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

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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	09/09/2021	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, face visors, and hand hygiene (v17, Archived). Amended search strategy. Includes literature identified up to 30 August 2021.

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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 September 2021, are to establish the following:

- The transmission routes of COVID-19;
- The personal protective equipment (PPE) requirements;
- The environmental survivability of COVID-19;
- The requirements for cleaning/decontamination of the care environment.

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), Public Health England, 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). These superseded sections are still available to view in an archived draft. Targeted rapid reviews will be undertaken on these subject areas in the future should the need arise.

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 7 – survival in the environment) 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] More recently, in their 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] The CDC state that there are several well-documented examples in which transmission appears to have occurred over long distances or times, however the references provided in the report, which are largely from outbreak reports in overcrowded community settings (restaurants, recreation, gyms) do not provide clear evidence of 'traditional' airborne transmission (defined as long distance transmission of respiratory aerosols). The evidence base for possible human-human airborne transmission, as presented by the CDC, is largely from community settings.[22-24] 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. In the absence of robust evidence for airborne transmission, a more accurate description of what might be facilitated in those specific circumstances as described by both the CDC and WHO is 'short-range aerosol' transmission, whereby poor ventilation combined with overcrowding/close contact in small spaces provide the conditions for respiratory aerosols to remain suspended in the air thus increasing the risk of transmission. 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). 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.[25] Currently there is no clear evidence of 'traditional' long-range airborne transmission of SARS-CoV-2 from outbreak reports. 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 recognising symptoms 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.

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 actual 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).

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[26-36] or settle plates[37] 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.[38, 39] 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);[35] 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,[40-42] airborne isolation rooms of general wards,[43, 44] PPE-removal rooms,[45-47] ICUs,[38, 46, 48-50] hospital corridors,[38, 47] bays,[51] long-term care rooms,[50] and single patient rooms.[51-55] 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.[45] 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.[48] 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.[56] 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.[57] 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.[52] 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).[51] 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.[58] 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.[59]

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.[60] 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.[61]

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.[62] 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.[43, 50, 51, 53, 55, 57, 63, 64] 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, 65] 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, 66] 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.[67] It should also be recognised that as well as producing aerosols, these procedures produce a spectrum of droplet sizes including larger droplet particles.[68-70]

The WHO further defines an AGP as those procedures which result in the production of airborne particles (aerosols).[67] 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.[67] 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.[67] 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.[67] 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.[71] 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).[72] 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 Thermofisher TaqPath assay used in the UK Lighthouse laboratories.[73] 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, [74] 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 Kent 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;[75] and in Scotland, 97% of sequenced cases (data up to 28 May 2021).[76] Whilst evidence is still being amassed regarding variants, there is so far no indication that the transmission modes have changed and therefore no changes required to the current IPC measures.

Further information regarding the new variant(s) is provided in a separate ARHAI Scotland **rapid review.**

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 no clear 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.[77] 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.[78] 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.[79-81] 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.[81] 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.[82] 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.[83] 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).[84] 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.[85] 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.[86] 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.[87] 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.[88] 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.[89] 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.[90] 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).[90] 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.[91] Mirroring of community transmission was also identified at a large public hospital in Madrid,[92] and at three hospitals in the Netherlands; contacts with COVID-19 individuals was reported from out-with the hospital and from contact with colleagues.[93] Complete genome sequencing of 50 HCW and 18 patients suggested that the observed patterns were most consistent with multiple introductions into the hospital.[93] Genetic sequencing provided confirmatory evidence for community transmission to a HCW, ruling out suspected transmission from two COVID-19 patients.[94] 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.[95] 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.[96] Sharing of patient transport was implicated in facilitating patient-patient transmission between renal dialysis patients, where WGS assisted identification of the cluster.[97] In a Portuguese hospital, WGS also assisted identification of both HCW to patient and HCW to HCW transmission on a non-COVID-19 ward.[98] Although WGS can help in identifying nosocomial clusters, it is often impossible to determine the source and subsequent direction of transmission.[99] 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.[100] More recently in the period from July 2021 onwards, there has not been the same increase in nosocomial cases driven by the rise in community cases as observed in previous waves. It is likely that vaccination has had an influence in this regard.

