID-19 infection amongst healthcare workers reproduced in Appendix B.

PPE Use in Healthcare Workers

Up-to-date evidence on the effectiveness of PPE in healthcare workers is available in the living rapid review⁴⁻⁶. We have searched each update for results in relation to (a) mask use; (b) full vs. partial use of PPE; (c) frequency/consistency of PPE use; and (d) infection control training and education. The review provides a narrative summary of findings in relation to coronavirus exposure and PPE use and results are consistent across all updates. A notable finding from update 10 is that seven studies consistently found that exposure to COVID-19 in a household or private setting is associated with increased risk of infection in HCWs (adjusted odds ratios [ORs] range from 2.55 to 8.98 and in most studies, **household or private setting exposure is a stronger risk factor than work exposure**).

Masks^b

The living review continues to report **consistent and robust evidence for the association between mask use and decreased infection risk from SARS-CoV-2** in healthcare workers (ORs from 0.002 to 0.71 for significant studies- or 1.7 including non-significant studies^c). While the initial review in 2020 extrapolated from results of studies on non-SARS-CoV-2 specific data, the more recent updates have focused on data from studies of SARS-CoV-2 infection only. Results are thus likely to be relevant to

^a Chou et al initially updated the living review monthly, then changed to a bi-monthly schedule. As evidence shows little change month-on-month in June 2021 the review moved to a bi-annual update schedule. The initial review in 2020 extrapolated from results of studies on non-SARS-CoV-2 specific data. The more recent updates have focused on data from studies of SARS-CoV-2 infection. This, and slight changes to the search and inclusion criteria, has resulted in changes in the numbers of papers included over time. Thus numbers of paper reported here may not be completely consistent with numbers reported in the two previous versions of this briefing.

^b Review updates 9 & 10 add three new studies, thus 11 studies are included in update 10.

^c This OR of 1.70 is based on a study where only 2/478 persons did not wear masks.

the current situation. **However, all results relate to variants earlier than Omicron.** Studies also suggest that **N95 (FFP2) respirators are associated with decreased risk compared with surgical masks (ORs in the region of 0.75 in most cases).** These studies are confounded by factors such as N95 being used in higher risk areas or during higher risk procedures (e.g. AGPs). No meta-analysis was conducted, but summary tables can be found in the update supplementary materials. The evidence remains clear for consistency of use of masks, with **consistent use providing better protection than inconsistent use.**

UK Health Security Agency (UKHSA) updated the review of the effectiveness of face coverings in reducing community transmission of COVID-19 in October 2021³, drawing on evidence reviews up until 14th September 2021. The review includes 25 studies (23 observational studies, two RCTs). The report suggests that **face coverings reduce the spread of COVID-19 in the community**, through source control, wearer protection, and universal masking, but draws no conclusions as to face coverings are more effective as source control or wearer protection. RCT evidence (medium quality) from one RCT provides direct evidence that face coverings (**surgical and cloth face coverings**) are **effective when used as universal masking, particularly for surgical masks and for older people**, and that the interventions to increase face covering use also increased social distancing. The other RCT was inconclusive, reporting a non-significant reduction in COVID-19 infections from wearer protection using surgical masks. Relatively few participants in this study developed COVID-19 and thus the study lacked precision. Contact tracing studies (n=8) that analysed face covering use suggest that **contacts of primary cases were less likely to develop COVID-19 if either or both wore a face covering.** Further, (mostly low quality) observational studies (n=15) had mixed results for the effectiveness of face coverings. For all these observational studies confounding factors such as differences between wearers and non-wearers of masks, and mitigation measures such as hand washing and social distancing could have impacted on the results.

UKHSA conclude that the results are broadly in line with the previous review; but that addition of RCTs and substantially more individual-level observational studies increase the certainty of the results and strengthens the evidence for the effectiveness of face coverings in reducing transmission in community settings. The authors of the large cluster RCT estimated that an increase from 0% to 100% of people wearing face coverings over the nose and mouth would be associated with 32% decrease in symptomatic COVID-19 seroprevalence.

A narrative systematic review⁷ identified by our updated search (Appendix A) focuses on aerosol particle size, transmission in the air and filtering/barrier properties of masks and reports that factors determining mask effectiveness are filter efficiency, facemask fit and proper use. Cloth masks provide marginal protection and surgical offer 30-50% against particles meeting aerosol definition. N95 masks provide better protection but effectiveness is still dependent on fit and proper use. Perhaps uncontroversially they conclude mask wearing “should only be considered a measure of protection rather than a complete control method”. A modelling study suggests that differences in variations in mask efficacy can be explained by differences in virus abundance in the environment⁸. Most environments and contacts are in conditions of low viral abundance, and surgical masks are effective, but virus rich environments require masks with greater filtering/barrier properties and overall masks are particularly effective in combination with other preventive measures.

