Public Health England

Protecting and improving the nation's health

COVID-19 transmission from the deceased

A rapid review

Contents

Main messages

1. The purpose of this rapid review was to identify and examine evidence on the risk of transmission from handling the bodies of deceased persons with suspected or confirmed coronavirus (COVID-19). The review includes 12 studies (including one preprint): 4 observational studies (with laboratory components) and 8 laboratory studies in autopsy settings (search up to 17 March 2021).

2. Evidence from laboratory studies conducted in autopsy settings suggests that Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) can persist in body fluids from the respiratory tract of deceased persons with confirmed COVID-19. However, more research is needed to understand the risk of transmission from contact with the body fluids of deceased persons with COVID-19 and its association with factors such as disease severity, disease duration and post-mortem interval.

3. Evidence from 3 case series suggests that the risk of transmission from the deceased in autopsy settings with strict infection control protocols is low. Evidence from a prevalence study in mortuary and cemetery workers in Qatar showed high infection rates, although the results suggested that transmission might have occurred in the community rather than from handling bodies of COVID-19 cases.

4. No epidemiological investigations reporting on transmission from handling bodies of COVID-19 cases were identified, potentially indicating that clusters of COVID-19 infection amongst persons handling the bodies of the deceased has not been reported. However, this does not constitute evidence of absence of risk.

5. Nearly all studies were conducted in autopsy settings and contained small samples, which limits their applicability to non-clinical settings. In particular, the level of infection control measures in place in these studies do not allow us to infer whether there is a risk of transmission from handling the bodies of deceased persons with suspected or confirmed COVID-19.

Background

A number of guidance documents on how to manage the body of deceased persons with suspected or confirmed COVID-19 have been issued by national and international organisations, such as the World Health Organization (WHO) (1), the European Centre for Disease Prevention and Control (ECDC) (2) and Public Health England (PHE) (3). The recommendations vary depending on the level of interaction with the body and on the setting (such as healthcare, care homes or household), including the level of personal protective equipment (PPE) to be used. In England, PPE requirements for handling bodies in non-clinical settings such as care homes include disposable gloves, disposable plastic aprons and fluid-resistant surgical masks, whilst eye and face protection should be worn only if there is a risk of contamination with splashes or droplets of blood or body fluids (3). The same level of PPE use is suggested for individuals in direct contact with the deceased in household settings, including those involved in faith-based rituals such as viewings and hygienic preparations. When performing autopsies and other invasive procedures, disposable gowns and FFP3 respirators are also recommended. In both non-clinical and autopsy settings, the use of body bags is only recommended in specific circumstances (excessive leaking of body fluids, etc), but should always be used when management of the deceased is performed by persons unfamiliar with appropriate safety protocols and PPE use (3). However, across all settings, the use of cloth wrappings and mouth barriers (cloth or mask) are suggested as a means to prevent droplet transmission from the respiratory tract and direct contact transmission.

A rapid systematic review on the safe management of bodies of deceased persons with suspected or confirmed COVID-19 conducted in the early stage of the COVID-19 pandemic by Yaacoub and others (search date up to 26 March 2020) remains the main reference on the safe management of the deceased (4). This review, which had been commissioned by the WHO to inform their guidance, did not identify direct evidence from the COVID-19 pandemic and mainly relied on existing guidance and on a study from the Severe Acute Respiratory Syndrome Coronavirus 1 (SARS-CoV-1) epidemic. Other reviews have since then been published, although they have mainly relied on guidelines and protocols (5 to 7).

COVID-19 is a respiratory disease which is mainly transmitted through respiratory particles that contain the SARS-CoV-2 virus. Whilst some risk of transmission via fomites (where transmission occurs through contact with infectious virus on surfaces) has been acknowledged, the risk is thought to be lower as compared to close contact or airborne transmission (8). However, the risk of transmission from the bodies of deceased persons with confirmed COVID-19 is still unclear. There are also some uncertainties on how long the virus can remain viable in the body after death and on whether this would be a risk for transmission. There is therefore a need to examine evidence on the risk of transmission from the bodies of deceased persons with suspected or confirmed COVID-19 in order to understand the risk for those handling these bodies.