Whilst transmission from asymptomatic HCWs has not been documented, 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.[101] 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.[102] 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.[103] Further, 7.9% were pre-symptomatic.[104] 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.[103] 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.[105] 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.[106] 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,[107] this was also noted as a risk factor in an Indian cohort.[108] In a French HCW cohort (n=99), not wearing facemasks during staff meetings was associated with risk of infection.[109] Poor mask compliance in visitors was also noted during an outbreak involving patients and visitors/guardians in a haematology ward in South Korea.[110] 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.[111] 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.[112]

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,[113] the specifics regarding requirements for visitors is outlined in the NIPCM COVID-19 addendum.[114]

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.[66] 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.[115] 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).[116] 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.[117] 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.[118] 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 medium risk (amber) and high risk (red) pathways (optional for AGPs in the low risk (green) pathway).
- Visitors should be managed according to the NIPCM COVID-19 addendum.
- When not providing patient care, HCWs should continue to adhere to the pandemic controls (physical distancing, extended mask wearing) as outlined in the NIPCM COVID-19 addendums.

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[119] 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.[120-122] 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.[123] 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.[123, 124] 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.[125] 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.[126] 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, $p < 0.001$).[71] 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).[127] 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.[128]

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.[129] The ECDC, CDC, and WHO advise against the use of respirators with exhalation valves for source control of COVID-19.[130-132] A recent **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.[67, 120, 122, 133-137] 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.[138-143]

When assessing the infection risk related to surgical masks and respirators, there is no clear evidence 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.[144] 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). [145] 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.[146] 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.[147] 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.[148] 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).[149] 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. 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).[150] 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). An example of this is a recently published (June 2021) pre-print study where HCW infection rates were considered after the introduction of unit-wide FFP3 respirators instead of surgical face masks (type IIR) for “red” wards in an English hospital; twice-weekly testing and vaccination were introduced at the same time as the FFP3 respirators, which is likely to have confounded the outcomes.[151] The small sample size and poor methodology of the study are further limitations.

The Australian National COVID-19 Clinical Evidence Taskforce recently 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.[152] 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 Health & Safety Executive (HSE). 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.[153]

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.[152] 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.[152] 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.[25] 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, with extended use of RPE a possible outcome of such a risk assessment.[114] A risk assessment algorithm was added in July 2021.

The World Health Organization, Canadian Government guidance, and Australian Government guidance recommends surgical face masks for routine care (non-AGP) of suspected/confirmed COVID-19 patients.[154-157] The US Centers for Disease Control and Prevention (CDC) recommend that HCWs can wear a well-fitting facemask for protection during non-AGP patient care encounters with patients not suspected of having COVID-19 (respirators are optional).[158] This would equate to care for patients on the low risk (green) pathway in the UK. 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.[100]

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.[159] 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 and care homes 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).[160] 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). Visitors to care homes must also wear FRSMs. 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.

The Scottish COVID-19 addendum for acute care settings published within the NIPCM on October 27th 2020 states that HCWs should wear a type IIR fluid resistant surgical mask for all direct contact with patients, and when carrying out AGPs in the green pathway.[114]

The UK Health and Safety Executive (HSE) position regarding RPE has remained unchanged; currently the use of respirators, such as FFP2 or FFP3, are only for the highest risk aerosol generating procedures which are undertaken in medical settings and during dental procedures (*correspondence provided by the UK IPC Cell*). The Scottish COVID-19 Addendum advises that respirators are worn by HCWs when carrying out AGPs in medium and high risk pathways. At all other times, HCWs are expected to be wearing Type IIR fluid-resistant surgical face masks. However, in recognition of the anxiety felt by many HCWs with regards to PPE provision, Scottish guidance recommends that 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.

