Routes of transmission of SARS-CoV-2: joint British Infection Association (BIA), Healthcare Infection Society (HIS), Infection Prevention Society (IPS) and Royal College of Pathologists (RCPath) guidance.

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1. Executive summary

The pandemic of the coronavirus disease 2019 (COVID-19), caused by a novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), occurred amid uncertainty about the dynamics of transmission and the possible management options for COVID-19 patients. This resulted in confusion for healthcare workers (HCWs) and hospital managers who often received conflicting advice on how to organise care and manage infected individuals without increasing the risk of transmission to HCWs and other patients. Advice for public has also been confusing and sometimes contradictory. As the evidence from the first wave emerged, we are now in position to summarise it and provide the guidance to on how to prevent SARS-CoV-2 transmission. This article is the first in the series of guidance documents produced jointly by Healthcare Infection Society, British Infection Association, Infection Prevention Society and Royal College of Pathologists. This guidance article describes routes of SARS-CoV-2 transmission, which will allow the public and healthcare professionals to understand how SARS-CoV-2 transmission occurs, so they can take appropriate precautions to protect themselves and others.

Upon the review of the evidence, the COVID-19 Rapid Guidance Working Party consider the different transmission routes as follows:

droplet transmission: *probable*

airborne transmission: *possible* (in some circumstances, e.g. aerosol generating procedures)

transmission via fomites: *possible*

vertical transmission: *unlikely*

transmission from different body fluids: *unlikely*

transmission via ocular surface: *possible*

The working party also concludes that it is probable that transmission occurs with close contact, although at the moment it is not possible to determine the distance or the duration for transmission to occur. Transmission from COVID-19 patients to HCWs in hospitals appears to be low, unless HCWs do not use appropriate Personal Protective Equipment (PPE). Transmission in care homes appears to be very high and needs particular considerations. Further research is required to allow for specific recommendations in this setting. The rationale for the above conclusions and the following recommendations is provided in section 8.

Recommendations

General recommendations:

GR1: You must adhere to regulations currently imposed by the government.

GR2: Keep as much distance from others as possible and try to maintain the recommended minimum 2 meters distance at all times.

GR3: Use face covering in enclosed spaces to protect yourself and others.

GR4: Reduce the time of contact with anyone outside your household to minimum.

GR5: To avoid transmission from fomites, decontaminate your hands frequently using soap and water, and when this is not possible, use hand sanitizer. **Good practice point:** Follow WHO advice on how to hand wash and how to hand rub

GR6: Transmission via ocular surface is possible, avoid touching your face and eyes with your hands.

GR7: Evidence suggests that a high proportion of transmissions occur between family members, friends, and co-workers. Adhere to the above recommendations when in contact with anyone in your social group or at work.

GR8: Airborne transmission in community settings is unlikely. Do not use masks and respirators specifically designed for protection against airborne organisms.

Good practice point: To protect yourself and others, follow WHO advice and avoid 3Cs: **C**losed spaces, **C**rowds, **C**lose contact.

Specific recommendations for persons working in health and care settings:

HR1: You must adhere to regulations imposed by your trust/employer.

HR2: For contact with healthcare staff and with patients not suspected or confirmed to have COVID-19, use general recommendations listed above.

HR3: For care of patients not suspected or confirmed to have COVID-19, use standard precautions, and adhere to using following PPE:

a. Gloves for all activities where there is a risk of exposure to blood or body fluids or when handling contaminated devices. Immediately remove the gloves at the end of activity and decontaminate your hands using soap and water or alcohol gel before the gloves are worn and immediately after they are removed

b. Disposable plastic aprons when there is a risk that your clothing may become contaminated with blood or body fluids or with pathogenic microorganisms
c. Eye protection when there is a risk of splashes from blood or body fluids.

HR4: For care of patients suspected or confirmed to have COVID-19, use contact and droplet precautions, and adhere to using following PPE for all activities:

a. Protective gown, which is tied around your neck and waist
b. Gloves with cuffs covering the cuffs of the gown
c. Eye protection
d. Medical-grade mask.

HR5: Risk of SARS-CoV-2 transmission from body fluids (faeces, urine, ocular excretions and sexual body fluids) is unlikely, use contact precautions and appropriate PPE and refrain from using additional precautions (e.g. respirator masks).

HR6: Most SARS-CoV-2 transmissions from patients to HCWs occurred when HCW did not use protection during aerosol generating procedures (AGPSs) on patients not suspected of having COVID-19. Use respirators designed for filtering airborne particles for any AGPs regardless of a patient's COVID-19 status.

HR7: Vertical transmission is unlikely but consider using additional precautions during the antepartum or during the process of labour and delivery. Reviewed studies reported avoiding unnecessary caesarean delivery, mothers advised to use a medical-grade mask, and parents using contact precautions immediately after the baby was born.

<u>Recommendations for managers in health and care settings:</u>

MR1: Adhere to current national guidelines for infection prevention and control, including those specific to COVID-19 as well as general ones for preventing infectious diseases.

2. Lay summary

The COVID-19 pandemic has had far reaching implications for health, economics and society. One of the many areas affected has been the ability of healthcare professionals to stop the spread of the infection in health and care settings both in hospital and in the community such as a dental surgery. With research being published since the emergence of the outbreak we now have a much better understanding of how to help prevent the spread of the infection. This document, which was co-produced by multiprofessional group, including infection researchers and a member of the public, provides the current evidence with recommendations to help frontline health professionals and managers. The timing of this guidance is important and as every day passes new evidence is emerging, however it is vital that people are aware what has been proven to work. We are aware that new evidence will come along which may contradict or add to some of our recommendations, however this is an important start in giving health providers and managers recommendations for limiting the spread of infections, which are evidence-based. The document contains explanation, evidence and a glossary of terms (Appendix 1). If you simply want to look at the recommendations to use please see executive summary section. Along with this document we are also publishing lay friendly materials for patients, carers and members of the public because it is vital that we recognise that we all have a part to play in reducing COVID-19 spread in hospitals and community.

3. Introduction

The pandemic of the coronavirus disease 2019 (COVID-19), which was first detected in Wuhan, China has quickly spread around the world and, at the time of writing, affected more than 55 million people.[1] The disease is caused by a novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which together with its close relative SARS-CoV belongs to a B lineage of beta-coronaviruses. The virus is also related to MERS-CoV virus from C lineage which was responsible for the outbreaks of Middle East Respiratory syndrome (MERS).

The first wave of pandemic occurred amid uncertainty about the dynamics of SARS-CoV-2 transmission and the possible management options for COVID-19 patients. This resulted in confusion for HCWs and hospital managers who often received conflicting advice on how to organise care and manage infected individuals without increasing the risk of transmission to HCWs and other patients. As the evidence has emerged, we are now in position to summarise it and provide the guidance to healthcare professionals on how to prevent healthcare associated COVID-19 disease when subsequent waves or localised outbreaks occur.

This guidance will be produced in a series of articles, each covering a different question relating to prevention of COVID-19 in health and care settings. This article is the first in the series and describes routes of SARS-CoV-2 transmission. Understanding the likelihood of transmission occurring via different routes is important, so the public as well as healthcare professionals can take appropriate precautions to protect themselves and others.

4. Guideline Development Team

4.1. Acknowledgements

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4.2. Source of funding

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4.3. Disclosure of potential conflict of interest

- No authors reported any conflict of interest (Appendix 2)

4.4. Relationship of authors with sponsor

BIA, HIS, IPS and RCPath commissioned the authors to undertake the Working Party Report. The authors are members of the societies. Further information is provided in Appendix 2.

4.5. Responsibility for guidance

The views expressed in this publication are those of the authors and have been endorsed by BIA, HIS and IPS and following rapid consultation.

5. Working Party Report

5.1. What is the Working Party Report?

The report is the first in a series of guidance documents covering key aspects of preventing transmission of SARS-CoV-2 in healthcare and care settings. The guidance also reviews the evidence for transmission dynamics of SARS-CoV-2 virus outside these settings. The diagnosis and management of COVID-19 disease in general are outside the remit of this guidance.

The working group recommendations have been developed systematically through multi-disciplinary discussions based on currently available evidence from published and pre-print sources. They should be used in the development of local protocols for all relevant health and care settings such as hospitals, nursing/care homes, primary care and dental practices.

5.2. Why do we need a Working Party Report for this topic?

The first wave of COVID-19 pandemic occurred amid uncertainty as to how it could be prevented and controlled. Concern still exists about subsequent waves or new outbreaks occurring. The evidence from the first wave has emerged and provides an opportunity to develop an evidence-based guidance for preventing and controlling future outbreaks.

5.3. What is the purpose of the Working Party Report's recommendations?

The main purpose is to inform clinicians, managers, and policy makers about the dynamics of transmission of SARS-CoV-2 and to provide evidence-based recommendations to prevent and control its spread in health and care settings. This document highlights current gaps in knowledge, which will help to direct future areas of research.

5.4. What is the scope of the guidance?

The scope of the guidance is to provide advice for the optimal provision of an effective and safe healthcare service during the time when COVID-19 remains a health threat. This guidance was developed with acute healthcare settings in mind but may be useful in other health and care settings such as dental practices and care homes.

5.5. What is the evidence for this guidance?

Topics for this guidance were derived from the initial discussion of the Working Party and review questions were designed in accordance with the PECO (P=population, E=exposure, C=comparator, O=outcome) framework for investigating the likelihood of developing a certain condition after exposure to an event.[2] To prepare these recommendations, the working group collectively reviewed relevant evidence from published and pre-print sources. Methods, which were in accordance with National Institute for Health and Care Excellence (NICE) manual for developing guidelines, are described fully below.

5.6. Who developed this guidance?

The working group included infectious diseases/microbiology clinicians, academic infection prevention and control (IPC) experts, systematic reviewers, and a lay representative.

5.7. Who is this guidance for?

Any healthcare practitioner, manager and policy maker may use this guidance and adapt it for their use. It is anticipated that users will mostly include clinical staff and IPC teams. Some parts of this guidance may also be beneficial to patients, carers and public.

5.8. How is the guidance structured?

To provide rapid advice, this guidance is produced in a series of articles, each covering a different question. Each will comprise an introduction, a summary of the evidence, and recommendations graded according to the available evidence. This article is the first in the series.

5.9. How frequently is the guidance reviewed and updated?

New evidence will be reviewed within one year to determine whether this guidance needs updating.

5.10. Aim

The aim of this guidance was to assess the current evidence for all aspects relating to dynamics and routes of transmission of SARS-COV-2 and preventing its transmission in hospitals and other care settings.

6. Methodology

6.1. Evidence search and appraisal

Topics for this guidance were derived from the initial discussions of COVID-19 Rapid Guidance Working Party Group. HIS also sent out e-newsletter to its members with an invitation to propose topics for this guidance. To prepare these recommendations, the Working Party collectively reviewed relevant evidence from published and pre-print sources. Methods, which were in accordance with NICE manual for developing guidelines with modifications that allowed a rapid review process, are described below. The modifications included systematically searching two electronic databases, including fewer members for the Working Party with one lay member, and quality assessment being conducted by one reviewer and checked by a second one.

6.2. Data sources and search strategy

Two electronic databases (Medline and EMBASE) were searched for articles published between 1^{st} January and 11^{th} May 2020; search terms were constructed using relevant MeSH and free text terms (Appendix 3). Additional hand searching was conducted in the following databases: WHO Chinese database, CNKI, China Biomedical Literature Service, Epistemonikos COVID-19 L·OVE platform, EPPI Centre living systematic map of the evidence, CORD-19, COVID-END, and the HIS's COVID-19 resources to identify pre-print and articles in press. Reference lists of identified reviews and included papers were scanned for additional studies. The searches were restricted to human-to-human transmission and the presence of the virus in the environment. No language restrictions were set.

6.3. Study eligibility and selection criteria

The members of the Rapid Guidance Working Party determined criteria for study inclusion. Any article presenting primary data on human-to human transmission of SARS-CoV-2 was included. Search results were downloaded to Endnote database and screened for relevance. One reviewer reviewed the title, abstracts, and full texts. A second reviewer checked at least 10% of the excluded studies at each sifting stage. Disagreements were first discussed between the two reviewers and if the consensus was not reached, a third reviewer was consulted. The results are shown in PRISMA diagram in Appendix 4.

6.4. Data extraction and quality assessment

Included epidemiological studies were appraised for quality using checklists recommended in the NICE guideline development manual. Environmental and laboratory studies were not appraised for the quality. Critical appraisal was conducted by one reviewer, and at least 10% was checked by the second. The results are available in Appendix 5. Data were extracted by one reviewer and checked/corrected by another. Data from the included studies were extracted to create the summary of findings tables of study description and data extraction (Appendix 6). Data were stratified into the type of transmission and where possible aggregated or otherwise described narratively. Where data were aggregated, meta-analyses were not conducted because the scope of this guidance was to establish whether transmission could take place via certain routes. Therefore, data from the studies which provided numerator and denominator were aggregated together for simplicity of presenting the results. These data should not be used as an indicator of the frequency at which these transmission events occurred. The list of the studies excluded at full text sift with a reason for this decision is provided in the excluded study tables (Appendix 7).

6.5. Rating of evidence and recommendations

Summary of findings tables were presented to the working group, and recommendations were prepared according to the nature and applicability of the evidence regarding the likelihood of transmission via a certain route. The likelihood of transmission via different routes was assessed using the criteria recommended by Shah et al (2020)[3] for classifying the possibility of intrauterine transmission. This classification system was adapted to reflect other routes of transmission by creating five mutually exclusive categories:

- Confirmed infection – strong evidence with proof that infection occurred via a route in question: e.g. the affected person had positive SARS-CoV-2 polymerase chain reaction (PCR) test AND possibility of infection via alternative routes was excluded
- Probable infection – strong evidence suggestive of infection, but lack of confirmatory proof that infection occurred via the route in question: e.g. the affected person had a positive PCR or symptoms suggestive of infection AND strong evidence suggestive that the infection occurred via the route in question
- Possible infection – evidence that is suggestive of infection but is incomplete: e.g. the affected person had a positive PCR or symptoms suggestive of infection AND evidence suggestive that the infection occurred via the route in question OR strong non-epidemiological evidence that viable virus (i.e. virus that was shown to infect cells in culture) was detected in samples related to a route in question
- Unlikely infection – little evidence for infection occurring via a route in question but cannot be completely ruled out: e.g. the affected person had a positive PCR test or symptoms

suggestive of infection AND weak evidence suggestive that the infection occurred via the route in question OR the person had negative PCR or no symptoms AND evidence for likely exposure via route in question OR weak non-epidemiological evidence that virus (viable or PCR) is detected in samples related to a route in question

- Confirmed no infection - strong evidence with proof that infection did not occur after exposure via a route in question: e.g. negative PCR AND strong evidence that exposure via certain route occurred OR strong non-epidemiological evidence that virus (viable or PCR) is not detected in samples related to a route in question.

The strength of the evidence was defined by drafting the GRADE (Grading of Recommendations Assessment, Development and Evaluation) tables (Appendix 8) and using the ratings 'high', 'moderate', 'low' and 'very low' to construct the evidence statements, which reflected the Working Party Group's confidence in the evidence. The strength of recommendation was adopted from GRADE and reflected the strength of the evidence statement. In instances where no evidence was identified from searches, the statement 'No evidence was found in studies published so far…' implies that no studies assessed this as an outcome. However, considering the nature of the studies from which the evidence was derived, the statement also suggests that transmission via a route in question does not occur or occurs rarely and has not yet been observed. Where there was no evidence or there was a paucity of evidence, good practice recommendations were made by expert experience and consensus. Group videoconferences were held regularly to assess the evidence and agree on recommendations. Any disagreements on recommendations or the strength of recommendation were resolved by discussion and voting by members of the working group.

6.6. Consultation process

Feedback on draft guidance was received from the HIS's Guidelines Committee and through rapid consultation with relevant stakeholders. The draft report was placed on HIS website for 7 days along with the HIS standard comment form. The availability of the draft was advertised via email and social media. Stakeholders were invited to comment on format, content, local applicability, patient acceptability, and recommendations. The working group reviewed stakeholder comments, and collectively agreed revisions (Appendix 9). The reviews received from individuals with declared conflict of interest or those who did not provide a declaration were excluded.

7. Results

The search identified a total of 1765 articles. After excluding duplicate and irrelevant studies and checking reference lists for related citations, a total of 130 were included.[4-135] Due a large number of papers being published daily, the decision was made not to update the search results before publication as this would significantly delay the guidance being available to readers. However, there were two articles,[134,135] which were published after the search date which were of significant clinical importance in the view of the working party group. Due to the large number of articles describing SARS-CoV-2 transmission, the decision was made not to include studies which focused on SARS-CoV, MERS-CoV and other beta-coronaviruses. Any evidence from these studies, which was thought to be relevant to this guidance was provided as background information.

Of the included studies there were 117 case studies/series,[5-16,20-28,30-61,63,65,68-80,82-91,94-104,106-133,135] thirteen were environmental surveys[4,17,18,29,62,64,66,67,81,93,105,134] and two were laboratory experiments.[19,92] Nine of these studies described the possibility of SARS-CoV-2 transmission via air,[17,18,26,29,64,67,81,92,134] four via droplets,[30,51,59,82] eleven via fomites[8,17-19,29,66,67,81,92,93,134] and 31 via the vertical route.[5,10,12,14,15,22,24,31,35,39,42,46,52,54,55,56,58,71,73,75,94,97,113-115,117,119-121,124,133] Other studies described the presence of virus in faecal matter (n=33),[4,13,21,25,31,36,38,45,50,53,62,59,68,69,72,88-91,93,95,96,101,104,105,108,111,112,122,125,126,129-131] urine (n=11),[15,31,38,53,68,72,91,96,130,131,133] ocular secretions (n=9)[11,20,85,87,102,106, 110,127,132] and sexual body fluids (n=3),[21,44,79] thus discussing the possibility of virus transmission from the body excretion and secretion products. Two studies also described the likely entry of the virus via the ocular surface.[49,127] Lastly a total of 41 studies described clusters and outbreaks.[6,7,9,16,23,27,28,31-34,37,38,41,43,47,48,57,60,61,63,65,70,74,76-78,80,83,84,86,98-100,103,107,109,116,118,123,128] These studies did not report transmission routes, but the transmission patterns helped to determine the most likely routes via which the virus is likely to spread.