Objective

The purpose of this rapid review was to identify and assess evidence from the COVID-19 pandemic to examine whether there is a risk of COVID-19 transmission associated with handling dead bodies with suspected or confirmed COVID-19 infection.

Methodology

A rapid review was conducted, following systematic methodologies but with shortcuts built in to accelerate the review process (9). Primary studies were identified through 2 different sources:

- one relevant systematic review which had been commissioned by the WHO to inform their guidance (search up to 26 March 2020) was identified (4) and used as a source for primary studies
- a literature search was undertaken to look for primary studies related to the COVID-19 pandemic, published (or available as preprint) between 26 March 2020 and 17 March 2021

Title and abstract screening was done in duplicate for 10% of the studies, and full text screening, data extraction and risk of bias assessment were conducted by one reviewer and checked by a second. Characteristics of included studies were tabulated and data combined in narrative review.

Risk of bias assessment was conducted using the Quality Criteria Checklist (QCC) tool which assesses the methodological quality of a study (10). Studies were given a quality rating of high, medium or low. Laboratory studies were not assessed.

Full details on the methodology are provided in Annexe A. A protocol was produced a priori and is available in Annexe C.

Evidence

Search results

The database searches returned 3,289 records and a further 17 studies were identified by citation analysis and Google Scholar searching. No primary studies from the COVID-19 pandemic had been identified in the systematic review by Yaacoub and others (4). After removal of duplicates, 1,762 records were screened by title and abstract. Of these, 79 full-text articles were assessed for eligibility and 12 were included in this review. A Preferred Reporting Items for Systematic Reviews and Analysis (PRISMA) diagram is provided in Annexe A.

Four studies were observational, one prevalence study (11) and 3 case series (12 to 14), of which 2 were conducted in Italy (12,13), one in Germany (14), and one in Qatar (11). These 4

studies reported on the potential risk of transmission when handling bodies of deceased persons with suspected or confirmed COVID-19, although 3 of them also included a laboratory component that reported on post-mortem SARS-CoV-2 persistency (12 to 14). The remaining 8 studies (of which one was a preprint) were laboratory studies conducted in autopsy settings, reporting on post-mortem stability and time-persistence of SARS-CoV-2 in body fluids. Six of these were conducted in Europe (15 to 20), one in the US (21) and one in India (22). Full details of the studies can be found in Annexe B.

Evidence on the risk of COVID-19 transmission from the deceased (Table B.1, Annexe B)

Four observational studies provided evidence on the risk of COVID-19 transmission from the deceased. One was a prevalence study conducted in Qatar that evaluated COVID-19 infection rates amongst mortuary and cemetery workers (11). The 3 other studies were descriptive case series conducted in autopsy settings that aimed to assess the number of COVID-19 infections amongst autopsy staff. The infection prevention and control (IPC) measures deployed across all 4 studies were reported and, at minimum, included the use of high-risk PPE and specific protocols for mitigating risk of infection.

Alishaq and others reported on the prevalence of COVID-19 infections among all mortuary and cemetery workers in Qatar (11). The study was conducted between March 2020 and October 2020, with swabs collected in July 2020 for cemetery workers and September 2020 for mortuary workers. Serological testing was carried out in September 2020 for all workers. In total, 9 out of 47 mortuary workers and 24 out of 76 cemetery workers tested positive for COVID-19 (Rapid Transmission Polymerase Chain Reaction (RT-PCR) or serological test) and a significant proportion of both groups were asymptomatic (33.3% and 83.3% respectively). Both mortuary and cemetery staff completed mandatory training to follow a specific protocol for handling the bodies of COVID-19 cases, including use of PPE, double body bags, social distancing, environmental cleaning and rapid burials with limited contact with the deceased. However, the results suggest that infections were due to contacts with a COVID-19 positive living case (OR 4.7, 95% CI 1.7–13.3) rather than by handling dead bodies. The results did not suggest that shared accommodation and professional occupations (mortician vs. non-mortician and cemetery vs. mortuary workers) were potential risk factors. This study was appraised as medium quality, due to a lack of information regarding the extent of compliance with IPC measures and to the high potential for recall bias when reporting contacts with individuals infected with COVID-19 in the community. While this study does not suggest that there was a risk of transmission from handling dead bodies of COVID-19 cases, it cannot be ruled out only based on these results. The applicability of these results to settings such as the UK is also unclear, due to factors such as different working conditions and shared accommodation between workers.

