ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Rapid review of the literature: Assessing the infection prevention and control measures for the prevention and management of COVID-19 in health and care settings

Version 25: 07 April 2022

Version history

Version	Date	Summary of changes
1.0	19/3/2020	Assessment of the emerging COVID-19 evidence base, includes literature identified up to 16 March 2020.
1.1	3/4/2020	Assessment of the emerging COVID-19 evidence base, includes literature identified up to 30 March 2020.
1.2	20/4/2020	Assessment of the emerging COVID-19 evidence base, includes literature identified up to 13 April 2020.
3.0	15/5/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 11 May 2020.
4.0	24/6/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 15 June 2020.
5.0	23/7/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 20 July 2020
6.0	2/9/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 31 August 2020
7.0	2/10/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 28 September 2020
8.0	05/11/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 02 November 2020
9.0	04/12/2020	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 30 November 2020
10.0	15/01/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 05 January 2021
11.0	05/02/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 01 February 2021
12.0	12/03/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 01 March 2021
13.0	09/04/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 29 March 2021
14.0	07/05/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 26 April 2021
15.0	11/06/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 31 May 2021
16.0	15/07/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 05 July 2021
17.0	11/08/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 02 August 2021
18.0	08/09/2021	Monthly update; this version has updated objectives and a reduced scope – the following sections have been archived: clinical presentation, atypical presentation, pre-symptomatic transmission, reinfection, incubation period, infectious period,

Version	Date	Summary of changes
		face visors, and hand hygiene (**v17, Archived**). Amended search strategy. Includes literature identified up to 30 August 2021.
19.0	08/10/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 27 September 2021.
20.0	04/11/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 25 October 2021.
21.0	09/12/2021	Monthly assessment of the emerging COVID-19 evidence base, includes literature identified up to 29 November 2021
22.0	13/01/2022	Monthly update; this version has updated objectives and a reduced scope – the following sections have been archived: Survival in the environment, Environmental decontamination **(V21.0 Archived).** Updated search strategy. Includes literature identified up to 27 December 2021.
23.0	07/02/2022	Monthly update; The search strategy has been amended. Includes literature updated up to 31 January 2022.
24.0	10/03/2022	Monthly update of the emerging COVID-19 evidence base, includes literature identified up to 28 February 2022.
25.0	07/04/2022	Monthly update of the emerging COVID-19 evidence base, includes literature identified up to 04 April 2022. **This is the final version of this rapid review.**

Contents

1. Aim

To provide a rapid review of the scientific evidence base to inform the infection prevention and control measures required for the prevention and management of COVID-19 in health and care settings.

2. Objectives

Objectives for the rapid review, as at January 2022, are to establish the following:

- The transmission routes of COVID-19;
- The personal protective equipment (PPE) requirements;

3. Methodology

The methodology for this rolling rapid review was developed to ensure frequent and timely assessment of the emerging evidence base could be provided.

Academic databases (Medline and Embase) were first searched on 5th March 2020 to identify relevant literature (see **Appendix 1** for search strategies). Searching was also conducted on the pre-print database, medRxiv (via NIH icite). Additional grey literature searching was conducted which included searching online resources from the World Health Organization (WHO), the US Centers for Disease Control and Prevention (CDC), the European Centre for Disease Prevention and Control (ECDC), UK Health Security Agency (UKHSA, formerly Public Health England), Public Health Scotland, UK, Scottish, Canadian and Australian Government guidance, the UK Scientific Advisory Group for Emergencies (SAGE), the Novel and Emerging Respiratory Virus Threats Group (NERVTAG).

In September 2021, the decision was made in conjunction with the CNOD COVID-19 Nosocomial Review Group (CNRG) to reduce sections of this rapid review in order to direct scientific resource to other priority areas. Updates are no longer being provided for the following sections: clinical presentation, atypical presentation, pre-symptomatic transmission, reinfection, incubation period, infectious period, face visors, decontamination of respirators, and hand hygiene. To account for this, a revised search strategy was developed and run from 23rd

September (see **Appendix 1**). In December 2021, a further decision was made in conjunction with the CNOD CNRG to further reduce sections of the review, with updates no longer being provided on survival in the environment, and environmental decontamination. A revised search strategy was developed and run from 13 December 2021. These superseded sections are still available to view in archived drafts: **Version 17 – August 2021** and **Version 21 – December 2021**. Targeted rapid reviews will be undertaken on these subject areas in the future should the need arise.

In April 2022, the decision was made in conjunction with the CNOD CNRG to end the rapid review with no further updates to be provided after April 2022. Evidence gaps identified from the pandemic will be considered in the NICPM systematic literature review updates.

Studies were excluded if they were published pre-2000, if they were published in non-English language and if they were animal studies.

Inclusion criteria was kept broad owing to SARS-CoV-2 being a novel pathogen, any study design was considered. Screening was undertaken by two reviewers, any uncertainty over the relevance of an article was decided by agreement between the two reviewers. As this was a rapid review, evidence was critiqued but not formally graded with the use of an appraisal tool, meaning that graded recommendations were not feasible.

The SIGN50 critical appraisal system is used for ARHAI Scotland systematic reviews and while time constraints meant individual studies were not entered into SIGN50 checklists for this rapid review, the SIGN50 principles were applied to critical analysis of the evidence base and data extraction from studies was entered directly into evidence tables developed for the rapid review.

3.1 Evidence updates

The emerging evidence base on COVID-19 is rapidly changing. To account for this, published literature is screened on a weekly basis and weekly evidence updates produced. Updates to the rapid review will be made on a monthly basis, or if the evidence base indicates that a change to recommendations is required.

4. Epidemiology

4.1 Transmission routes

Early analysis of the transmission of COVID-19 was thought to occur mainly via respiratory droplets[1-10] generated by coughing and sneezing, through direct contact[1, 3, 6-11] and indirect contact with contaminated surfaces.[1, 6, 7, 9, 10] These transmission routes were supported by early National[12-14] and international guidance.[15, 16] The World Health Organization (WHO) in a scientific brief published July 2020 supported that the main mode of transmission was via respiratory droplets, which are expelled when an infected person coughs, sneezes, talks or sings.[17] Transmission through contact with contaminated surfaces (fomite transmission) is considered possible due to the presence of COVID-19 viral RNA on surfaces (see section 6 – survival in the environment in archived version **21 – December 2021**) however there has so far been no published evidence to demonstrate singularly in real-life scenarios, as it is impossible to separate the contribution from other transmission modes.

As the pandemic has progressed, there have been growing calls to acknowledge a potential airborne transmission route. The European Centre for Disease Prevention and Control (ECDC) describe transmission as occurring via respiratory droplets, either by being inhaled or deposited on mucosal surfaces, including aerosols produced when coughing and speaking, however acknowledge that the relative role of large droplet, aerosol and fomite transmission remains unclear.[18] The US Centers for Disease Prevention & Control (CDC) stated in a scientific brief published 7th May 2021 that exposure to respiratory fluids occurs via inhalation of fine droplets and aerosol particles, deposition of droplets and particles onto exposed mucous membranes, as well as touching mucus membranes with hands soiled by exhaled respiratory fluids.[19] Risk of transmission is considered to be greatest within three to six feet of an infectious source where the concentration of emitted particles is greatest. The CDC also stated that airborne transmission may be possible under special circumstances, specifically: in enclosed spaces where there is inadequate ventilation or air handling, during prolonged exposure to respiratory particles, and where 'increased exhalation' may have occurred (exercising, singing, shouting).[19] The WHO published an updated scientific summary of COVID-19 transmission in December 2020, stating that outside of medical facilities, in addition to droplet and fomite transmission, aerosol transmission could occur in specific settings and circumstances, particularly in indoor, crowded and inadequately ventilated spaces, where infected persons spend long periods of time with others.[20] In interim IPC guidance published 12th July 2021, WHO stated that the virus spreads mainly between people who are in close contact with each other, typically within

1 metre (short-range).[21] On a Q&A webpage updated 23 December 2021, WHO state that transmission can occur in poorly ventilated and/or crowded indoor settings, where people tend to spend longer periods of time, as aerosols can remain suspended in the air or travel farther than conversational distance (called long-range aerosol or long-range airborne transmission).[22] The CDC state that there are several well-documented examples in which transmission appears to have occurred over long distances or times; the references provided in the report are largely from outbreak reports in overcrowded community settings (restaurants, recreation, gyms).[23-25 26] Outbreak reports are, by their nature, prone to many methodological limitations (e.g. self-report bias, publication bias, lack of robust data) however continue to be the main source of evidence regarding transmission modes. There have been a number of epidemiological studies of transmission events in quarantine hotels, where non-related individuals shown to have genetically identical SARS-CoV-2 infections has suggested airborne transmission between adjacent rooms across a corridor.[26] The airflow pattern supported an air-mediated route however being a retrospective study, air sampling was not available from the time of exposure. Quarantine staff attending the occupants tested negative when wearing surgical masks however transmission risk may be a reflection of the duration of exposure to the occupants. There is a possibility of undocumented exposure prior to entry to the hotel which would dilute the strength of the whole genome sequencing analysis, as background SARS-CoV-2 genetics were not considered.

It is now widely acknowledged that respiratory emissions are emitted in a spectrum of particle sizes that include larger droplets and smaller aerosols. The historical dichotomy of droplet/airborne transmission has resulted in rigid thinking with regards to the resultant mitigation measures that are required for infection prevention and control. As SARS-CoV-2 has shown, there is likely to be much variation in the infectiousness of respiratory pathogens that cannot be explained alone by the size of emitted respiratory particles. There are multiple factors involved in transmission risk, covering host-based (immune status/vaccine history, genetics, susceptibility), source-based (symptomology, time point in disease course) pathogen-centred (infectious dose, virulence), and environmental factors (humidity, temperature, ventilation). There is currently a lack of quantitative evidence regarding these individual factors and their relevant importance and interaction with each other.

Currently, the international evidence base supports that the primary transmission mode for SARS-CoV-2 involves close contact – this takes into account the spectrum of respiratory particle sizes produced at source. This is a move away from the historical dichotomy of droplet vs. airborne, instead acknowledging that an aerosol produced at source will also present the

risk of being transmitted at close range (e.g. within 2 metres) and that risk of onwards transmission is impacted by a number of variables including symptomology, duration of exposure, and ventilation among others. Currently there is limited evidence of 'traditional' long-range airborne transmission of SARS-CoV-2 from outbreak reports.

The UK Scientific Advisory Group for Emergencies (SAGE) in April 2021 stated that evidence suggests airborne transmission is most likely in poorly ventilated spaces but that applying full conventional airborne precautions throughout a hospital is neither practical nor likely to be necessary.[27] From unpublished Scottish outbreak reporting from acute care settings it is clear there is large variation in the size and duration of outbreaks, with some units experiencing just a few cases per outbreak cluster and others in the double figures. Consistently large outbreaks might be expected with a predominantly airborne transmission mode however there are many confounding factors that could impact the transmission rate. Prolonged shedding in a patient could also theoretically maintain an outbreak, inability of some patients to wear facemasks, breaches in control measures such as physical distancing, hand hygiene, adequate cleaning and PPE use and delays in diagnosis can also significantly contribute to the transmission rate. All of these have been reported consistently during outbreaks and are further fuelled by increasing inpatient numbers and staffing shortages. There are wards in which contact and droplet precautions were applied for managing COVID-19 patients with no onwards transmission. Without a detailed epidemiological investigation, ideally with whole genome sequencing, it is very challenging to obtain data from outbreak reports that provides reliable and valid assessment of the potential transmission modes and contributing factors.

It must be acknowledged that further research is required to determine the potential contribution of aerosol transmission of respiratory viruses, acknowledging a spectrum of particle sizes. This would include analysis of, for example, experimental studies that do not involve human-human transmission but demonstrate a theoretical aerosol 'potential'. These include experimental laboratory studies designed to assess visualisation of droplet expulsion from the human mouth/nose, mechanically-generated aerosol studies where the air is experimentally seeded with viral particles, animal studies involving an artificially infected donor and recipient, and air sampling studies where presence of viral RNA (and subsequent cell culture) is used as a proxy for transmission risk. These studies collectively demonstrate a potential for air-mediated transmission but are generally considered low quality evidence due to concerns regarding their validity and representativeness (particularly with regard to the animal studies). Promising research with novel techniques is emerging;[28] standardisation of techniques will allow comparison across studies.

Air sampling studies conducted in COVID-19 healthcare environments have shown mixed results. A number of international studies (South Korea, Ireland, China, Iran, Italy, Canada , Brazil) returned negative results for the presence of viral RNA by RT-PCR in air samples collected from active air sampling[29-40] or settle plates[41] in ICUs, single patient rooms, multi-bed bays, general corridors, fever clinics, EDs, rooms of long term care facilities, treatment rooms and throat swab sampling rooms, and 'clean' areas.[42, 43] In these studies, patients were often intubated, mechanically ventilated, on non-invasive ventilation or receiving high-flow nasal oxygen (HFNO). The distance between the air samplers and the patients varied from 0.6m to 5m. Symptom severity, number of days since symptom onset, and environmental ventilation provision in these studies also varied. There has been an attempt to assess the influence of ventilation on the observed outcomes of air sampling (and environmental sampling);[38, 44] this is a methodologically challenging task with many confounding factors to account for.