8. Rationale for recommendations

Droplet transmission

Both, SARS-CoV and MERS-CoV viruses are predominantly transmitted via the droplet route.[136,137] The droplet route was recognized as a primary route of transmission of SARS-CoV by the scientific community, based on epidemiological evidence and the reproductive number (R_0) of approximately 3, which is consistent with close contact and therefore transmission through respiratory droplets.[138] Direct and indirect contact between respiratory droplets and the mucous membranes has been implicated as the route of transmission in some healthcare and community SARS outbreaks in Hong Kong.[136,137] Human-to-human transmission of MERS-CoV typically occurred in HCWs and family members who cared for infected persons and were therefore directly exposed to the virus by close contact with respiratory secretions.[139] The R_0 of MERS-CoV is generally considered to be <1, however for nosocomial outbreaks in Saudi Arabia and South Korea it was estimated as 2-5.[140] One study, which assessed the reproductive number for SARS-CoV-2 early in the epidemic in China, estimated that R_0

could be as high as 5.7 [CI95% 3.8-8.9] and could have been a result of travel and gatherings associated with Lunar New Year celebrations during which time lack of awareness of the new pathogen could have facilitated its spread.[141] The authors also recognised that compared to SARS-CoV, SARS-CoV-2 has a much higher affinity to the ACE-2 receptor, which both viruses use to enter the cell. This means that SARS-CoV-2 virus is more infectious, which may be a reason for a higher reproductive number.

Epidemiological evidence for SARS-CoV-2

There was inconsistent evidence from four studies,[30,51,59,82] which investigated the possibility of droplet transmission for SARS-CoV-2 virus. Two of these studies concluded that droplet transmission was at least partially responsible for the outbreaks involving choir practice attendees of whom 52/60 (86.7%) developed symptoms or tested positive for COVID-19[30] and restaurant patrons of whom 10/90 (11%) acquired infection.[59] An additional study found no SARS-CoV-2 transmission on a busy long distance flight, which authors concluded was consistent with droplet rather than airborne transmission.[82] Conversely, a different paper[51] describing the same restaurant outbreak involving 11% of restaurant patrons, concluded that the transmission via droplet route was not likely considering that close contact was not observed and the low ventilation rate of air conditioning and suggested that transmission occurred via airborne route.

Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider the droplet transmission route to be ***probable****.*

Airborne transmission

There is a current debate within the scientific community about the extent to which SARS-CoV-2 is able to be transmitted via the airborne route. Some confusion also exists because the term ‘aerosol’ is frequently used as a synonym of ‘airborne’. Aerosols refer to respiratory particles, which are found in the air, and their size is the predominant reason for their ability to remain suspended (airborne).[142] The generally accepted threshold for these particles to be considered airborne is <5µm.[142] Thus, the term ‘respiratory aerosol’ encompasses both the airborne particles and the larger particles which are known as droplets. It is widely accepted that humans may produce both sizes of respiratory aerosols during normal breathing, coughing, or sneezing and that larger droplets may desiccate and form smaller ‘airborne’ particles.[142] However, it is not known whether infectious SARS-CoV-2 virus is present in these small particles, and if so, how long it can stay viable in the air. One SARS outbreak in Hong Kong was suspected to be a result of airborne aerosols arising from infected faecal matter, which was distributed via the building’s drainage system.[143] The dynamics of nosocomial outbreaks in Hong Kong and Toronto also suggested an airborne route was possible in some circumstances.[144] As a result, SARS-Co-V-1 virus was coined to be an 'opportunistic' airborne microorganism, meaning that while the droplets may be the main route of transmission, there may be some circumstances when airborne transmission occurs, e.g. during AGPs[144,145] or in rare circumstances when viable virus in excrement became aerosolised after flushing the toilet as reported in one outbreak.[138,146] Despite recognising SARS-CoV virus to be spread primarily via the droplet route, WHO[138] also acknowledged that airborne transmission in some circumstances was likely, mainly occurring when aerosolisation of respiratory droplets occurred, although transmission of aerosolisation of other infectious materials (e.g. faeces or urine through flushing) was also possible. Similarly, MERS-CoV is thought to have an ability to spread via airborne particles as reported during a hospital outbreak among haemodialysis and intensive care unit ICU patients.[147] Additionally, evidence from one study, which collected air samples from areas occupied by MERS patients, found culturable virus in rooms, toilets and the neighbouring corridor, suggesting that airborne transmission was possible.[148]

Epidemiological evidence for SARS-CoV-2

There was inconsistent evidence from four studies,[30,51,59,82] which considered the possibility of airborne transmission. Two of these studies[30,51] reported that airborne transmission was plausible, with one[30] reporting an outbreak which affected 52/60 (86.7%) of choir practice attendees and another[51] reporting 10/90 (11%) of restaurant patrons being infected from an asymptomatic index patient, some of whom had no direct contact or fomite exposure. However, another study which reported the investigation of the same restaurant outbreak concluded that there was no evidence of airborne transmission,[59] and one study[82] found no transmission on a long distance flight, with the authors concluding that droplet transmission was more likely.

Presence of SARS-CoV-2 RNA in air

There was inconsistent evidence from seven environmental surveys,[17,18,26,29,66,81,134] which investigated the presence of viral RNA in rooms housing COVID-19 patients. Two of these studies[17,26] found no SARS-CoV-2 RNA in the collected air samples placed in the rooms of COVID-19 patients who were talking, breathing and coughing,[17,26] some of whom were also intubated.[26] One of these studies placed air samplers (n=4) in distance less than 1m from the patients[17] while the other set up four impingers (n=4) at a distance of 2-5m away from the patients.[26] In contrast, three studies[29,81,134] reported presence of SARS-CoV-2 RNA in the air surrounding COVID-19 patients. One study,[29] which distributed air samplers around the rooms and areas near COVID-19 patients found that 14/40 of air samples from ICUs and 2/16 from general wards contained SARS-CoV-2 RNA and that the virus might have travelled as far as 4m away from the patients. Another study[81] placed a total of twelve air samplers at various distances in and outside of rooms of COVID-19 patients with mild or asymptomatic infection. Seven personal air samplers were used for sampling HCWs entering the rooms wearing appropriate PPE, and who were advised to maintain at least 6ft (1.8m) distance away from the patients. The study reported that that five of the twelve samples in rooms and hallways were contaminated with SARS-CoV-2 RNA, two of which were placed at distances further than 1.8m. All seven personal air samplers were also found to contain SARS-CoV-2. Another study collected 1m^3 air samples (distance from patients not reported) and found that 14/31 of them contained SARS-CoV-2 RNA. Further, two small studies[18,66] assessing presence of SARS-CoV-2 RNA in the air in rooms of COVID-19 patients found four of six rooms which were investigated were contaminated. One of these studies placed NIOSH air samplers in three rooms[15] (n=2 per room) with 12 air changes an hour at a distance of less than 1m to 2.1m away from the patients. The authors reported that particles were of sizes >4µm as well as smaller particles of 1-4µm which can remain in the air for longer. The second study placed air samplers in the rooms and obtained swabs from air outlet fans (n=3 each), and reported that while air samples were negative, two of three air outlets were contaminated. Two of these studies[81,134] assessed the viability of the SARS-CoV-2 virus in culture (Vero E6,[81,134] Caco2[134]) and neither of them found any evidence of viable virus.

Duration of viable virus in the air

There was weak evidence from one laboratory study[92] assessing the duration that SARS-CoV-2 virus stayed viable in the air. This study used a $10^{5.25}$TCID$_{50}$ SARS-CoV-2 dose generated by three-jet nebuliser fed into a Collison drum to create an aerosolised environment, with resulting inoculum representative of upper and lower respiratory tract with 20-22 cycle threshold values. The authors reported that SARS-CoV-2 remained culturable in Vero E6 cells after 3hrs of remaining in the air with a reduction of infectious titre from $10^{3.5}$ to $10^{2.7}$ TCID$_{50}$/L.

Viral load

There was inconsistent evidence from four environmental surveys[17,18,64,134] which reported the SARS-CoV-2 viral load assessed as number of viral RNA particles per m^3 or the number of viral RNA particles/m^3/hr. One study[17] reported that no viral copies were found in the four samples collected in the rooms of COVID-19 patients who were breathing talking and coughing, while another,[18] which collected samples of less than 1m to 2.1m away from patients reported $1.84x10^3$ to $3.38x10^3$ copies of viral RNA present in the three samples they collected. The authors reported that these were contained in larger droplets of >4µm in size as well as droplet nuclei of 1 to 4µm. An additional study,[64] which investigated viral load as the number of viral particles/m^3/hr collected from a total of 35 samples from air samplers distributed through different locations within the hospital, reported that viral load was up to 113 in ICU, up to 42 in general wards and up to 11 in public areas. The authors reported that not only rooms and toilets were contaminated but also areas such as offices, workstations and changing rooms. The last study,[134] which collected air samples from areas housing COVID-19 patients reported that the viral load ranged from 10 to 1000 RNA copies/m^3. This was the only study that assessed the viability of the SARS-CoV-2 virus in Vero E6 and Caco2 cell cultures and it did not find any evidence of the virus being viable.

Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider the airborne transmission route to be ***possible****, although the group also acknowledged that this would occur only in some circumstances, predominantly during Aerosol Generating Procedures.*

Transmission via fomites

Outbreaks of SARS in healthcare and community settings in Hong Kong[136,137] implicated fomites as the route of transmission and one MERS outbreak occurring in a hospital in South Korea was thought to involve fomites.[149]

Epidemiological evidence for SARS-CoV-2

There was weak evidence from two studies, which considered the possibility of indirect human-to-human transmission via fomites in the outbreak involving 35 cases in a shopping centre[8] and in a choir practice outbreak affecting 52 individuals.[30] Both studies concluded that fomites could have contributed to transmission of SARS-CoV-2.

Presence of SARS-CoV-2 on surfaces

There was moderate evidence from seven environmental surveys, which assessed the presence of SARS-CoV-2 viral RNA in hospital rooms housing COVID-19 patients, with outcome measures reported either as the number of contaminated surfaces,[29,66,81,93,134] the number of contaminated rooms[15,16] or the number of contaminated PPE items.[66,67,93] One study,[29] which investigated presence of viral RNA on floors and high touch surfaces found that these were contaminated in ICUs caring for more severe cases (54/124, 44%) as well as in general wards where milder cases were present (9/114, 8%). Another study[66], which investigated toilets, floors and high touch surfaces, reported that 15/25 were contaminated and that the highest contamination was found on toilets 12/14. They also found viral RNA on surfaces in three out of five patient rooms, while no contamination was found on floors. Similar findings were obtained in another study[81] which sampled common room surfaces, toilets, and personal items. Of the total of 134 samples tested, 114 (85%) were found to be contaminated with SARS-CoV-2 RNA. These included floors under beds (5/5 sampled), bedside tables or bed rails (18/24), toilets (17/21), personal phones (15/18) and remote controls (12/18). In one study,[134] where samples were collected from high touch surfaces including bed rails, sinks, computer keyboards, clinical equipment, ward telephones and other surfaces, a total of 114/218 (52.3%) surfaces were found to be contaminated with SARS-CoV-2 RNA. In contrast, one small study[93] reported no contamination of hospital surfaces including door handles, bedside tables, monitors, sinks and bedrails, although the authors reported that these results might have been confounded by the fact that a frequent cleaning with 1000mg/L of chlorine was in operation (every 4hrs in ICU and 8hrs in general wards). One study[18] which reported the number of rooms contaminated with SARS-CoV-2 RNA, found that 17/30 (57%) of rooms housing COVID-19 patients were contaminated whilst another study[17] sampling one room found contamination at the first but not the second episode of sampling. Studies evaluating contamination of PPE where AGPs were not undertaken,[63,64,90] found no contamination on gowns, respirators, masks, visors or goggles, while shoes were found to be contaminated only once (1/109 samples). One study attempted to assess viability of the virus obtained from the surfaces[134] in Vero E6 and Caco2 cells and reported that none of the 114 samples contaminated with SARS-CoV-2 RNA yielded culturable virus.

Survival of viable virus on different types of surfaces

There was weak evidence from two laboratory studies,[19,92] which assessed the ability of viable virus to survive on different types of surfaces (number of surfaces not provided). One study[19] used 5µl droplet of $10^{7.8}TCID_{50}$/ml SARS-CoV-2 viral culture inoculated onto different types of surfaces including printing and tissue paper, wood, cloth, glass, banknote, stainless steel and plastic and maintained at room temperature (22°C) and 65% humidity. The authors reported that virus tends to survive better on smooth surfaces (glass and banknote 4 days, stainless steel and plastic 7 days), than on porous surfaces (paper less than 3hrs, wood and cloth 2 days). Another study[92] used a 10^5 $TCID_{50}$ SARS-CoV-2 virus inoculated onto plastic, stainless steel, copper and cardboard. The authors reported that SARS-CoV-2 remained viable for up to 4 hours on copper surfaces and 24 hours on cardboard. The virus was able to survive up to 48hrs and 72hrs on stainless steel and plastic surfaces respectively, although its infectious titre reduced to $10^{0.6}TICD_{50}$ on both surfaces.

Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider the transmission via fomites to be ***possible****.*

Vertical transmission

One meta-analysis, which evaluated the pregnancy outcomes of women infected by beta-coronaviruses[150] found that no cases of vertical transmission occurred in pregnant women affected by

SARS (n=14) or MERS (n=4). Thus, vertical transmission was considered unlikely, although poor maternal, foetal, and neonatal outcomes were frequently observed.[150]

Epidemiological evidence for SARS-CoV-2

There was moderate evidence from 30 case series/study articles, which investigated the possibility of vertical transmission for SARS-CoV-2 virus.[5,10,12,14,17,22,24,31,35,39,42,46,52,54-56,58,71,73,75,94,97,113-115,117,119-121,124,133] The results showed that from the total of 367 babies reported by these studies, eleven (3%) were reported[5,22,39,94,117,120,121] to be possibly infected *in utero*. However, the evidence for this is questionable as none of these babies were tested for the presence of SARS-CoV-2 RNA at birth, which raises a possibility that they could have been infected intrapartum or postpartum. Additionally, for three of these babies, conclusions were based on the presence of IgM antibodies at birth with no evidence of SARS-CoV-2 presence.[22,120]

Evidence for presence of SARS-CoV-2 RNA in maternal/neonatal tissues and products of conception

There was a moderate evidence from 13 case series/study articles,[10,25,31,35,42,54,71,73,94,97,113,115,117] which investigated the presence of SARS-CoV-2 viral RNA in different types of maternal and neonatal tissues and products of conception. The analysis of pooled results showed absence of viral RNA in samples obtained from cord blood (n=46), amniotic fluid (n=44), breast milk (n=0), vaginal secretions (n=8) and serum (n=1). Sampling of placenta revealed 3/19 (16%) positive samples, all three reported in one study[71] in women with severe COVID-19 disease with authors indicating that contamination from maternal tissues and fluids was likely.

Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider the vertical transmission route to be ***unlikely****.*

<u>Transmission of SARS-CoV-2 from different body fluids</u>

Previous studies reported presence of SARS-CoV and MERS-CoV viral RNA in different body fluids and waste products including faeces,[151-155] urine[151,153-156] and ocular secretions,[157,158] with two further studies reporting infectious virus isolated in culture from urine and stool specimens.[159,160] Viral RNA was also found in gastrointestinal and urinary tracts of individuals affected by SARS or MERS.[161,162] This suggests that infection from exposure to body fluids is, at least theoretically, possible. Furthermore, one study describing an outbreak of SARS in residential complex in Hong Kong demonstrated a link between faeces from a symptomatic patient with diarrhoea and widespread transmission to others via the drainage system.[143] Additionally, unpublished data (being unpublished, these did not meet our criteria for inclusion in this guidance) from Chinese Center for Disease Control and Prevention demonstrated the possibility of SARS-CoV-2 virus in faeces becoming aerosolised after being flushed in the toilet.[146] The authors reported that the virus was deposited on surfaces (taps, showers, and sinks) of bathrooms in other apartments sharing the same sewage pipe. The data also identified individuals who later became ill with COVID-19, and who were linked to the same sewage pipe, although it is not clear whether these cases became ill as a result of exposure from infectious aerosols arising from the sewage.

Faecal matter

Epidemiological evidence

No evidence was found in studies published so far, that faecal matter was responsible for transmission of SARS-CoV-2 virus to other persons.

Evidence of presence of SARS-CoV-2 RNA in faecal matter

There was moderate evidence from 33 case series, case studies and environmental surveys, which assessed the presence of viral RNA in anal swabs,[21,25,36,45,72,88,101,112,126] or stools[15,31,38,50,53,68,69,89-91,95,96,101,104,108,111,122,125,129-131] of COVID-19 patients or in sewage taken during the pandemic in community settings[4,62,105] or in a hospital caring for COVID-19 patients.[93] These studies found consistent evidence for the presence of SARS-CoV-2 RNA in such specimens. Overall, SARS-CoV-2 RNA was found in anal swabs of 25/72 (35%) COVID-19 patients, in stool specimens of 215/439 (49%) patients and in 50/65 (77%) of sewage samples.

Evidence of presence of viable SARS-CoV-2 virus in faecal matter

There was weak evidence from one case series, one case study and two environmental surveys, which assessed the presence of culturable SARS-CoV-2 virus in stools[96, 129]or sewage.[4,93] One case series study,[96] which assessed virus viability in four stool samples with high SARS-CoV-2 viral load, reported that two of these samples yielded culturable virus and that the patients from whom the samples came, did not have diarrhoea. A case study[129] of one patient with severe pneumonia reported that the SARS-CoV-2 virus isolated from a faecal sample obtained 15 days after the onset of the disease was cultured in Vero E6 cells and observed under scanning electron microscope. The environmental surveys found no viable virus in six sewage samples that they tested. The first of these studies[4] collected the samples from untreated sewage from the municipal pumping station and wastewater treatment plant in the middle of the pandemic, approximately five to seven weeks after the first cases appeared in the area. Of two samples found to be positive for SARS-CoV-2 virus by PCR, neither was viable in culture. Another study[93] collected samples from hospital sewage disinfection pools with the wastewater coming from isolation rooms of COVID-19 patients. Four samples, which were previously found to contain SARS-CoV-2 RNA, yielded no viable virus cultured in Vero E6 cells.

*Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider SARS-CoV-2 transmission from infected faecal matter to be **unlikely**.*

Urine

Epidemiological evidence

No evidence was found in studies published so far, that urine was responsible for transmission of SARS-CoV-2 virus to other persons.

Evidence of presence of SARS-CoV-2 RNA in urine

There was moderate evidence from eleven case series and case studies, which assessed the presence of SARS-CoV-2 RNA in urine, with outcome measure defined as number of patients with positive sample[31,38,53,68,72,91,130,131,135] or number of positive urine samples.[15,96] These studies demonstrated that urine is rarely contaminated with SARS-CoV-2 viral RNA. Studies which assessed the number of patients with any positive urine sample found that in 8/150 (5.3%) urine was contaminated with SARS-CoV-2 RNA. Studies which assessed the outcome as the number of positive urine samples, found no evidence of this occurring (0/82, 0%).

Evidence of presence of viable SARS-CoV-2 virus in urine

There was weak evidence from one case study,[135] which attempted to isolate infectious virus from urine sample obtained 12 days post-infection from one COVID-19 patient. This study found evidence that the virus was culturable in Vero E6 cells, with cytopathic effects observed in cells after three days.

*Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider SARS-CoV-2 transmission from infected urine to be **unlikely**.*

Ocular secretions and transmission via ocular surface

Epidemiological evidence

No evidence was found in studies published so far, that ocular secretions we responsible for transmission of SARS-CoV-2 virus to other persons.

There was weak evidence from two case series and case studies,[49,127] which reported occurrence of SARS-CoV-2 transmission in three HCWs. These studies reported that all three cases occurred when the HCWs did not wear equipment to protect their eyes, wore it inconsistently, or touched their eyes when working with infected patients.

Evidence of presence of SARS-CoV-2 RNA in ocular secretions

There was moderate evidence from nine case series and case studies, which assessed the presence of SARS-CoV-2 RNA in ocular secretions.[11,20,85,87,102,106,110,127,132] These studies consistently demonstrated a rare presence of SARS-CoV-2 RNA in ocular secretions, with 8/194 (4%) of samples yielding positive results.

Evidence of presence of viable SARS-CoV-2 virus in ocular secretions

No evidence was found in studies published so far, that viable SARS-CoV-2 was found in ocular secretion specimens.

*Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider SARS-CoV-2 transmission from infected ocular secretions to be **unlikely**.*

*Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider transmission via ocular surface to be **possible**.*

Sexual body fluids

Epidemiological evidence

No evidence was found in studies published so far, that sexual body fluids were responsible for transmission of SARS-CoV-2 virus to other persons.

Evidence of presence of SARS-CoV-2 RNA in sexual body fluids

There was weak evidence from three case series studies, which assessed the presence of SARS-CoV-2 viral RNA in sexual body fluids.[21,44,79] One study evaluating the presence of the virus in semen[44] found 6/38 (16%) of specimens being infected while the remaining two studies[21,79] found no SARS-CoV-2 RNA in a total of 45 vaginal secretion samples.

Evidence of presence of viable SARS-CoV-2 virus in sexual body fluids

No evidence was found in studies published so far, which reported that viable SARS-CoV-2 was found in sexual body fluid samples.

*Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party consider SARS-CoV-2 transmission from infected sexual body fluids to be **unlikely**.*

Transmission dynamics of SARS-CoV-2

The transmission dynamics for SARS-CoV and MERS-CoV were different, which may reflect their infectivity via different transmission routes. The SARS outbreak originated in southern China and it is thought that many cases were due to super-spreader index patients who infected many individuals.[163] Examples of individuals who caused such events are a fishmonger from southern China who infected

30 HCWs and eventually was implicated as the index patient in an outbreak in surrounding hospitals; a doctor from a Chinese hospital who infected 23 hotel guests and who subsequently carried the virus to other countries including Vietnam, Canada and Singapore; and a Hong Kong housing estate where one index patient with diarrhoea was responsible for transmitting the virus to over 200 estate residents.[143,163-166] Other outbreaks occurred mostly in hospitals[163] and isolated cases later occurred when researchers working with SARS-CoV in laboratory settings were infected following exposure.[167] Transmission of MERS-CoV occurs mostly from infected camels via direct contact or from consuming camel meat and milk.[139] Human-to-human transmission occurs but is thought to be relatively rare and is limited to a close contact with severely ill people.[139] The majority of secondary cases are known to be either HCWs or close family members sharing the same household. Secondary cases also tend to develop milder symptoms and be less infectious to others.[139]

Epidemiological evidence of SARS-CoV-2 transmission occurring within households

There was moderate evidence from 17 outbreak studies,[7,16,27,28,31,34,37,41,47,48,54,78,84,86,98,99,128] which investigated the possibility of SARS-CoV-2 transmission occurring between household members. The studies collectively reported a total of 1119 cases with an overall attack rate of 25%. The attack rate varied widely from none to all members of the household being infected.

Epidemiological evidence of SARS-CoV-2 transmission occurring between family and friends

There was moderate evidence from 14 outbreak studies, which reported a total of 179 cases of SARS-CoV-2 transmission occurring among family members[6,16,23,27,33,34,40,43,74,77,78,107,116,118] and a further five outbreak studies describing 11 cases occurring between friends.[33,40,99,107,109] These persons did not share a household with infected index cases, but were reported to have close contact exposure while eating meals, visiting each other or travelling together. The overall attack rate for family contacts was 24.6%, although as with household transmission, this varied widely from 14% to all family members being infected. The overall attack rate for exposure between friends was 8%.

Epidemiological evidence of SARS-CoV-2 transmission occurring in workplaces

There was moderate evidence from six outbreak studies,[23,27,70,76,78,80] which investigated SARS-CoV-2 transmission in work environment where there was no exposure to the customers. The studies reported that a total of 122 individuals were affected with an overall 10% attack rate. One study[70] also reported that 94/97 (97%) COVID-19 individuals were working on the same floor, with many also situated on the same side of the building. Another study[76] reported that 7/94 (7%) were most likely infected because of breakout sessions and team building activities which allowed a close and sometimes physical contact between the individuals.

Epidemiological evidence of SARS-CoV-2 transmission occurring in supermarkets and shopping centres

There was weak evidence from three outbreak studies,[76,103,123] which investigated SARS-CoV-2 transmission in supermarkets and shopping centres. The studies reported a total of 22 employees and 21 customers being infected, with attack rates of 12% and 0.02% respectively. However, in one study[73] where employees had close contact with infected customers, the attack rate was higher (29%).

Epidemiological evidence for SARS-CoV-2 transmission occurring during church service

There was weak evidence from three studies[76,99,116] reporting five outbreaks, where exposure during the church service affected a total of 20 cases with an attack rate of 2%. Of the 20 cases, four were described as sitting very close to the index patients[76,99] and one was found to occupy the same space during a different service later that day.[99]

Epidemiological evidence for SARS-CoV-2 transmission occurring in acute healthcare settings

There was moderate evidence from eight outbreak studies,[7,16,28,32,43,83,84,100] which investigated the occurrence of SARS-CoV-2 transmission occurring in acute healthcare settings. The outbreaks showed that transmission in these settings is relatively low and affected 37 HCWs, 13 patients and seven visitors caring for their sick relatives. The attack rate for HCWs was 0.9% and mostly occurred in HCWs who reported prolonged contact with the index patients and being present during AGPs without the use of PPE (31/37, 84%);[32,83,84] in the remaining six cases the staff were reported to have worn PPE.[16] The overall attack rate for patients and visitors was not established.

Epidemiological evidence for SARS-CoV-2 transmission occurring in care homes

There was weak evidence from one outbreak study[61] describing transmission in a nursing home. This study described an outbreak which involved a total of 101 residents, 50 staff and 16 visitors. The authors did not provide a denominator, but based on the reported bed capacity of 130, the attack rate among residents was 78%.

Epidemiological evidence for SARS-CoV-2 transmission occurring in other settings

There was weak evidence from a total of 11 outbreak studies,[8,23,27,60,63,65,70,74,78,82,128] which investigated transmission occurring in other settings. They reported that the risk of acquiring the virus from these settings was low. One study[27] estimated that 6/1052 (0.6%) of infected cases acquired the virus during public gatherings and a further 5/1052 (0.5%) acquired the virus from no apparent close contact with known COVID-19 cases. Isolated incidents occurred in a public bath (n=8 cases),[57] public transport (n=14),[27,78] tour groups travelling together (n=8)[65,128] and during a flight in which a passenger sat next to an individual later diagnosed with COVID-19 (n=1).[128]

Upon the review of the above evidence, the COVID-19 Rapid Guidance Working Party conclude that it is ***probable that transmission occurs with close contact****, although at the moment it is not possible to determine the distance or the duration for transmission to occur. Transmission from COVID-19 patients to HCWs in hospitals is low, unless HCWs do not use appropriate PPE. Transmission in care homes appears to be very high and needs particular considerations.*

Recommendations

General recommendations:

GR1: You must adhere to regulations currently imposed by the government.

GR2: Keep as much distance from others as possible and try to maintain the recommended minimum 2 meters distance at all times.

GR3: Use face covering in enclosed spaces to protect yourself and others.

GR4: Reduce the time of contact with anyone outside your household to minimum.

GR5: To avoid transmission from fomites, decontaminate your hands frequently using soap and water, and when this is not possible, use hand sanitizer. **Good practice point:** Follow WHO advice on how to hand wash and how to hand rub

GR6: Transmission via ocular surface is possible, avoid touching your face and eyes with your hands.

GR7: Evidence suggests that a high proportion of transmissions occur between family members, friends, and co-workers. Adhere to the above recommendations when in contact with anyone in your social group or at work.

GR8: Airborne transmission in community settings is unlikely. Do not use masks and respirators specifically designed for protection against airborne organisms.

Good practice point: To protect yourself and others, follow WHO advice and avoid 3Cs: **C**losed spaces, **C**rowds, **C**lose contact.

Specific recommendations for persons working in health and care settings:

HR1: You must adhere to regulations imposed by your trust/employer.

HR2: For contact with healthcare staff and with patients not suspected or confirmed to have COVID-19, use general recommendations listed above.

HR3: For care of patients not suspected or confirmed to have COVID-19, use standard precautions, and adhere to using following PPE:

a. Gloves for all activities where there is a risk of exposure to blood or body fluids or when handling contaminated devices. Immediately remove the gloves at the end of activity and decontaminate your hands using soap and water or alcohol gel before the gloves are worn and immediately after they are removed
b. Disposable plastic aprons when there is a risk that your clothing may become contaminated with blood or body fluids or with pathogenic microorganisms
c. Eye protection when there is a risk of splashes from blood or body fluids.

HR4: For care of patients suspected or confirmed to have COVID-19, use contact and droplet precautions, and adhere to using following PPE for all activities:

a. Protective gown, which is tied around your neck and waist
b. Gloves with cuffs covering the cuffs of the gown
c. Eye protection
d. Medical-grade mask.

HR5: Risk of SARS-CoV-2 transmission from body fluids (faeces, urine, ocular excretions and sexual body fluids) is unlikely, use contact precautions and appropriate PPE and refrain from using additional precautions (e.g. respirator masks).

HR6: Most SARS-CoV-2 transmissions from patients to HCWs occurred when HCW did not use protection during aerosol generating procedures (AGPSs) on patients not suspected of having COVID-19. Use respirators designed for filtering airborne particles for any AGPs regardless of a patient’s COVID-19 status.

HR7: Vertical transmission is unlikely but consider using additional precautions during the antepartum or during the process of labour and delivery. Reviewed studies reported avoiding unnecessary caesarean delivery, mothers advised to use a medical-grade mask, and parents using contact precautions immediately after the baby was born.

<u>Recommendations for managers in health and care settings:</u>

MR1: Adhere to current national guidelines for infection prevention and control, including those specific to COVID-19 as well as general ones for preventing infectious diseases.

9. Conclusions

As with other coronaviruses, SARS-CoV-2 appears to spread predominantly via droplet route, although transmission via fomites and airborne route is also possible. It has also been established that the virus can enter via ocular surface to reach and infect respiratory tract successfully. Current literature suggests that other routes of transmission are unlikely and if infections via these routes occur, they are rare and are yet to be documented. Determining routes via which the virus can infect others is important because it helps to define precautions that need to be taken to stop an infection chain. Based on the evidence reviewed in this guidance it can be confirmed that precautions, which have been previously highlighted and are recommended in this guidance are sufficient to avoid transmission. It is noteworthy that SARS-CoV-2 virus appears to have higher affinity to ACE2 receptors which makes it more infectious compared to previous coronaviruses from the same family, namely SARS-CoV and MERS-CoV. Another factor to consider is a possibility of transmission from infected but asymptomatic individuals. This means that adhering to these recommendations is more important than ever to minimise the spread of this highly infectious virus.

10. Further research

Research recommendations:

RR1: Outbreak studies, which thoroughly investigate the transmission dynamics of affected cases for example, in relation to separation distances needed to sufficiently reduce the risk of human-to-human transmission.

RR2: Laboratory studies under controlled conditions to demonstrate the range of spread of droplets of different sizes that could carry potentially infectious dose of SARS-CoV-2

RR3: Environmental sampling studies around patients newly admitted with COVID-19 to determine presence of infectious virus by using culture techniques

RR4: Studies on preventing COVID-19 in care home settings

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Appendices

Appendix 1 – glossary

Appendix 2 – guideline development and conflicts of interest

Appendix 3 – search strategy

Appendix 4 – sifting

Appendix 5 – a) QA checklist, b) QA results

Appendix 6 – evidence tables a) characteristics of included studies, b) summary of findings tables

Appendix 7 – excluded studies table

Appendix 8 – GRADE table

Appendix 9 – consultation

Appendix 1: Glossary

ACE-2 receptor: a protein, which is found on surface of many cells (including lung cells). The protein normally regulates different functions in the body such as blood pressure. Some coronaviruses such as SARS-CoV and SARS-CoV-2 have proteins which can attached the virus to ACE-2. In this case, ACE-2 acts as a receptor to allow the virus to enter the cell.

Aerosol generating procedure: a medical procedure which produces aerosols particles from the respiratory tract. The particles are small enough to be considered 'airborne' and can lead to a transmission of infection to a person who conducts a procedure (usually a healthcare worker). Some examples include intubation of a patient, suctioning, dental procedures, some surgeries where high speed devices are used and bronchoscopy.

Aggregated: grouped or linked together. In this guidance the term is used describe the event to combine the data from all available studies without conducting a formal statistical analysis.

AGP: see aerosol generating procedures

Caco2 cells: cells which were once taken from a patient with colorectal cancer. Unlike normal human cells, these cells are 'immortalised' because due to a mutation, they are able to divide indefinitely. For viruses, e.g. SARS-CoV-2, the cells are inoculated in the laboratory setting (see viral culture) to determine if the virus is able to infect other cells.

Collison drum: or Collison nebuliser, is a laboratory device used for generating aerosols from liquids. The liquid can be inoculated with micro-organisms, which can then be assessed for their ability to survive in the air, depending on the size of aerosols produced.

COVID-19: Coronavirus Disease, a respiratory disease caused by infection with SARS-CoV-2 virus, which was first identified in December 2019.

Culturable virus: a virus which was has an ability to infect other cells in viral culture. A viral sample for an experiment is usually obtained from different body tissues or environment with an aim to determine whether the virus obtained in a sample is infectious.

Denominator: a divisor – a number below a line in a fraction, in statistics the number represents a total number of samples or individuals in the experiment.

Epidemiological: relating to a study of epidemiology – a field of medicine which investigates the frequency and determinants (e.g. causes or risk factors) of health-related issues. These could be infectious and non-infectious diseases, injuries, natural disasters and other.

Fomite: inanimate objects, which are contaminated with infectious agents (e.g. viruses) and can transfer them to a person who subsequently becomes infected. Examples include clothes, door handles, toilet seats, eating utensils etc.

HCW: Healthcare Workers; the term may refer to a person who delivers care (e.g. nurse or doctor), but more broadly includes any member of staff e.g. cleaners or receptionists, including non-paid staff such as volunteers and chaplains who work in healthcare setting.

IgM: Immunoglobulin M, a type of immunoglobulin (also known as antibody), is a molecule that is produced as a response of immune system following an exposure to pathogen. IgM appears early in an infection and plays a lesser role in subsequent infections. The significance of IgM in this guidance is that this molecule is too large to be able to cross placenta, therefore IgM found in an infant at birth suggests an *in utero* exposure to pathogen; foetus is able to produce IgM from about 20 weeks. Maternal IgM can be passed to an infant via milk through breastfeeding.

Impinger: a device for collecting small particles suspended in the air e.g. dust or microorganisms. In the collection process, a pre-defined amount of air is pumped into a tube and reacts with a liquid medium inside.

Infectious dose: also minimum infectious dose, the amount of virus that is necessary to cause a disease. For example, only 10-100 viral particles are sufficient to cause norovirus infection. The infectious dose for SARS-CoV-2 is currently unknown, although it has been proposed that this is around 1000 copies.

Inoculum: a substance used for inoculation – in research or diagnostics, a process of transferring microorganisms onto a medium where they can grow and reproduce.

Intrapartum: at birth, a time period which starts with the onset of labour and ends with the delivery of the placenta.

MERS: Middle East Respiratory Syndrome, a disease caused by MERS-CoV virus.

MERS-CoV: Middle East Respiratory Syndrome Coronavirus, a beta-coronavirus causing Middle East Respiratory Syndrome, which was first discovered in Saudi Arabia. It is a close cousin of SARS-CoV and SARS-CoV-2.

MeSH: Medical Subject Headings, a set of terms, which are used to index biomedical literature. Together with keywords, MeSH terms are used for searching articles relevant to the topic of interest.

Meta-analysis: performing of an analysis by combining data from more than one study in order to determine an overall result.

Neonatal: relating to a newborn.