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. UK and Scottish COVID-19 guidance further clarifies that valved respirators should not be worn by HCWs when sterility over the surgical field is required as exhaled breath is unfiltered e.g. in theatres/surgical settings or when undertaking a sterile procedure.[114, 161] 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 medium risk (amber) and high risk (red) pathways.
- HCWs 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.
- The unit-wide use of FFP3 respirators should be considered in clinical areas used for the high risk pathway where there remains an unacceptable risk of transmission despite

application of mitigation measures following a risk assessment as per the NIPCM COVID-19 Acute care 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.

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.[162] 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 PHE was updated on 20th August 2020 with the publication of IPC guidance for remobilisation of service in health and care settings.[163] A major change was the introduction of 3 patient pathways for COVID-19 which set out the PPE requirements for each area. The guidance was updated and renamed to '*Guidance for maintaining services within health and care settings*' on 21st January 2021[164] with the latest version 1.2 published on 1st June 2021.[161] Whilst sessional use of single use PPE/RPE items continued to be minimised in the recommendations, the guidance states that sessional or extended use of facemasks (all pathways) or FFP3 respirators (together with eye/face protection) can be applied in the medium and high risk pathways where airborne precautions are indicated e.g. AGPs undertaken for COVID-19 cohorted patients/individuals.[161]

Scottish COVID-19 guidance (in the form of an addendum) was published in the NIPCM on 27th October 2020 and also includes the implementation of 3 patient pathways. There is 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 is no longer a requirement in Scottish settings for sessional PPE use, apart from FRSMs which can be worn sessionally. The addendum advises 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 recommends 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.[114] A risk assessment algorithm was added in July 2021.

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.

The Scottish and UK PPE guidelines remain in line with those issued by the World Health Organization.

UK IPC pandemic COVID-19 guidance has never recommended decontamination of respirators.[162] 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.[165] 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.[166] 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.[167] 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.[167] 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.[168] 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[168] 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 in line with physical distancing measures.
- Consideration should be given to the unit wide application of airborne precautions where the number of cases of COVID-19 in amber and red pathways 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 high risk pathway where there remains an unacceptable risk of transmission despite application of mitigation measures following a risk assessment as per the NIPCM COVID-19 Acute care 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. Survival in the environment

A number of environmental sampling studies of rooms/areas occupied by COVID-19 patients and surrounding areas sampled various locations prior to environmental cleaning; viral RNA was found on multiple surfaces including the bed, bed sheets, bed rail, locker, chair, computer table, keyboard, light switches, sink, taps, floor and staff shoes, window ledge, PPE storage area, hand sanitiser dispensers, air outlet fans, elevator buttons, as well as the toilet bowl surface and handle, door handle, and medical equipment (ventilators, monitors, blood pressure cuffs, thermometers, drainage bags, high flow oxygen generator, endotracheal tube, infusion pumps , endoscope).[27-30, 32, 37, 38, 40, 44, 48, 51-53, 56, 63, 64, 169-183] Personal items such as mobile phones, TV remotes, towels and toothbrushes were also contaminated.[28, 51, 63, 64, 170, 183] Overall, positive rates were significantly higher in medical areas compared to office areas and buffer rooms for donning PPE; contamination in these areas was found on telephones, desktops, keyboards, computer mice and water machine buttons.[37, 176] Sampling carried out prior to environmental cleaning across patient care areas and non-patient care areas of an