Studies that have reported positive air samples are also heterogeneous in terms of patient symptoms, duration since symptom-onset, ventilation provision, and distance of sampler placement from patients. Positive air samples have been reported in isolation rooms and corridors of COVID-designated hospitals,[45-48] airborne isolation rooms of general wards,[49, 50] PPE-removal rooms,[51-53] ICUs,[42, 52, 54-57] hospital corridors,[42, 53, 58, 59] bays,[60] long-term care rooms,[56] and single patient rooms.[58-67] Active air sampling in 2 Wuhan hospitals demonstrated positive results in PPE-removal rooms, which led the author to suggest resuspension of virus-laden aerosols from the surface of contaminated PPE was contributing to air contamination; very low/non-detectable concentrations of viral RNA was detected in COVID-19 ICUs.[51] Active air sampling in an ICU treating 15 patients with severe disease and in a general ward treating 24 patients with mild disease returned positive results in 35% of samples collected from the ICU and 12.5% of samples from the general ward.[54] A study at a hospital in China detected viral RNA in one out of 12 bedside air samples collected at a distance of 0.2 metres; breath condensate samples from the patient were also positive however it is not possible to distinguish droplet from airborne detection in this study, and there was no data provided regarding the clinical procedures conducted in the room before or during sampling.[68] Active air sampling in a London hospital detected viral RNA in samples from multiple patient areas however repeat sampling returned positive results in 3 areas only.[69] When testing was carried out in the presence of tracheostomies, only 1 of 8 samples was positive. One out of 12 active air samples taken from COVID-19 patient rooms in a hospital in Wuhan tested positive within 10cm of a patient undergoing endotracheal intubation for invasive mechanical ventilation.[61] Four out of 55 samples taken <1m from patients at 8 hospitals in England tested positive; 3 of the 4 patients were undergoing AGPs at the time (CPAP, non-invasive ventilation).[60] One study has

demonstrated the presence of viral RNA in the filters of exhaust ducts located ~50 metres from COVID-19 patient rooms; samples were collected by placing cut sections of HEPA filter into viral transport medium.[70] Identification of viral RNA on air ducts/ventilation grilles has been highlighted as potentially indirect evidence of aerosol production, however unpicking the potential contributors to contamination in these studies is challenging.[71]

Notably, there is large heterogeneity in the sampling method employed in these studies, and no recognised standard for air sampling, which may impact the observed outcomes. The ventilation systems and modifications also differed significantly between settings. A major limitation in these studies is the lack of detail regarding the types, timing and duration of clinical procedures carried out, therefore limiting a full understanding of their potential impact on the observed sampling results. Positive air samples from ICUs/patient rooms may be a reflection of the higher aerosol risk that is related to aerosol-generating procedures (AGPs) that are conducted in these high risk clinical settings. Conversely, the observed negative air samples in some studies may be impacted by the ventilation provision, as a higher air change rate (the number of air changes in the space per hour) has been shown to be associated with a lower infection risk in modelling studies.[72] A living systematic review assessing air sampling was unable to identify any pattern between the type of hospital setting (e.g. ICU versus non-ICU) and RT-PCR positivity in air samples.[73]

Few studies have tested viability of air samples. Four out of 6 samples taken from a single hospital room containing 2 COVID-19 patients at a hospital in Florida were positive; inoculation in Vero E6 cells showed cytopathic effect, suggesting viability.[74] Again, this study does not detail the types of patient care activities performed in these rooms. Most studies have been unable to identify viable virus or viral replication in air samples collected from hospital inpatient rooms.[49, 56, 60, 62, 64, 69, 75, 76] Viral culture is often used as a proxy for infectivity however there is no certainty that individuals with non-culturable samples are not infectious.

Aerosol-generating procedures

Aerosol-generating procedures have been associated with an increased risk of transmission of previous coronaviruses (SARS-CoV and MERS-CoV)[16, 77] and a number of AGPs (mostly airway management) have been implicated as risk factors for transmission of SARS-CoV-2 to health and care workers (HCWs)[9, 78] however attributing risk to specific procedures with any level of certainty is challenging. The concept of an 'aerosol generating procedure' arose following the study of SARS-CoV transmission events where it was observed that a pathogen, which was consistently associated with droplet or contact transmission, appeared to have the potential to infect HCWs via the airborne route during specific procedures. This is reflected in

the World Health Organization's (WHO) definition of an AGP which states that AGPs create the potential for airborne transmission of infections that may otherwise only be transmissible by the droplet route.[79] It should also be recognised that as well as producing aerosols, these procedures produce a spectrum of droplet sizes including larger droplet particles.[80-82]

The WHO further defines an AGP as those procedures which result in the production of airborne particles (aerosols).[79] Particles which they describe as being <5 micrometres (μm) in size and as such can remain suspended in the air, travel over a distance and may cause infection if inhaled.[79] These particles are created by air currents moving over the surface of a film of liquid, the faster the air, the smaller the particles produced.[79] Using this definition there are potentially many medical or patient care procedures which could be classed as 'aerosol generating' but whether they lead to an increased risk of respiratory infection transmission is a different and important question. The 2014 WHO guidance is specific in its wording, outlining that '*some procedures potentially capable of generating aerosols are associated with increased risk of SARS transmission to health-care workers*' and they outline that, regarding pandemic and epidemic prone acute respiratory infections, it is for these procedures that airborne precautions should be used.[79] Medical and patient care procedures should be assessed based not only on their capacity to generate aerosols but also on their ability to generate infectious aerosols and an association with relevant transmission events. For example, whilst it has been observed under experimental conditions using healthy volunteers that continuous positive airway pressure ventilation (CPAP) and high flow nasal oxygen delivery (HFNO) (both AGPs) may produce less aerosols than coughing, there was no assessment of the generation of infectious aerosols in these scenarios tested.[83] Health Protection Scotland conducted a review of the evidence base for a number of clinical procedures for their consideration as AGPs in relation to increased risk of respiratory infection transmission, in collaboration with the Department of Health and Social Care's New and Emerging Respiratory Virus Threat Assessment Group (NERVTAG).[84] Additional clarity was provided regarding dental procedures and surgical/post-mortem procedures; risk during dentistry is related to the use of high-speed devices such as ultrasonic scalers and high-speed drills. In surgery/post-mortem, risk is related to the use of high speed cutting if this involves the respiratory tract or paranasal tissues.

Variants of concern

In December 2020, a new SARS-CoV-2 variant (Variant of Concern (VOC) 202012/01), also known as B.1.1.7 lineage, was identified in the south west of England. In June 2021, the World Health Organization released new nomenclature for variants of concern, using the Greek

alphabet. B.1.1.7 (aka Alpha) differs by 29 nucleotide substitutions from the original Wuhan strain, having multiple spike protein mutations with one of the S-gene mutations deleting two amino acids at positions 69 and 70 causing a reproducible S-gene target failure (SGTF) in the Thermo Fisher TaqPath assay used in the UK Lighthouse laboratories.[85] The observed rapid increase in COVID-19 cases overall in the south west of England was temporally associated with the emergence of the new variant in this area in November 2020. SAGE/NERVTAG stated there is 'high confidence' that this variant is spreading faster than other SARS-CoV-2 virus variants currently circulating in the UK, with apparent evidence that is consistent with an increase in transmissibility being a factor. Preliminary evidence suggested the possibility of lower Ct values in those infected with this variant, which is consistent with an increase in viral load, [86] however this has not been demonstrated in more recent studies. There is so far no evidence to suggest an increase in severity of symptoms or mortality associated with this new variant. Since the emergence of the Alpha variant, several additional variants have been identified including the B.1.617.2 variant first identified in India, denoted 'Delta'. Data from 25-31 July 2021 showed that the Delta variant accounted for approximately 99% of sequenced cases in England;[87] and in Scotland, 97% of sequenced cases (data up to 28 May 2021).[88] From 21st October 2021, the new Variant Under Investigation VUI-21OCT-01, AY.4.2. accounted for a slowly increasing proportion of cases in the UK'.[89]

On 26th November 2021, WHO designated the variant B.1.1.529 (Omicron) a variant of concern.[90] It has been established that Omicron is now the dominant variant across all UK countries, accounting for >90% of COVID-19 cases in Scotland. Omicron has been partitioned into 4 sub-lineages: BA.1, BA.1.1, BA.2 and BA.3.[91] Sub-lineage BA.2 (VUI-22Jan-01) was designated variant under investigation by UKHSA on 19 January 2022 with 1,072 genomically confirmed cases in England as of 24 January 2022. The REACT-1 cohort in England reported that between 5- 20 January 2022, 0.8% Omicron samples sequenced in the study were the BA.2 lineage.[92] Preliminary data suggested BA.2 appears to have increased growth rate and higher secondary attack rates compared to Omicron BA.1. On 25 February 2022, the UKHSA performed an updated risk assessment which stated that the BA.2 variant has become the dominant variant in the UK. The risk assessment also reported there was high quality evidence that BA.2 had an increased growth advantage, citing data from multiple countries; it reported with moderate confidence that this advantage may be associated with a shorter serial interval; and that preliminary laboratory studies show an increased binding affinity with ACE2 compared with BA.1, which is unlikely to influence immune evasion but may influence transmissibility.[93] However due to relatively small numbers and limited data on this sub-lineage, there is a level of uncertainty.[94, 95] A (pre-print) cohort analysis of data from Danish households reported the

Omicron BA.2 sub-lineage as more transmissible than BA.1 sub-lineage with a secondary attack rate of 39% to 29% respectively. However, this study used only a proportion of positive tests for WGS.[96]

Evidence relating to the Omicron variant was initially captured in a separate ARHAI Scotland rapid review; published updates to the rapid review were scheduled on a weekly basis and ended with publication of **Version 6.0**, which included evidence captured to 13th January 2022. Whilst evidence is still being amassed regarding variants, there is so far no indication that the viral kinetics[91] and transmission modes have changed and therefore no changes required to the current IPC measures. This is consistent with the WHO and ECDC's guidance in the context of VOCs that recommends vigilant adherence to the current recommended IPC measures including PPE to prevent transmission of SARS-CoV-2.[21, 91]

Conclusion:

- Transmission of SARS-CoV-2 is thought to occur mainly through close contact with an infectious individual, mediated by respiratory particles.
- Currently there is limited evidence of 'traditional' long-range airborne transmission of SARS-CoV-2, however the contribution of air-mediated transmission, acknowledging a spectrum of droplet sizes, requires further research.

4.2 Nosocomial transmission

Data regarding symptoms in HCWs confirms a mirroring of symptoms experienced by the community/general population.[97] In a Dutch cohort of 86 COVID-19-positive HCWs, the majority suffered relatively mild disease and 93% met a case definition of fever and/or coughing and/or shortness of breath.[98] Other symptoms included headache, runny nose, sore throat, chest pain, and diarrhoea. A large proportion (63%) of those screened worked whilst being symptomatic, therefore the possibility of HCW-HCW and HCW-patient transmission (or indeed community transmission) cannot be ruled out, especially considering only 3% reported exposure to a positive inpatient.

There are published reports of clear nosocomial transmission during the earlier stages of the epidemic both in the UK and abroad.[99-101] In Glasgow, nosocomial infection was documented in patients admitted to medicine for the elderly wards across three hospital sites; 103 patients tested positive after 14 days of admission.[101] Mean age of the cohort was 82 years however the infections were recorded prior to the roll out of the Scottish over 70's testing policy (with repeat

testing at day 5) on 29th April 2020; had this been in place, infections would very likely have been identified earlier, as atypical presentation and dementia were challenges for diagnosis in this cohort. Reports from a South West London hospital revealed that 51 of 500 analysed admissions developed COVID-19 nosocomially whilst inpatients.[102] A separate inpatient cohort (n=435) from a London teaching hospital reported that 47 cases over a 6 week period met the definition for definite hospital acquisition (symptom onset 14 days or more after admission); many of these cases were identified as having been in the same bay or ward as a patient with PCR-confirmed COVID-19.[103] Analysis of cases admitted between 1st March and 19th April 2020 at a south-east London teaching hospital revealed that 7.1% (58 cases) were classed as hospital-associated; median time from admission to symptom onset was 32.5 days (IQR 21-65).[104] Nosocomial transmission from an unknown individual to a patient in an ITU, with subsequent transmission to 5 patients and 16 HCWs within the ward, occurred at a tertiary care university hospital in the UK. The infection cluster occurred after hospital visits were stopped and at the same time as lockdown was announced.[105] A lack of social distancing between staff may have contributed to transmission, as the working environment did not allow adequate spacing; unfortunately WGS was not carried out in this study therefore it was not possible to analyse the transmission events with greater clarity. An outbreak on the paediatric dialysis unit of a German hospital involved transmission from an index patient to 7 HCWs and 3 patients.[106] Transmission from an undiagnosed neurosurgery patient to 12 HCWs occurred at a hospital in Wuhan; appropriate PPE was not worn, with many HCWs not wearing surgical masks.[107] Possible transmission from an undiagnosed patient to 3 HCWs was suspected to have occurred when performing a bronchoscopy ('procedure' masks were worn, not respirators), however genetic sequencing was not carried out and contact tracing is not described in detail.[108] A case report describes possible transmission from a 94 year old patient with atypical presentation (delirium, abdominal pain) to 9 HCWs and another inpatient after the patient was treated in three wards over 5 days with no infection control precautions.[109] A hospital outbreak in Australia early in the pandemic involving 10 patients and 12 staff was assessed as being as a result of individuals either coming into direct contact with an infected person without transmission-based precautions, or due to a documented PPE breach.[110] The differing case definitions used by various studies to define hospital-associated COVID-19 make direct comparisons challenging.

Research conducted in March/April 2020 with NHS England Trusts to inform the Scientific Advisory Group for Emergencies (SAGE) suggested that nosocomial transmission of COVID-19 was occurring during that time, with 8.2% of cases being diagnosed 14 days post-admission (inter-quartile range 3.8% to 12.0%). It was reported that few Trusts were assessing the

possible involvement of HCWs in transmissions – notably, this was prior to the introduction of universal mask wearing.

As sustained community transmission has occurred as the pandemic has progressed, it has become more challenging to identify true nosocomial transmission events particularly in regards to HCW acquisition. In Scotland, during the period 1st March-6th June 2020, HCWs or their households made up 17.2% (360/2097) of all hospital admissions for COVID-19 in the working age population.[111] Healthcare workers in patient-facing roles were at higher risk of hospital admission (hazard ratio 3.30, 2.13-5.13) than non-patient-facing HCWs, as were their household members (1.79, 1.10-2.91).[111] Most patient facing HCWs were in "front door" roles (e.g. paramedics, acute receiving specialties, intensive care, respiratory medicine). Those in non-patient-facing roles had a similar risk of hospital admission as the general population. This was not the case in an English cohort; screening of 1654 symptomatic HCWs by an English NHS Trust between March 10-31st 2020 identified 240 (14%) positive individuals; comparison of rates between staff in patient-facing and non-patient facing roles found no evidence of a difference, suggesting that data may reflect wider patterns of community transmission rather than nosocomial-only transmission.[112] Mirroring of community transmission was also identified at a large public hospital in Madrid,[113] and at three hospitals in the Netherlands; contacts with COVID-19 individuals were reported from out-with the hospital and from contact with colleagues.[114] Complete genome sequencing of 50 HCW and 18 patients suggested that the observed patterns were most consistent with multiple introductions into the hospital.[114] Genetic sequencing provided confirmatory evidence for community transmission to a HCW, ruling out suspected transmission from two COVID-19 patients.[115] Whole genome sequencing was used as part of outbreak investigations at a hospital in Ireland and revealed that HCWs moving between wards were responsible for transmission to patients and other HCWs.[116] Transmission between surgical staff at a hospital in Florida, US, was identified prior to the introduction of universal masking in the facility; surgical staff at the time were wearing N95 respirators when treating suspected/confirmed COVID-19 patients; this highlights the risk of transmission potentially not linked to provision of care.[117] Sharing of patient transport was implicated in facilitating patient-patient transmission between renal dialysis patients, where WGS assisted identification of the cluster.[118] In a Portuguese hospital, WGS also assisted identification of both HCW to patient and HCW to HCW transmission on a non-COVID-19 ward.[119] Although WGS can help in identifying nosocomial clusters, it is often impossible to determine the source and subsequent direction of transmission.[120] This is especially the case where there is limited data on the genetic background of strains circulating in the community, and incomplete genetic analysis of nosocomial cases. In March 2021, the UK Scientific Advisory Group for

Emergencies (SAGE) stated that evidence shows there is variation in both nosocomial infection rates and HCW infection rates, which cannot be explained by levels of respiratory protection alone, with key drivers of nosocomial infection being the community infection rate and hospital occupancy.[121]

Every ward in every Scottish acute, specialist and community hospital is included in the reporting of COVID-19 clusters/outbreaks to ARHAI Scotland; this represents 277 hospitals, inclusive of thousands of hospital wards across Scotland. An outbreak cluster in Scottish acute care settings is reported when two or more unexpected patient or staff cases are identified in a non-COVID-19 ward (or two or more staff cases in a COVID-19 ward) and may include some cases that are not associated with the hospital (nosocomial epidemiological case definitions are not applied to each case).