NIOSH: an aerosol sampler which was developed by National Institute for Occupational Safety and Health (USA). The sampler collects airborne particles, which contain bacteria, fungi and viruses. The obtained samples can then be used to assess the concentration of a given microorganism in the air and therefore to determine safety of the environment.

Ocular: relating to the eye.

PCR: polymerase chain reaction, a laboratory technique which allows taking a small sample of DNA (molecule containing a genetic material) and rapidly produce a large number of copies. This technique can also be used for diagnostic purposes, e.g. viral detection. In this instance, a primer (a small molecule that contains a DNA sequence of interest) is used and defines which part of DNA is going to be amplified. If the same DNA sequence exists in a test sample, PCR will reproduce a lot of copies which will be detectable. A variant of PCR known as RT-PCR can be used to detect RNA sequence (see RNA).

Placenta: an organ that develops in the uterus during pregnancy. The placenta delivers air and nutrients to the foetus and removes its waste products.

Postpartum: a period usually defined as six weeks from giving birth.

PRISMA diagram: a flow chart which illustrates different parts of systematic review process, in particular it maps out a number of articles which were included and excluded at each step.

Products of conception: any human tissue derived during pregnancy, e.g. placenta, umbilical cord and the cord blood.

Reproductive number: or basic reproduction number (R_0), is the number of individuals that are expected to get an infection from one infected person. If $R_0 > 1$, the infection is able to spread within the population and the higher the number, the more difficult it is to control. The reproductive number depends on many factors such as infectiousness of the organism, the length of time an infected person can spread the disease, number of people in contact with an infected person, number of immune people and different control mechanisms.

RNA: Ribonucleic acid, is a molecule which is usually derived from DNA. RNA contains a small portion of genetic material, needed for creation of a specific product. Most organisms use DNA to store their genetic material and make RNA when these products are needed. Some viruses use RNA, which gives them an additional advantage as once they enter the cell, their RNA is ready to be 'translated' into the products they encode for. Coronaviruses, including SARS-CoV-2 use RNA to store their genetic code.

SARS: Severe Acute Respiratory Syndrome, a disease caused by SARS-CoV virus.

SARS-CoV: Severe Acute Respiratory Syndrome Coronavirus. The virus was the cause of the SARS epidemic, which began in China in 2003 and spread around the world, mostly affecting East Asian countries. The virus is closely related to SARS-CoV-2 and to a slightly more distant cousin MERS-CoV.

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2. The virus is the cause of the COVID-19 pandemic, which was first identified in China in 2019 and quickly spread around the world. The virus is closely related to SARS-CoV and to a slightly more distant cousin MERS-CoV.

$TCID_{50}$: fifty percent tissue culture infective dose, is the measure of infectious virus concentration used in cell culture. It is defined as the amount of virus that is required to kill or cause pathogenic effect in 50% of the culture cells.

Vero E6 cells: immortalised cells derived from a kidney of green monkey. Unlike other cells, Vero E6 do not produce a molecule called interferon. Interferons are signalling molecules which are released from a cell after it was infected with a virus, so that the neighbouring cells can heighten their anti-virus defences. Because this molecule is not released in Vero E6 cells, they are often used for researching or detecting viable viruses.

Vertical transmission: a direct mother to child transmission that occurs before, during or shortly after birth. Transmission can occur via placenta, infected tissues during delivery or through breast milk.

Viable virus: see culturable virus

Viral culture: a laboratory technique which uses virus inoculated into cells, with the aim to test whether the virus has an ability to survive, reproduce and infect other cells.

Viral load: number of viral particles in a sample taken from an individual or environment. The amount of virus is important because the higher the number of particles in the environment, the higher the likelihood of a person becoming infected. See infectious dose.

Appendix 2: Guideline Development

a) Introduction

The need for a guideline within this area was agreed between HIS, BIA, IPS, RCPath and BSAC at the beginning of the first wave of COVID-19 affecting UK in March 2020. The need arose from the concerned healthcare workers reporting the lack of evidence in this area. Further meetings between the participating bodies confirmed the need for the establishment of a COVID-19 Rapid Guidance working party. Members were chosen to reflect the range of stakeholders. Feedback from the members of respective societies was used to establish a basis for review questions. The final structure of these questions in PECO format was agreed collectively during subsequent teleconference meetings. After the agreement was reached, if the need for new questions arose, these were considered for inclusion at subsequent meetings. No payment was made to anyone involved in this guideline.

b) Conflict of interest

Conflict of interest was registered from all working group members and during the ongoing review up until the point of completion. In the event of a potential conflict being identified, the working group agreed that the member should not contribute to the section affected.

Appendix 3: Search strategy

PECO Question: What are the routes of transmission of beta-coronaviruses between humans?

Note: as specified by the protocol, SARS-CoV and MERS-CoV transmission would be considered only if sufficient evidence did not exist concerning SARS-CoV-2 transmission. The review included a total of 130 primary studies describing SARS-CoV-2, without the need to include evidence from other viruses. Instead, brief information relating to SARS and MERS viruses was introduced at each introductory section.

Population:	Any person at risk of exposure in the community or healthcare setting
Exposure:	Exposure to the betacoronavirus via any route
Comparison:	No comparison group
Outcomes:	Evidence of transmission to another person
Study design:	Any study reporting primary data

Literature search terms:

EMBASE/MEDLINE

1 coronavirus.mp. or exp Coronavirinae

2 exp SARS coronavirus/ or coronovirus.mp. or exp Coronavirus infection/

3 severe acute respiratory syndrome.mp. or severe acute respiratory syndrome/ or respiratory distress syndrome/

4 Severe acute respiratory syndrome coronavirus 2.mp.

5 SARS-CoV-2.mp.

6 SARSCoV-2.mp.

7 SARSCov2.mp.

8 SARS-Cov2.mp.

9 SARS-CoV9.mp.

10 COVID19.mp.

11 nCoV-2019.mp. or SARS-related coronavirus/

12 COVID-19.mp.

13 2019-nCoV.mp.

14 2019nCoV.mp. or Betacoronavirus/

15 HCoV-19.mp.

16 novel coronavirus.mp.

17 wuhan virus.mp.

18 wuhan coronavirus.mp.

19 hubei virus.mp.

20 hubei coronavirus.mp.

21 huanan virus.mp.

22 huanan coronavirus.mp.

23 wuhan pneumonia.mp.

24 hubei pneumonia.mp.

25 huanan pneumonia.mp.

26 CoV.mp.

27 2019 novel.mp.

28 Ncov.mp.

29 n-cov.mp.

30 Seafood market pneumonia.mp.

31 air/ or air.mp.

32 airway.mp. or airway/

33 airborne particle/ or airborne.mp.

34 air borne.mp.

35 airbourne.mp.

36 air bourne.mp.

37 airborn.mp.

38 air born.mp.

39 breath$.mp. or breathing/

40 talk$.mp.

41 cough$.mp. or coughing/

42 sneezing/ or sneez$.mp.

43 aerosol.mp. or aerosol/

44 droplet.mp.

45 spray.mp.

46 flush.mp. or flushing/

47 respiratory droplet.mp.

48 fecal-oral.mp.

49 faecal-oral.mp.

50 food contamination/ or foodborne.mp.

51 foodborn.mp.

52 foodbourne.mp.

53 environment.mp. or environment/

54 environmental contamination.mp.

55 surface.mp.

56 touch.mp. or touch/

57 AGP.mp.

58 aerosol generating procedure.mp.

59 droplet nuclei.mp. or disease transmission/

60 ingest.mp.

61 fomite.mp. or fomite/

62 contact.mp.

63 suction.mp. or suction/

64 inhalation/

65 airborne particle/

66 drink.mp.

67 mouth/

68 cigarette/

69 kiss.mp.

70 ventilation.mp. or air conditioning/

71 saliva/

72 body fluid.mp. or body fluid/

73 body fluid.mp.

74 spit.mp.

75 sputum.mp.

76 transmission.mp. or virus transmission/

77 transmissibility.mp.

78 spread.mp.

79 *basic reproduction number/

80 route.mp.

81 mode.mp.

82 cross infection/ or crossinfection.mp.

83 expos$.mp.

84 viral load.mp. or virus load/

85 infectivity.mp.

86 infectiousness.mp.

87 1 or 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 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30

88 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75

89 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86

90 88 and 89

91 87 and 90

92 limit 91 to yr="2020 -Current"

93 limit 92 to (animals and animal studies)

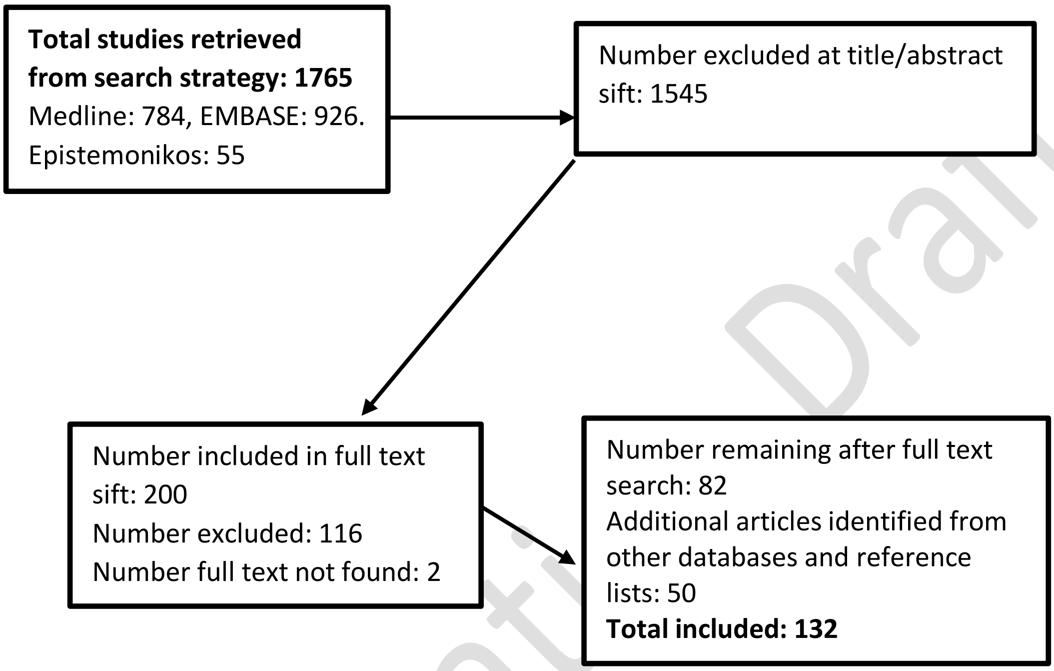
94 *in vitro study/

95 92 not 93

96 95 not 94

Appendix 4: PRISMA diagram

Summary of the data extraction and literature review process:



Appendix 5: Quality assessment

a) QA checklist

The checklist used for assessing the quality of the included case series/studies was can be found here.

b) QA results

authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Alzamora, 2020[5]	Grey	Red	Red	Grey	Grey	Green	Green	Yellow	Red	Grey
Bai, 2020[6]	Green	Green	Green	Green	Yellow	Red	Green	Green	Red	Green
Burke, 2020[7]	Green	Green	Green	Red	Yellow	Red	Red	Red	Red	Green
Cai, 2020[8]	Yellow	Yellow	Yellow	Red	Yellow	Red	Red	Red	Red	Green
Chan, 2020[9]	Yellow	Green	Green	Yellow	Yellow	Red	Green	Green	Red	Green
Chen, 2020[10]	Yellow	Green	Green	Yellow	Yellow	Red	Green	Green	Red	Green
Chen, 2020b[11]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Green	Grey
Chen, 2020c[12]	Red	Green	Green	Yellow	Yellow	Red	Red	Green	Red	Green
Chen, 2020d[13]	Red	Green	Green	Yellow	Yellow	Red	Green	Green	Red	Green
Chen, 2020e[14]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Chen, 2020f[15]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Cheng, 2020[16]	Green	Green	Green	Green	Yellow	Green	Green	Green	Red	Green
Colavita, 2020[20]	Grey	Green	Grey	Grey	Grey	Red	Green	Green	Red	Grey
Cui, 2020[21]	Green	Green	Green	Yellow	Yellow	Green	Red	Green	Red	Green
Dong, 2020[22]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Dong, 2020b[23]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Grey	Green
Fan, 2020[24]	Red	Green	Green	Red	Red	Green	Green	Green	Red	Grey
Fan, 2020b[25]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Gan, 2020[27]	Green	Green	Yellow	Yellow	Green	Green	Red	Green	Green	Green
Ghinai, 2020[28]	Green	Green	Green	Grey	Yellow	Green	Green	Green	Green	Grey
Hamner, 2020[30]	Green	Green	Red	Grey	Green	Red	Red	Green	Green	Green

Han, 2020[31]	grey	green	grey	grey	grey	green	green	green	red	grey
Heinzerling, 2020[32]	green	green	green	red	green	red	green	green	red	green
Huang, 2020[33]	red	green	green	red	yellow	red	green	green	red	green
Huang, 2020b[34]	green	green	green	green	green	red	red	green	grey	green
Iqbal, 2020[35]	grey	green	grey	grey	grey	red	green	green	red	grey
Jiang, 2020[36]	grey	green	grey	grey	grey	green	green	green	grey	grey
Jiang, 2020b[37]	green	green	green	yellow	green	red	green	green	grey	green
Jiehao, 2020[38]	green	green	green	green	green	green	green	green	red	green
Khan, 2020[39]	green	green	green	yellow	yellow	green	green	green	red	green
Kong, 2020[40]	green	green	green	green	green	green	green	red	green	green
Le, 2020[41]	grey	green	grey	grey	grey	green	green	green	red	grey
Lee, 2020[42]	grey	green	grey	grey	grey	green	green	green	grey	grey
Li, 2020[43]	red	green	green	yellow	yellow	green	green	red	red	green
Li, 2020b[44]	green	green	green	green	red	red	red	red	red	green
Li, 2020c[45]	grey	green	grey	grey	grey	green	green	green	red	grey
Li, 2020d[46]	green	green	green	grey	green	green	green	green	red	green
Li, 2020e[47]	green	green	green	green	green	red	green	green	red	green
Li, 2020f[48]	green	green	green	yellow	yellow	green	green	green	green	green
Li, 2020g[49]	grey	green	green	grey	grey	grey	green	green	green	grey
Li, 2020h[50]	green	green	green	yellow	yellow	green	yellow	green	red	green
Li, 2020i[51]	green	green	green	green	green	red	red	green	green	green
Li, 2020j[52]	grey	green	grey	grey	grey	green	green	green	red	grey
Ling, 2020[53]	green	green	green	grey	yellow	red	green	grey	green	green
Liu, 2020[54]	green	green	green	yellow	yellow	green	green	green	red	green
Liu, 2020b[55]	green	green	green	yellow	yellow	green	green	green	red	green

Liu, 2020c[56]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Liu, 2020d[57]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Grey	Grey
Lowe, 2020[58]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Lu, 2020[59]	Green	Green	Green	Grey	Green	Red	Red	Green	Green	Green
Luo, 2020[60]	Green	Green	Green	Yellow	Yellow	Red	Red	Green	Green	Green
McMichael, 2020[61]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Ng, 2020[63]	Green	Green	Green	Grey	Green	Red	Grey	Green	Green	Green
Okada, 2020[65]	Yellow	Green	Green	Yellow	Yellow	Green	Green	Green	Grey	Grey
Pan, 2020[68]	Green	Green	Green	Yellow	Yellow	Red	Green	Grey	Red	Green
Park, 2020[69]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Green	Grey
Park, 2020b[70]	Green	Green	Green	Green	Green	Red	Red	Green	Green	Green
Penfield, 2020[71]	Green	Green	Green	Green	Green	Green	Green	Red	Red	Green
Peng, 2020[72]	Yellow	Green	Yellow	Yellow	Yellow	Green	Green	Green	Red	Green
Peng, 2020b[73]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Grey	Grey
Phan, 2020[74]	Yellow	Green	Green	Green	Green	Green	Green	Green	Red	Grey
Pierce-Williams, 2020[75]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Pung, 2020[76]	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green
Qian, 2020b[77]	Yellow	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Qiu, 2020[78]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Qiu, 2020b[79]	Yellow	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Green
Rothe, 2020[80]	Yellow	Green	Green	Red	Red	Red	Red	Green	Green	Green
Schwartz, 2020[82]	Green	Green	Green	Green	Green	Red	Red	Green	Green	Green
Schwierzeck, 2020[83]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Scott, 2020[84]	Green	Green	Green	Green	Green	Red	Red	Green	Green	Green
Seah, 2020[85]	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Green

Song, 2020[86]	Yellow	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Sun, 2020b[87]	Green	Green	Green	Green	Green	Green	Red	Green	Red	Green
Tan, 2020[88]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Tan, 2020b[89]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green
Tang, 2020[90]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Green	Grey
To, 2020[91]	Green	Green	Green	Green	Red	Green	Green	Red	Red	Green
Wang, 2020b[94]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Wang, 2020c[95]	Green	Green	Green	Yellow	Yellow	Red	Green	Red	Red	Green
Wang, 2020d[96]	Red	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Green
Wang, 2020e[97]	Grey	Green	Grey	Grey	Grey	Green	Green	Green	Red	Grey
Wang, 2020f[98]	Green	Green	Green	Green	Green	Yellow	Red	Green	Red	Green
Wei, 2020[99]	Green	Green	Green	Green	Green	Red	Red	Red	Green	Grey
Wei, 2020b[100]	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Wu, 2020[101]	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Green
Wu, 2020b[102]	Green	Green	Green	Green	Yellow	Green	Green	Green	Red	Green
Wu, 2020c[103]	Green	Green	Green	Red	Red	Green	Green	Green	Green	Green
Wu, 2020d[104]	Yellow	Green	Green	Yellow	Yellow	Red	Green	Green	Red	Green
Xia, 2020[106]	Yellow	Green	Green	Yellow	Yellow	Red	Red	Green	Red	Green
Xia, 2020b[107]	Green	Green	Green	Yellow	Red	Green	Green	Green	Green	Green
Xiao, 2020[108]	Green	Green	Green	Yellow	Yellow	Green	Red	Green	Red	Green
Xiao, 2020b[109]	Red	Green	Green	Yellow	Yellow	Red	Green	Green	Green	Green
Xie, 2020[110]	Green	Green	Green	Green	Green	Red	Red	Green	Red	Green
Xing, 2020[111]	Green	Green	Green	Green	Green	Red	Green	Green	Red	Green
Xu, 2020[112]	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green
Yan, 2020[113]	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green