emergency department revealed positive samples in patient care areas only (from stretchers, pulse oximeters, blood pressure cuffs, plastic screens between patients, and the floor).[184] A study that sampled multiple surfaces within an emergency triage unit and a sub-intensive care ward identified positive samples on 2 CPAP helmets only.[185] It is possible that environmental cleaning, carried out 4 hours prior, may have impacted results. Environmental sampling studies are often limited as they omit information regarding frequency of environmental cleaning, or conduct sampling immediately following cleaning.[186-188] Viable virus has been detected in three studies from samples collected from the surfaces of fixtures, fittings and medical equipment in COVID-19 patient rooms[28, 55, 189] but most studies have failed to demonstrate viability.[53, 64, 176, 185, 188] The potential effect of disease progression and viral shedding on environmental contamination has not been investigated extensively, however one study has demonstrated a significant correlation between viral load ranges in clinical samples and positivity rate of environmental samples ($p < 0.001$).[190] When the viral load of clinical samples was higher than or equal to 3 log copies/ml, environmental contamination with SARS-CoV-2 could be detected. However, the sample size in this study was small and further research is required to confirm these findings. Environmental contamination was detected in two hotel rooms occupied by quarantined cases that were pre-symptomatic during their stay, which highlights the risk of environmental contamination from shedding in the pre-symptomatic phase.[191] Viral RNA contamination of high touch surfaces in public places (shops, banks, fuel station) has also been demonstrated but viability was not tested.[192] In general, sampling studies highlight the potential for environmental contamination, particularly of frequently-touched areas, but the risk of acquiring infection from contaminated environmental sites remains unknown. Very few studies have tested viability of PCR-positive samples obtained from environmental swabbing. Sampling of surfaces considered to be low touch (tops of door frames, tops of shelving units) in a number of long term care facilities in Canada generated positive PCR samples but viability could not be demonstrated in culture; care activities in these settings were not provided in detail.[35] An in-vivo study tested the viability of SARS-CoV-2 under a number of experimental conditions and found that cells remained viable for 3-5 days at room temperature.[193] In light of limited data for SARS-CoV-2 regarding survival time in the environment, evidence was assessed from studies conducted with human coronaviruses including MERS-CoV and SARS-CoV, and human coronavirus 229E. From largely experimental studies, human coronaviruses are capable of surviving on inanimate objects and can remain viable for up to 5 days at temperatures of 22-25°C and relative humidity of 40-50% (which is typical of air conditioned indoor environments).[11, 194-198] Experimental evidence indicates that SARS-CoV-2 survival in the environment is negatively impacted by increasing temperature.[199-201] Survival is also dependent on the surface type.[195, 201-203] Experimental studies using SARS-CoV-2 strains have reported