A retrospective observational study assessed possible causative factors for the increase and subsequent decrease in nosocomial cases across 3 hospitals in Lanarkshire between October 2020 and March 2021; it is notable that the trend in nosocomial cases mirrored that of community cases at the time in Lanarkshire.[122] During the observation period, there were multiple changes in policy and procedures (introduction of vaccination, asymptomatic staff testing, community lockdown) which prevents analysis of the effectiveness of any one in isolation. While window opening is highlighted in the paper, there is no strong evidence to suggest a direct causative effect on the observed clusters. A number of factors specific to the hospital in question are likely to have hindered attempts to prevent and manage nosocomial clusters, specifically a lack of single rooms, an elderly patient population, a significant increase in the number of inpatients, and movement of patients between wards.

In the period from July-December 2021, there was not the same increase in nosocomial cases driven by the rise in community cases as observed in previous waves. It is likely that vaccination had an influence in this regard. With the arrival of the Omicron variant in December 2021, hospital admissions and subsequently nosocomial transmission risk has increased as a result of the high community transmission. Following a decrease in nosocomial clusters in February 2022, rates have increased again in line with a community increase however changes in community testing mean that positivity rates within the general population can no longer be used as a denominator and no longer provides healthcare with an early warning system for increased nosocomial activity. Whilst vaccination has had an effect in reducing hospital COVID-19 admissions and the risk of onwards transmission, transmission can occur in the vaccinated which indicates that the vaccine does not necessarily reduce infectiousness in all cases.[123] This

may give some indication that control measures are working in hospitals with clusters/outbreaks being identified early and brought under control quickly.

A UK study identified a small proportion (0.5% of 1,032) of asymptomatic-positive HCWs during a routine screening study in April 2020, highlighting the risk of transmission from these individuals.[124] HCWs working in 'red' or 'amber' wards were significantly more likely to test positive than those working in 'green' wards (p=0·0042) – this was the case for both symptomatic and asymptomatic-positive HCWs. Contact tracing at a hospital in the US that involved testing of asymptomatic HCWs revealed a number of exposures between staff to have occurred when the index HCW case was pre-symptomatic.[125] None of the confirmed HCW cases occurred in staff working on COVID-19 designated wards; exposure on non-COVID-19 wards was attributable to delayed diagnosis which was reduced as availability of testing and awareness of atypical presentations increased, and as routine admission screening was implemented. The authors proposed that some of the transmission to HCWs might have been attributable to non-compliance with facemask use in nonclinical shared work areas (e.g. nursing station, staff work, or break rooms) or during activities such as meals when facemasks were removed, and social distancing was not maintained. Data from 4 London care homes identified 44 residents (17% of the 264 cohort) that were asymptomatic-positive and remained so at follow-up.[126] Further, 7.9% were pre-symptomatic.[127] Some SARS-CoV-2 sequence variants were highly similar between residents and/or staff within a single care home; there were also multiple distinct clusters of SARS-CoV-2 sequence types within single nursing homes, suggestive of multiple introductions.[126] Analysis of 24 Irish care homes found the median proportion of asymptomatic-positive staff was 19.6% (IQR 11.8-52.3%); asymptomatic was defined as without symptoms 7-days either side of a test.[128] Over 25% of residents with lab-confirmed infection were asymptomatic. It was not possible to determine the impact of these individuals on transmission in these settings.

In Scottish acute settings, unpublished outbreak reporting has highlighted the contribution of both HCWs and patients to nosocomial transmission (and visitors to a lesser degree).
A number of recurring themes have emerged when considering factors likely to contribute to transmission. Non-clinical HCW activities include car-sharing, socialising outside of work, and shared break times. Patient risk was linked to inpatients not wearing face coverings, patients moving around clinical areas, and patients being transferred between wards prior to a PCR result. Poor compliance with mask wearing (in HCWs and visitors) and physical distancing as well as HCWs working whilst symptomatic were also identified. A report published by the Healthcare Safety Investigation Branch concluded that more should be done with regards to the design of ward work systems and equipment layout to mitigate the risk of nosocomial

transmission.[129] In particular, the investigation observed limited mitigation strategies in the design of the physical environment, and in staff work patterns, to enable staff to take breaks in environments whilst maintaining physical distancing. Typically, due to limited time available to take a break, staff would need to use small rooms adjacent to their clinical environment, with a lack of opportunities to increase levels of ventilation. Although the investigation involved NHS England trusts, there are similarities in the built environment and nursing cultures in Scotland, and these issues are likely experienced in other countries too. At a German hospital, removal of masks during staff breaks was identified as a potential contributor to transmission between staff,[130] this was also noted as a risk factor in an Indian cohort.[131] In a French HCW cohort (n=99), not wearing facemasks during staff meetings was associated with risk of infection.[132] Poor mask compliance in visitors was also noted during an outbreak involving patients and visitors/guardians in a haematology ward in South Korea.[133] Expert opinion has also identified the difficulties in maintaining adherence to physical distancing, particularly in older builds with nightingale wards, highlighting that a whole systems approach should be implemented to mitigate human nature/behaviour and support adherence.[134] Looking at non-acute settings, a study of Canadian care homes indicated that overcrowding was associated with higher incidence of infection and mortality, indicating that inability to isolate residents may have facilitated transmission.[135]

With regards to the risk of transmission from visitors, there is a lack of clear evidence in the literature. Visitors have been implicated as potential sources of transmission in Scottish acute settings in a small number of incidents (unpublished) however the nature of retrospective investigation coupled with the complexities of contact tracing during a global pandemic prevents confirmation of the precise transmission routes. Visitors are also at risk of acquiring COVID-19 whilst visiting healthcare facilitates and anecdotally this has occurred in Scotland. Whilst the aim from an infection prevention and control perspective is to reduce the infection risk, consideration must be given to the unintended negative effects on patients and families where visiting is restricted. This is particularly an issue in situations involving critical care and end of life care. The Scottish Government has produced guidance to support the safe reintroduction of visitors into hospital settings,[136] the specifics regarding requirements for visitors is outlined in the NIPCM Winter (21/22), Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.[137]

It is notable that not all unprotected exposures to COVID-19-positive individuals result in transmission, even when being exposed to AGPs without respiratory protection.[78] None of the 21 HCWs that reported contact with an undiagnosed patient with mild respiratory symptoms at a Swiss hospital tested positive when tested 7 days later.[138] The patient underwent routine

clinical examinations, blood draws, electrocardiograms, chest X-rays and had nasopharyngeal swabs taken; masks were never worn by HCWs during the patient's care. In Germany, a physician worked over a number of days in a hospital whilst symptomatic (coughing, fever) and with no mask, but did not transmit infection to any of the 254 identified contacts (HCWs and patients).[139] In Singapore, 41 HCWs were exposed to multiple AGPs at a distance of less than 2 metres for at least 10 minutes while wearing predominantly surgical masks (only 25% wore N95 respirators) whilst caring for a patient with undiagnosed COVID-19; none of the HCWs developed symptoms or tested positive (with repeat testing) in the 14 days following exposure.[140] Exposure to 5 patients with atypical presentations at a hospital in Singapore was not associated with subsequent infection in HCWs; the majority were wearing surgical masks at the time; the potential impact of varying viral load in these patients was not investigated.[141] This highlights the role of multiple factors in transmission.

Conclusion:

- Standard Infection Control Precautions (SICPs) should always be applied in all situations regardless of the infectious nature of the patient.
- Droplet precautions should be implemented when in close contact (within 2 metres), or providing direct patient care to a suspected/confirmed COVID-19 patient.
- Airborne precautions should be implemented when undertaking an AGP on a suspected/confirmed COVID-19 patient within the respiratory pathway.
- Visitors should be managed according to the NIPCM Winter (21/22), Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.
- When not providing patient care, HCWs should continue to adhere to the pandemic controls (e.g. extended mask wearing) as outlined in the NIPCM Winter (21/22), Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.
- Vaccinated individuals should continue to adhere to COVID-19 IPC measures in place.

5. Personal protective equipment

5.1 Evidence for mask type

There are two main categories of masks worn by HCWs; 1) surgical face masks, and 2) respirators. Surgical face masks do not provide protection against airborne particles and are not classified as respiratory protective devices[142] therefore respirators are typically reserved for protection against airborne infectious agents. The historical dichotomy of 'droplet' versus 'airborne' transmission mode resulted in a mutually exclusive relationship between transmission mode and mask type (surgical face mask for droplet transmission, and respirators for airborne transmission).

With regards to surgical face masks, it is vital that a distinction is made between the evidence pertaining to fluid-resistant surgical face masks (FRSM) (Type IIR) and standard (non-fluid-resistant) surgical face masks (Types I & II). Surgical masks are tested against the safety standard BS EN 14683:2019; this series of tests measures the performance of a surgical mask in bacterial filtration efficiency (BFE), breathing resistance and splash resistance. Type II and Type IIR surgical masks are both tested against this standard with them needing to meet a minimum BFE of 98%; however only Type IIR masks must pass the splash resistance test with a resistance of at least 16.0kPa. The terms 'fluid resistant' and 'fluid repellent' are often used interchangeably to denote a Type IIR surgical mask, however, terminology may vary internationally and a 'fluid repellent' mask may occasionally describe a mask that does not meet the BS EN 14683:2019 splash resistance standard and which is not suitable for protection against splash or spray i.e. a Type II surgical mask. In the UK, when recommended for infection prevention and control purposes a 'surgical mask' will be a fluid-resistant (Type IIR) surgical mask.

5.1.1 Face masks for source control

Standard surgical face masks (i.e. Type II) can be worn by an infectious individual as source control to prevent transmission.[143-145] To demonstrate this, a study by *Leung et al* tested the efficacy of surgical masks at reducing the detection of seasonal (non-COVID-19) coronavirus in exhaled breath from infected patients.[146] Coronavirus could be detected in ~40% of samples collected from non-mask wearers (n=10) but was not detected in exhaled air from patients that wore surgical masks (n=11). The masks used were Type II, i.e. they were not fluid-resistant. This study was limited by the small sample size – due in part to the fact that a large proportion

of infected participants had undetectable viral shedding in exhaled breath. Studies assessing Type II surgical masks have also reported reduced detection of seasonal influenza in exhaled breath in mask wearers.[146, 147] An environmental sampling study of multiple sites (prior to environmental cleaning) surrounding 3 hospitalised COVID-19 patients yielded negative results; two of these patients wore surgical masks continually and the critical bed-bound ICU patient had a closed loop circuit ventilator.[148] All patients tested positive by throat swab on the day of sampling and the masks and the closed suction tube tested positive.

In regards to source control, an experimental study using 12 healthy volunteers found that air escape from the sides/top of a 3-layer pleated surgical mask led to a reduction in efficiency from >90% (for air that passes through the mask) to ~70% while talking and a reduction from 94% to 90% for coughing.[149] This demonstrated that whilst air escape does limit the overall efficiency of surgical masks at reducing expiratory particle emissions, masks do provide substantial reduction. Using healthy volunteers in an experimental set up, a fluid resistant surgical mask was found to significantly reduce aerosol emissions from both speaking (0.113 vs 0.038, $p = 0.002$), and coughing (1.40 vs 0.075, $p < 0.001$).[83] In another study, both surgical and cloth masks were found to be more effective in blocking release of coarse aerosols compared to fine aerosols from mild/asymptomatic seronegative patients (n=57).[150] An experimental study using simulated SARS-CoV-2 virus expulsions and mannequin heads demonstrated a synergistic protective effect when both the spreader and receiver wore a mask (cotton or surgical), suggesting that universal face covering/mask wearing is likely to have a protective effect overall.[151]

Concern has been raised regarding the suitability of respirators for providing source control, specifically where respirators are fitted with exhalation valves that offer no filtration of exhaled air. It is stated in the NIPCM that respirators must never be worn by an infectious patient due to the nature of the respirator filtrating incoming air rather than expelled air.[152] The ECDC, CDC, and WHO advise against the use of respirators with exhalation valves for source control of COVID-19.[153-155] An **ARHAI Scotland rapid review** that assessed respirators demonstrated consistency in the evidence that valved respirators should not be used for source control. It must therefore be acknowledged that there is a risk that staff later identified as infectious whilst wearing a valved respirator may have presented an exposure risk to patients and staff if within 2 metres.

5.1.2 Face masks for protection

Whereas standard Type II surgical face masks can be worn by an infectious individual to prevent transmission, it is the fluid-resistant nature of FRSMs that provides additional protection to the wearer (e.g. HCW) against droplet-transmitted infectious agents. Guidance consistently recommends that HCWs should wear a Type IIR FRSM as PPE when caring for a patient known, or suspected, to be infected with an infectious agent spread by the droplet route.[79, 143, 145, 156-160] In UK health and care settings, surgical masks must be fluid-resistant, 'CE' marked and compliant with Medical Device Directive (MDD/93/42/EEC) and the Personal Protective Equipment Regulations 2002.[161-166]

When assessing the infection risk related to surgical masks and respirators, there is no clear evidence from 'in the field' studies that respirators offer any additional protection against coronaviruses. A major limitation is that the majority of evidence is observational in nature and thus is clouded by bundled infection control approaches, poor descriptions of mask types (with a focus on comparison to FFP2 rather than FFP3 respirators) and an unclear distinction between AGP and non-AGP care. Assessment of PPE use against similar coronaviruses i.e. severe acute respiratory virus (SARS), provided weak evidence that droplet precautions (i.e. surgical face masks) are adequate. A systematic review and meta-analysis combining 6 case-control and 3 cohort studies, found that use of respirators/surgical masks provided significant protection against SARS-CoV among exposed HCWs (OR=0.22; 95% CI: 0.12-0.40). Wearing surgical masks (OR=0.13; 95% CI: 0.03-0.62) or N95 respirators (OR=0.12; 95% CI: 0.06-0.26) (versus no RPE) both reduced the risk of SARS-CoV by approximately 80%. No protective effect was reported for disposable cotton or paper masks. The existing evidence base in the review was sparse and the indications (and compliance) for mask/respirator use varied between the included studies.[167] The type of surgical mask was not reported in all studies. A case control study that compared PPE use in 241 non-infected HCWs and 13 infected HCWs with documented exposure to 11 index patients with SARS-CoV found that none of the infected staff wore surgical masks or respirators (2 wore paper masks). [168] However, RT-PCR analysis was not used to confirm infection in this study (confirmation of HCWs relied on serological analysis), and recall bias for PPE use may have affected results. Inadequate reporting of RPE/mask indications and compliance was a major limitation in a systematic review and meta-analysis conducted by *Bartoszko et al*, which included 4 RCTs and reported that, compared to N95 respirators, the use of medical masks was not associated with an increase in laboratory-confirmed viral respiratory infection or respiratory illness.[169] There was significant variation in surgical mask type between the included studies (Type IIR FRSMs were not used in every

study). A rapid review conducted specifically to assess the RPE requirements for COVID-19 in primary care determined that the evidence base was weak as the included studies were focussed on influenza transmission, not COVID-19; these studies provided weak support for the use of standard surgical masks in non-AGP settings.[170] A recent update to a Cochrane systematic review that assessed full body PPE for the prevention of exposure to highly infectious diseases (including COVID-19) found that covering more parts of the body leads to better protection but usually comes at the cost of more difficult donning or doffing and less user comfort, and may therefore even lead to more contamination.[171] Certainty of the evidence was judged as low due to the fact that almost all findings were based on one or at most two small simulation studies.