Nonetheless, findings are overall consistent with research reported to SAGE on 10th September 2020⁹ that N95/FFP2¹⁰ mask (penetration by contaminants <0.01%) is better than medical mask (penetration 44%) which is better than general cloth mask (penetration 97%). The latter thus may offer the wearer reassurance, but little or no real protection. A rapid review by PHE (1st October 2020) of factors associated with COVID-19 in care homes and interventions to prevent ingress and transmission identified only weak observational evidence for universal mask wearing in residential

care as part of fuller package of interventions and identifies the need for further research on all interventions including PPE and mask use in residential care settings.

Other PPE – gloves, gowns, eye protection.

The living review also reports associations between use of gloves, gowns, eye protection, shoe covers, and decreased risk of transmission (29 studies included in update 10). Studies are reasonably consistent in that **full PPE use (gloves, mask, gown, and eye protection) was associated with decreased risk of infection compared to partial or no PPE use** (ORs from 0.03-0.68). Some studies however find association between PPE use (including glove use) and increased risks. These findings likely relate to PPE use being a marker of exposure risk, inadequate training and inconsistent use (e.g. findings of staff not wearing PPE in staff rooms during breaks), and methodological issues in the studies.

The Cochrane review (version 15th May 2020 as reported in September 2020) on PPE use¹¹ with infectious diseases included 24 studies, (22 simulation studies, 14 randomised). The review evaluates which types of full-body PPE, and which donning and doffing methods, have the least risk of contamination, and which training methods increase compliance. Overall, the authors found low- to very low-certainty evidence that covering larger areas of the body results in better protection. Gowns may provide better protection against contamination than aprons. PPE made of breathable material, which is associated with greater user satisfaction, was not demonstrated to be worse than water repellent material. The evidence is limited, based on small sample simulation studies. The review also highlights low-certainty evidence from one SARS-related study and two simulation studies that more active training (video/computer simulation or face-to-face training) in PPE use decreases noncompliance with donning and doffing guidelines to a greater extent than passive training (lectures only). At December 2021 there has been no update on this review since May 2020.

The HSE report¹² on aprons, gowns and eye protection draws on the Cochrane review as providing core evidence and concludes that aprons and gowns are suitable, but points to pros and cons during donning, use and doffing. HSE also point out the lack of evidence on the effectiveness of goggles or face shields. No evidence is identified that directly relates to residential social care settings.

Our updated search identified one new review of direct relevance since June 2021. This review¹³ assesses the utility of face shields as protection from coronavirus transmission for healthcare workers, with seven studies fulfilling their inclusion criteria. The use of a face shield alone as protection against COVID-19 is insufficient. They conclude **face shields should not be used for respiratory protection, much less replace it**, and should be used simultaneously with other forms of protection including masks, other PPE and IPC measures. N95 should be used when there is risk of aerosol. They highlight that there are no industry standards for face shields, with numerous different models on the market, requiring rigorous evaluation of both their protective and usability properties.

PPE in Social Care Settings

A review by Khunti *et al.*¹⁴ (August 2020) highlights that most of the guidance surrounding PPE use focuses on emergency or inpatient care settings and it is often assumed that primary or community care settings (which may include social care) are at low risk in comparison. The reality is likely much more nuanced, as community care may often expose healthcare workers and those they care for to a high degree of risk through close prolonged contact (see below¹⁵). The Khunti *et al.* review found little direct evidence for the effectiveness of PPE in primary or community care. However, indirect evidence from single-centre experimental studies supports the appropriate use of PPE in community and social care settings according to PHE¹⁵ and WHO¹⁶ guidelines in order to protect against COVID-19. The reviews discussed above on community use of masks strongly reinforces this view.

One study, new to the living review update 10, reports on PPE use in nursing homes in the USA finding increased risk related to PPE use (OR=2.18 (1.26 to 3.80)). The authors of that study¹⁷ were at pains to point out the higher rates of infection in nursing home personnel in their study compared to hospital personnel (13.1%, (11.5% to 14.9%) vs 3.1%, (2.7% to 3.5%)). They point to the use of PPE in nursing homes as being a marker of the infection risk related to where staff were working (i.e. on a COVID-19 unit), potentially exacerbated by staffing shortages, poor training, and artefacts related to staff workplace allocations and seropositivity from earlier infection.