Yang, 2020[114]	yes	yes	yes	unclear	unclear	no	yes	yes	yes	yes
Yang, 2020b[115]	yes	yes	yes	unclear	unclear	no	yes	yes	no	yes
Yong, 2020[116]	yes	yes	unclear	yes	yes	unclear	unclear	yes	yes	yes
Yu, 2020[117]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Yu, 2020b[118]	yes	yes	yes	unclear	unclear	yes	yes	yes	yes	yes
Zambrano, 2020[119]	not applicable	yes	not applicable	not applicable	not applicable	yes	yes	yes	no	not applicable
Zeng, 2020[120]	yes	yes	yes	not applicable	unclear	no	yes	yes	no	yes
Zeng, 2020[121]	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Zhang, 2020[122]	yes	yes	yes	not applicable	unclear	no	no	yes	no	yes
Zhang, 2020b[123]	yes	yes	yes	yes	yes	no	no	yes	yes	yes
Zhang, 2020c[124]	yes	yes	yes	unclear	unclear	yes	yes	yes	no	yes
Zhang, 2020d[125]	yes	yes	yes	unclear	unclear	no	yes	yes	no	yes
Zhang, 2020e[126]	yes	yes	yes	unclear	unclear	no	no	yes	no	yes
Zhang, 2020f[127]	not applicable	yes	not applicable	not applicable	not applicable	unclear	unclear	yes	yes	not applicable
Zhang, 2020g[128]	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
Zhang, 2020h[129]	not applicable	yes	not applicable	not applicable	not applicable	no	no	yes	no	not applicable
Zhang, 2020i[130]	not applicable	yes	not applicable	not applicable	not applicable	no	yes	yes	no	not applicable
Zheng, 2020[131]	yes	yes	yes	yes	unclear	yes	yes	yes	yes	yes
Zhou, 2020[132]	yes	yes	yes	unclear	unclear	yes	yes	yes	no	yes
Zhu, 2020[133]	yes	yes	yes	unclear	unclear	yes	yes	yes	no	yes
Sun, 2020[134]	not applicable	yes	not applicable	not applicable	not applicable	no	no	no	no	not applicable

yes, unclear, no, not applicable

Appendix 6: Evidence tables

a) characteristics of included studies

Author, Year	Study Design	Country	Population	Transmission route	Comparator	Outcomes
Ahmed, 2020[4]	Environmental survey	Australia	Environment	Faecal	No comparator	Environmental contamination
Alzamora, 2020[5]	Case study	Peru	Pregnant woman + neonate	Vertical	No comparator	No of cases
Bai, 2020[6]	Case series	China	Adults in community	Not described	No comparator	No of cases
Burke, 2020[7]	Case series	USA	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Cai, 2020[8]	Case series	China	Mall visitors and staff	Fomites	No comparator	No of cases
Chan, 2020[9]	Case series	China	Family	Not described	No comparator	No of cases
Chen, 2020[10]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Chen, 2020b[11]	Case study	China	COVID-19 +ve patient	Ocular	No comparator	No of individuals with +ve samples
Chen, 2020c[12]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Chen, 2020d[13]	Case series	China	COVID-19 +ve patient	Faecal, urine	No comparator	No of individuals with +ve samples
Chen, 2020e[14]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Chen, 2020f[15]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases

Cheng, 2020[16]	Case series	Taiwan	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Cheng, 2020b[17]	Environmental survey	Hong Kong	Room of COVID-19 patient	Air	No comparator	Environmental contamination
Chia, 2020[18]	Environmental survey	Singapore	Environment	Air, fomites	No comparator	Environmental contamination
Chin, 2020[19]	Laboratory experiment	China	Different fomites	Fomites	No comparator	Virus survival
Colavita, 2020[20]	Case study	Italy	COVID-19 +ve patient	Ocular	No comparator	No of individuals with +ve samples
Cui, 2020[21]	Case series	China	Female COVID+ve patients	Faecal Sexual	No comparator	No of +ve samples
Dong, 2020[22]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Dong, 2020b[23]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Fan, 2020[24]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Fan, 2020b[25]	Case study	China	COVID-19 +ve patient	Faecal	No comparator	No of individuals with +ve samples
Faridi, 2020[26]	Environmental survey	Iran	ICU rooms with COVID-19 patients	Air	No comparator	Environmental contamination
Gan, 2020[27]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Ghinai, 2020[28]	Case series	USA	Contacts of COVID-19 patients	Cluster	No comparator	No of cases
Guo, 2020[29]	Environmental survey	China	ICU & general wards	Air, fomites	No comparator	Environmental contamination

Hamner, 2020[30]	Case series	USA	Adults attending choir practice	Droplet, fomites	No comparator	No of cases
Han, 2020[31]	Case series	Korea	COVID-19 patients	Faecal, urine, vertical	No comparator	No of cases
Heinzerling, 2020[32]	Case series	USA	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Huang, 2020[33]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Huang, 2020b[34]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Iqbal, 2020[35]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Jiang, 2020[36]	Case study	China	COVID-19 patients	Faecal	No comparator	No of individuals with +ve samples
Jiang, 2020b[37]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Jiehao, 2020[38]	Case series	China	COVID-19 children	Faecal, urine	No comparator	No of individuals with +ve samples
Khan, 2020[39]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Kong, 2020[40]	Case series	Korea	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Le, 2020[41]	Case series	Vietnam	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Lee, 2020[42]	Case series	Korea	Pregnant woman + neonate	Vertical	No comparator	No of cases
Li, 2020[43]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases

Li, 2020b[44]	Case series	China	Male COVID-19 patients	Sexual	No comparator	No of +ve samples
Li, 2020c[45]	Case study	China	COVID-19 patients	Faecal	No comparator	No of individuals with +ve samples
Li, 2020d[46]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Li, 2020e[47]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Li, 2020f[48]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Li, 2020g[49]	Case series	China	Healthcare workers	Ocular	No comparator	No of cases
Li, 2020h[50]	Case study	Korea	COVID-19 patients	Faecal	No comparator	No of individuals with +ve samples
Li, 2020i[51]	Case series	China	Restaurant guests	Droplet	No comparator	No of cases
Li, 2020j[52]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Ling, 2020[53]	Case series	China	Convalescent COVID adult patients	Faecal, urine	No comparator	No of individuals with +ve samples
Liu, 2020[54]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Liu, 2020b[55]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Liu, 2020c[56]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Liu, 2020d[57]	Case study	Taiwan	Contacts of COVID-19 patients	Not described	No comparator	No of cases

Lowe, 2020[58]	Case study	Australia	Pregnant woman + neonate	Vertical	No comparator	No of cases
Lu, 2020[59]	Case series	China	Restaurant guests	Droplet	No comparator	No of cases
Luo, 2020[60]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
McMichael, 2020[61]	Case series	USA	Family	Not described	No comparator	No of cases
Medema, 2020[62]	Environmental survey	Netherlands	Sewage water in main cities	Faecal	No comparator	No of +ve samples
Ng, 2020[63]	Case series	Singapore	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Liu, 2020[64]	Environmental survey	China	Environment	Air	2 blank controls	Environmental contamination
Okada, 2020[65]	Case series	Thailand	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Ong, 2020[66]	Environmental survey	Singapore	Environment of COVID +ve patients	Air, fomites	No comparator	Environmental contamination
Ong, 2020b[67]	Environmental survey	Singapore	Environment of COVID +ve patients	Fomites	No comparator	Environmental contamination
Pan, 2020[68]	Case series	Hong Kong	COVID-19 patients	Faecal, urine	No comparator	No of individuals with +ve samples
Park, 2020[69]	Case study	Korea	Paediatric COVID-19 patient	Faecal	No comparator	No of individuals with +ve samples
Park, 2020b[70]	Case series	Korea	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Penfield, 2020[71]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases

Peng, 2020[72]	Case series	China	COVID +ve patients	Faecal, urine	No comparator	No of individuals with +ve samples
Peng, 2020b[73]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Phan, 2020[74]	Case series	Vietnam	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Pierce-Williams, 2020[75]	Case series	USA	Pregnant woman + neonate	Vertical	No comparator	No of cases
Pung, 2020[76]	Case series	Singapore	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Qian, 2020b[77]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Qiu, 2020[78]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Qiu, 2020b[79]	Case series	China	COVID +ve patients	Sexual	No comparator	No of +ve samples
Rothe, 2020[80]	Case series	Germany	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Santarpia, 2020[81]	Environmental survey	USA	Environment of COVID +ve patients	Fomites, air	No comparator	Environmental contamination
Schwartz, 2020[82]	Case series	Canada	Aircraft crew & passengers	Droplet Air	No comparator	No of cases
Schwierzeck, 2020[83]	Case series	Germany	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Scott, 2020[84]	Case series	USA	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Seah, 2020[85]	Case series	Singapore	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples

Song, 2020[86]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Sun, 2020b[87]	Case series	China	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples
Tan, 2020[88]	Case study	Vietnam	COVID +ve patient	Faecal	No comparator	No of individuals with +ve samples
Tan, 2020b[89]	Case series	China	Child COVID +ve	Faecal	No comparator	No of individuals with +ve samples
Tang, 2020[90]	Case study	China	COVID +ve patient	Faecal	No comparator	No of individuals with +ve samples
To, 2020[91]	Case series	China	COVID +ve patients	Faecal, urine	No comparator	No of individuals with +ve samples
Van Doremalen, 2020[92]	Laboratory experiment	USA	Surfaces	Fomites	SARS-CoV-2 vs SARS-CoV	Environmental contamination
Wang, 2020[93]	Environmental survey	China	Environment	Fomites, faecal	No comparator	Environmental contamination
Wang, 2020b[94]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Wang, 2020c[95]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Wang, 2020d[96]	Case series	China	COVID +ve patients	Faecal, urine	No comparator	No of +ve samples
Wang, 2020e[97]	Case study	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Wang, 2020f[98]	Case series	China	Household contacts of COVID-19 patients	Not described	No comparator	No of cases
Wei, 2020[99]	Case series	Singapore	Contacts of COVID-19 patients	Not described	No comparator	No of cases

Wei, 2020b[100]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Wu, 2020[101]	Case series	China	COVID +ve patients	Faecal	No comparator	No of +ve samples
Wu, 2020b[102]	Case series	China	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples
Wu, 2020c[103]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Wu, 2020d[104]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Wurtzer, 2020[105]	Environmental survey	France	Wastewater samples during pandemic	Faecal	No comparator	No of +ve samples
Xia, 2020[106]	Case series	China	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples
Xia, 2020b[107]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Xiao, 2020[108]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Xiao, 2020b[109]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Xie, 2020[110]	Case series	China	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples
Xing, 2020[111]	Case series	China	Paediatric COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Xu, 2020[112]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Yan, 2020[113]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases

Yang, 2020[114]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Yang, 2020b[115]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Yong, 2020[116]	Case series	Singapore	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Yu, 2020[117]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Yu, 2020b[118]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Zambrano, 2020[119]	Case study	Honduras	Pregnant woman + neonate	Vertical	No comparator	No of cases
Zeng, 2020[120]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Zeng, 2020[121]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Zhang, 2020[122]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Zhang, 2020b[123]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Zhang, 2020c[124]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Zhang, 2020d[125]	Case series	China	COVID +ve children	Faecal	No comparator	No of individuals with +ve samples
Zhang, 2020e[126]	Case series	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Zhang, 2020f[127]	Case study	China	Nurse	Ocular	No comparator	No of cases

Zhang, 2020g[128]	Case series	China	Contacts of COVID-19 patients	Not described	No comparator	No of cases
Zhang, 2020h[129]	Case study	China	COVID +ve patients	Faecal	No comparator	No of individuals with +ve samples
Zhang, 2020i[130]	Case study	China	COVID +ve patients	Faecal, urine	No comparator	No of individuals with +ve samples
Zheng, 2020[131]	Case series	China	COVID +ve patients	Faecal, urine	No comparator	No of individuals with +ve samples
Zhou, 2020[132]	Case series	China	COVID +ve patients	Ocular	No comparator	No of individuals with +ve samples
Zhu, 2020[133]	Case series	China	Pregnant woman + neonate	Vertical	No comparator	No of cases
Zhou, 2020[134]	Environmental survey	United Kingdom	Environment	Air, fomites	No comparator	Environmental contamination
Sun, 2020[135]	Case study	China	COVID +ve patients	Urine	No comparator	No of individuals with +ve samples

b) summary of findings tables

Droplet transmission vs airborne transmission

Author, Year	Outcome measure	No of participants		Incidence			Reviewer's comments
		Exposure	Control	No of +ves	Control	Evidence of transfer	
Hamner, 2020[30]	No of cases	60	-	52	-	Multiple opportunities for droplet and fomite transmission	Also included in surfaces
Li, 2020i[51] Lu, 2020[59]	No of cases	83 (in the same dining room)	-	9	-	**Lu:** Most probable droplet transmission facilitated by air conditioning **Li:** likely aerosol transmission, evidence for no close contact and no fomite transmission	Reported by two different studies, slightly different interpretation of results. 83 guests ate lunch in the restaurant, one guest (index) was pre-symptomatic, later diagnosed as +ve. 9 people from three families got sick, two families overlapping 53 and 73min with the family of index patient – both at neighbouring tables directly in the line of the flow of air conditioning. Airborne not likely as none of the staff and none of the guests who were not in the line of the air conditioning got sick. 20 were in direct flow, another 10 were at the tables <2m from index table but not in the flow of AC
		20 (in direct flow)	10 (not in direct flow)	9	0		
Schwartz, 2020[82]	No of cases	Approx. 340	-	0	-	Data suggest droplet rather than airborne transmission	One symptomatic (dry cough) COVID+ve individual on the 15hr flight, his wife asymptomatic and developed symptoms the next day. Both wore masks and had mild symptoms. No passengers or crew were infected. Authors suggested that airplane transmission reports may be biased with contacts sharing exposure before boarding the plane.

Presence of SARS-CoV-2 in air

Author, Year	Setting	Outcome measure	No of samples	No (%) PCR +ve	No (%) Viable in culture	Evidence of interpersonal transmission	Reviewer's comments
Contaminated samples							
Cheng, 2020b[17]	Hospital room with COVID-19 patient	No of contaminated samples	4	0	NR	NR	Air taken in 4 scenarios: normal breathing, deep breathing, speaking, coughing.
Faridi, 2020[26]	Hospital rooms with COVID+ve patients	No of contaminated impingers	4	0	NR	NR	4 impingers placed 1.5-1.8m from the floor & 2-5m away from COVID-19 patients for 1hr. Some patients coughed or were intubated
Guo, 2020[29]	Hospital rooms with COVID-19 patients	No of contaminated samples	40 ICU 16 General ward	14 (35%) ICU 2 (12.5%) General ward	NR	NR	Air samples mostly contaminated around patient areas and downstream, although upstream also observed. Virus traveling up to 4m.
Santarpia, 2020[81]	Hospital rooms with COVID-19 patients	% of contaminated samples	NR	P: 100% l H: 66.7%	0		P: Personal space – patient's isolation area; H: Hallway outside the patient's isolation area; highest load in samplers near patients Authors suggested aerosols exist even without cough and AGPs
Zhou, 2020b[134]	Hospital areas with COVID-19 patients	No of contaminated air samples	31	14 (38.7%)	0		
Contaminated rooms							
Chia, 2020[18]	Hospital rooms with COVID-19 patients	No of rooms contaminated	3	2	NR	NR	Three NIOSH samples per room (general ward) located 0.7, 0.9 and 1.2m from the floor and 1-2.1 away from COVID patients for 4hrs.
Ong, 2020[66]	Hospital rooms with COVID-19 patients	No of rooms contaminated	3	2	NR	NR	Air outlets outside the room
Viral load							

Cheng, 2020b[17]	Hospital room with COVID-19 patient	Viral particles/m^3	4	0	NR	NR	4 scenarios: normal breathing, deep breathing, speaking, coughing
Chia, 2020[18]	Hospital rooms with COVID-19 patients	Viral particles/m^3	3	$1.84x10^3$-$3.38x10^3$			Three NIOSH samples per room (general ward) located 0.7, 0.9 and 1.2m from the floor and 1-2.1 away from COVID patients for 4hrs.
Ning, 2020[64]	Hospital for COVID-19 patients, patient areas	Viral particles/m^3/hr	11	0-113	NR	NR	Highest in ICU (two samples tested, yielding 31 and 113, but these were deposits rather than aerosols)
	Hospital for COVID-19 patients, medical areas	Viral particles/m^3/hr	13	0-42	NR	NR	Possibility of airborne transmission if the areas are small, not well ventilated and overcrowded
	Public areas: inside & outside the hospital	Viral particles/m^3/hr	11	0-11	NR	NR	Possibility of airborne transmission if the areas are small, not well ventilated and overcrowded
Zhou, 2020b[134]	Hospital areas with COVID-19 patients	Viral particles/m^3	14	10-1000	0	NR	

Survival of SARS-CoV-2 in air

Author	Surface	SARS-CoV-2	SARS-CoV	Comments
Van Doremalen, 2020[92]	Time virus viable in air	>3hrs	>3hrs	Aerosol transmission plausible for both viruses. The differences in epidemiology of these viruses are probably due to other factors e.g. asymptomatic transmission, higher viral loads