An observational study that collected self-report data regarding preferred mask use (surgical or FFP2) of healthcare workers in Switzerland found that FFP2 preference whilst caring for COVID-19 patients was non-significantly associated with a decreased risk for SARS-CoV-2 positivity (adjusted hazard ratio [aHR] 0·8, 95% CI 0·6-1·0, p=0·052).[172] The factor most strongly associated with a positive SARS-CoV-2 test was exposure to a positive household contact (adjusted HR [aHR] 10·1, 95% CI 7·5-13·5, p<0·001). This study was not able to definitively show that HCWs acquired infection as a result of their work, further, participation in the study was non-mandatory and compliance with stated mask preference was not assessed.[172] In a US HCW cohort (n=345), the most common reason for a significant exposure to a COVID-19 patient was use of a surgical mask instead of a respirator during an AGP (206/345, 55.9%), however this was not associated with testing positive (RR 0.99, 95% CI 0.96-1, P=1).[173] When assessing such studies it is a heuristic bias to assume that PPE provision (or lack of) is the sole reason for transmission; multiple factors determine the risk of transmission from one individual to another (including for example infectiousness of the patient, viral load, infectious dose, contact time). Attempts have been made to determine if unit-wide use of FFP3 respirators instead of surgical masks result in reduced risk to HCWs through comparison of PPE use; unfortunately these studies are often limited by their confounding factors offering potentially alternative explanations for the different patterns of infection observed, such as vaccination status, changes to testing protocols and other infection control practices.[174] A larger study comprising comparison of Trust-level RPE use had similar limitations, including unvalidated PPE data and uncontrolled confounding factors, and did not assess HCW infection rates.[175]

The Australian National COVID-19 Clinical Evidence Taskforce in June 2021 published a living systematic literature review on the topic of RPE/surgical masks but was unable to produce evidence-based graded recommendations due to the limited evidence base.[176] Only

1 randomised trial was included to inform the Australian RPE recommendations and this study only assessed coronaviruses OC43, 229E, NL63 and HKU1. In the surgical masks group the infection rate was 493 per 1000, compared to 571 per 1000 in the P2/N95 group, with an odds ratio of 0.73 (95% CI 0.30-1.77). The certainty of the evidence was rated as low due to serious indirectness and serious imprecision. A total of 17 observational studies were included that reported on both SARS-CoV-1 (n=5) and SARS-CoV-2 (n=12). The rate of infection in the surgical mask group was 50 per 1000, and in the P2/N95 group was 39 per 1000, with an odds ratio of 1.34 (CI 96% 1.06-1.70). The certainty of the evidence was rated very low due to serious risk of bias, serious indirectness and serious imprecision. The inclusion of observational studies in the Australian guideline meta-analysis, plus the inclusion of studies reporting on SARS-CoV-1 can be criticised however the evidence has been appropriately rated as low/very low quality by the critical appraisal tools and this is reported in the evidence summary by the authors. As a result of the low quality evidence base, consensus recommendations, rather than evidence-based recommendations, were developed. None of the studies identified in the Australian review involved use of FFP3 respirators (all were N95/FFP2/P2), and this could be seen as a limitation relevant for Scotland/UK where use of FFP3 respirators are mandatory over other respirator types as per the UK Health & Safety Executive (HSE). Regardless of this mandatory provision, the UK Health Security Agency (UKHSA) (previously PHE) recently concluded that in healthcare settings N95 respirators may be more effective than surgical masks in reducing the risk of infection in the mask wearer.[177] This recommendation was made by an expert panel supported by an evidence review (of systematic and rapid reviews) that included only 2 reviews relevant to healthcare settings and neither provided a direct comparison between surgical masks and respirators. Further, the literature search was conducted in April 2021, 6 months prior to publication, and did not include the Australian National COVID-19 Clinical Evidence Taskforce systematic review (discussed above). The recommendation was rated 'low certainty' based on the evidence included (rated low or very low certainty) however the evidence included is arguably insufficient for formulation of evidence-based recommendations.

Whilst an FFP3 respirator is the recommended RPE for use in the UK, it may not be reasonably practicable to use these if global supplies of FFP3 respirators are low during a pandemic. In this scenario, the WHO advise that an FFP2 could be used as an alternative. In March 2021, the UK Health and Safety Executive concluded in a rapid review that N95 respirators (used out with the UK) were comparable to FFP2 respirators and that both would provide comparable protection against coronavirus as long as the wearer was face-fit tested.[178]

Australian consensus recommendations for face masks state that for HCWs providing direct patient care or working within the patient/client/resident zone for individuals with suspected or confirmed COVID-19, the choice between P2/N95 respirator or surgical mask should be based on an assessment of risk of transmission.[176] The risk assessment should include consideration of: the individual patient/client/resident's pre-existing likelihood of COVID-19; current prevalence and transmission of COVID-19 in the population; setting-specific factors such as the likelihood of increased generation and dispersion of airborne particles and enclosed areas with low levels of ventilation; and closeness and duration of contact.[176] Eye protection (goggles, safety glasses, face visors) is also recommended for direct patient care of suspected/confirmed COVID-19 patients. It is important to note that the Australian consensus recommendations were made in a time of low community prevalence when asymptomatic individuals were not classified as suspected cases.

Further advocating the use of a risk assessment with regard to RPE and transmission risk, SAGE in April 2021 advised that if an unacceptable risk of transmission remains after rigorous application of the hierarchy of controls it may be necessary to consider the extended use of RPE for patient care in specific situations, taking into consideration the likelihood, duration and proximity of exposure to a COVID-19 case and what other measures have been applied in the setting.[27] This is in acknowledgement of the risk of aerosol transmission out with AGPs. In response, Scottish guidance was updated in May 2021 to include further detail on risk assessments applied using the hierarchy of controls for inpatient wards selected for planned placement of the high risk pathway (as of November 2021 termed the 'respiratory' pathway), with extended use of RPE a possible outcome of such a risk assessment.[179] A risk assessment algorithm was added in July 2021.

The World Health Organization and Australian Government guidance recommends surgical face masks for routine care (non-AGP) of suspected/confirmed COVID-19 patients.[180-182] In October 2021, WHO published an annexe to their IPC guidance that included a conditional recommendation stating that '*respirators can be used instead of surgical masks based on HCW values and preferences about having the highest perceived protection possible to prevent SARS-CoV-2 infection*', even in settings where AGPs are not performed.[183] This was based on expert opinion by the guidance development group having rated the certainty of the evidence base very low (inconsistency and indirectness - studies conducted before the emergence of the Delta variant, evaluation of non-SARS-CoV-1 infection or assessment of non-clinical outcomes). This recommendation is akin to that developed by the Australian COVID-19 Evidence Task Force,[176] in that the evidence base was insufficient for the development of evidence-based recommendations, however the WHO recommendation is ambiguous in terms of

implementation. The WHO annexe further states that '*local values, preferences, and practicalities should play an important role in directing local choices on the use of respirators versus medical masks'*. WHO guidance was further extended in December 2021 to recommend that respirators should be worn in care settings where ventilation is known to be poor or cannot be assessed or in cases where ventilation systems are not properly maintained.[184] The recommendation was made without involvement of the WHO IPC Guideline Development Group, and in the absence of any new evidence regarding mask effectiveness or transmission mode. The rationale for the recommendation was based on the limited vaccine coverage in HCWs around the world and the potential immune escape with Omicron. In Scotland, vaccine coverage in HCWs is high, and the current IPC guidance currently provides wider use of respirators following a hierarchy of control risk assessment. The UK IPC Cell considered the WHO guidance and concluded no change to the current UK IPC guidance was necessary, apart from a strengthening of messaging around the current IPC mitigations. Additionally, in December 2021, the Canadian Government updated their guidance to recommend the use of respirators for direct patient care of patients with suspected/confirmed COVID-19, and that staff should conduct a point-of-care risk assessment for selection of PPE for all other patient encounters; this change was applicable to all care settings.[185] Likewise, the Irish Health Protection Surveillance Centre (HPSC) updated their recommendations for the use of PPE in the context of the COVID-19 pandemic to extend respirator use as a requirement for all patient care – not just for Covid-19 patients.[186] There is however inconsistency in the Irish guidance which states that surgical masks can be used for 'low risk' patient care activities such as initial clinical assessments, taking a respiratory swab, recording temperature, inserting a PVC, administering IV fluids, and helping to feed a patient. The Canadian and Irish guidance documents do not provide evidence/rationale for the move to respiratory protection and they have not incorporated an assessment of the adequacy of ventilation.

The US Centers for Disease Control and Prevention (CDC) recommend that HCWs located in counties with substantial or high transmission should consider N95 respirators in situations where additional risk factors for transmission are present such as the patient is not up to date with all recommended vaccine doses, unable to use source control, and the area is poorly ventilated; universal use may be considered in affected units or in units considered at higher risk for transmission. This is akin to the hierarchy of control risk assessment that is currently in place in Scottish guidance. In the 6th update of ECDC IPC guidance, respirators rather than surgical masks are recommended when caring for suspected/confirmed patients.[18] The ECDC make reference to the weak evidence base underpinning their recommendation, stating that

"*with the exception of AGPs, it is unclear whether respirators provide better protection than medical masks against other coronaviruses and respiratory viruses such as influenza*".[18]

The UK Scientific Advisory Group for Emergencies (SAGE) acknowledged that the impact of greater use of FFP3 masks on the overall level of transmission in HCWs is unknown, but that this should not be taken to show an absence of effect, stating that policy-makers may have to make decisions based on a range of additional factors.[121]

Guidance issued by the Scottish Government on 23rd June 2020 advised that all staff in hospitals and care homes in Scotland are required to wear a 'medical' face mask at all times throughout their shift, from 29th June 2020 onwards.[187] Face mask/covering requirements were extended to include primary care (GP practices, dentists, opticians and pharmacies) and wider community care (including adult social or community care and adult residential settings, care home settings and domiciliary care) on 18th September 2020. Patients and visitors to hospitals must wear a face covering. This guidance was updated on 5th July 2021 to state that staff in clinical and non-clinical areas of hospitals are specifically required to wear a type IIR fluid resistant surgical face mask (FRSM).[188] Additionally, FRSMs must also be made available to and worn by all hospital inpatients (unless exempt) across all pathways, where it can be tolerated and does not compromise clinical care (e.g. when receiving oxygen therapy or when in labour). These measures are in recognition of the risk of pre-symptomatic and asymptomatic transmission, and the difficulties in maintaining physical distancing in the workplace. These recommendations are in-line with guidance produced by the World Health Organization, which states that in areas of known/suspected community or cluster transmission, universal masking should be implemented for all persons (staff, patients, visitors, service providers, others) within the health facility.[20] This was based on expert opinion. It should be noted that the fluid resistant component of masks is not required for source control however, guidance in Scotland advises use of fluid resistant surgical masks (Type IIR) at all times to avoid confusion and error in mask selection moving between direct patient care activities and general circulation within healthcare facilities.

On 29th November 2021, the Scottish COVID-19 Addenda were replaced by the Winter (21/22) Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.[137] The guidance is intended to support management of an increase in respiratory viruses during the ongoing COVID-19 pandemic whilst promoting the application of IPC precautions more akin to pre pandemic IPC. The 3 COVID-19 pathways were replaced with a respiratory and non-respiratory pathway. HCWs in the non-respiratory pathway are advised to wear a type IIR fluid resistant surgical mask for all direct contact with patients on the non-

respiratory pathway. Respirators are to be worn for direct patient care of patients on the respiratory pathway where AGPs are being performed and where unit wide airborne precautions are in place (patients having AGPs undertaken who cannot be placed in single isolation rooms). When not delivering patient care, surgical face masks are to be worn sessionally.

It is important to note that not all FFP3 respirators are fluid-resistant; valved respirators can be shrouded or unshrouded. Respirators with unshrouded valves are not considered to be fluid-resistant and therefore should be worn with a full face shield if blood or body fluid splashing is anticipated. This must be taken into consideration where FFP3 respirators are being used for protection against COVID-19 transmission. As per the NIPCM, valved respirators should not be worn by HCWs when sterility over the surgical field is required, as exhaled air is unfiltered e.g. in theatres/surgical settings or when undertaking a sterile procedure. This is a consideration that extends beyond COVID-19 and takes account of potential surgical site infection risk.

Note: the evidence base regarding respirator use is further detailed in the **ARHAI Scotland respirators rapid review**.

Conclusion:

- HCWs should wear a type IIR fluid-resistant surgical face mask during any activities/procedures where there is a risk of blood, body fluids, secretions or excretions splashing or spraying onto their nose or mouth.
- HCWs across all pathways should wear a type IIR fluid-resistant surgical face mask throughout their shift.
- Non-medical staff and HCWs off duty/out-with clinical areas should wear a type IIR FRSM at all times whilst at work except in some circumstances, e.g. when working alone; or in a closed office where other transmission measures are in place (i.e. physical distancing; ventilation; access to hand washing facilities, and regular cleaning).
- Inpatients across all pathways should wear a type IIR fluid-resistant surgical mask at all times if they can be tolerated and care is not compromised.
- Airborne precautions (FFP3 respirators) are required when performing AGPs on patients in the respiratory pathway.
- The unit-wide use of FFP3 respirators should be considered in clinical areas used for the respiratory pathway where there remains an unacceptable risk of transmission despite application of mitigation measures following a risk assessment as per the NIPCM Winter

(21/22) Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.

- A non-valved (rather than a valved) respirator should be worn when sterility directly over a surgical field/sterile site is required.
- The use of FFP2 respirators should be considered where there are shortages of FFP3 respirators.
- All patients and visitors entering a healthcare setting should wear a face covering.
- All visitors entering a care home should wear a type IIR fluid-resistant surgical mask however mask wearing when within a resident's room can be relaxed as per current visiting guidance.