Aquila and others (rated high for quality) reported on a study conducted in an autopsy facility in Italy, where staff wore FFP3 masks, eye protection and disposable gowns, used a double body bag, and had vaporised chlorine baths on entry and exit to the autopsy suite (12). Throughout the study period, autopsy staff were exposed to 29 patients who had died with confirmed or suspected COVID-19 positive status. All 8 autopsy staff tested negative for COVID-19, both 7 and 15 days after the autopsies was performed.

A second study (rated low for quality) conducted in an autopsy facility in Italy between February and April 2020, reported on the risk of transmission to autopsy staff (13). During this period, 19 autopsies were conducted, and none of the 8 autopsy staff involved tested positive or developed symptoms of COVID-19 at a median of 16 days after autopsy. Staff wore PPE (including 4 pairs of gloves at once, FFP3 mask and eye protection), used a double body bag, and worked in an autopsy suite with a ventilation system.

Hirschbuhl and others (rated low for quality) evaluated the risk of transmission to 4 autopsy staff in a hospital in Germany in April 2020 (14). The autopsy staff conducted full autopsies on 19 deceased cases with confirmed COVID-19 infection throughout the 24-day study period. All 4 autopsy staff were negative for COVID-19 when tested on 8 May and 11 May 2020 and did not show any symptoms after the last autopsy was performed. Staff wore PPE (including an FFP3 mask, eye protection and 3 pairs of gloves) and worked in an autopsy suite with whole-room ventilation.

The 3 case series studies (no control group) were all carried out in autopsy settings where strict IPC measures were in place (FFP3 mask, eye protection, gloves, ventilation, and so on). None of the studies examined whether their respective IPC measures had a mitigating effect on transmission risk to autopsy staff, potentially limiting the applicability of the findings to clinical settings with comparable IPC measures (12 to 14). Additionally, the number of included autopsy staff was small, ranging from 4 (14) to 8 (12,13), and it was not always clear how frequently staff came into contact with bodies of deceased persons with COVID-19 (study period not always reported and/or lack of detail provided on the exposure risk). Finally, demographic information about the included autopsy workers (such as age or ethnicity) was not provided.

Main findings

Evidence from 3 case series conducted in autopsy settings suggests that the risk of transmission from handling bodies of deceased persons with COVID-19 is low when appropriate IPC measures are in place (including FFP3 masks, eye protection and gloves). Evidence from an additional study indicated high rates of infection among mortuary and cemetery staff in Qatar, although the results suggest that infections may have occurred within the wider community rather than by handling dead bodies.

SARS-CoV-2 detection in body fluids of the deceased (Table B.2, Annexe B)

In total, 11 studies reported the detection of SARS-CoV-2 in body fluids of deceased persons with suspected or confirmed COVID-19: eight laboratory studies (including one preprint) (15 to 22) and 3 of the observational studies included in the previous section (12 to 14). Only studies that reported detection in fluids emitted from the respiratory tract and from the eyes were included (see Annexe A for more details). One of these studies also reported on SARS-CoV-2 detection on the surface of the skin.

Of these 11 studies, 4 were conducted in Germany (14,15,18,20), 4 in Italy (12,13,16,17), and one each in India (22), the United States (21) and Austria (19). All studies were conducted in

autopsy settings and included between one (16) to 79 (15) deceased COVID-19 cases. In 9 studies, the inclusion criteria was confirmed COVID-19 infection before death (13 to 20,22) and 2 studies included deceased cases with either confirmed or suspected COVID-19 infection before death (12,21).

The sampling methodologies varied significantly across studies, including the time-interval between death and the initial post-mortem swab collection (2 hours to 36 days) and the time-interval between swab collection and sample analysis. Across all studies, swabs were used to collect samples from either the respiratory tract, eyes or skin. Detection of SARS-CoV-2 Ribonucleic Acid (RNA) was conducted by RT-PCR (which does not distinguish between live and dead virus or viral fragments) in all studies. Four studies also carried out virus isolation in cell culture: one in swab samples (18), and the 3 others in tissue samples from the respiratory tract and the eye (13,15,20).