viability on plastics for up to 120 hours, for 72 hours on stainless steel, 120 hours on glass,[204] 24 hours on acrylic,[202] and up to 8 hours on carpet, copper and upholstery.[202, 205, 206] Viability was quantified by end-point titration on Vero E6 cells. An experimental study conducted with human coronavirus 229E found that the virus persisted on Teflon, PVC, ceramic tiles, glass, and stainless steel for at least 5 days (and 3 days for silicon rubber) at 21°C and a relative humidity of 30-40%.[207] Another experimental study performed using 3 variants of SARS-CoV-2 (B.1.1.7, B.1.351 and their common predecessor, EPI_ISL_407073) demonstrated that the virus remained viable for up to 7 days at 19°C and 57% relative humidity following inoculation on stainless steel coupons, with no significant difference in viability once the inoculums had dried ($p = 0.12$). Significantly higher units of the B.1.1.7 and B.1.351 variants were recovered compared to their common predecessor during the drying process ($p = 0.01$), however, further research in this area is necessary to determine the implications of these findings.[208] Infectivity of the persistent viral cells was demonstrated experimentally using a plaque assay in both of these experimental studies, however the infectivity of surface-contaminating SARS-CoV-2 in real-life conditions remains unknown. Experimental testing in the dark (zero UV) found that SARS-CoV-2 could survive for prolonged periods on multiple surface types however the negation of UV is not representative of real-life scenarios and the results of such experiments must be interpreted with caution.[209] Another experimental study detected viable SARS-CoV-2 virus for up to 7 days on hydrophobic surfaces (i.e. stainless steel, Tyvek, disposable gowns, bank notes and surgical masks) and 3 days on hydrophilic surfaces (i.e. cotton and polyester shirts) at 21°C and average relative humidity of 45%.[203] One study that examined the stability of human coronaviruses on textiles found HCoV-OC43 to remain infectious on polyester for ≥72 hours, on cotton for ≥24 hours, and on polycotton for ≥6hours. Only Polyester was able to demonstrate HCoV-OC43 transfer onto PVC up to 72 h post inoculation, whereas no transfer was detected from cotton or polycotton immediately after inoculation[210]. Survival of human coronaviruses and surrogates in water is influenced by temperature (viral inactivation increases with increasing temperatures) and organic or microbial pollution.[211] A 99.9% viral titre reduction was observed after 2-3 days in waste water in an experimental study using human coronavirus 229E, suggesting low survivability in waste water.[212] Samples taken from the treated sewage outlets of a number of COVID-19 Chinese hospitals were negative.[213, 214] Samples taken (with varying methodology) from external water treatment plants in the UK, Netherlands, France, Spain, the US, and Canada) tested positive in line with the detection of cases in the population which suggests that RT-PCR analysis of sewage could be a potential surveillance tool.[215-223] Testing of sewage treatment works is now being carried out by the Scottish Environment Protection Agency (SEPA) to determine if such data exists to generate a surveillance system. A report prepared for SAGE in November 2020 and April 2021, advised that UK wastewater

surveillance programs for COVID-19 have been in place across England, Scotland and Wales since early summer 2020 and is a reliable, timely and cost-effective surveillance method, particularly during low prevalence, and to identify local variants.[224, 225] An analysis of wastewater collected from 6 large urban wastewater treatment plants in England and Wales demonstrated that SARS-CoV-2 RNA is readily detected in wastewater influent across a range of concentrations (from $<1.2 \times 10^3$ to 1.5×10^4 genome copies 100 mL^{-1}).[226] Additionally, levels of SARS-CoV-2 and the genetic variants of the virus observed in wastewater generally correlated with clinical COVID-19 cases within the community.[226] In Orkney (population equivalent 7750 in the catchment area), virus was detected in the wastewater where less than 10 positive cases had been recorded.[224] Wastewater sampling in Switzerland identified the presence of mutations indicative of the new UK variant B.1.1.7 in early December 2020 prior to detection of the first clinical sample in Switzerland.[227] In Canada, it was found retrospectively that wastewater sampling accurately predicted a surge in community cases 48 hrs prior to their detection.[223] There is currently no evidence that COVID-19 is transmitted from sewage/grey water or contaminated drinking water.[224, 228]

Conclusion:

- Due to the uncertainty regarding the environmental survivability of SARS-CoV-2 in real-life conditions, it is essential that the environment is clutter free and frequency of routine cleaning is increased, particularly frequently-touched surfaces.

7. Environmental decontamination

Evidence for cleaning of the care environment for COVID-19 is limited; studies that evaluate the susceptibility of coronaviruses to cleaning/disinfectant products differ by their methodology and often use animal coronaviruses in experimental conditions.[194, 195, 229] An experimental study using a SARS-CoV isolate, tested three different surface disinfectants but all required over 30 minutes exposure time to inactivate the virus to levels below detection.[229] Limited evidence suggests that coronaviruses are susceptible to chlorine-based disinfectants and ethanol-based antiseptics.[195, 230, 231] Kampf et al summarised the efficacy of various disinfectants against both human and animal coronaviruses and found that a concentration of 0.1% sodium hypochlorite was effective in 1 minute and, for the disinfection of small surfaces, 62-71% ethanol revealed a similar efficacy.[195] Laboratory analysis has shown that SARS-CoV-2 can be inactivated in vitro in under 1 minute using 1000mg/L available chlorine.[232] Experimental testing has shown SARS-CoV-2 on inanimate surfaces (stainless steel, plastic, glass, PVC, cardboard) can be