5.2 UK PPE guidance

For general patient care (i.e. non-AGP situations), the first edition of the UK IPC pandemic COVID-19 guidance initially recommended type IIR FRSMs, disposable aprons and disposable gloves.[14] The decision to wear eye protection was based on risk assessment (but considered essential when carrying out AGPs). Fluid-resistant long sleeve gowns were recommended for management of confirmed cases and when carrying out AGPs.[14] FFP3 respirators were recommended when carrying out AGPs and when in high risk areas where AGPs are being conducted. The FFP3 recommendation was based on expert opinion from NERVTAG which recommended that airborne precautions should be implemented at all times in clinical areas considered AGP 'hot spots' e.g. Intensive Care Units (ICU), Intensive Therapy Units (ITU) or High Dependency Units (HDU) that are managing COVID-19 patients (unless patients are isolated in a negative pressure isolation room/or single room, where only staff entering the room need wear a FFP3 respirator).

The UK IPC pandemic COVID-19 guidance was updated on 2nd April 2020 with a move to PPE based on risk of exposure to possible (not suspected/confirmed) cases, with recommended ensembles for specific care areas/clinical situations.[189] The guidance stated that '*incidence of COVID-19 varies across the UK and risk is not uniform and so elements of the updated guidance are intended for interpretation and application dependent on local assessment of risk*'. While this was not in line with the evidence base at that time for COVID-19 as presented in this rapid review, it was based on the potential challenges in establishing whether patients and individuals meet the case definition for COVID-19 prior to a face-to-face assessment or care

episode. There was also a move towards sessional use of PPE considering the recognised global shortage of PPE stockpiles at the time and perhaps in recognition of the fact that the change in UK PPE recommendations were likely to result in greater use of PPE by a wider staff group which would deplete existing UK stocks.

UK PPE guidance published by UKHSA was updated on 20th August 2020 with the publication of IPC guidance for remobilisation of service in health and care settings.[190] The guidance was updated and broadened to include seasonal respiratory infections on 24th November 2021, with the latest version last updated on 15th March 2022.[191] This guidance states that FRSMs and RPE (together with eye/face protection) may be worn sessionally when providing care to cohorted patients, or in high-risk areas where AGPs are undertaken for cohorted patients, respectively.[191]

Scottish COVID-19 guidance (in the form of an addendum) was published in the NIPCM on 27th October 2020 and also included the implementation of 3 patient pathways. There was a return to SICPs-based PPE, with PPE usage dictated by anticipated blood and/or body fluid exposure, and respirators only required for AGPs on patients in the amber and red pathways. As per the PHE UK guidance, there was no longer a requirement in Scottish settings for sessional PPE use, apart from FRSMs which can be worn sessionally. The addendum advised that consideration may need to be given to unit-wide application of airborne precautions where the number of cases of high and medium-risk pathway patients requiring AGPs increases and all such patients cannot be managed in a single side room. In recognition of the anxiety felt by many HCWs with regards to PPE provision, Scottish guidance recommended that when prevalence is high, and where staff have concerns about potential exposure to themselves, they may choose to wear an FFP3 respirator rather than an FRSM when performing an AGP on a low-risk pathway patient; this is a personal PPE risk assessment. In June 2021, this recommendation was amended with the removal of the requirement for prevalence to be high when making a personal PPE risk assessment for FFP3 use for AGPs on low risk pathways. In response, Scottish guidance was updated in May 2021 to include further detail on risk assessments applied using the hierarchy of controls for inpatient wards selected for planned placement of the high risk pathway, with extended use of RPE a possible outcome of such a risk assessment.[179] A risk assessment algorithm was added in July 2021.

In November 2021, the Winter (21/22) Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) addendum replaced the COVID-19 addendums.[137] The guidance is intended to support management of an increase in respiratory viruses during the ongoing COVID-19 pandemic whilst promoting the application of IPC precautions more akin to

pre pandemic IPC. The 3 COVID-19 pathways were replaced with a respiratory and non-respiratory pathway. On 1 April 2022, changes were made to the Scottish Winter (21/22) Respiratory addendum to allow NHS Boards to balance system pressure harms which were outweighing the COVID-19 harms. This coincided with publication of a **Scottish Government DL** on 31 March 2022. The changes were largely related to relaxation of testing requirements in asymptomatic HCWs, introduction of rapid diagnostic testing (including point of care tests) and Lateral Flow Devices (LFDs) in certain circumstances, and changes to the management of patient contacts (provided rapid diagnostic test or LFD is negative each day, TBPs need not be applied and exemption of isolation in patients who are fully vaccinated and have tested PCR positive in the previous 28 days). No changes were made to the PPE recommendations.

Reuse of PPE (FFP3/FF2/N95 respirators, fluid-resistant gowns or coveralls, goggles and face visors) as advised for periods of PPE shortages in a previous version of the IPC guidance in April 17th 2020, is no longer recommended in Scottish settings.

UK IPC pandemic COVID-19 guidance has never recommended decontamination of respirators.[189] Respirators should be discarded if they become moist, visibly soiled, damaged, or become hard to breathe through. The ECDC recommends that, where reuse of respirators is considered as a last resort option to economise on use of PPE, the risk of the surface of the respirator becoming contaminated by respiratory droplets is considered to be lower when it is covered with a visor.[192] However this ensemble is dependent on a plentiful supply of visors.

As highlighted in an ECRI report, the reported pathogen transfer risk from contact during donning and doffing during reuse was considered to be higher than the risk from sessional wear.[193] Unfortunately there is no evidence available to assess the impact on filtration efficacy or the risk of transmission associated with reuse of RPE in clinical settings. A study that assessed efficacy of type IIR FRSMs and N95 respirators that were worn sessionally and reused did not include a reliable control group for comparison which prevented assessment of the efficacy of continuous wear/reuse.[194] RPE was reported to be stored between shifts in a paper bag in lockers; the extent of reuse was not reported. Compared with continuous use of FRSMs, respirators were associated with more problems for the wearer including significantly greater discomfort, trouble communicating with the patient, headaches, difficulty breathing, and pressure on the nose.[194] The WHO '*Rational use of PPE for COVID-19*' mentions that respirators can and have previously been used for extended periods of time to treat multiple patients with the same diagnosis.[195] Whilst WHO state that there is evidence to support respirators maintaining their protection over longer periods of time, it may not be comfortable to use one respirator for longer than 4 hours and this should be avoided[195] as reuse may increase

the potential for contamination and contact transmission of infectious agents (not just SARS-CoV-2). This risk must be balanced against the need to provide respiratory protection for HCWs providing care and to those performing AGPs. To reduce the risk of transmission associated with PPE reuse it is essential that HCWs demonstrate stringent compliance with all other infection control precautions, hand hygiene, and environmental decontamination. Irrespective of the measure implemented, HCWs must have IPC education and training on the correct use of PPE and other IPC precautions, including demonstration of competency in appropriate procedures for donning and doffing PPE and hand hygiene. These issues are for consideration by the Health and Safety Executive (HSE). The HSE approved the sessional use and reuse of PPE in the UK for COVID-19 and expects NHS Boards to have an agreed action plan that includes consideration of all measures to manage usage effectively.

Conclusion:

- PPE should be single-use unless otherwise stated by the manufacturer.
- Continuous use of Type IIR surgical face masks in clinical and non-clinical areas is required.
- Consideration should be given to the unit wide application of airborne precautions where the number of cases of COVID-19 in the respiratory pathway requiring AGPs increases and patients/individuals cannot be managed in single or isolation rooms.
- The unit-wide use of FFP3 respirators should be considered in clinical areas used for the respiratory pathway where there remains an unacceptable risk of transmission despite application of mitigation measures following a risk assessment as per the NIPCM Winter (21/22) Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum.
- In periods of PPE shortages, sessional use of respirators is preferred over reuse.
- In periods of PPE shortages, the decision to reuse PPE (respirators, fluid-resistant gowns or coveralls, goggles and face visors) should be based on a risk assessment considering the care activities, patient population, and the state of the PPE in question.

6. Areas for further research

An overarching limitation of all identified evidence is the novel nature of SARS-CoV-2 and the limited ability for robust research at the early stages of an outbreak.

More work is needed to improve and develop culture techniques to allow determination of the viability of viral particles detected in clinical and environmental samples. This will assist with determination of the infectious dose and will provide insight into the duration of infectivity, particularly in relation to the prolonged viral shedding that is observed in respiratory and faecal samples.

Of particular importance is the need to undertake further research to determine the potential contribution of aerosol transmission of respiratory viruses (not limited to SARS-CoV-2), acknowledging a spectrum of particle sizes, which is understandably beyond the scope of a rapid review.

Further research is required to determine the extent of atypical presentations, pre-symptomatic, and asymptomatic transmission and the overall impact of these on transmission. A robust epidemiological evidence base will assist with the development of infection control measures that are targeted and evidence-based.

Assessment of the efficacy of UVGI and other novel decontamination technologies for environmental decontamination and for the decontamination of PPE would inform COVID-19 IPC guidance and provide reassurance for health and care workers. Studies investigating the efficacy of detergents for environmental cleaning would provide a clear evidence base to support a move away from chlorine-based disinfection in the medium risk pathway.

7. Limitations

An overarching limitation of all identified evidence is the novel nature of SARS-CoV-2 and the limited ability for robust research during a pandemic. Most papers highlight the need for further research.

There are a number of inherent limitations related to rapid reviews, including risk of publication bias, potential omission of key evidence, and the provision of a descriptive analysis of evidence rather than a qualitative analysis. There is a risk of duplication of reported cases as case reports become part of a larger body of evidence.

Consequently, conclusions from this rapid review should be interpreted with caution and considered alongside additional streams of evidence (for example local epidemiological data).

Appendix 1 – Search strategies

Search Strategies used for academic databases.

The search terms for searches conducted from 5th March 2020 until 14th September 2020 were as follows:

1. COVID-19.mp.
2. SARS-CoV-2.mp.
3. 2019-nCoV.mp.
4. novel coronavirus.mp.
5. exp coronavirus/
6. 1 or 2 or 3 or 4 or 5
7. exp infection control/
8. exp disinfection/
9. exp decontamination/
10. exp personal protective equipment/
11. surgical mask?.mp.
12. hand hygiene.mp.
13. clean*.mp.
14. transmission.mp.
15. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
16. 6 and 16
17. limit 17 to English language
18. limit 18 to yr="2020 -Current"

Search terms for 21st September 2020 until 22nd February 2021 were as follows:

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kw,ab.
3. disinfection.ti,kw,ab.
4. decontamination.ti,kw,ab.
5. personal protective equipment.ti,kw,ab.
6. ppe.ti,kw,ab.
7. surgical mask*.ti,kw,ab.
8. respiratory protective device*.ti,kw,ab.
9. respirator.ti,kw,ab.
10. FFP3.ti,kw,ab.
11. eye protective device*.ti,kw,ab.
12. goggles.ti,kw,ab.
13. face shield*.ti,kw,ab.
14. visor*.ti,kw,ab.
15. safety glasses.ti,kw,ab.
16. hand hygiene.ti,kw,ab.
17. clean*.ti,kw,ab.
18. transmission.ti,kw,ab.[1]
19. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
20. 1 and 19
21. limit 20 to english language
22. limit to human
23. limit 22 to dd=_____-_____[2]

Search terms for 1st March 2021 until 16th August 2021 were as follows:

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kw,ab.
3. disinfection.ti,kw,ab.
4. decontamination.ti,kw,ab.
5. personal protective equipment.ti,kw,ab.
6. ppe.ti,kw,ab.
7. surgical mask*.ti,kw,ab.
8. respiratory protective device*.ti,kw,ab.
9. respirator.ti,kw,ab.
10. respirators.ti,kw,ab.
11. FFP3*.ti,kw,ab.
12. eye protective device*.ti,kw,ab.
13. goggles.ti,kw,ab.
14. face shield*.ti,kw,ab.
15. visor*.ti,kw,ab.
16. safety glasses.ti,kw,ab.
17. hand hygiene.ti,kw,ab.
18. clean*.ti,kw,ab.
19. transmission.ti,kw,ab.
20. airborn*.ti,kw,ab.

21. aerosol*.ti,kw,ab.[1]
22. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23. 1 and 20
24. limit 21 to english language
25. limit 22 to dd= _____ - _____[2]

Search strategy used for pre-print database.

"infection control" OR disinfection OR decontamination OR "personal protective equipment" OR ppe OR "surgical mask" OR "respiratory protective device" OR respirator OR respirators OR FFP3 OR "eye protective device" OR goggles OR "face shield" OR visor OR "safety glasses" OR "hand hygiene" OR clean* OR "transmission" OR airborn* OR aerosol*

Date limited to previous week.

Search terms for 23rd August 2021 until 6th December 2021 were as follows:

Embase

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kw,ab.
3. disinfection.ti,kw,ab.
4. decontamination.ti,kw,ab.
5. personal protective equipment.ti,kw,ab.

[1] Search areas adjusted to ".ti,kf,ab." for search on Medline

[2] Date limit term changed to "dt=" for search on Medline

6. ppe.ti,kw,ab.
7. surgical mask*.ti,kw,ab.
8. respiratory protective device*.ti,kw,ab.
9. respirator.ti,kw,ab.
10. respirators.ti,kw,ab.
11. FFP3*.ti,kw,ab.
12. clean*.ti,kw,ab.
13. transmission.ti,kw,ab.
14. airborn*.ti,kw,ab.
15. aerosol*.ti,kw,ab.
16. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17. 1 and 16
18. limit 17 to english language
19. limit 18 to dd=20200928-20201005 [Edit dates as appropriate]

Medline

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kf,ab.
3. disinfection.ti,kf,ab.
4. decontamination.ti,kf,ab.
5. personal protective equipment.ti,kf,ab.
6. ppe.ti,kf,ab.
7. surgical mask*.ti,kf,ab.
8. respiratory protective device*.ti,kf,ab.
9. respirator.ti,kf,ab.

10. respirators.ti,kf,ab.
11. FFP3*.ti,kf,ab.
12. clean*.ti,kf,ab.
13. transmission.ti,kf,ab.
14. airborn*.ti,kf,ab.
15. aerosol*.ti,kf,ab.
16. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17. 1 and 16
18. limit 17 to english language
19. limit 18 to dt=20200928-20201005 [Edit dates as appropriate]

MedRxiv

"infection control" OR disinfection OR decontamination OR "personal protective equipment" OR ppe OR "surgical mask" OR "respiratory protective device" OR respirator OR respirators OR FFP3 OR clean* OR "transmission" OR airborn* OR aerosol*

Search terms for 13th December 2021 until 17th January 2022 were as follows:

Embase

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kw,ab.
3. personal protective equipment.ti,kw,ab.
4. ppe.ti,kw,ab.
5. surgical mask*.ti,kw,ab.
6. respiratory protective device*.ti,kw,ab.
7. respirator.ti,kw,ab.
8. respirators.ti,kw,ab.