A summary table of the results for deceased cases with confirmed COVID-19 is presented in Table 1.

Detection in the respiratory tract

Ten studies reported on the detection of SARS-CoV-2 by RT-PCR in swabs from the respiratory tract, collected from the nose (nasopharyngeal) (12,14 to 18,21,22), the throat (oropharyngeal) (12,15,16,18,19,22), the trachea (14,17,18) or the lung (12 to 14,17 to 19,22). The time-interval between death and initial sample collection ranged from 2 hours (12) to 35 days (16). The longest time-interval between death and final sample collection was 35 days post-mortem (16).

Three studies assessed SARS-CoV-2 RNA persistence in the respiratory tract by collecting and testing swabs at regular intervals after death. Aquila and others included both suspected (n=9) and confirmed (n=20) COVID-19 cases and found that all post-mortem naso-oropharyngeal swabs were negative in the suspected cases, while swabs from the confirmed group were positive in 11 cases (12). Out of these 11 cases positive after death, 9 were still positive 24 hours post-mortem (final time-point tested). Endobronchial (lung) swabs were tested only once (24 hours post-mortem) for 5 confirmed cases, of which 2 were positive.

Skok and others found that throat swabs collected during autopsies were positive for 22 out of the 28 confirmed COVID-19 cases, and 17 of the 19 and 16 of the19 for right and left lung, respectively (19). Time-persistence was assessed for 14 cases, showing that when the first post-mortem throat swab was positive, consecutive throat swabs remained positive up to 128 hours after autopsy (5.3 days; final point tested). Similarly, Heinrich and others reported that nasopharyngeal swabs collected during autopsies were positive for all 79 confirmed cases included in the study, and that they remained positive up to 168 hours after autopsy (7 days; final point tested) for all the 11 confirmed cases included in the time-persistence experiment (15). In both cases, there was no significant variation with time in the cycle threshold (Ct) values, suggesting that there was no significant post-mortem variation in viral load in the throat or nose in the body of deceased persons with confirmed COVID-19 (15, 19).

The remaining studies only reported on SARS-CoV-2 detection at one time-point after death, although there was a wide variation in when this was done. Dell'Aquila and others found that

nasal and/or tracheal swabs were positive for 9 out of the 12 confirmed cases (12 to 120 hours post-mortem) but that only 5 out of 12 had positive lung swabs (17). However, Basso and others found that endobronchial (lung) swabs were positive for all 22 confirmed cases (1 to 6 days post-mortem) (13). Two other studies reported high positivity rate for nasopharyngeal swabs, with 24 out of 28 confirmed cases (21) and 16 out of 17 (14), although collection time was not specified. Two additional studies reported positive swabs collected 15 days after burial (naso-oropharyngeal swab; lung swab negative) (22) and 35 days after death (nasopharyngeal) (16), although they only included one confirmed case each.

While these results show that SARS-CoV-2 RNA can be detected in the respiratory tract of confirmed cases up to 35 days post-mortem, they do not provide evidence on infectivity as RT-PCR tests do not distinguish between live and dead virus or viral fragments. Viral culture tests were conducted in only 3 studies, which all successfully isolated the virus in the respiratory tract of confirmed COVID-19 cases: in 4 out of 6 cases (up to 36 hours post-mortem; pharyngeal tissue) (15), in one out of one case (6 days post-mortem; lung tissue) (13), and in 2 out of 4 cases (4 and 17 days post-mortem; oropharynx, trachea and lung swabs) (18). To note that the author of this last study reported that the 2 cases for which the virus had been successfully isolated died of COVID-19 after 2 and 11 days of illness, compared to more than 19 days for the 2 cases for which the virus could not be isolated at 1 day and 9 days post-mortem (18). Similarly, Dell'Aquila and others had reported a negative correlation between the negativity of the lung swabs and the number of days since ante-mortem swabs (17). These results, together with the time-persistence results that showed that there was no significant post-mortem variation in viral load, suggest that SARS-CoV-2 persistence in the respiratory tract might be more strongly associated with duration of disease before death (and therefore infectiousness at time of death) than time since death.