inactivated by 70% ethanol, 70% isopropanol, and 0.1% hydrogen peroxide.[231] Specifically, complete inactivation was observed in 30 seconds with ethanol and isopropanol, and in 60 seconds with 0.1% hydrogen peroxide; complete viral inactivation on cotton fabric was observed after 30 seconds with 0.1% sodium laureth sulphate, which is a surfactant present in almost all household cleaning/ personal hygiene agents (e.g. dishwashing liquid, hand soaps and shampoos).[231] Ijaz *et al*[233] provided *in vitro* evidence of the efficacy of a range of cleaning agents against SARS-CoV-2 on common high touch surfaces. Testing during this study found that at 20˚C 44% w/w ethanol disinfectant spray was able to inactivate SARS-CoV-2 with a 5 minute contact time. Under the same conditions and contact time 1.9% lactic-acid-based surface cleanser, and 0.45% benzalkonium chloride-cleaner, both produced log reductions >4.0. At 20˚C and a contact time for 1 minute or less 0.12% p-chloro-m-xylenol (PCMX), 2.4% w/w citric acid disinfecting wipes, and 0.25% hydrochloric acid-based toilet cleaner all resulted in log reductions >3.0 (>4 for PCMX and 0.25% hydrochloric acid). All results were similar to those found for the sodium hypochlorite cleaners tested; 0.14% sodium hypochlorite cleaner, and 0.32% sodium hypochlorite bathroom cleaner.[233] Unfortunately there is a paucity of evidence regarding the efficacy of detergents at deactivating SARS-CoV-2, and due to the novel nature of this infectious agent there is an assumption that only disinfectants will be effective. In vitro analysis of a number of laboratory detergents used for biochemical analysis demonstrated some efficacy against SARS-CoV-2 however the detergents were not designed for environmental cleaning.[234] The CDC states that, in addition to physical removal of SARS-CoV-2, surface cleaning is likely to degrade the virus, while surfactants in cleaners/detergents can disrupt and damage the membrane of an enveloped virus like SARS-CoV-2.[235]

The WHO recommends that, for coronaviruses, commonly used hospital-level disinfectants such as sodium hypochlorite (at a concentration of 0.5%) are effective for cleaning environmental surfaces, and 70% ethanol is suitable for disinfecting small surfaces.[16] A sampling study found that twice daily cleaning of frequently-touched areas using 5000 ppm of sodium dichloroisocyanurate (a source of free chlorine) resulted in negative swab results for COVID-19 in isolation rooms that had just been cleaned; samples taken from rooms prior to cleaning had multiple positive samples from frequently-touched areas.[169] Similar results were reported from a Chinese hospital in which surfaces were routinely wiped with 1000 mg/L chlorine-containing disinfectant every 4 hours in isolation ICUs and every 8 hours in general isolation wards; none of the environmental samples in these areas tested positive for SARS-CoV-2 contamination.[213] Negative results were also found from sampling of 90 surfaces following disinfection in a Wuhan hospital dedicated to treating COVID-19 patients, in which a

comprehensive environmental decontamination protocol was implemented.[77] It consisted of chlorine dioxide air disinfection 4 times a day for 2 hours at a time in COVID-19 wards, irradiation of empty wards with UV light once per day for 1 hour, ultra-low volume spraying of chlorine dioxide (500mg/L) for air disinfection in public areas, and surfaces/objects were 'wrapped' with chlorine-containing disinfection solution (1000mg/L) twice a day.

For situations where health and care settings are at capacity and/or have no breaks in admissions or bed occupancy, the opportunity to conduct a terminal clean or a deep clean may be limited. Solutions to this may include modification to the deep clean regime to allow as high a level of decontamination to be carried out during constant occupancy as possible.