Transmission via fomites

Author, Year	Setting	Surface tested	Outcome measure	No of samples	No (%) of PCR +ve	No (%) of viable in culture	No (%) of intrapersonal transmission	Reviewer's comments
Contaminated surfaces								
Guo, 2020[29]	Areas housing COVID-19 patients	Different surfaces (floors, high touch, etc.)	No of contaminated surfaces	124 ICU 114 General	54 in ICU 9 in general ward	NR	NR	Possible transmission via fomites
Ong, 2020[66]	Areas housing COVID-19 patients	Different surfaces incl. toilet, floors and high touch	No of surfaces contaminated	25	15	NR	NR	Surfaces in patient room & toilet mostly contaminated: 12/14 & 3/5; anteroom and floor no contamination
Santarpia, 2020[81]	Areas housing COVID-19 patients	Different surfaces	% of surfaces contaminated	NR	80.4%	NR	NR	76.5% personal items and 81% toilet samples contaminated, less shedding on D8 and 9 than D5-7
Wang, 2020[93]	Areas housing COVID-19 patients	Surfaces	No of surfaces contaminated	36	0	-	NR	Cleaned w/ 1000mg/L Cl 4hrs in ICU and 8hrs in general wards
Zhou, 2020b[134]	Areas housing COVID-19 patients	Surfaces	No of surfaces contaminated	218	114	0		
Contaminated PPE								
Ong, 2020[66]	Clinical areas with COVID-19 patients	PPE (gown, visor, mask, shoes)	No of items contaminated	10	1	NR	NR	Only shoes contaminated
Ong, 2020b[67]	Clinical areas with COVID-19 patients	PPE (goggles, respirators, shoes)	No of items contaminated	90	0	-	NR	Usual care, no aerosol generating procedures
Wang, 2020[93]	Clinical areas with COVID-19 patients	PPE (respirators and gloves)	No of items contaminated	9	0	-	NR	
Total			No of items contaminated	**109**	**1 (0.9%)**	**NR**	**NR**	

Contaminated rooms								
Chia, 2020[18]	Clinical areas with COVID-19 patients	Surfaces in ICU and general wards (not specified)	No of contaminated rooms	30	17	NR	NR	No differences when stratified by symptoms, but higher contamination in the first week of illness
Viral load								
Cheng, 2020b[17]	Clinical areas with COVID-19 patients	Bedside bench	Viral load on surface	2	$6.5x10^2$/ml once 0 once	NR	NR	
Intrapersonal transmission								
Cai, 2020[8]	Shopping centre	Surfaces (not specified)	Number of cases	NR	NR	NR	28	Lack of contact between cases suggests indirect transmission via fomites

Survival of SARS-CoV-2 on different surfaces

Author	**Surface**	**SARS-CoV-2**	**SARS-CoV**	**Comments**
Chin, 2020[19]	Paper (printing & tissue)	<3hrs	-	Except for surgical mask, virus more stable on smooth vs porous surfaces
	Wood	<2d	-	
	Cloth	<2d	-	
	Glass	<4d	-	
	Bank note	<4d	-	
	Surgical mask	<7d	-	
	Plastic	<7d	-	

Van Doremalen, 2020[92]	Copper	<4hrs	8hrs	Aerosol and fomite transmission plausible for both viruses. The differences in epidemiology of these viruses are probably due to other factors e.g. asymptomatic transmission, higher viral loads
	Cardboard	24hrs	8hrs	
	Plastic	72hrs	72hrs	
	Stainless steel	72hrs	48hrs	

Vertical transmission

Author	Number of exposed babies	Number of COVID-19 positive mothers	Number of infected babies	Types of tissues tested by PCR for COVID-19 RNA presence					
				Cord blood	Amniotic fluid	Placenta	Serum	Breast milk	Vaginal secretions
Alzamora, 2020[5]	1	1	1[i]	NR	NR	NR	NR	NR	NR
Chen, 2020[10]	9	9	0	0/6	0/6	NR	NR	0/6	NR
Chen, 2020c[12]	5	5	0	NR	NR	NR	NR	NR	NR
Chen, 2020e[14]	4	4	0	NR	NR	NR	NR	NR	NR
Chen, 2020f[15]	3	3	0	NR	NR	0/3	NR	NR	NR
Dong, 2020[22]	1	1	1[ii]	NR	NR	NR	NR	NR	NR
Fan, 2020b[25]	2	2	0	0/2	0/2	0/2	NR	0/2	0/2
Han, 2020[31]	NR	NR	NR	NR	NR	NR	NR	0/1	NR
Iqbal, 2020[35]	1	1	0	NR	0 (1)	NR	NR	NR	NR
Khan, 2020[39]	17	17	2[iii]	NR	NR	NR	NR	NR	NR
Lee, 2020[42]	4	4	0	0/1	0/1	NR	NR	NR	NR
Li, 2020d[46]	2	3	0	NR	NR	NR	NR	NR	NR
Li, 2020j[52]	1	1	0	NR	NR	NR	NR	NR	NR

Liu, 2020[54]	19	19	0	0/19	0/19	NR	NR	NR	NR
Liu, 2020b[55]	3	3	0	NR	NR	NR	NR	NR	NR
Liu, 2020c[56]	13	14	0	NR	NR	NR	NR	NR	NR
Lowe, 2020[58]	1	1	0[iv]	NR	NR	NR	NR	NR	NR
Penfield, 2020[71]	32	32	0	NR	NR	3/11[ix]	NR	NR	NR
Peng, 2020b[73]	1	1	0	0/1	NR	0/1	0/1	0/1	NR
Pierce-Williams, 2020[75]	64	65	0	NR	NR	NR	NR	NR	NR
Wang, 2020b[94]	1	1	1[v]	0/1	NR	NR	NR	NR	NR
Wang, 2020e[97]	1	1	0	0/1	0/1	0/1	NR	NR	NR
Yan, 2020[113]	86	86	0	0/10	0/10	NR	NR	NR	0/6
Yang, 2020[114]	NR	20	0	NR	NR	NR	NR	NR	NR
Yang, 2020b[115]	6	6	0	0/4	0/4	NR	NR	NR	NR
Yu, 2020[117]	7	7	1[vi]	0/1	NR	0/1	NR	NR	NR
Zambrano, 2020[119]	1	1	0	NR	NR	NR	NR	NR	NR
Zeng, 2020[120]	6	6	2[vii]	NR	NR	NR	NR	NR	NR
Zeng, 2020[121]	33	33	3[viii]	0/NR	0/NR	0/NR	NR	NR	NR

Zhang, 2020c[124]	10	10	0	NR	NR	NR	NR	NR	NR
Zhu, 2020[133]	10	10	0	NR	NR	NR	NR	NR	NR
Total:	**364**	**367**	**11**	**0/46**	**0/44**	**3/19**	**0/1**	**0/10**	**0/8**
No of studies	**30**	**30**	**31**	**10**	**8**	**6**	**1**	**4**	**2**

i – baby separated from mother at birth, chest x-ray normal at this time, not tested at birth but +ve 16hrs later; ii – no tissues tested, but at 2hrs post-delivery SARS-CoV-2 antibodies were present in neonate, suggesting in utero exposure, neonate tested negative; iii – suspected vertical transmission, but authors stated that no convincing evidence of vertical transmission was found; iv – baby breastfed from the start, parents using contact precautions; v – baby tested +ve 36hrs after birth, no testing done at birth; vi - tested +ve after 36hrs, placenta and cord blood -ve, authors suggest no vertical infection; vii - two infants had elevated antibodies, but tested -ve for COVID-19; viii - 3 babies developed COVID-19: 2 of three within 2 days, the third baby septic and born w/ foetal distress but also infected Enterobacter, tested +ve for COVID-19 later. No babies were tested for COVID at birth and no samples blood cord, placenta and amniotic fluid +ve. Authors concluded vertical transmission cannot be ruled out; ix – authors suggested intrapartum exposure, although they also asserted that due to the mixing fluids and tissues during the delivery, contamination of placenta from maternal sources is also possible.

Transmission from infected body fluids – faecal matter

Author, Year	Sample	Outcome measure	No of samples	No of PCR +ve samples	No of samples viable in culture	No of documented transmissions	Reviewer's comments
Anal swab							
No of individuals							
Cui, 2020[21]	Anal swab	No of positive individuals	35	1	NR	NR	
Fan, 2020b[25]	Anal swab	No of positive individuals	1	1	NR	NR	Up to D28
Jiang, 2020[36]	Anal swab	No of positive individuals	1	1	NR	NR	Persistently +ve
Li, 2020c[45]	Anal swab	No of positive individuals	1	1	NR	NR	
Peng, 2020[72]	Anal swab	No of positive individuals	7	2	NR	NR	
Tan, 2020[88]	Anal swab	No of positive individuals	1	1	NR	NR	Up to D23
Xu, 2020[112]	Anal swab	No of positive individuals	10	8	NR	NR	Up to 1 month
Zhang, 2020e[126]	Anal swab	No of positive individuals	16	10	NR	NR	4/16 +ve on day 0, 6/16 +ve on day 5
Total:			**72**	**25 (35%)**	**NR**	**NR**	
No of samples							
Wu, 2020[101]	Anal swab	No of positive samples	120	12	NR	NR	clearance in digestive tract occurs after the OP swabs -ve
Total:			**120**	**12 (10%)**	**NR**	**NR**	
Stool							
No of individuals							

Chen, 2020f[15]	Stool	No of positive individuals	42	28	NR	NR	
Han, 2020[31]	Stool	No of positive individuals	2	2	NR	NR	
Jiehao, 2020[38]	Stool	No of positive individuals	6	5	NR	NR	
Li, 2020h[50]	Stool	No of positive individuals	13	2	NR	NR	Up to 15 days after discharge
Ling, 2020[53]	Stool	No of positive individuals	66	11	NR	NR	Convalescent patients
Pan, 2020[68]	Stool	No of positive individuals	2	0	NR	NR	
Park, 2020[69]	Stool	No of positive individuals	1	1	NR	NR	1 child known COVID-19 +ve, stool positive until D17, after symptoms resolved
Tan, 2020b[89]	Stool	No of positive individuals	10	3	NR	NR	From D16 onwards
Tang, 2020[90]	Stool	No of positive individuals	1	1	NR	NR	Multiple exposures, stool +ve 17-24 days after exposure, otherwise asymptomatic
To, 2020[91]	Stool	No of positive individuals	15	4	NR	NR	
Wang, 2020c[95]	Stool	No of positive individuals	17	11	NR	NR	Up to 40 days
Wu, 2020d[104]	Stool	No of positive individuals	74	41	NR	NR	Samples +ve up to mean 28d after symptom onset, max 47d
Xiao, 2020[108]	Stool	No of positive individuals	73	39	NR	NR	39/73 patients had +ve stool samples for up to 12d, persisted after respiratory samples -ve
Xing, 2020[111]	Stool	No of positive individuals	3	3	NR	NR	Up to 20d after NP samples _ve
Zhang, 2020[122]	Stool	No of positive individuals	14	5	NR	NR	Delay of few days after OP samples +ve
Zhang, 2020d[125]	Stool	No of positive individuals	3	3	NR	NR	OP swabs -ve but anal swabs +ve from day 10 onwards

Zhang, 2020i[130]	Stool	No of positive individuals	1	1	NR	NR	
Zheng, 2020[131]	Stool	No of positive individuals	96	55	NR	NR	Low at the onset and increasingly more prevalent up to 3 weeks from the onset
Total:			**439**	**215 (49%)**	**NR**	**NR**	
No of samples							
Wang, 2020d[96]	Stool	No of positive samples	153	44	2/4	NR	Multiple samples from patients, first +ve faecal sample on D7
Wu, 2020[101]	Stool	No of positive samples	244	24	NR	NR	clearance in digestive tract occurs after the OP swabs -ve
Zhang, 2020h[129]	Stool	No of positive samples	NR	NR	1/1	NR	Culturable virus isolated
Total:			**397**	**68 (17%)**	**3/5 (60%)**	**NR**	
Sewage							
Ahmed, 2020[3]	Sewage	No of positive samples	9	2	0/2	NR	A different assay used returned no positive samples
Medema, 2020[62]	Sewage	No of positive samples	18	15	NR	NR	Results in table 3: samples collected in Feb were before epidemic and were all -ve. Once the epidemic started 15/18 were +ve by at least one of four probes
Wang, 2020[93]	Sewage	No of positive samples	5	4	0/4	NR	PCR +ve but not viable in culture
Wurtzer, 2020[105]	Sewage – untreated	No of positive samples	23	23	NR	NR	
	Sewage – treated		8	6	NR	NR	
Total:			**65**	**50 (77%)**	**0/6**	**NR**	

Transmission from infected body fluids – ocular tissues and secretions

Author, Year	Sample	Outcome measure	No of samples	No of PCR +ve samples	No of samples viable in culture	No of documented transmissions	Reviewer's comments
Tears							
Seah, 2020[85]	Tears	No of people with positive samples	17	0	-	-	0/64 samples -ve, no patients had ocular symptoms
Xie, 2020[110]	Tears	No of people with positive samples	33	2	NR	NR	Authors speculated that low number of cases was due to most samples taken >week after symptoms started. The positive samples were collected 4 and 5 days after symptoms
Total:			**50**	**2 (4%)**			
Ocular discharge							
Zhang, 2020f[127]	Ocular discharge	No of people with positive samples	72	1	NR	NR	
Total:			**72**	**1 (1.4%)**			
Conjunctival swab							
Chen, 2020b[11]	Conjunctival swab	No of people with positive samples	1	1	NR	NR	
Sun, 2020b[87]	Conjunctival swab	No of people with positive samples	72	1	NR	NR	2/72 had conjunctivitis, 1 of 2 tested +ve, mean day eyes tested 18D
Wu, 2020b[102]	Conjunctival swab	No of people with positive samples	28	2	NR	NR	12/28 had ocular symptoms

Xia, 2020[105]	Conjunctival swab	No of people with positive samples	30	1	NR	NR	Average time from symptom to swab taken approx. 7 days
Zhou, 2020[132]	Conjunctival swab	No of people with positive samples	63	3			2/3 probable and one definite. None of 3 patients displayed ocular symptoms. 1/63 patients had ocular symptoms but tested -ve
Total:			**194**	**8 (4%)**			
Ocular swab							
Colavita, 2020[20]	Ocular swab	No of people with positive samples	1	1	NR	NR	
Total:			**1**	**1 (100%)**			

Evidence for virus entering via ocular surface

Author	**Outcome measure**	**No exposed**	**No infected**	**Comments**
Li, 2020g[49]	No of positive individuals	2	2	Two case studies: 1) anaesthetist tended to undiagnosed COVID-19 patient with routine PPE (no goggles), developed conjunctivitis on D3 and developed pneumonia days later; 2) nurse from fever clinic developed conjunctivitis and later developed pneumonia Both suspected transmission via conjunctiva, subsequently infecting respiratory tract via nasolacrimal duct system
Zhang, 2020f[127]	No of positive individuals	1	1	Occupational transmission, nurse reported wearing respirator at all times but sometimes without goggles and touching her eyes. Developed conjunctivitis (+ve for COVID) and later developed pneumonia. Not possible to determine the source of virus

Transmission from infected body fluids – sexual body fluids

Author, Year	Sample	Outcome measure	No of samples	No of PCR +ve samples	No of samples viable in culture	No of documented transmissions	Reviewer's comments
Semen							
Li, 2020b[44]	Semen	No of positive samples	38	6	NR	NR	NR
Vaginal							
Cui, 2020[21]	Vaginal swab	No of positive samples	35	0	NR	NR	NR
Qiu, 2020b[79]	Vaginal fluid	No of positive samples	10	0	NR	NR	NR

Transmission from infected body fluids – urine

Author, Year	Sample	Outcome measure	No of samples	No of PCR +ve samples	No of samples viable in culture	No of documented transmissions	Reviewer's comments
No of positive individuals							
Han, 2020[31]	Urine	No of positive individuals	2	1	NR	NR	
Jiehao, 2020[38]	Urine	No of positive individuals	2	0	n/a	n/a	
Ling, 2020[53]	Urine	No of positive individuals	58	4	NR	NR	
Pan, 2020[68]	Urine	No of positive individuals	2	0	n/a	n/a	
Peng, 2020[72]	Urine	No of positive individuals	7	1	NR	NR	
To, 2020[91]	Urine	No of positive individuals	10	0	n/a	n/a	
Zhang, 2020i[130]	Urine	No of positive individuals	1	0	NR	NR	
Zheng, 2020[131]	Urine	No of positive individuals	67	1	NR	NR	
Sun, 2020[135]	Urine	No of positive individuals	1	1	1	NR	
Total:			**150**	**8**	**1**	**NR**	
No of positive samples							
Chen, 2020f[15]	Urine	No of positive samples	10	0	n/a	n/a	
Wang, 2020d[96]	Urine	No of positive samples	72	0	n/a	NR	
Total:			**82**	**0**	**NR**	**NR**	

Dynamics of SARS-CoV-2 transmission

Author, year	Index case(s)	Type of exposure	Number exposed	Number infected	Subsequent cases*	Comments
Bai, 2020[6]	1 family member traveling from Wuhan	Family gatherings	5	5	NR	One apparently asymptomatic patient met up with family to visit someone in hospital. No cases of COVID in the area then
Burke, 2020[7]	10 patients w/ travel history	Household	19	2	0	
		Community	104	0	n/a	Defined as at least 10min contact at 6 feet or less
		Healthcare	100	0	n/a	defined as at least 10min contact at 6 feet or less in the shared room or up 2 two hrs in the same airspace (e.g. examination room after COVID patient was seen)
		Healthcare workers	222	0	n/a	Anyone who came to contact with patient or their infectious material
Cheng, 2020[16]	100 COVID +ve patients	Household	151	10	NR	
		Family gatherings	76	5	NR	
		Healthcare	698	6	NR	
		Other	1836	1	NR	
Dong, 2020b[23]	Multiple index cases	Exposure from family	NR	59	NR	A total of 101 cases with no exposure to Wuhan or other endemic areas, infected locally. Cases stratified into the type of exposure.
		Exposure in public places	NR	28	NR	
		Exposure at work	NR	12	NR	
		Exposure not identified	NR	2	NR	
Gan, 2020[27]	NR	Household	NR	914	NR	Not possible to determine index cases and no of exposed individuals. This is a breakdown of 1052 cases where it was possible to determine their source of infection.
		Family gatherings		12		
		Public transport		7		
		Other gatherings		6		