Detection in the eye

Two laboratory studies analysed swab samples from different parts of the eye, including the cornea (transparent tissue covering the pupil and iris), conjunctiva (tissue lining the inside of eyelids and whites of the eyes) and vitreous humor (transparent gel that fills the eye) (20,21). Rates of positive tests (RT-PCR) ranged from 1 out of 10 in the anterior cornea swabs to 5 out of 10 in the posterior corneal swabs (21). Conjunctiva swabs were tested in both studies, with 5 out of 11 swabs positive in one study (20), and 3 out of 10 in the other study (21).

Virus isolation by means of viral culture tests in corneal samples were reported by one study, however all samples tested were negative (collected at a mean post-mortem interval of 2.7 days) (20).

Table 1. Summary table – post-mortem SARS-CoV-2 detection in body fluids of the deceased (confirmed COVID-19 cases)

Author, ref	Number of participants	Swab location	Time-points	Initial post-mortem swab results [relevant tissue sample results]	Consecutive post-mortem swab results
Aquila and others, 2020 (12)	20 (confirmed cases only)	Respiratory tract: naso-oropharyngeal and endobronchial	Up to 24 hours post-mortem	Positive RT-PCR: • 11 out of 20 naso-oropharyngeal swabs	Positive RT-PCR 24h post-mortem: • 9 out of 11 naso-oropharyngeal swabs • 2 out of 5 endobronchial swabs
Skok and others, 2021 (19)	28	Respiratory tract: throat and lung	Up to 128 hours (5.3 days) after post-mortem examination	Positive RT-PCR: • 22 out of 28 throat swabs (average Ct: 28.12) • 17 out of 19 right lung swabs (average Ct: 28.53) • 16 out of 19 left lung swabs (average Ct: 29.01)	• n=14: when initial throat swab was positive, consecutive swabs remained positive (tested up to 128h for 1 sample) • no significant variation in Ct
Heinrich and others, 2021 (15)	79	Respiratory tract: nasopharyngeal	Up to 168 hours (7 days) after post-mortem examination	Positive RT-PCR: • 79 out of 79 (median Ct: 29.52) [Virus isolation successful in 4 out of 6 pharyngeal tissues (up to 35.8h post-mortem)]	• Positive RT-PCR 7 days post-mortem: 11 out of 11 • no time-dependent effects Ct
Dell'Aquila and others, 2020 (17)	12	Respiratory tract: nasopharyngeal, tracheal and lung	one time-point: mean 44 hours post-mortem (range: 12 to 120 hours)	Positive RT-PCR: • 9 out of 12 for nasopharyngeal and/or tracheal swab (median Ct: 28.5), including 1 nasal swab collected 120h (5 days) post-mortem • 5 out of 12 for lung swabs	Not conducted
Casagrande and others, 2021(20)	11	Eyes: conjunctival	one time-point: mean (SD): 2.7 (1.7) days post-mortem	Positive RT-PCR: • 5 out of 11 for conjunctiva [Virus isolation unsuccessful in all corneal samples]	Not conducted
Basso and others, 2020 (13)	22	Respiratory tract: endobronchial	one time-point: median 3 days post-mortem (range: 1 to 6 days)	Positive RT-PCR: • 22 out of 22 [Virus isolation successful in 1/1 lung sample (6 days post-mortem)]	Not conducted
Plenzig and others, 2021 (18)	4	Skin: perioral, palms and inner elbows Respiratory tract: oropharyngeal, tracheal and lung	one time point each: 1, 4, 9, and 17 days post-mortem	Positive RT-PCR: • One out of 4 for both palm (1 day post-mortem), all negative for elbows Successful virus isolation: 2 out of 4: • One for oropharynx, trachea and lung (4 days post-mortem) • One for perioral, trachea and lung (17 days post-mortem)	Not conducted
Prasad and others, 2021 (22) (preprint)	1	Respiratory tract: naso-oropharyngeal and lung	one time-point: 15 days after burial (and tested 21 days later)	Positive RT-PCR for naso-oropharyngeal swabs (Ct: 25.3-34) but negative lung swabs	Not conducted
Beltempo and others, 2021 (16)	1	Respiratory tract: naso-oropharyngeal	one time-point: 35 days post-mortem	Positive RT-PCR: • One out of one	Not conducted
Hirschbuhl and others, 2020 (14)	17	Respiratory tract: nasopharyngeal, tracheal and bronchial	Not reported	Positive RT-PCR: • 16 out of 17 for at least one of the swabs	Not conducted
Sawant and others, 2020 (21)	10 (swabs results only)	Respiratory tract: nasopharyngeal Eyes: conjunctival, corneal and vitreous	Not reported	Positive RT-PCR: • 6 out of 10 nasopharyngeal swabs • 3 out of 10 conjunctiva swabs • 1 out of 10 anterior corneal sabs • 5 out of 10 posterior corneal swabs • 3 out of 10 vitreous swabs	Not conducted