Training^d

The living review reports a consistent association across studies between infection control training and decreased infection risk, with not being trained being associated with higher risk. However only one study reports a significant relationship. The evidence is limited as risk factor studies are retrospective, with the possibility of recall bias regarding use of PPE. None of the studies used an RCT design, some studies did not control for confounders, and those that did were limited in their ability to control for exposure. PHE/NHS launched an IPC toolkit in July 2021 for NHS organisations¹⁸. It follows a conventional booklet format available online, but has not been formally evaluated.

Behaviour

Behavioural measures to support proper **doffing and donning** and general infection control measures should be promoted in tandem with PPE use¹⁹. Research from healthcare settings emphasises the importance of training staff in correct donning and doffing procedures and safe disposal of PPE after use. However, none of the associations in the living review between infection and donning/doffing procedures or with training in donning/doffing are significant.

Hand hygiene

Handwashing is also considered in the living rapid review with four studies reporting on association with risk of SARS-CoV-1 infection, generally with poor practice being associated with increased risk. However only one study reports significant results with poor handwashing practice having OR=2.64 (1.04 to 6.71). As a key intervention of known effectiveness, handwashing recommendations should be applied across the board for all healthcare workers. Hand hygiene guidelines are generally informed by the WHO's "five moments for hand hygiene"²⁰ which recommend that healthcare workers clean their hands 1) before touching a patient; 2) before clean/aseptic procedures; 3) after body fluid exposure/risk; 4) after touching a patient; and 5) after touching patient surroundings. Hand hygiene is a behaviour very amenable to behavioural intervention and use of behaviour change techniques, and more effort is needed in this regard²¹.

Use of PPE

It is highly likely that correct and comprehensive use of masks, gloves, gowns, eye protection, etc., together with behavioural infection control measures, such as hand washing and physical distancing, will result in a decreased risk of coronavirus transmission. Handwashing is an intervention available in all healthcare settings. However, a major caveat relating to PPE is that these procedures must be properly instigated (including donning and doffing) and consistently followed if they are to be effective. Standard precautions should be taken where risk is low (e.g. handwashing and use of masks). Contact and droplet precautions should be taken for suspected or confirmed cases of COVID-19 (e.g. handwashing, mask, gown, goggles, and gloves). **To date the literature related to SARS-COV-2 and training in use of PPE suggests that far more needs to be done to ensure social care staff are properly trained.**

^d Two new studies were added at update 9 and none at update 10.

Our updated search (Appendix A) identified a further review of training in use of PPE focussing on donning/doffing²². Although PPE skills can be mastered in a controlled learning environment, maintaining the integrity of the procedure during critical situations is challenging. The review highlights the opportunities for e-learning and other technology solutions to provide training and education under pandemic conditions but that much more work is required, especially in terms of clinical benefits to patients. We also identified a review and meta-analysis of IPC measures in general workplace settings²³. **Meta-analyses revealed lower COVID-19 positivity estimates in workplace settings that implemented combined measures compared with settings that applied single measures.** Combinations of PPE, timely and thorough outbreak investigation (contact tracing and isolation), syndromic surveillance and testing, and staff zoning emerge as important considerations. They also highlight that these measures should be paired with improved building ventilation and indoor air quality.

Two reviews identified by our updated search identify adverse effects to PPE use amongst healthcare workers, including dermatological reactions to PPE use²⁴ and headaches related to PPE use²⁵. Perhaps not surprisingly mask use is associated with adverse skin reactions around the mouth/cheeks and nose (mask wearing median 57% adverse reactions). Duration of wearing is associated with occurrence and severity. The evidence on type of mask is unclear but N95 masks appear to be associated with more problems. Many reactions are relatively minor, if uncomfortable, and wearers benefit from prophylactic use of hydrocolloid dressing on pressure areas. There is widespread self-report of headache related to mask or goggle use (26%-91%). Type of mask (surgical vs N95) and how long the mask is worn during a shift are important variables for headache generation.