		Public spaces		5		
		Work		2		
Ghinai, 2020[28]	1 returning from China	Household	1	1	0	Community and healthcare contacts were those of the wife or the husband she infected
		Community	152	0	n/a	
		Healthcare	195	0	n/a	
Han, 2020[31]	1 family member	Household	6	4	NR	One family member infected others, not possible to determine who was the index case and where the infection came from
Heinzerling, 2020[32]	1 undiagnosed patient	Healthcare	121	3	NR	Patient not suspected of COVID, managed with standard precautions, underwent multiple AGPs. Those infected spent more time w/ patient, performed physical examinations and were present during AGPs
Huang, 2020[33]	1 patient travelling from Wuhan	Family gathering	7	1	NR	One who got sick stayed with index patient for approx. 30 min; in a poorly ventilated room with doors and windows closed
		Gatherings with friends	15	6	NR	Those who got sick were sitting in a direct flow of the air conditioning in the restaurant where they had dinner
Huang, 2020b[34]	1 family member, returning from Wuhan	Household	2	2	n/a	Three cases infected at dinner transmitted the virus to one household member and 3 relatives at another family dinner
		Family gatherings	8	3	4	
Jiang, 2020b[37]	2 patients travelling from Wuhan	Household	4	2	4	The infected household contacts further infected 2 family members from another household 2/4 and one member of the third household (who went on and infected 1 of 4 of his household)
Kong, 2020[40]	16 patients	Household or family gathering	NR	7	NR	Not possible to determine the exact number of household and family contacts
		Gathering with friends	NR	3	NR	
Le, 2020[41]	1 patient in contact w/ Wuhan	Household	6	1	NR	One grandmother living with husband and two children, infected neonate who stayed with them for few days, parents of the neonate not infected
Li, 2020[44]	1 patient changing trains at Wuhan station	Family gatherings	2	2	NR	One patient travelled via Wuhan station where he most likely was infected. He infected his two daughters, a son-in-law he was caring for in hospital and the neighbouring patient. The neighbouring patient infected
		Caring for family in hospital	1	1	0	

		Neighbouring patient	1	1	1	
Li, 2020e[47]	1 patient	Household	5	4	NR	index patient travelled to his home where he infected 4/5 household members
Li, 2020f[48]	105 patients	Household	392	64	NR	Other exposure routes not explored
Liu, 2020[54]	Wife returning from Wuhan	Household	1	1	0	
Luo, 2020[60]	1 patient returning from Wuhan	Public bath	NR	8	NR	Index patient showered in a public bath centre (already symptomatic w/ cough), patients who were infected visited the centre 1-6 days after the index patient. Authors suggest the survival of virus in hot, humid environments
McMichael, 2020[61]	Not identified	Residents in facility A	Approx. 130 (118 tested)	101		One care home resident found infected, had no travel history or contact w/ known COVID case. By the time COVID suspected, at least 45 staff and residents displayed symptoms. Not possible to determine the index case or who infected whom.
		Staff in facility A	NR	50		
		Visitors to facility A	NR	16		
Ng, 2020[63]	2 patients on a flight from Wuhan to Singapore	Passengers on the flight	92	2	0	Everyone wore masks, one tested positive and one inconclusive (tested +ve for one gene but not another), both on D3
Okada, 2020[65]	2 patients on 2 flights from Wuhan	Travel with the same tour group	34	0	n/a	Index patients not symptomatic at the time of boarding, so no PPE used, flights approx. 4hrs
		Passengers on flight 2 rows before and after	30	0	n/a	
		Crew members	18	0	n/a	
		Airport health officer	2	0	n/a	
Park, 2020b[70]	Not identified	11th floor employees	216	94		Outbreak in a call centre on 11th floor. Commercial/residential building. Commercial: floors 1-11 (call centre with outbreak 7-9 &11), residential

		Employees on other floors	706	3		floors 12-19. Most of the infected people from the 11th floor were on the same side of the building. 225 household contacts of 97 patients followed up, 34/225 +ve. Residents and employees had frequent contact in the lobby and elevators.
		Residents	201	0		
		Visitors	20	0		
Phan, 2020[74]	1 patient returning from Wuhan	Family sharing hotel room	2	1	NR	The family travels to four cities in Vietnam, close contacts were those on a plane, train and taxis
		Close contacts	28	0	n/a	
Pung, 2020[76]	A tour group from China	Shop assistants	17	5	3	At least 5/20 in the tour group symptomatic. Shop assistants reported assisting the tourists, 4/5 applying medicinal oil to their hands (30min visit), 1/5 assisting in a jewellery store (1hr visit).
	17 conference attendees from China	Conference attendees	94	7	13	Internal conference for an international company: 17 attendees were from China and at least 1 from Wuhan – not possible to determine the index case. Close interactions with cases during dining, breakout sessions and team building activities (with physical contact). Other close contacts (e.g. hotel staff) monitored but did not develop symptoms
	Chinese couple from Wuhan attending church	Attended the same church service	140	3	0	Two +ve cases attended the service as the index couple, another +ve case attended the church later but sat in the seat occupied by one of the index cases
Qian, 2020b[77]	2 infected in a temple	Family gatherings	4	3	3	Four cases exposed via family visit later had a family dinner with 3 relatives – all three subsequently infected
Qiu, 2020[78]	29 index cases	household	NR	31	5	Total of 24 clusters. Family gatherings: 2/4 infected family members later infected 2 of their household contacts. Work: infected the colleague who later infected 3 of his household members. Public transport: One of the passengers later transmitted the virus to his sister over dinner
		Family gatherings	NR	4	2	
		Work	NR	1	3	
		Public transport	NR	7	1	
Rothe, 2020[80]	Pre-symptomatic business partner from China	Work	NR	2	2	Pre-symptomatic index case infected two people, two other people had no contact with index, thus infected by the cases
Schwierzeck, 2020[83]	1 index patient	Nosocomial	NR	47		28 HCWs, 12 patients and 7 accompanying persons infected. Type of exposure was either cumulative 15-minutes face-to-face contact without usage of PPE (patients or their carers) or HCWs exposed during treatment or nursing in a distance of ≤ 2 meters, without PPE (HCWs)

Scott, 2020[84]	1 index, returned from Wuhan	Sharing the car to/from work	5	0	n/a	No cases infected despite close contact. Authors concluded it may have been due to mild symptoms (non-productive cough only)
		HCWs	3	0	n/a	
		Household	2	0	n/a	
		Intimate contact	1	0	n/a	
		HCWs, medium risk exposure	5	0	n/a	
Song, 2020[86]	4 index cases with direct or indirect contact with Wuhan	Household	20	19		Not possible to determine if index cases infected others
Wang, 2020f[98]	85 index patients	Household	155	47		85 index patients distributed among 76 households
Wei, 2020[99]	6 index patients (6 clusters)	Singing practice	NR	1	NR	Six clusters, cluster A excluded from data extraction as already included in Pung, 2020. Household included three separate clusters, each with one index and one infected case. In the church cluster, infected cases sat one row behind the index patient
		Household	NR	3	NR	
		Church service	NR	2	NR	
		Gathering with friends	NR	1	NR	
Wei, 2020b[100]	Two surgical patients	Hospital environment	NR	14 some infected via contact with staff, not possible to determine		Staff had either direct or indirect contact with patients, no staff wore PPE as patients were pre-symptomatic and not suspected COVID-19 +ve
Wu, 2020c[103]	Not determined	Department store	NR	25	15	There were 6 employees affected – not possible to determine whether there was only one index case between them. The areas where they worked were on the same floor and close to each other. There were further 19 cases of customers infected. These 25 further infected 15 cases
Xia, 2020b[107]	Index case with travel history to Wuhan	Family gathering	15	7	2	Multiple exposures for the family, having meals together, sometimes staying in the house, one case with whom index had dinner a few times infected 2 of her household members
		Friends gathering	60	0	0	
Xiao, 2020b[109]	2 index cases, infected at the gym	Friends gathering	NR	3		Two cases had multiple exposures at the gym (COVID cases were linked to the gym later), both had contact with one case, and the three of them travelled together to another city. On arrival, one index case had dinner with four friends, 2/4 were later found infected – 3hr exposure with

						possibilities for transmission via droplets and direct contact when touching each other's hands.
Yong, 2020[116]	2 index cases from Wuhan	1. Church A service	NR	5 (or 4)	0 (or 1)	Five people infected. One case – not possible to determine whether infected from index cases or another infected person. One case responsible for outbreak 2
		2. Family gathering	NR	6	1	One case responsible for infecting their family member and also for starting outbreak 3
		2. Church B service	NR	9	7	Nine cases infected in the church who then infected another 7 cases
Yu, 2020b[118]	2 family members travelled from Wuhan	Family gatherings	2	2	n/a	Two pre-symptomatic patients travelled from Wuhan and stayed with the family,
Zhang, 2020b[123]	Not identified	Supermarket employees	120	11	12	8,437 people screened, 120 employees (full time and temporary), 8,224 customers and 93 close family contacts of the infected cases.
		Customers	8224	2	NR	
Zhang, 2020g[128]	Index patient returning to China	Household	2	1	n/a	One woman returning from Singapore to China found +ve. All close contacts isolated. Passengers included those in the same row or up to 2 rows from patient. Flight attendant served the patient on a plane. Retrospective tracing revealed index had contact with COVID+ve cases in China before traveling to Singapore
		Passengers on a plane	5	0	n/a	
		Flight attendant	1	0	n/a	
	5 Wuhan passengers	Non-Wuhan passengers	220	1	n/a	110 Wuhan passengers travelled together as a part of a tour group to Singapore and Malaysia (10hr + 4 hr flights). 5 were found +ve and probable index cases. The non-Wuhan passenger sat next to infected case on a returning flight.
		Flight attendants	11	0	n/a	
		Wuhan passengers	105	6	NR	

* Defined as those with no exposure to index case, infected from the person infected by index case

Household – living at the same property, family gathering – meeting with other family members, e.g. family meals (in or out), family visits, traveling together

Appendix 7: Excluded studies table

Citation	reason
Abduljalil J.M., Abduljalil B.M. Epidemiology, genome, and clinical features of the pandemic SARS-CoV-2: a recent view. New Microbes New Infect, 2020; 35:no pagination	no primary data
Acuna-Zegarra M.A., Santana-Cibrian M., Velasco-Hernandez J.X. Modeling behavioral change and COVID-19 containment in Mexico: A trade-off between lockdown and compliance. Math Biosci, 2020; 108370.	no primary data
Adekunle I.A., Onanuga A.T., Akinola O.O. et al. Modelling spatial variations of coronavirus disease (COVID-19) in Africa. Sci Total Environ, 2020; 729:no pagination	no primary data
Advani S.D., Smith B.A., Lewis S.S. et al. Universal masking in hospitals in the COVID-19 era: Is it time to consider shielding? Infect Control Hosp Epidemiol, 2020; 1-2	no primary data
Agalar C., Ozturk Engin D. Protective measures for covid-19 for healthcare providers and laboratory personnel. Turk J Med Sci, 2020; 50(SI-1):578-584	no primary data
Ali Y., Alradhawi M., Shubber N. et al. Personal protective equipment in the response to the SARS-CoV-2 outbreak - A letter to the editor on World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). Int J Surg, 2020; 76:71-6	no primary data
Amirian E.S. Potential Fecal Transmission of SARS-CoV-2: Current Evidence and Implications for Public Health. Int J Infect Dis, 2020; no pagination	no primary data
Anderson E.L., Turnham P., Griffin J.R. et al. Consideration of the Aerosol Transmission for COVID-19 and Public Health. Risk Anal, 2020; 40(5):902-907	no primary data
Anderson R.M., Heesterbeek H., Klinkenberg D. et al. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet, 2020; 395(10228):931-934	no primary data
Arons M.M., Hatfield K.M., Reddy S.C. et al. Presymptomatic SARS-CoV-2 Infections and Transmission in a Skilled Nursing Facility. N Eng J Med, 2020	no data on transmission
Au Yong P.S., Chen X. Reducing droplet spread during airway manipulation: lessons from the COVID-19 pandemic in Singapore. Brit J Anaesth, 2020; no pagination	no data on transmission
Auler A.C., Cassaro F.A.M., da Silva V.O. et al. Evidence that high temperatures and intermediate relative humidity might favor the spread of COVID-19 in tropical climate: A case study for the most affected Brazilian cities. Sci Total Environ, 2020; 731:139178	no primary data
Azap A., Erdinc F.S. Medical mask or N95 respirator: When and how to use? Turk J Med Sci, 2020; no pagination	no primary data
Baettig S.J., Parini A., Cardona I. et al. Morand GB. Case series of coronavirus (SARS-CoV-2) in a military recruit school: clinical, sanitary and logistical implications. BMJ Mil Health, 2020	no data on transmission
Bahl P., Doolan C., de Silva C. et al. Airborne or droplet precautions for health workers treating COVID-19? J Infect Dis, 2020	no primary data
Balachandar V., Mahalaxmi I., Kaavya J. et al. COVID-19: Emerging protective measures. Eur Rev Med Pharmacol Sci, 2020; 24(6):3422-3425	no primary data
Balachandar V., Mahalaxmi I., Subramaniam M. et al. Follow-up studies in COVID-19 recovered patients - is it mandatory? Sci Total Environ, 2020; 729:139021	no primary data
Banik R.K., Ulrich A.K. Evidence of short-range aerosol transmission of SARS-CoV-2 and call for universal airborne precautions for anesthesiologists during the COVID-19 pandemic. Anesth Analg, 2020	no primary data
Bi Q., Mei S., Ye C. et al. Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study. Lancet Infect Dis, 2020; no pagination	no data on transmission
Bonato G., Dioscoridi L., Mutignani M. Faecal-oral transmission of SARS-COV-2: practical implications. Gastroenterology, 2020	no primary data
Britton P.N., Marais B.J. Questions raised by COVID-19 case descriptions. J Paediatr Child Health, 2020; 56(4): 652	no primary data
Briz-Redon A., Serrano-Aroca A. A spatio-temporal analysis for exploring the effect of temperature on COVID-19 early evolution in Spain. Sci Total Environ, 2020; 728:138811	no primary data
Broderick D., Kyzas P., Sanders K. et al. Surgical tracheostomies in Covid-19 patients: important considerations and the "5Ts" of safety. Br J Oral Maxillofac Surg, 2020; 58(5): 585–589	no data on transmission
Brown J, Pope C. Personal protective equipment and possible routes of airborne spread during the COVID-19 pandemic. Anaesthesia, 2020; 75(8):1116-1117.	no primary data
Bulut C, Kato Y. Epidemiology of COVID-19. Turk J Med Sci, 2020; 50(SI-1):563-570	no primary data
Cabrini L., Landoni G., Zangrillo A. Minimise nosocomial spread of 2019-nCoV when treating acute respiratory failure. Lancet, 2020; 395(10225):685	no primary data

Cai S.J., Wu L.L., Chen D.F. et al. Analysis of bronchoscope-guided tracheal intubation in 12 cases with COVID-19 under the personal protective equipment with positive pressure protective hood. Chinese Chin J Tuberc Resp Dis, 2020; 43(0):E033	no data on transmission
Canova V., Lederer Schlapfer H., Piso R.J. et al. Transmission risk of SARS-CoV-2 to healthcare workers - observational results of a primary care hospital contact tracing. Swiss Med Wkly, 2020; 150:w20257	not possible to retrieve
Cao Q., Chen Y.-C., Chen C.-L. SARS-CoV-2 infection in children: Transmission dynamics and clinical characteristics. J Formos Med Assoc, 2020; 119(3):670-673	no primary data
Carducci A., Federigi I., Liu D. et al. Making waves: Coronavirus detection, presence and persistence in the water environment: State of the art and knowledge needs for public health. Water Res, 2020; 179:115907	no primary data
Celik I., Saatci E., Eyuboglu F.O. Emerging and reemerging respiratory viral infections up to covid-19. Turk J Med Sci, 2020; 50(SI-1):557-562	no primary data
Chang D., Lin M., Wei L. et al. Epidemiologic and Clinical Characteristics of Novel Coronavirus Infections Involving 13 Patients Outside Wuhan, China. JAMA, 2020; 323(11):1092-1093	no data on transmission
Chang D., Xu H., Rebaza A. et al. Protecting health-care workers from subclinical coronavirus infection. Lancet Respir Med, 2020; 8(3):e13	no primary data
Chen C, Gao G, Xu Y, et al. SARS-CoV-2-positive sputum and feces after conversion of pharyngeal samples in patients with COVID-19. Ann Intern Med, 2020; M20-0991	no data on transmission
Chen D, Xu W, Lei Z, et al. Recurrence of positive SARS-CoV-2 RNA in COVID-19: a case report. Int J Infect Dis, 2020; 93:297-299	no data on transmission
Chen M.-J., Chang K.-J., Hsu C.-C. et al. Precaution and Prevention of Coronavirus Disease 2019 (COVID-19) Infection in the Eye. J Chin Med Assoc, 2020; no pagination	no primary data
Chen P., Zhang Y., Wen Y. et al. Epidemiological and clinical characteristics of 136 cases of COVID-19 in main district of Chongqing. J Formos Med Assoc, 2020; 119(7):1180-1184	no data on transmission
Chen X., Tian J., Li G. Initiation of a new infection control system for the COVID-19 outbreak. Lancet Infect Dis, 2020; 20(4):397-398	no data on transmission
Chen X., Liu Y., Gong Y. et al. Perioperative Management of Patients Infected with the Novel Coronavirus: Recommendation from the Joint Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists. Anesthesiology, 2020; 132(6): no pagination	no primary data
Chen Y, Li L. SARS-CoV-2: virus dynamics and host response. Lancet Infect Dis, 2020; 20(5):515-516	no primary data
Cheng V.C.-C., Wong S.-C., Chuang V.W.-M. et al. The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. J Infect, 2020; 81(1):107–114	no data on transmission
Cheung J.C., Ho L.T., Cheng J.V. et al. Staff safety during emergency airway management for COVID-19 in Hong Kong. Lancet Respir Med, 2020; 8(4):e19	no primary data
Choi S.-H., Kim H.W., Kang J.-M. et al. Epidemiology and clinical features of coronavirus disease 2019 in children. Korean J Pediatr, 2020; 63(4):125-132	no primary data
Chou R., Dana T., Buckley D.I. et al. Epidemiology of and Risk Factors for Coronavirus Infection in Health Care Workers: A Living Rapid Review. Ann Intern Med, 2020; 173(2):120-136	no primary data
Chow V.L.Y., Chan J.Y.W., Ho V.W.Y. et al. Tracheostomy during COVID-19 pandemic-Novel approach. Head Neck, 2020; 1-7	no data on transmission
Cook T.M. Personal protective equipment during the coronavirus disease (COVID) 2019 pandemic - a narrative review. Anaesthesia, 2020; 75(7):920-927	no primary data
Cordier P.-Y., De La Villeon B., Martin E. et al. Health workers' safety during tracheostomy in COVID-19 patients: Homemade protective screen. Head Neck, 2020; 42(7):1361-1362	no data on transmission
Corman V.M., Rabenau H.F., Adams O. et al. SARS-CoV-2 asymptomatic and symptomatic patients and risk for transfusion transmission. Transfusion, 2020; 60(6):1119-1122	no primary data
Correia G., Rodrigues L., Gameiro da Silva M. et al. Airborne route and bad use of ventilation systems as non-negligible factors in SARS-CoV-2 transmission. Med Hypotheses, 2020; 141:(no pagination)	no primary data
Couper K., Taylor-Phillips S., Grove A. COVID-19 in cardiac arrest and infection risk to rescuers: A systematic review. Resuscitation, 2020; 151:59-66	no primary data
David A.P., Jiam N.T., Reither J.M. et al. Endoscopic Skull Base and Transoral Surgery During the COVID-19 Pandemic: Minimizing Droplet Spread with a Negative-Pressure Otolaryngology Viral Isolation Drape (NOVID). Head Neck, 2020; 1577-1582	no data on transmission
Day A.T., Sher D.J., Lee R.C. et al. Head and neck oncology during the COVID-19 pandemic: Reconsidering traditional treatment paradigms in light of new surgical and other multilevel risks. Oral Oncology, 2020; 105:104684	no primary data