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Detection on the skin

One study reported the detection of SARS-CoV-2 (RT-PCR and viral culture test) on the surface of the body (palms, elbows and skin surrounding the mouth) of 4 deceased cases, each at different time-point after death (18). The palms of both hands of one deceased case tested RT-PCR positive at one day post-mortem, but virus isolation was not successful. However, virus isolation was achieved for a perioral swab (sample collected from the lips and skin surrounding the mouth) from a different case (17 days after death; RT-PCR had not been performed for this swab) for which virus isolation had also been successful for trachea and lung swabs (oropharynx swabs had not been collected/tested).

Main findings

The evidence identified indicates that SARS-CoV-2 RNA can be detected by RT-PCR in swabs from the respiratory tract up to 35 days after death (final time-point tested), however this does not provide evidence on infectivity as RT-PCR tests do not distinguish between live and dead virus or viral fragments. Only 4 out of 11 studies performed viral culture tests, of which 3 suggested that viable (infectious) virus could persist in the respiratory tract of confirmed COVID-19 cases at different time-points after death. One study reported that viable (infectious) virus had been detected 17 days after death (final time-point tested) in swabs from the respiratory tract and from the skin around the mouth of a deceased person with confirmed COVID-19, but not in other confirmed COVID-19 cases with shorter post-mortem intervals (one day and 9 days after death). More research is needed to understand the transmission risk from contact with the different body fluids of deceased persons with COVID-19 and its association with factors such as disease severity, disease duration and post-mortem interval.

Limitations

The literature search was limited to COVID-19 evidence published between 26 March 2020 and 17 March 2021 from Medline, Embase, medRxiv, SSRN and WHO COVID-19 database. The aim of this work was to update an existing review, however due to a high volume of retrieved results with the original search strategy it was adapted to reduce the quantity of irrelevant evidence retrieved (noise) and so may not have identified all eligible studies.

The evidence on transmission from handling the bodies of deceased persons with suspected or confirmed COVID-19 was limited to 3 case-series and one prevalence study, which did not include comparator groups. Three of these studies were conducted in autopsy settings, which limits the applicability of the findings to clinical settings with strict IPC measures. The applicability to UK settings of the results of the prevalence study conducted in Qatar is also unclear, due to factors such as different working conditions and shared accommodation between workers. As no outbreak investigations or epidemiological evidence were identified, an additional search was conducted to ensure that this was not due to our search strategy. However, no further evidence was identified.

Due to the limited evidence identified, laboratory studies that reported on the stability of SARS-CoV-2 in body fluids of deceased persons with suspected or confirmed COVID-19 were included. Only studies reporting on fluids which could be contacted with while handling bodies (especially from the nose, mouth, eye) and on the skin were included, although these results should be considered as an intermediate outcome (not direct evidence on transmission). As this was not the primary objective of this review, relevant studies might have been missed. No formal risk of bias assessment was completed for these studies and their findings are limited due to small sample sizes and variation in methods between studies (difference in type of samples, time of collection, detection method, etc).

One of the 11 studies identified was preprint and should be treated with caution as it has not been peer reviewed, nor subject to publishing standards and may be subject to change.

As with all reviews, the evidence identified may be subject to publication bias, whereby null or negative results are less likely to have been published by the authors.