In light of the concern raised regarding aerosol transmission following the identification of positive air samples from hospital rooms,[44, 45, 64, 169, 236] alternative decontamination techniques that offer air decontamination should be explored. Air disinfection using ultraviolet-C light, termed ultraviolet germicidal irradiation (UVGI) is accomplished via several methods: irradiating the upper-room air only, irradiating the full room (when the room is not occupied or protective clothing is worn), and irradiating air as it passes through enclosed air-circulation and heating, ventilation, and air-conditioning (HVAC) systems.[237] UVGI is also used in self-contained room air disinfection units. The overarching limitation of most UVGI systems is that the room must be vacated whilst disinfection is taking place; any reductions in aerosol/surface contamination will be short-lived as once the room is re-occupied, potentially infectious viral particles may again be circulating. UVGI air decontamination should therefore not be used as a replacement for optimum ventilation provision, however it may have a future use for terminal decontamination and/or in rooms in which AGPs are carried out where improvements to the existing ventilation provision are not possible. One before/after observational study that tested a UVC robot within an American long term care facility had respiratory system infection rates as an outcome measure however the methodological limitations meant that causation could not be proven; there was no certainty that the observed respiratory system infection rate decreases were due to the UVC treatment alone (and not in part due to the manual cleaning that preceded the UCGI treatment).[238] A number of experimental studies have tested the efficacy of UVGI (specifically UVC) at inactivating SARS-CoV-2;[204, 239-245] all of the experimental studies reported on surface decontamination, none of the studies assessed air decontamination. It was not possible to summarise the collective findings of these studies due to the heterogeneity in methodology; the dose of UV, duration of exposure, and distance between the lamp and test isolate varied. Individually, these studies demonstrated efficacy under their varying experimental conditions. In one study, a dose of 1.8mW/cm2 UVC was effective at inactivating experimentally contaminated glass, plastic and gauze.[245] Another *in vitro* study reported a 10-minute exposure (34.9 mJ/cm2)

on glass and plastic, and 15 minutes (52.5 mJ/cm2) on stainless steel was required to lower viral titre to below the level of detection [239] Further research into UVC decontamination of SARS-CoV-2 is warranted in real-life trials. A review of UV decontamination technology by HPS recommended that UV light systems can be used as an additional measure when performing terminal room decontamination.[246] However, as surface cleaning is required prior to UVC disinfection, UVC technology will not offer any time-saving benefits and can only be seen as an adjunct to standard environmental decontamination.

The latest version of the PHE IPC guidance advises that low risk (green) COVID-19 pathways can revert to general purpose detergents for routine cleaning, as opposed to widespread use of disinfectants.[164] The Scottish COVID-19 addendum further advises that the use of general purpose detergent for cleaning in the low risk pathway is sufficient with the exception of isolation/cohort areas where patients with a known or suspected infectious agent are being nursed.[114] This was extended to the medium risk (amber) pathway in June 2021.

Conclusion:

- Frequency of environmental cleaning/decontamination in the high and low risk pathways should be increased to at least twice daily, focusing on frequently-touched areas.
- A general purpose detergent should be used for routine cleaning in low risk (green) and medium risk (amber) pathways.
- A combined detergent/disinfectant solution at a dilution of 1,000 parts per million available chlorine (ppm available chlorine (av.cl.)) should be used for transmission-based environmental decontamination as per the NIPCM, in high-risk COVID-19 pathways and any settings experiencing cases/outbreaks. Small surfaces, and those which cannot be cleaned by chlorine-based agents, can be disinfected with 70% ethanol.
- Where terminal cleaning cannot be carried out due to constant occupancy, a modified enhanced clean should be carried out where possible.
- Further research is required to determine the effectiveness of UVC technology for decontamination of SARS-CoV-2.

8. 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.

9. 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 onwards 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 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. 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.

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

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

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*

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