Another potential factor to consider in relation to frail or older people is the risk of falls from long gowns or other ill-fitting PPE, although currently there is no literature reporting on PPE trip hazards. Providing care for people with communication issues relating to deafness or cognitive impairment can provide additional challenges when it comes to PPE use. For people with hearing loss, mask use results in reduced acoustic transmission and prevents lip reading, and may also be uncomfortable for those wearing hearing devices²⁶. Furthermore, mask use is not suitable for those with severely compromised respiratory systems²⁷ or those who cannot remove or adjust their own masks²⁸. Many residents will fall into these categories and hence mask use is more often observed amongst staff and visitors rather than residents themselves.

Apps

In May 2020, an app was launched by the NHS to support social care workers during the COVID-19 pandemic²⁹. The app provided care workers in England with guidance and learning resources on crucial areas such as infection control, as well as wellbeing toolkits to support staff through the pandemic. **The app was closed down on 31st March 2021.** The Social Care Institute for Excellence (SCIE) has set up online hygiene training in response to the COVID-19 pandemic for care providers (<https://www.scie.org.uk/e-learning/infection-control>). This course covers the basics of infection control (how infections spread and how to prevent spread, hand hygiene, managing the care environment, laundry safely, use of PPE, and waste disposal) and is reported as taking about 30 minutes to complete online. As far as we know, the effectiveness of the course has not been evaluated. An existing evidence-based digital intervention <https://germdefence.org/> was adapted for the COVID-19 pandemic with recent evidence for change in intentions to improve infection control behaviours³⁰. Whilst Germ Defence was designed for the public it is relevant to social care workers, both in their home lives and their work lives and should be promoted. NIHR have recently funded an initial study to modify Germ Defence for residential care settings.

Conclusion

The evidence reviewed in this briefing is all based on studies undertaken before the identification of the Omicron variant, and indeed in populations that did not have the levels of vaccination currently observed in UK social care staff, residents or the UK general public. That said there is no obvious reason to reject the evidence presented herein. Overall there is likely to be an intersection between high risk, high exposure and low resource, which needs to be addressed when considering how best to reduce transmission across different health and social care settings. **It is highly likely that the use of masks, gloves, gowns and other PPE together with behavioural infection control measures, such as hand washing, will result in a decreased risk of coronavirus transmission in social care.** However the major caveat here is that these procedures must be properly instigated (including donning, doffing, and disposal of used PPE) and consistently followed if they are to be effective. There is little direct evidence for the effectiveness of PPE in social care, but we recommend that infection control measures are implemented based on the WHO risk classification. Standard precautions should be taken where risk is low (e.g. handwashing and use of masks). Contact and droplet precautions should be taken for suspected or confirmed cases of COVID-19 (e.g. handwashing, mask, gown, goggles, and gloves). Situations in which there is likely to be aerosol generation require further measures.

17th December 2021

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This paper presents independent research funded by the National Institute for Health Research. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care or its partners.