Conclusions

The overall evidence on the risk of transmission from handling the bodies of deceased persons with suspected or confirmed COVID-19 is limited to 12 studies (4 observational and 8 laboratory studies), mainly from autopsy settings with extensive infection control protocols in place.

Limited evidence from 3 case series conducted in autopsy settings indicates a minimal risk of COVID-19 transmission from the deceased when appropriate preventive measures and infection control protocols are adhered to. Although findings from one study indicated high rates of infection among mortuary and cemetery staff in Qatar, the results suggest that transmission might have occurred in the community rather than from handling bodies of COVID-19 cases.

No epidemiological investigations reporting on transmission from handling bodies of COVID-19 cases were identified. Whilst this might suggest that clusters of COVID-19 infection amongst persons handling the bodies of the deceased has not been reported, this does not constitute evidence of absence of risk.

Evidence reported by laboratory studies suggests that SARS-CoV-2 can persist in body fluids from the respiratory tract of deceased persons with confirmed COVID-19. Whilst these results do not provide direct evidence on the risk of transmission from getting into contact with these fluids, they indicate potential infectivity. This suggests that appropriate PPE should be recommended when there is a risk of contact with the body fluids of deceased persons with COVID-19.

Nearly all studies contained small samples and were conducted in autopsy settings, which limits their applicability to non-clinical settings. More research is needed on the potential infectivity of the different body fluids of deceased persons with COVID-19 and its association with factors such as disease severity, disease duration (and whether the patient was infectious at time of death) and post-mortem interval. This would have practical

consequences for public health advice, especially in relation to guidance and PPE recommendation when handling the bodies of deceased persons with suspected or confirmed COVID-19 in the community.

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Disclaimer

PHE's rapid reviews aim to provide the best available evidence to decision makers in a timely and accessible way, based on published peer-reviewed scientific papers, unpublished reports and papers on preprint servers. Please note that the reviews: i) use accelerated methods and may not be representative of the whole body of evidence publicly available; ii) have undergone an internal, but not independent, peer review; and iii) are only valid as of the date stated on the review.

In the event that this review is shared externally, please note additionally, to the greatest extent possible under any applicable law, that PHE accepts no liability for any claim, loss or damage arising out of, or connected with the use of, this review by the recipient and/or any third party including that arising or resulting from any reliance placed on, or any conclusions drawn from, the review.

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Annexe A. Methods

This report employed a rapid review approach to address the review question:

What is the risk of transmission of COVID-19 from the deceased?

Our rapid review approach follows systematic methodologies, but with shortcuts built in to accelerate the review process (9). In particular, only 10% of the screening on title and abstract were screened in duplicate; full text screening, data extraction and risk of bias assessment were performed by one reviewer and checked by another one; and an existing rapid review was used as source for primary studies published up to 26 March 2020.

Notes

1. One relevant review was identified through a scoping search (4). The search strategy of this review included primary and secondary evidence from COVID-19 as well as indirect evidence from systematic reviews on SARS and Middle East respiratory syndrome (MERS). The cut-off date for these searches was 26 March 2020.
2. It was agreed that a literature search would be undertaken to update the above review by searching for primary evidence specific to COVID-19 published since 26 March 2020, up to 17 March 2021.

Protocol

A protocol was produced by the project team before the literature search began, specifying the research question and the inclusion and exclusion criteria. The protocol is available in Annexe C.

Sources searched

Ovid Medline, Ovid Embase, medRxiv, SSRN and the WHO COVID-19 Research Database. medRxiv and SSRN were searched via the NLM COVID portfolio interface.

Search strategy

Searches were conducted for papers published between 26 March 2020 and 17 March 2021.

Search terms covered main aspects of the research question. The search strategy is based on the one used by Yaacoub and others (4), but was adapted to reduce the noise (that is, the number of irrelevant hits) as the amount of studies published on COVID-19 since the original search had increased dramatically (specifically, the terms ’body’, ‘bodies’ and ’dead’ were used in combination with other terms, rather than on their own). The search strategy for Ovid Medline is presented in Box A.1.