9. FFP3*.ti,kw,ab.
10. transmission.ti,kw,ab.
11. airborn*.ti,kw,ab.
12. aerosol*.ti,kw,ab.
13. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. 1 and 13
15. limit 14 to english language
16. limit 15 to dd=20211129-20211206 [Edit dates as appropriate]

Medline

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kf,ab.
3. personal protective equipment.ti,kf,ab.
4. ppe.ti,kf,ab.
5. surgical mask*.ti,kf,ab.
6. respiratory protective device*.ti,kf,ab.
7. respirator.ti,kf,ab.
8. respirators.ti,kf,ab.
9. FFP3*.ti,kf,ab.
10. transmission.ti,kf,ab.
11. airborn*.ti,kf,ab.
12. aerosol*.ti,kf,ab.
13. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. 1 and 13
15. limit 14 to english language
16. limit 15 to dt=20211129-20211206 [Edit dates as appropriate]

MedRxiv

"infection control" OR disinfection OR decontamination OR "personal protective equipment" OR ppe OR "surgical mask" OR "respiratory protective device" OR respirator OR respirators OR FFP3 OR "transmission" OR airborn* OR aerosol*

Search terms for 24th January 2022 onwards were as follows:

Embase

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kw,ab.
3. personal protective equipment.ti,kw,ab.
4. ppe.ti,kw,ab.
5. surgical mask*.ti,kw,ab.
6. medical mask*.ti.kw.ab.
7. respiratory protective device*.ti,kw,ab.
9. respirator.ti,kw,ab.
9. respirators.ti,kw,ab.
10. FFP3*.ti,kw,ab.
11. transmission.ti,kw,ab.
12. airborn*.ti,kw,ab.
13. aerosol*.ti,kw,ab.
14. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13
15. 1 and 14
16. limit 15 to english language
17. limit 15 to dd=20220117-20220124 [Edit dates as appropriate]

Medline

1. (coronavirus or corona virus or ncov* or covid* or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19).mp.
2. infection control.ti,kf,ab.
3. personal protective equipment.ti,kf,ab.
4. ppe.ti,kf,ab.
5. surgical mask*.ti,kf,ab.
6. medical mask*.ti,kf,ab.
7. respiratory protective device*.ti,kf,ab.
8. respirator.ti,kf,ab.
9. respirators.ti,kf,ab.
10. FFP3*.ti,kf,ab.
11. transmission.ti,kf,ab.
12. airborn*.ti,kf,ab.
13. aerosol*.ti,kf,ab.
14. 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13
15. 1 and 13
16. limit 15 to english language
17. limit 16 to dt=20220117-20220124 [Edit dates as appropriate]

MedRxiv

“infection control” OR disinfection OR decontamination OR “personal protective equipment” OR ppe OR “surgical mask” OR “respiratory protective device” OR respirator OR respirators OR FFP3 OR “transmission” OR airborn* OR aerosol*

References

1. To KKW, Tsang OTY, Chik-Yan Yip C, et al. Consistent detection of 2019 novel coronavirus in saliva. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America* 2020; 12.
2. Wang FS and Zhang C. What to do next to control the 2019-nCoV epidemic? *The Lancet* 2020; 395: 391-393. Note.
3. Rothan HA and Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *Journal of Autoimmunity* 2020: 102433. Review.
4. Xia J, Tong J, Liu M, et al. Evaluation of coronavirus in tears and conjunctival secretions of patients with SARS-CoV-2 infection. *Journal of Medical Virology* 2020; 26: 26.
5. Peeri NC, Shrestha N, Rahman MS, et al. The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned? *International journal of epidemiology* 2020; 22.
6. Yang Y, Shang W and Rao X. Facing the COVID-19 outbreak: What should we know and what could we do? *Journal of medical virology* 2020; 24.
7. Lai CC, Shih TP, Ko WC, et al. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *International Journal of Antimicrobial Agents* 2020; (no pagination). Review.
8. Jin YH, Cai L, Cheng ZS, et al. A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia (standard version). *Military Medical Research* 2020; 7 (1) (no pagination). Review.
9. Wax RS and Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Canadian Journal of Anesthesia* 2020. Review.
10. Wu YC, Chen CS and Chan YJ. Overview of The 2019 Novel Coronavirus (2019-nCoV): The Pathogen of Severe Specific Contagious Pneumonia (SSCP). *Journal of the Chinese Medical Association: JCMA* 2020; 11.
11. Li JY, You Z, Wang Q, et al. The epidemic of 2019-novel-coronavirus (2019-nCoV) pneumonia and insights for emerging infectious diseases in the future. *Microbes and infection* 2020; 19.

12. Public Health England. *COVID-19: infection prevention and control guidance*. 6 March 2020 2020.

13. Department of Health Ireland. *COVID-19 (Coronavirus): Advice. How COVID-19 (Coronavirus) spreads.* 10 March 2020 2020.

14. Department of Health and Social Care (DHSC) PHWP, Public Health Agency (PHA) Northern Ireland, Health Protection Scotland (HPS), Public Health England,. *COVID-19; Guidance for infection prevention and control in healthcare settings*. 2020.

15. Centres for Disease Control and Prevention (CDC). Coronavirus Disease 2019 (COVID-19) – How COVID-19 Spreads, (2020).

16. World Health Organization. *Infection prevention and control during health care when coronavirus (nCoV) infection is suspected. Interim guidance*. 25 January 2020 2020.

17. World Health Organization. *Transmission of SARS-CoV-2: implications for infection prevention precautions - Scientific Brief.* . 9 July 2020 2020.

18. European Centre for Disease Prevention and Control. *Infection prevention and control and preparedness for COVID-19 in healthcare settings. Sixth update – 9 February 2021*. 9 February 2021 2021.

19. US Centers for Disease Control and Prevention. *Scientific Brief: SARS-CoV-2 Transmission*. 7 May 2021 2021.

20. World Health Organization. *Mask use in the context of COVID-19. Interim guidance, 1 December 2020.* . 1 December 2020 2020.

21. World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed - Interim guidance - 12 July 2021. 2021.

22. World Health Organization. Coronavirus disease (COVID-19): How is it transmitted?, (2021).

23. Miller SL, Nazaroff WW, Jimenez JL, et al. Transmission of SARS-CoV-2 by inhalation of respiratory aerosol in the Skagit Valley Chorale superspreading event. Indoor Air 2020 2020/09/27. DOI: 10.1111/ina.12751.

24. Kwon KS, Park JI, Park YJ, et al. Evidence of Long-Distance Droplet Transmission of SARS-CoV-2 by Direct Air Flow in a Restaurant in Korea. J Korean Med Sci 2020; 35: e415. 2020/12/02. DOI: 10.3346/jkms.2020.35.e415.

25. Li Y, Qian H, Hang J, et al. Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant. . medRxiv 2020; PRE-PRINT.

26. Fox-Lewis A, Williamson F, Harrower J, et al. Airborne Transmission of SARS-CoV-2 Delta Variant within Tightly Monitored Isolation Facility, New Zealand (Aotearoa). Emerging Infectious Disease journal 2022; 28. DOI: 10.3201/eid2803.212318.

27. Scientific Advisory Group for Emergencies. HOCI and EMG: Masks for healthcare workers to mitigate airborne transmission of SARS-CoV-2, 25 March. 23 April 2021 2021.

28. Oswin HP, Haddrewll AE, Otero-Fernandez M, et al. The dynamics of SARS-CoV-2 infectivity with changes in aerosol microenvironment. *MedRxiv* 2022.

29. Faridi S, Niazi S, Sadeghi K, et al. A field indoor air measurement of SARS-CoV-2 in the patient rooms of the largest hospital in Iran. *Sci Total Environ* 2020; 725: 138401. 2020/04/14. DOI: 10.1016/j.scitotenv.2020.138401.

30. Jerry J, O'Regan E, O'Sullivan L, et al. Do established infection prevention and control measures prevent spread of SARS-CoV-2 to the hospital environment beyond the patient room? *J Hosp Infect* 2020 2020/06/27. DOI: 10.1016/j.jhin.2020.06.026.

31. Ahn JY, An S, Sohn Y, et al. Environmental contamination in the isolation rooms of COVID-19 patients with severe pneumonia requiring mechanical ventilation or high-flow oxygen therapy. *J Hosp Infect* 2020 2020/08/24. DOI: 10.1016/j.jhin.2020.08.014.

32. Wei L, Lin J, Duan X, et al. Asymptomatic COVID-19 Patients Can Contaminate Their Surroundings: an Environment Sampling Study. *mSphere* 2020; 5 2020/06/26. DOI: 10.1128/mSphere.00442-20.

33. Kim UJ, Lee SY, Lee JY, et al. Air and Environmental Contamination Caused by COVID-19 Patients: a Multi-Center Study. *J Korean Med Sci* 2020; 35: e332. 2020/09/23. DOI: 10.3346/jkms.2020.35.e332.

34. Declementi M, Godono A, Mansour I, et al. Assessment of air and surfaces contamination in a COVID-19 non-Intensive Care Unit. *Med Lav* 2020; 111: 372-378. 2020/10/31. DOI: 10.23749/mdl.v111i5.9991.

35. Wei L, Huang W, Lu X, et al. Contamination of SARS-CoV-2 in patient surroundings and on personal protective equipment in a non-ICU isolation ward for COVID-19 patients with prolonged PCR positive status. *Antimicrob Resist Infect Control* 2020; 9: 167. 2020/10/31. DOI: 10.1186/s13756-020-00839-x.

36. Dumont-Leblond N, Veillette M, Mubareka S, et al. Low incidence of airborne SARS-CoV-2 in acute care hospital rooms with optimized ventilation. *Emerg Microbes Infect* 2020: 1-36. 2020/11/19. DOI: 10.1080/22221751.2020.1850184.

37. Lane MA, Brownsword EA, Babiker A, et al. Bioaerosol sampling for SARS-CoV-2 in a referral center with critically ill COVID-19 patients March-May 2020. *Clin Infect Dis* 2021 2021/01/29. DOI: 10.1093/cid/ciaa1880.

38. Dumont-Leblond N, Veillette M, Bherer L, et al. Positive no-touch surfaces and undetectable SARS-CoV-2 aerosols in long-term care facilities: An attempt to understand the contributing factors and the importance of timing in air sampling campaigns. *Am J Infect Control* 2021 2021/02/16. DOI: 10.1016/j.ajic.2021.02.004.

39. Dubey A, Kotnala G, Mandal TK, et al. Evidence of presence of SARS-CoV-2 virus in atmospheric air and surfaces of dedicated COVID hospital. *Journal of medical virology* 2021.

40. Ayuso SA, Soriano IS, Augenstein VA, et al. The Aerosolization of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2): Phase I**.** *The Journal of surgical research* 2022; 274: 108-115.

41. Wu S, Wang Y, Jin X, et al. Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. *Am J Infect Control* 2020 2020/05/15. DOI: 10.1016/j.ajic.2020.05.003.

42. Razzini K, Castrica M, Menchetti L, et al. SARS-CoV-2 RNA detection in the air and on surfaces in the COVID-19 ward of a hospital in Milan, Italy. *Sci Total Environ* 2020; 742: 140540. 2020/07/04. DOI: 10.1016/j.scitotenv.2020.140540.

43. Moraes Bruna CQ, Ciofi-Silva CL, de Paula AV, et al. SARS-CoV-2 aerosol generation during respiratory equipment reprocessing. *Antimicrobial Resistance & Infection Control* 2021; 10: 82.

44. Vlachokostas A, Burns CA, Salsbury TI, et al. Experimental evaluation of respiratory droplet spread to rooms connected by a central ventilation system.

45. Ding Z, Qian H, Xu B, et al. Toilets dominate environmental detection of severe acute respiratory syndrome coronavirus 2 in a hospital. *Sci Total Environ* 2020; 753: 141710. 2020/09/07. DOI: 10.1016/j.scitotenv.2020.141710.

46. Baboli Z NN, Babaei AA, Ahmadi M, Sorooshian A, Birgani YT, Goudarzi G. On the airborne transmission of SARS-CoV-2 and relationship with indoor conditions at a hospital. *Atmospheric Environment* 2021: 118563.

47. Santarpia JL, Herrera VL, Rivera DN, et al. The size and culturability of patient-generated SARS-CoV-2 aerosol. *Journal of exposure science & environmental epidemiology* 2021.

48. Lei H, Ye F, Liu X, et al. SARS-CoV-2 environmental contamination associated with persistently infected COVID-19 patients. *Influenza Other Respir Viruses* 2020; 14: 688-699. 2020/06/25. DOI: 10.1111/irv.12783.

49. Ong SWX, Tan YK, Coleman KK, et al. Lack of viable SARS-CoV-2 among PCR-positive air samples from hospital rooms and community isolation facilities. *Infect Control Hosp Epidemiol* 2021: 1-17. 2021/01/26. DOI: 10.1017/ice.2021.8.

50. Chia PY, Coleman KK, Tan YK, et al. Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients. *Nature Communications* 2020; 11: 2800. DOI: 10.1038/s41467-020-16670-2.

51. Liu Y, Ning Z, Chen Y, et al. Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. *Nature* 2020 2020/04/28. DOI: 10.1038/s41586-020-2271-3.

52. Passos RG, Silveira MB and Abrahao JS. Exploratory assessment of the occurrence of SARS-CoV-2 in aerosols in hospital facilities and public spaces of a metropolitan center in Brazil. *Environ Res* 2021; 195: 110808. 2021/01/30. DOI: 10.1016/j.envres.2021.110808.

53. Stern RA, Koutrakis P, Martins MAG, et al. Characterization of hospital airborne SARS-CoV-2. *Respir Res* 2021; 22: 73. 2021/02/28. DOI: 10.1186/s12931-021-01637-8.

54. Guo ZD, Wang ZY, Zhang SF, et al. Aerosol and Surface Distribution of Severe Acute Respiratory Syndrome Coronavirus 2 in Hospital Wards, Wuhan, China, 2020. *Emerg Infect Dis* 2020; 26: 1583-1591. 2020/04/11. DOI: 10.3201/eid2607.200885.

55. Kenarkoohi A, Noorimotlagh Z, Falahi S, et al. Hospital indoor air quality monitoring for the detection of SARS-CoV-2 (COVID-19) virus. *Sci Total Environ* 2020; 748: 141324. 2020/08/18. DOI: 10.1016/j.scitotenv.2020.141324.

56. Mallach G, Kasloff SB, Kovesi T, et al. Aerosol SARS-CoV-2 in hospitals and long-term care homes during the COVID-19 pandemic. *PloS one* 2021; 16: e0258151.

57. Silva PG, Gonçalves J, Lopes AI, et al. Evidence of Air and Surface Contamination with SARS-CoV-2 in a Major Hospital in Portugal. *International Journal of Environmental Research and Public Health* 2022; 19. DOI: 10.3390/ijerph19010525.