Appendix A – Search Strategy

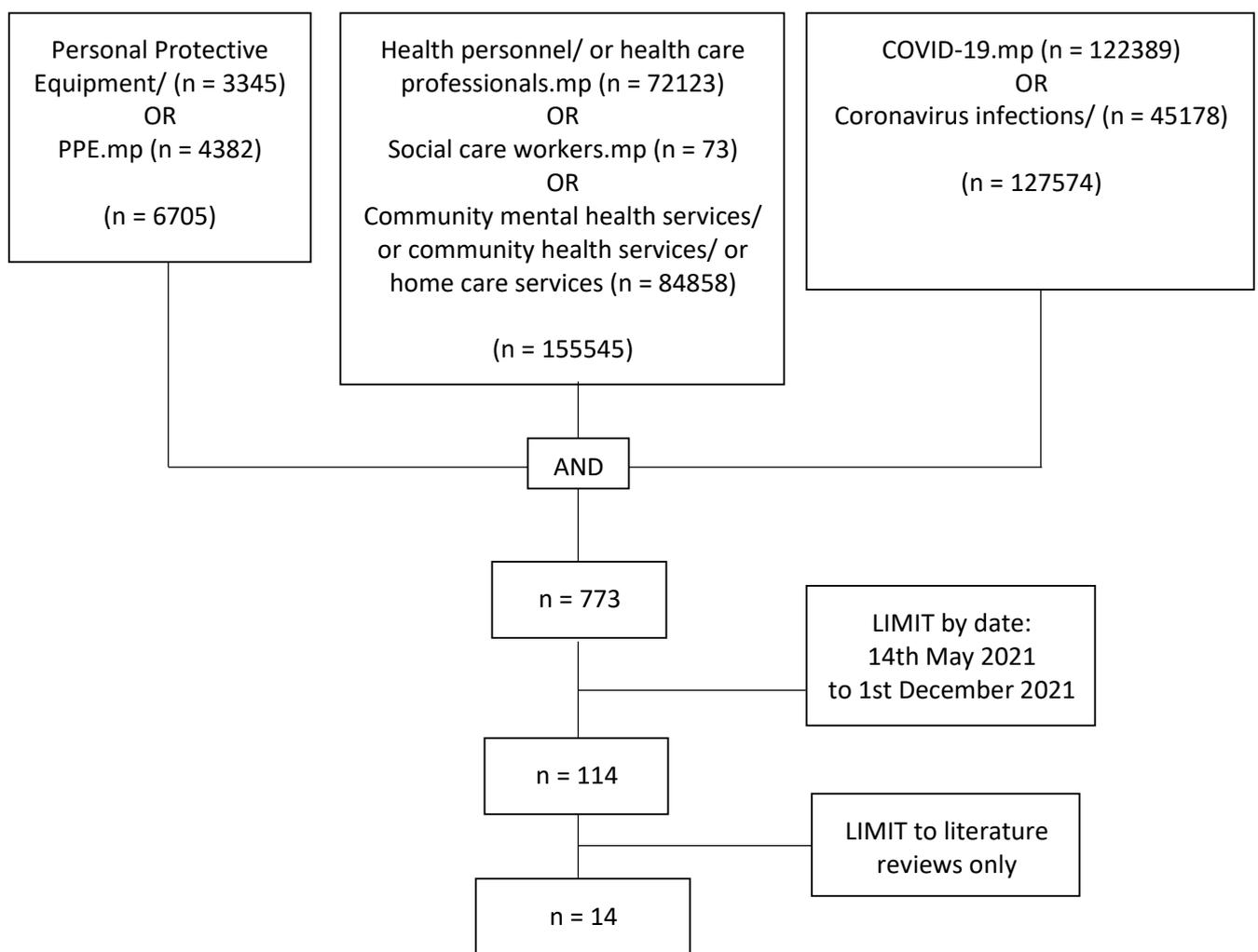
PPE and Social Care – Search Strategy (update 1st December 2021) NB identical search strategy until 14th May 2021 for previous update yielded 39 papers, only 2 of which were relevant.

Search for PPE effectiveness in health and social care

(a) Google Scholar keywords/terms.

1. personal protective equipment
2. PPE
3. effectiveness
4. health care professionals
5. social care workers
6. residential care
7. community health services
8. COVID-19

(b) MEDLINE (Ovid) Search Strategy Flow Chart:



Title, abstract and full text review identified 7/14 papers as not presenting data relevant to this review. The seven remaining papers are referenced in this briefing.

Appendix B – Evidence map from Chou et al 2021.

Supplement Table 7. Risk factors for SARS-CoV-2 infection in HCWs evidence map

Risk factor	Size of evidence	Effect
Age	++++	●
Sex	++++	●
Race/ethnicity	+++	●
Antibody status	+	◆
HCW role	++++	●
Directness or intensity of contact	++++	◆
Participation in high-risk procedure	+++	◆
Education/training	+	◆
Mask use	++	◆
PPE use	+++	●

Size of evidence	Strength of evidence	Effect
++++ >50 studies; >200,000 HCWs	● Moderate	■ Positive association
+++ 20-50 studies; >100,000 HCWs	◆ Low	□ Negative association
++ 10-20 studies; >50,000 HCWs	■ Insufficient	□ No association
+ <10 studies; <20,000 HCWs	- No evidence	

Chou R, et al. Update alert 10: epidemiology of and risk factors for coronavirus infection in health care workers. *Ann Intern Med.* 16 November 2021. [Epub ahead of print]. doi:10.7326/M21-4294
 Supplementary Tables: https://www.acpjournals.org/doi/suppl/10.7326/M21-4294/suppl_file/M21-4294_Supplement.pdf

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- ¹⁰ HSE *Rapid evidence review: Part 1 Equivalence of N95 and FFP2 masks*, concludes there is no material difference between N95 and FFP2 masks and both would provide comparable protection against coronavirus as long as the wearer was face-fit tested. **Since this review UK IPC guidance has been updated and requires FFP3 respirators to be worn where AGPs are being performed.** <https://www.hse.gov.uk/coronavirus/ppe-face-masks/face-mask-equivalence-aprons-gowns-eye-protection.htm> (accessed 10/12/21-webpage last updated 09/12/21).
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