De Simone B., Chouillard E., Di Saverio S. et al. Emergency surgery during the COVID-19 pandemic: what you need to know for practice. Ann R Coll Surg Engl, 2020; 102(5):323-332	no primary data
Desai A.N., Patel P. Stopping the Spread of COVID-19. JAMA, 2020; 323(15):1516	no primary data
Dexter F., Parra M.C., Brown J.R. et al. Perioperative COVID-19 Defense: An Evidence-Based Approach for Optimization of Infection Control and Operating Room Management. Anesth Analg, 2020;20:10.1213	no primary data
Dexter F., Elhakim M., Loftus R.W. et al. Strategies for daily operating room management of ambulatory surgery centers following resolution of the acute phase of the COVID-19 pandemic. J Clin Anesth, 2020; 64:109854	no primary data
Di Mascio D., Khalil A., Saccone G. et al. Outcome of Coronavirus spectrum infections (SARS, MERS, COVID 1 -19) during pregnancy: a systematic review and meta-analysis. Am J Obstet Gynecol, 2020; 100107	no primary data
Diaz-Quijano F.A., Rodriguez-Morales A.J., Waldman E.A. Translating transmissibility measures into recommendations for coronavirus prevention. Rev Saude Publica, 2020; 54:43	no primary data
Dietz L., Horve P.F., Coil D.A. et al. 2019 Novel coronavirus (CoviD-19) pandemic: Built environment considerations to reduce transmission. mSystems, 2020; 5(2):e00245-20	no primary data
Ding J., Fu H., Liu Y. Prevention and control measures in radiology department for COVID-19. Eur Radiol, 2020; 30(7): 3603–3608	no primary data
Ding S, Liang TJ. Is SARS-CoV-2 Also an Enteric Pathogen with Potential Fecal-Oral Transmission: A COVID-19 Virological and Clinical Review. Gastroenterology, 2020; 159(1):53–61	no primary data
Dona D., Minotti C., Costenaro P. et al. Fecal-oral transmission of sars-cov-2 in children: is it time to change our approach? Pediatr Infect Dis J, 2020; 39(7):e133-e134	no primary data
Dong Y., Mo X., Hu Y. et al. Epidemiology of COVID-19 among children in China. Pediatrics, 2020; 145(4):e20200702	no data on transmission
Duran P., Berman S., Niermeyer S. et al. COVID-19 and newborn health: systematic review. Rev Panam Salud Pública, 2020; 44:e54	no primary data
Eissenberg T., Kanj S.S., Shihadeh A.L. Treat COVID-19 as Though It Is Airborne: It May Be. AANA J, 2020; 88(3):29-30	no primary data
El Kassas M., Al Shafie A., Abdel Hameed A.S. et al. Emergency endoscopic variceal band ligation in a COVID-19 patient presented with hematemesis while on mechanical ventilation. Dig Endosc, 2020; 32(5):812-815	no data on transmission
Elli L., Rimondi A., Scaramella L. et al. Endoscopy during the Covid-19 outbreak: experience and recommendations from a single center in a high-incidence scenario. Dig Liver Dis, 2020; 52(6):606–612	no primary data
Fathizadeh H., Maroufi P., Momen-Heravi M. et al. Protection and disinfection policies against SARS-CoV-2 (COVID-19). Infez Med, 2020; 28(2):185-191	no primary data
Fattorini D, Regoli F. Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy. Environ Pollut, 2020; 264:114732	no data on transmission
Ferioli M., Cisternino C., Leo V. et al. Protecting healthcare workers from sars-cov-2 infection: Practical indications. Eur Respir J, 2020; 29(155):1-10	no primary data
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Yao Y., Tian Y., Zhou J. et al. Epidemiological characteristics of SARS-CoV-2 infections in Shaanxi, China by 8 February 2020. Eur Respir J, 2020; 55(4): no pagination	no data on transmission
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Yin S., Peng Y., Ren Y. et al. The implications of preliminary screening and diagnosis: Clinical characteristics of 33 mild patients with SARS-CoV-2 infection in Hunan, China. J Clin Virol, 2020; 128:104397	no data on transmission
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Yu Y.X., Sun L., Yao K. et al. Consideration and prevention for the aerosol transmission of 2019 novel coronavirus. Chin J Ophthalmol, 2020; 56:E008	no primary data
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Zhang J.-F., Yan K., Ye H.-H. et al. SARS-CoV-2 turned positive in a discharged patient with COVID-19 arouses concern regarding the present standard for discharge. Int J Infect Dis, 2020; 97:212-214	no data on transmission
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Zhang R., Li Y., Zhang A.L. et al. Identifying airborne transmission as the dominant route for the spread of COVID-19," by Renyi Zhang, Yixin. Proc Natl Acad Sc. U.S.A, 2020; 117, 14857–14863	major flaws in data collection & analysis
Zhao C., Viana A. Jr., Wang Y. et al. Otolaryngology during COVID-19: Preventive care and precautionary measures. Am J Otolaryngol, 2020; 102508	no primary data
Zhao S., Ling K., Yan H. et al. Anesthetic Management of Patients with COVID 19 Infections during Emergency Procedures. J Cardiothorac Vasc Anesth, 2020; 34(5):1125-1131	no data on transmission
Zhao Z., Li X., Liu F. et al. Prediction of the COVID-19 spread in African countries and implications for prevention and control: A case study in South Africa, Egypt, Algeria, Nigeria, Senegal and Kenya. Sci Total Environ, 2020; 729:138959	no primary data
Zheng Y., Xiong C., Liu Y. et al. Epidemiological and clinical characteristics analysis of COVID-19 in the surrounding areas of Wuhan, Hubei Province in 2020. Pharmacol Res, 2020; 157:104821	no data on transmission
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Appendix 8: GRADE table

Outcome	Type of outcome	No of studies	No of participants/ samples	Quality of studies	Overall classification of evidence	Overall effect	Overall decision for likelihood of transmission
Droplet transmission							
Epidemiological evidence for droplet transmission of SARS-CoV-2	Primary outcome	4	60[30] 90[51,59] ~340[82]	Low quality[i]	Inconsistent	3 of 4 studies provide some evidence for droplet transmission. Based on evidence from SARS and MERS this is considered a primary route	Probable
Airborne transmission							
Epidemiological evidence for airborne transmission of SARS-CoV-2	Primary outcome	4	60[30] 90[51,59] ~340[82]	Low quality[i]	Inconsistent	2 of 4 studies provide some evidence for airborne transmission.	Possible
Presence of SARS-CoV-2 in air	Secondary (surrogate) outcome	7	No of samples: 4,[17] 4,[26] 56,[29] NR,[81] 31[134] No of rooms: 3,[18] 3,[66]	Not assessed[ii]	Inconsistent	3 of 5 studies found presence of viral RNA in air samples. 2 of 2 studies found presence of viral RNA in rooms.	
Presence of viable SARS-CoV-2 in air	Secondary (surrogate) outcome	2	NR,[81] 31[134]	Not assessed[ii]	Weak	0 of 2 studies found presence of viral RNA in air samples.	
Duration of viable SARS-CoV-2 in air	Secondary (surrogate) outcome	1	NR[92]	Not assessed[ii]	Weak	1 of 1 studies found evidence that virus can survive in air for up to 3hrs	

SARS-CoV-2 load in the air	Secondary (surrogate) outcome	4	4,[15] 3,[18] 35,[64] 14[134]	Not assessed[ii]	Inconsistent	3 of 4 studies found evidence of viral RNA with up to 1000 copies/m^3	
Fomite transmission							
Epidemiological evidence for transmission of SARS-CoV-2 via fomites	Primary outcome	2	NR,[8] 60[30]	Low quality[i]	Weak	2 of 2 studies provide some evidence for transmission via fomites	Possible
Presence of SARS-CoV-2 on surfaces	Secondary (surrogate) outcome	7	Contaminated surfaces: 238,[29] 25,[66] NR,[81] 36,[93] 218[134] Contaminated PPE: 10,[66] 90,[67] 9[93] Contaminated rooms: 30[18] Viral load: 2[17]	Not assessed[ii]	Moderate[iii]	4 of 5 studies found evidence of viral RNA on surfaces, one study showed no results but also reported frequent cleaning 1 of 3 studies found evidence of viral RNA on PPE. Only 1/109 samples contaminated with virus 1 of 1 studies found evidence of viral RNA in rooms 1 of 1 studies found evidence of viral RNA $6.5x10^2$/ml once and 0 next time	
Presence of viable SARS-CoV-2 on surfaces	Secondary (surrogate) outcome	1	114[134]	Not assessed[ii]	Weak	1 of 1 studies found no evidence of viable virus on surfaces	
Survival of viable SARS-CoV-2 on surfaces	Secondary (surrogate) outcome	2	NR,[19] NR[92]	Not assessed[ii]	Weak	2 of 2 studies found evidence that virus can survive on different	

						surfaces. The time of survival depends on type of surface	
Vertical transmission							
Epidemiological evidence for vertical transmission of SARS-CoV-2	Primary outcome	30	Total 367[5,10,12,14,15,22,24,31,35,39,42,46,52,54,55,56,58,71,73,75,94,113-115,117,119-121,124,133]	Low quality[i]	Moderate[iii]	7/30 studies found 11/367 babies infected. However, these studies did not test for COVID-19 at birth, so there is a high risk that transmission occurred peripartum	Unlikely
Evidence for presence of SARS-CoV-2 RNA in maternal/neonatal tissues and products of conception	Secondary (surrogate) outcome	13	Total 467 for cord blood [25,42,54,73,94,97,113,115,117] Total 44 for amniotic fluid[10,25,35,42,54,97,113,115,121] Total 19 for placenta[15,25,71,73,97,117,121] Total 1 for serum[73] Total 10 for breast milk[10,25,31,73] Total 8 for vaginal secretions[25,113]	Low quality[i]	Moderate[iii]	1 of 13 studies found evidence for virus presence in these tissues. This study found 3 placentas with viral RNA but also reported that contamination could have occurred during delivery	
Transmission from body fluids							
Epidemiological evidence for transmission of SARS-CoV-2 from faecal matter	Primary outcome	0	n/a	n/a	No evidence	No evidence	Unlikely

Evidence of presence of SARS-CoV-2 RNA in faecal matter	Secondary (surrogate) outcome	32	No of individuals with positive anal swabs: total 72[21,25,36,45,72,88,112,126] No of positive anal swabs: 120[101] No of individuals with positive stool: total 439[15,31,38,50,53,68,69,89-91,95,104,108,111,121,125,130,131] No of positive stool samples: total 397[96,101,129] No of positive sewage samples: total 65[4,62,93,105]	All studies low quality[i] except,[4,62,93,105] which were not assessed[ii]	Moderate[iii]	31 of 32 studies found evidence of virus in anal swabs, stools or sewage. One study which did not find evidence of this was conducted on stool samples of two patients.	
Evidence of presence of viable SARS-CoV-2 virus in faecal matter	Secondary (surrogate) outcome	4	No of stool samples with viable virus: total 5[96,129] No of sewage samples with viable virus: total 6[4,93]	Low quality[i], [96,129] not assessed[ii] [4,93]	Weak	2 of 2 studies found evidence of viable virus in stool 0 of 2 studies found evidence of viable virus in sewage	
Epidemiological evidence for transmission of SARS-CoV-2 from urine	Primary outcome	0	n/a	n/a	No evidence	No evidence	Unlikely
Evidence of presence of SARS-CoV-2 RNA in urine	Secondary (surrogate) outcome	11	No of individuals with positive urine sample: total 150[31,38,53,68,72,91,130,131,135]	Low quality[i]	Moderate[iii]	5 of 9 studies found evidence of viral RNA in urine of 8/150 individuals	

			No of positive samples: total 82[15,96]			0 of 2 studies found evidence of viral RNA in urine samples (0/82)	
Evidence of presence of viable SARS-CoV-2 virus in urine	Secondary (surrogate) outcome	1	1[135]	Low quality[i]	Weak	1 of 1 studies found evidence for viable virus in one individual	
Epidemiological evidence for transmission of SARS-CoV-2 via ocular surface	Primary outcome	2	2,[49] 1[127]	Low quality[i]	Weak	2 of 2 studies found evidence for transmission via ocular surface in 3/3 individuals	Possible
Epidemiological evidence for transmission of SARS-CoV-2 from ocular secretions	Primary outcome	0	n/a	n/a	No evidence	No evidence	Unlikely
Evidence of presence of SARS-CoV-2 RNA in ocular secretions	Secondary (surrogate) outcome	9	No of individuals with positive tear samples: total 50[82,110] No of individuals with positive ocular discharge samples: 72[127] No of individuals with positive conjunctival swab samples: total 194[11,87,102,106,132] No of individuals with positive ocular swabs: total 1[20]	Low quality[i]	Moderate[iii]	1 of 2 studies found evidence for viral RNA in tears of 2/50 individuals 1 of 1 studies found evidence for viral RNA in ocular discharge of 1/72 individuals 5 of 5 studies found evidence for viral RNA in tears of 8/194 individuals 1 of 1 studies found evidence for viral RNA in tears of 1/1 individuals	

Evidence of presence of viable SARS-CoV-2 virus in ocular secretions	Secondary (surrogate) outcome	0	n/a	n/a	No evidence	No evidence	
Epidemiological evidence for transmission of SARS-CoV-2 from sexual body fluids	Primary outcome	0	n/a	n/a	No evidence	No evidence	Unlikely
Evidence of presence of SARS-CoV-2 RNA in sexual body fluids	Secondary (surrogate) outcome	3	Semen: 38[44] Vaginal fluid: 35[21] Vaginal swab: 10[79]	Low quality[i]	Weak	1 of 1 studies found evidence for viral RNA in semen of 6/38 of men 0 of 2 studies found evidence for viral RNA in vaginal fluid or swabs of 45 women	
Evidence of presence of viable SARS-CoV-2 virus in sexual body fluids	Secondary (surrogate) outcome	0	n/a	n/a	No evidence	No evidence	
Transmission dynamics							
Epidemiological evidence of SARS-CoV-2 transmission occurring within households	Secondary (surrogate) outcome	17	1119[7,16,27,28,31,34,37,41,47,48,52,78,84,86,98,99,128]	Low quality[i]	Moderate[iii]	Evidence shows that transmission usually occurs with close contact, although distance and duration has not been established. Transmission in healthcare settings is low and is usually due to no or	Suggest close contact transmission
Epidemiological evidence of SARS-CoV-2 transmission occurring between family and friends	Secondary (surrogate) outcome	14	179[6,16,23,27,33,34,40,43,74,77,78,107,116,118]	Low quality[i]	Moderate[iii]		
Epidemiological evidence of SARS-CoV-2 transmission occurring in workplaces	Secondary (surrogate) outcome	6	122[23,27,70,76,78,80]	Low quality[i]	Moderate[iii]		

Epidemiological evidence of SARS-CoV-2 transmission occurring in supermarkets and shopping centres	Secondary (surrogate) outcome	3	22[76,103,123]	Low quality[i]	Weak	inappropriate wear of PPE. Transmission in care homes high.	
Epidemiological evidence for SARS-CoV-2 transmission occurring during church service	Secondary (surrogate) outcome	3	NR[76,99,116]	Low quality[i]	Weak		
Epidemiological evidence for SARS-CoV-2 transmission occurring in acute healthcare settings	Secondary (surrogate) outcome	8	NR[7,16,28,32,43,83,84,100]	Low quality[i]	Moderate[iii]		
Epidemiological evidence for SARS-CoV-2 transmission occurring in care homes	Secondary (surrogate) outcome	1	NR[61]	Low quality[i]	Weak		
Epidemiological evidence for SARS-CoV-2 transmission occurring in other settings	Secondary (surrogate) outcome	11	NR[8,23,27,60,63,65,70,74,78,82,128]	Low quality[i]	Weak		

[I] – low quality due to study design – case studies/series
[II] – studies not assessed for quality (environmental surveys and experiments in laboratory settings)
[III] – low quality studies, but a relatively large number and show consistent results

Classification of the evidence	
Strong	Further research unlikely to change confidence in the estimate of the effect
Moderate	Further research may impact the estimate of the effect and may change its strength
Weak	Further research very likely to impact the estimate of the effect and change its strength
Inconsistent	Current studies show conflicting evidence, further research will very likely change the estimate of the effect

Appendix 9: Consultation

- TBC