58. Grimalt JOV, H.; Fraile-Ribot, P.A.; Marco, E.; Campins, A.; Orfila, J.; van Drooge, B.L.; Fanjul, F. Spread of SARS-CoV-2 in hospital areas. . *Environmental Research* 2021; 204.

59. Thuresson S, Fraenkel C-J, Sasinovich S, et al. Airborne SARS-CoV-2 in hospitals – effects of aerosol-generating procedures, HEPA-filtration units, patient viral load and physical distance. *Clinical Infectious Diseases* 2022: ciac161. DOI: 10.1093/cid/ciac161.

60. Moore G, Rickard H, Stevenson D, et al. Detection of SARS-CoV-2 within the healthcare environment: a multicentre study conducted during the first wave of the COVID-19 outbreak in England. *MedRxiv* 2020; PREPRINT.

61. Tan L, Ma B, Lai X, et al. Air and surface contamination by SARS-CoV-2 virus in a tertiary hospital in Wuhan, China. *Int J Infect Dis* 2020 2020/07/31. DOI: 10.1016/j.ijid.2020.07.027.

62. Ben-Schmuel A, Brosh-Nissimov T, Glinert I, et al. Detection and infectivity potential of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) environmental contamination in isolation units and quarantine facilities. *Clinical Microbiology and Infection* 2020; PRE-PROOF.

63. Munoz-Price LS, Rivera F and Ledeboer N. Air contamination of households versus hospital inpatient rooms occupied by SARS-CoV-2 positive patients. *Infect Control Hosp Epidemiol* 2021: 1-14. 2021/02/05. DOI: 10.1017/ice.2021.45.

64. Kotwa JD, Jamal AJ, Mbareche H, et al. Surface and Air Contamination With Severe Acute Respiratory Syndrome Coronavirus 2 From Hospitalized Coronavirus Disease 2019 Patients in Toronto, Canada, March-May 2020. *The Journal of infectious diseases* 2022; 225: 768-776. DOI: 10.1093/infdis/jiab578.

65. Gregorio PHP, Mariani AW, Brito J, et al. Indoor Air Quality and Environmental Sampling as Support Tools to Detect SARS-CoV-2 in the Healthcare Setting. *J Occup Environ Med* 2021; 63: 956-962. 2021/11/06. DOI: 10.1097/JOM.0000000000002284.

66. Orenes-Pinero E, Navas-Carrillo D, Moreno-Docon A, et al. Confirmation of SARS-CoV-2 airborne dissemination indoors using "COVID-19 traps". *J Infect* 2021 2021/12/27. DOI: 10.1016/j.jinf.2021.12.017.

67. Truyols Vives J, Muncunill J, Toledo Pons N, et al. SARS-CoV-2 detection in bioaerosols using a liquid impinger collector and ddPCR. *Indoor Air* 2022; 32: e13002..

68. Feng B, Xu K, Gu S, et al. Multi-route transmission potential of SARS-CoV-2 in healthcare facilities. *Journal of Hazardous Materials* 2021; 402.

69. Zhou J, Otter JA, Price JR, et al. Investigating SARS-CoV-2 surface and air contamination in an acute healthcare setting during the peak of the COVID-19 pandemic in London. *medRxiv* 2020; PREPRINT.

70. Nissen K, Krambrich J, Akaberi D, et al. Long-distance airborne dispersal of SARS-CoV-2 in COVID-19 wards. *Sci Rep* 2020; 10: 19589. 2020/11/13. DOI: 10.1038/s41598-020-76442-2.

71. Cheng VC, Fung KS, Siu GK, et al. Nosocomial outbreak of COVID-19 by possible airborne transmission leading to a superspreading event. *Clin Infect Dis* 2021 2021/04/15. DOI: 10.1093/cid/ciab313.

72. de Oliveira PM, Mesquita LCC, Gkantonas S, et al. Evolution of spray and aerosol from respiratory releases: theoretical estimates for insight on viral transmission. *Proceedings of the Royal Society A* 2021; 477.

73. Heneghan CJ, Spencer EA, Brassey J, et al. SARS-CoV-2 and the role of airborne transmission: a systematic review [version 1; peer review: 1 approved with reservations, 2 not approved]. *F1000 Research* 2021; 10: 232.

74. Lednicky JA, Lauzardo M, Fan ZH, et al. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients. *medRxiv* 2020; PRE-PRINT.

75. Binder RA, Alarja NA, Robie ER, et al. Environmental and Aerosolized SARS-CoV-2 Among Hospitalized COVID-19 Patients. *J Infect Dis* 2020 2020/09/10. DOI: 10.1093/infdis/jiaa575.

76. Santarpia JL, Rivera DN, Herrera VL, et al. Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care. *Scientific Reports* 2020; 10: 12732. DOI: 10.1038/s41598-020-69286-3.

77. Tran K, Cimon K, Severn M, et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One* 2012; 7: e35797. 2012/05/09. DOI: 10.1371/journal.pone.0035797.

78. Heinzerling A, Stuckey MJ, Scheuer T, et al. Transmission of COVID-19 to Health Care Personnel During Exposures to a Hospitalized Patient - Solano County, California, February 2020. *MMWR Morb Mortal Wkly Rep* 2020; 69: 472-476. 2020/04/17. DOI: 10.15585/mmwr.mm6915e5.

79. World Health Organization. Infection prevention and control of epidemic and pandemic prone acute respiratory infections in health care. WHO Guidelines. 2014.

80. Thompson KA, Pappachan JV, Bennett AM, et al. Influenza aerosols in UK hospitals during the H1N1 (2009) pandemic--the risk of aerosol generation during medical procedures. *PLoS One* 2013; 8: e56278. 2013/02/19. DOI: 10.1371/journal.pone.0056278.

81. Chung FF, Lin HL, Liu HE, et al. Aerosol distribution during open suctioning and long-term surveillance of air quality in a respiratory care center within a medical center. *Respir Care* 2015; 60: 30-37. 2014/10/16. DOI: 10.4187/respcare.03310.

82. Simonds AK, Hanak A, Chatwin M, et al. Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. *Health Technol Assess* 2010; 14: 131-172. 2010/10/07. DOI: 10.3310/hta14460-02.

83. Hamilton F, Gregson F, Arnold D, et al. Aerosol emission from the respiratory tract: an analysis of relative risks from oxygen delivery systems. . *MedRxiv* 2021.

84. Health Protection Scotland. *Assessing the evidence base for medical procedures which create a higher risk of respiratory infection transmission from patient to healthcare worker.* 12 May 2020 2020.

85. European Centre for Disease Prevention and Control. *Threat assessment brief: rapid increase of a SARS-CoV-2 variant with multiple spike protein mutations observed in the United Kingdom.* 20 December 2020 2020. ECDC.

86. Kidd M, Richter A, Best A, et al. S-variant SARS-CoV-2 is associated with significantly higher viral loads in samples tested by ThermoFisher TaqPath RT-QPCR. *MedRxiv* 2020; NOT PEER REVIEWED.

87. Public Health England. SARS-CoV-2 variants of concern and variants under investigation in England. Technical briefing 20. *(Accessed 16th August 2021)* 2021.

88. Scottish Government. Coronavirus (COVID-19): Analysis. Coronavirus (COVID-19): modelling the epidemic in Scotland (Issue No. 62). Published 30 July 2021.

89. UK Health Security Agency. **SARS-CoV-2 variants of concern and variants under investigation in England: Technical briefing 26**, (2021, accessed 25/10/21).

90. World Health Organization. Statement: Update on Omicron, 28 November 2021. 2021.

91. European Centre for Disease Prevention and Control (ECDC). *Assessment of the further spread and potential impact of the SARS-CoV-2 Omicron variant of concern in the EU/EEA, 19th update. 27 January 2022*. ECDC: Stockholm 2022.

92. Elliott P, Eales O, Bodinier B, et al. Post-peak dynamics of a national Omicron SARS-CoV-2 epidemic during January 2022. (2022).

93. UK Health Security Agency (UKHSA). Risk assessment for SARS-CoV-2 variant: VUI-22JAN-01 (BA.2). 23 Feb 2022.

94. UK Health Security Agency (UKHSA). *SARS-CoV-2 variants of concern and variants under investigation in England Technical briefing 35. 28 January 2022*. UKHSA, 2022.

95. UK Health Security Agency (UKHSA). *Weekly national Influenza and COVID-19 surveillance report Week 4 report (up to week 3 data) 27 January 2022*. UKHSA, 2022.

96. Lyngse FP, Kirkeby CT, Denwood M, et al. Transmission of SARS-CoV-2 Omicron VOC subvariants BA.1 and BA.2: Evidence from Danish Households. *medRxiv* 2022: 2022.2001.2028.22270044. DOI: 10.1101/2022.01.28.22270044.

97. Lai X, Wang M, Qin C, et al. Coronavirus Disease 2019 (COVID-2019) Infection Among Health Care Workers and Implications for Prevention Measures in a Tertiary Hospital in Wuhan, China. *JAMA Netw Open* 2020; 3: e209666. 2020/05/22. DOI: 10.1001/jamanetworkopen.2020.9666.

98. Kluytmans-van den Bergh M.F.Q. BAGM, Pas S.D., Bentvelsen R.G., van den Bijllaardt W., van Oudheusden A.J.G., van Rijen M.M.L., Verweij J.J., Koopmans M.P.G., Kluytmans J.A.J.W. . SARS-CoV-2 infection in 86 healthcare workers in two Dutch hospitals in March 2020. *medRxiv* 2020; NOT PEER REVIEWED.

99. Wang X, Zhou Q, He Y, et al. Nosocomial outbreak of COVID-19 pneumonia in Wuhan, China. *Eur Respir J* 2020; 55 2020/05/06. DOI: 10.1183/13993003.00544-2020.

100. Jewkes SV, Zhang Y and Nicholl DJ. Nosocomial spread of COVID-19: lessons learned from an audit on a stroke/neurology ward in a UK district general hospital. *Clin Med (Lond)* 2020; 20: e173-e177. 2020/07/29. DOI: 10.7861/clinmed.2020-0422.

101. Davis P, Gibson R, Wright E, et al. Atypical presentations in the hospitalised older adult testing positive for SARS-CoV-2: a retrospective observational study in Glasgow, Scotland. *Scott Med J* 2020: 36933020962891. 2020/10/13. DOI: 10.1177/0036933020962891.

102. Field RE, Afzal I, Dixon J, et al. Cohort profile: Preliminary experience of 500 COVID-19 positive cases at a South West London District General Hospital**.** *medRxiv* 2020; UNPUBLISHED.

103. Rickman HM, Rampling T, Shaw K, et al. Nosocomial transmission of COVID-19: a retrospective study of 66 hospital-acquired cases in a London teaching hospital. *Clin Infect Dis* 2020 2020/06/21. DOI: 10.1093/cid/ciaa816.

104. Khonyongwa K, Taori SK, Soares A, et al. Incidence and outcomes of healthcare-associated COVID-19 infections: significance of delayed diagnosis and correlation with staff absence. *J Hosp Infect* 2020 2020/10/17. DOI: 10.1016/j.jhin.2020.10.006.

105. Asad H, Johnston C, Blyth I, et al. Health care workers and patients as Trojan horses: a COVID19 ward outbreak. *Infection Prevention in Practice* 2020; 2.

106. Schwierzeck V, Konig JC, Kuhn J, et al. First reported nosocomial outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in a pediatric dialysis unit. *Clin Infect Dis* 2020 2020/04/28. DOI: 10.1093/cid/ciaa491.

107. Wei XS, Wang XR, Zhang JC, et al. A cluster of health care workers with COVID-19 pneumonia caused by SARS-CoV-2. *J Microbiol Immunol Infect* 2020 2020/05/04. DOI: 10.1016/j.jmii.2020.04.013.

108. Dantes RB, Jones TT and Neujahr DC. Delayed Recognition of Community Transmission of COVID-19 Resulting in Healthcare Worker Infections. *Infect Control Hosp Epidemiol* 2020: 1-6. 2020/06/11. DOI: 10.1017/ice.2020.285.

109. Tay HS and Harwood R. Atypical presentation of COVID-19 in a frail older person. *Age Ageing* 2020 2020/04/22. DOI: 10.1093/ageing/afaa068.

110. Tennant E, Figtree M, Tallon J, et al. Epidemiological and genomic analysis of a Sydney hospital COVID-19 outbreak. *MedRxiv* 2022; PRE-PRINT.

111. Shah ASV, Wood R, Gribben C, et al. Risk of hospital admission with coronavirus disease 2019 in healthcare workers and their households: nationwide linkage cohort study. *BMJ* 2020; 371: m3582. 2020/10/30. DOI: 10.1136/bmj.m3582.

112. Hunter E, Price DA, Murphy E, et al. First experience of COVID-19 screening of health-care workers in England. *Lancet* 2020; 395: e77-e78. 2020/04/26. DOI: 10.1016/S0140-6736(20)30970-3.

113. Folgueira MD and al. e. SARS-CoV-2 infection in health care workers in a large public hospital in Madrid, Spain, during March 2020. . *MedRxiv* 2020; NOT PEER REVIEWED.

114. Sikkema RSea. COVID-19 in healthcare workers in three hospitals in the South of the Netherlands, March 2020. *medRxiv* 2020; UNPUBLISHED.

115. Safdar N, Moreno GK, Braun KM, et al. Determining the source of transmission of SARS-CoV-2 infection in a healthcare worker. *medRxiv* 2020; PRE-PRINT.

116. Lucey M, Macori G, Mullane N, et al. Whole-genome sequencing to track SARS-CoV-2 transmission in nosocomial outbreaks. *Clin Infect Dis* 2020 2020/09/22. DOI: 10.1093/cid/ciaa1433.

117. Parkulo MA, Brinker TM, Bosch W, et al. Risk of SARS-CoV-2 Transmission Among Coworkers in a Surgical Environment. *Mayo Clin Proc* 2021; 96: 152-155. 2021/01/09. DOI: 10.1016/j.mayocp.2020.10.016.

118. Francis RV, Billam H, Clarke M, et al. The impact of real-time whole genome sequencing in controlling healthcare-associated SARS-CoV-2 outbreaks. *Journal of Infectious Diseases* 2021; 23: 23.

119. Borges V, Isidro J, Macedo F, et al. Nosocomial Outbreak of SARS-CoV-2 in a "Non-COVID-19" Hospital Ward: Virus Genome Sequencing as a Key Tool to Understand Cryptic Transmission. *Viruses* 2021; 13 2021/05/01. DOI: 10.3390/v13040604.

120. Queromes G, Destras G, Bal A, et al. Characterization of SARS-CoV-2 ORF6 deletion variants detected in a nosocomial cluster during routine genomic surveillance, Lyon, France. *Emerg Microbes Infect* 2021: 1-56. 2021/01/06. DOI: 10.1080/22221751.2021.1872351.

121. Scientific Advisory Group for Emergencies. *Eighty-third SAGE meeting on COVID-19, 11 March 2021*. 11 March 2021 2021.

122. Dancer SJ, Cormack K, Loh M, et al. Healthcare-acquired clusters of COVID-19 across multiple wards in a Scottish health board. *J Hosp Infect* 2021 2021/12/06. DOI: 10.1016/j.jhin.2021.11.019.

123. Kerneis S, Planas D, Imbeaud S, et al. Transmission of SARS-CoV-2 Alpha Variant (B.1.1.7) From a BNT162b2-Vaccinated Individual. *Open Forum Infect Dis* 2021; 8: ofab369. 2021/08/12. DOI: 10.1093/ofid/ofab369.

124. Rivett L, Sridhar S, Sparkes D, et al. Screening of healthcare workers for SARS-CoV-2 highlights the role of asymptomatic carriage in COVID-19 transmission. *Elife* 2020; 9 2020/05/12. DOI: 10.7554/eLife.58728.

125. Zabarsky TF, Bhullar D, Silva SY, et al. What are the sources of exposure in healthcare personnel with coronavirus disease 2019 infection? *Am J Infect Control* 2020 2020/08/17. DOI: 10.1016/j.ajic.2020.08.004.

126. Graham NSN, Junghans C, Downes R, et al. SARS-CoV-2 infection, clinical features and outcome of COVID-19 in United Kingdom nursing homes. *medRxiv* 2020; PRE-PRINT.

127. Ladhani SN, Chow JY, Janarthanan R, et al. Investigation of SARS-CoV-2 outbreaks in six care homes in London, April 2020. *EClinicalMedicine* 2020: 100533. 2020/09/15. DOI: 10.1016/j.eclinm.2020.100533.

128. Kennelly SP, Dyer AH, Martin R, et al. Asymptomatic carriage rates and case-fatality of SARS-CoV-2 infection in residents and staff in Irish nursing homes. *medRxiv* 2020; PRE-PRINT.

129. Healthcare Safety Investigation Branch. *COVID-19 transmission in hospitals: management of the risk - a prospective safety investigation. Independent report by the Healthcare Safety Investigation Branch I2020/018*. October 2020 2020.

130. Brandt MP, Jager W, Epple S, et al. SARS-CoV-2 outbreak in medical employees in a large urologic department: Spread, containment and outcome. *Am J Infect Control* 2021 2021/02/23. DOI: 10.1016/j.ajic.2021.02.011.

131. Sharma S, Mohindra R, Rana K, et al. Assessment of Potential Risk Factors for 2019-Novel Coronavirus (2019-nCov) Infection among Health Care Workers in a Tertiary Care Hospital, North India. *J Prim Care Community Health* 2021; 12: 21501327211002099. 2021/03/16. DOI: 10.1177/21501327211002099.

132. Davido B, Gautier S, Riom I, et al. The first wave of COVID-19 in hospital staff members of a tertiary care hospital in the greater Paris area: A surveillance and risk

factors study. *Int J Infect Dis* 2021; 105: 172-179. 2021/02/20. DOI: 10.1016/j.ijid.2021.02.055.

133. Jung J, Lee J, Jo S, et al. Nosocomial Outbreak of COVID-19 in a Hematologic Ward. *Infect Chemother* 2021; 53: 332-341. 2021/07/04. DOI: 10.3947/ic.2021.0046.

134. Richterman A, Meyerowitz EA and Cevik M. Hospital-Acquired SARS-CoV-2 Infection: Lessons for Public Health. *JAMA* 2020 2020/11/14. DOI: 10.1001/jama.2020.21399.

135. Brown KA, Jones A, Daneman N, et al. Association Between Nursing Home Crowding and COVID-19 Infection and Mortality in Ontario, Canada. *JAMA Intern Med* 2021; 181: 229-236. 2020/11/10. DOI: 10.1001/jamainternmed.2020.6466.

136. Scottish Government. *Visiting guidance for hospitals in Scotland - Safely supporting visiting across Scotland's hospitals*. 2 December 2020 2020.

137. ARHAI Scotland. Winter (21/22) Respiratory Infections in Health and Care Settings Infection Prevention and Control (IPC) Addendum. 29 November 2021 2021.

138. Canova V, Lederer Schlapfer H, Piso RJ, et al. Transmission risk of SARS-CoV-2 to healthcare workers -observational results of a primary care hospital contact tracing. Swiss Med Wkly 2020; 150: w20257. 2020/04/26. DOI: 10.4414/smw.2020.20257.

139. Wendt R, Nagel S, Nickel O, et al. Comprehensive investigation of an in-hospital transmission cluster of a symptomatic SARS-CoV-2-positive physician among patients and healthcare workers in Germany. Infect Control Hosp Epidemiol 2020: 1-3. 2020/06/04. DOI: 10.1017/ice.2020.268.

140. Ng K, Poon BH, Kiat Puar TH, et al. COVID-19 and the Risk to Health Care Workers: A Case Report. Ann Intern Med 2020; 172: 766-767. 2020/03/17. DOI: 10.7326/L20-0175.

141. Chow A, Htun HL, Kyaw WM, et al. Atypical COVID-19: Preventing transmission from unexpected cases. Infect Control Hosp Epidemiol 2020: 1-3. 2020/08/14. DOI: 10.1017/ice.2020.419.

142. Health and Safety Executive. Respiratory protection equipment at work. A practical guide. 2013.

143. Department of Health England and Health Protection Agency. Pandemic (H1N1) 2009 Influenza. Summary infection control guidance for ambulance services during an influenza pandemic. 2009.

144. The Healthcare Infection Control Practices Advisory Committee (HICPAC) and The Centres for Disease Control (CDC). Core Infection Prevention and Control Practices for Safe Healthcare Delivery in All Settings – Recommendations of the Healthcare Infection Control Practices Advisory Committee. 2017.

145. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. American Journal of Infection Control 2007; 35: S65-S164.

146. Leung N, Chu DKW, Shiu E, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nature Medicine 2020.

147. Johnson DF DJ, Birch C, et al. A quantitative assessment of the efficacy of surgical and N95 masks to filter influenza virus in patients with acute influenza infection. Clin Infect Dis 2009; 49: 275-277. DOI: 10.1086/600041.

148. Su WL, Hung PP, Lin CP, et al. Masks and closed-loop ventilators prevent environmental contamination by COVID-19 patients in negative-pressure environments. J Microbiol Immunol Infect 2020 2020/05/20. DOI: 10.1016/j.jmii.2020.05.002.

149. Cappa C, Asadi S, Barreda S, et al. Expiratory aerosol particle escape from surgical masks due to imperfect sealing. Research Square 2021; PRE-PRINT/NOT PEER REVIEWED.

150. Adenaiye OO, Lai J, Jacob Bueno De Mesquita P, et al. Infectious SARS-CoV-2 in Exhaled Aerosols and Efficacy of Masks During Early Mild Infection. (2021).

151. Ueki H, Furusawa Y, Iwatsuki-Horimoto K, et al. Effectiveness of Face Masks in Preventing Airborne Transmission of SARS-CoV-2. mSphere 2020; 5 2020/10/23. DOI: 10.1128/mSphere.00637-20.

152. Health Protection Scotland. National Infection Prevention and Control Manual - Chapter 2 (Trasmission-based precautions). Accessed 13 March 2020 2020. Health Protection Scotland.

153. World Health Organization. Coronavirus disease (COVID-19): Masks - Q & A 9 October 2020 2020.

154. ECDC. Using face masks in the community - Reducting COVID-19 transmission from potentially asymptomatic or pre-symptomatic people through the use of face masks. 8 April 2020. 8 April 2020 2020.

155. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19) - Healthcare Workers - Personal protective equipment Questions and Answers. 8 August 2020 2020.

156. Association of periOperative Registered Nurses (AORN). Recommended Practices for Prevention of Transmissible Infections in the Perioperative Practice Setting, (2007).

157. Association for Professionals in Infection control and Epidemiology (APIC), American Nurses Association, Association of Occupational Health Professionals in Healthcare, et al. Do's and don'ts for wearing procedure masks in non-surgical healthcare settings. 2015.

158. Loveday HP, Wilson JA, Pratt RJ, et al. epic3: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England. Journal of Hospital Infection 2014; 86: S1-S70.

159. Occupational Safety and Health Administration (OSHA). Guidance on Preparing Workplaces for an Influenza Pandemic. 2009.

160. Gemmell L, Birks R, Radford P, et al. Infection control in anaesthesia. Anaesthesia 2008; 63: 1027-1036. Review.

161. Health and Safety Executive. The Control of Substances Hazardous to Health Regulations 2002. 2013.

162. UK Government. The Personal Protective Equipment Regulations 2002. 2002.

163. Coia JE, Ritchie L and Fry C. Use of Respiratory and facial protection. Nursing Times 2014; 110: 18-20.

164. Coia JE, Ritchie L, Adisesh A, et al. Guidance on the use of respiratory and facial protection equipment. Journal of Hospital Infection 2013; 85: 170-182. Short Survey.

165. Bunyan D, Ritchie L, Jenkins D, et al. Respiratory and facial protection: A critical review of recent literature. Journal of Hospital Infection 2013; 85: 165-169. Review.

166. MacIntyre CR, Seale H, Dung TC, et al. A cluster randomised trial of cloth masks compared with medical masks in healthcare workers. BMJ Open 2015; 5: e006577.

167. Offeddu V, Yung CF, Low MSF, et al. Effectiveness of Masks and Respirators Against Respiratory Infections in Healthcare Workers: A Systematic Review and Meta-Analysis. Clin Infect Dis 2017; 65: 1934-1942. 2017/11/16. DOI: 10.1093/cid/cix681.

168. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 2003; 361: 1519-1520. 2003/05/10. DOI: 10.1016/s0140-6736(03)13168-6.

169. Bartoszko JJ, Farooqi MAM, Alhazzani W, et al. Medical Masks vs N95 Respirators for Preventing COVID-19 in Health Care Workers A Systematic Review and Meta-Analysis of Randomized Trials. Influenza Other Respir Viruses 2020 2020/04/05. DOI: 10.1111/irv.12745.

170. Greenhalgh T, Chan XH, Khunti K, et al. What is the efficacy of standard face mask compared to respirator masks in preventing COVID-type respiratory illnesses in primary care staff? 30 March 2020 2020. Oxford COVID-19 Evidence Service Team.

171. Verbeek JH, Rajamaki B, Ijaz S, et al. Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. Cochrane Database Syst Rev 2020; 4: CD011621. 2020/04/16. DOI: 10.1002/14651858.CD011621.pub4.

172. Haller S, Gusewell S, Egger T, et al. Impact of respirator versus surgical masks on SARS-CoV-2 acquisition in healthcare workers: a prospective multicentre cohort. Antimicrobial resistance and infection control 2022; 11: 27.

173. Shah VP, Breeher LE, Hainy CM, et al. Evaluation of healthcare personnel exposures to patients with severe acute respiratory coronavirus virus 2 (SARS-CoV-2) associated with personal protective equipment. Infect Control Hosp Epidemiol 2021: 1-5. 2021/05/13. DOI: 10.1017/ice.2021.219.

174. Ferris M, Ferris R, Workman C, et al. Efficacy of FFP3 respirators for prevention of SARS-CoV-2 infection in healthcare workers. *Elife* 2021; 10 2021/11/17. DOI: 10.7554/eLife.71131.

175. Lawton T, Butler M and Peters C. Airborne protection for staff is associated with reduced hospital-acquired COVID-19 in English NHS Trusts. *J Hosp Infect* 2021 2021/12/04. DOI: 10.1016/j.jhin.2021.11.018.

176. National COVID-19 Clinical Evidence Taskforce. *Australian guidelines for SARS-CoV-2 infection prevention and control of COVID-19 in healthcare workers. V1.0*. 10 June 2021 2021.

177. UK Health Security Agency. *The role of face coverings in mitigating the transmission of SARS-CoV-2. An overview of evidence.* October 2021 2021.

178. Health and Safety Executive. *Rapid review evidence - Delivered by HSE for the Government Chief Scientific Adviser - Part one: equivalence of N95 and FFP2 masks, Part two: aprons, gowns and eye protection*. 24 March 2021 2021.

179. ARHAI Scotland. *Scottish COVID-19 infection prevention and control addendum for acute settings*. 27 October 2020 2020. National Infection Prevention and Control Manual: NHS National Services Scotland.

180. World Health Organization. *Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed: interim guidance, 29 June 2020*. 29 June 2020 2020.

181. Australian Government. *Recommended minimum requirements for the use of masks or respirators by health and residential care workers in areas with significant community transmission of COVID-19*. 23 October 2020 2020.

182. Australian Government. *Infection Control Expert Group - The use of face masks and respirators in the context of COVID-19, Version 4.0*. 11 March 2021 2021.

183. World Health Organization. Annexe to Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed - Interim guidance. 1 October 2021 2021.

184. Kampf G. Potential role of inanimate surfaces for the spread of coronaviruses and their inactivation with disinfectant agents. *Infection Prevention in Practice* 2020; 2 (2) (no pagination). Review.

185. Chang L, Yan Y and Wang L. Coronavirus Disease 2019: Coronaviruses and Blood Safety. *Transfusion Medicine Reviews* 2020. Review.

186. Health Protection Surveillance Centre (HPSC). *Current recommendations for the use of Personal Protective Equipment (PPE) in the context of the COVID-19 pandemic v2.6 29.12.2021*. 29 December 2021 2021.

187. Scottish Government. *COVID-19: Interim guidance on the extended use of medical masks and face coverings in hospitals and care homes V2.0*. 18 September 2020 2020.

188. Scottish Government. Coronavirus (COVID-19): guidance on the extended use of face masks and face coverings in hospitals, primary care, wider community care and adult care homes**.** 2021; Accessed 18/06/2021.

189. Public Health England. *COVID-19: infection prevention and control*. 2 April 2020 2020.

190. Public Health England. *COVID-19: Guidance for the remobilisation of services within health and care settings. Infection prevention and control recommendations. Version 1.0*. 20 August 2020 2020.

191. UKHSA. Guidance: **Infection prevention and control for seasonal respiratory infections in health and care settings (including SARS-CoV-2) for winter 2021 to 2022**. 2022; (Accessed 22nd March 2022).

192. ECDC. Infection prevention and control and preparedness for COVID-19 in healthcare settings. Second update - 31 March 2020. 2020.

193. ECRI. Safety of extended use and reuse of N95 respirators - Clinical evidence assessment. March 2020 2020. ECRI.

194. MacIntyre CR, Wang Q, Cauchemez S, et al. A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers. *Influenza Other Respir Viruses* 2011; 5: 170-179. 2011/04/12. DOI: 10.1111/j.1750-2659.2011.00198.x.

195. World Health Organization. *Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19) -Interim Guidance*. 27 February 2020 2020. World Health Organization.