Additional searches (Google Scholar) and citation analysis on Web of Science, Google Scholar and Cocites (co-citation analysis, snowballing and related articles) were performed. Although this was not part of the search strategy outlined in the protocol, it was agreed a posteriori by the

review team due to the absence of outbreak investigations identified. Only one additional relevant study was identified.

Box A.1. Search strategy Ovid Medline

1. (Cadaver* or Corpse* or carcass* or mortem* or cremat* or Immur* or promessi* or composting or dissolut* or grave* or tomb* or bu?ri* or bur?y* or Adipocere or ((livor or rigor or algor) adj mortis) or ((Postmortem or Post-mortem) adj change) or Cruor or Autolys?s or interment* or entombment* or sepltur* or (pass* adj away)).tw,kw.
2. ((manag* or handl* or care or caring or dead or infected or dispos*) adj3 (body or bodies)).tw,kw.
3. deceased.tw,kw.
4. Burial/
5. exp Cadaver/
6. Mortuary Practice/
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp coronavirus/
9. exp Coronavirus Infections/
10. COVID-19/
11. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
12. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
13. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
14. or/8-13
15. 7 and 14
16. limit 15 to dt= 20200326-20210317
17. limit 16 to English language

Inclusion and exclusion criteria

Article eligibility criteria are summarised in Table A.1.

The main objective of this rapid review was to assess the risk of transmission to individuals handling bodies of deceased persons with suspected or confirmed COVID-19. Outcome measures were not specified in the protocol so “any measures deemed appropriate to assess transmission risk [would] be considered”. Due to the limited number of studies identified reporting on risk from handling dead bodies, studies reporting on post-mortem virus persistence in body fluids were included (these studies had been coded at the screening stage). Only studies reporting on fluids from the respiratory tract, from the eyes and from the gastrointestinal tract (urine and faeces; but no study identified on these) collected with a swab were considered for inclusion as virus persistence in these fluids were considered as an intermediate outcome for transmission risk when handling bodies. Studies focusing on internal organs and tissue sample analysis were excluded. Studies that reported both on swab and tissue samples results were included, although only results from swab samples were discussed, except for 3 studies which reported on virus isolation in tissues from the respiratory tract and from the eye.

Table A.1. Inclusion and exclusion criteria

	Included	Excluded
Population	• bodies of deceased persons with suspected or confirmed COVID-19 • individuals handling these bodies	
Settings	All	
Context	COVID-19 pandemic	Other infectious diseases
Intervention/ exposure	• handling of bodies of deceased persons with suspected or confirmed COVID-19 • any strategy to manage bodies of deceased persons	Studies looking at viral load and viral shedding will be considered only if performed on dead bodies with the aim to assess transmission risk
Outcomes	Risk of COVID-19 transmission to the individual handling the bodies Measures: • any measures deemed appropriate to assess transmission risk will be considered	
Language	English	
Date of publication	26 March 2020 to 17 March 2021	

	Included	Excluded
Study design	• experimental or observational studies • outbreak investigation	• systematic or narrative reviews • guidelines • opinion pieces • modelling studies
Publication type	Published and preprint	

Screening

Title and abstract screening was done by 2 reviewers: 10% of the eligible studies were screened in duplicate (disagreements were resolved by discussion) and the remainder were screened by one reviewer.

Full text screening was done by one reviewer and checked by a second.

Figure A.1 illustrates this process.

Data extraction and risk of bias assessment

Data extraction was done by one reviewer and checked by a second. Only results directly relevant to the review questions were extracted (for instance, if a study collected tissues from internal organs for SARS-CoV-2, it was reported in the method column, but results were not extracted).

The 4 studies reporting directly on transmission were assessed using the Academy of Nutrition and Dietetics QCC for primary research (10). This risk of bias tool, not specific to nutrition, can be applied to most study designs (observational and experimental), and is therefore suitable for rapid reviews of mixed type of evidence. It is composed of 10 validity questions based on the criteria and domains identified by the Agency for Healthcare Research and Quality to assess the methodological quality of a study (that is, the extent to which a study has minimised selection, measurement and confounding biases) (23). In the QCC tool, 4 questions are considered critical (on selection bias, group comparability/confounding, interventions/exposure and outcome). A study will be rated as high quality if the answers to the 4 critical questions is ‘yes’ (and at least one additional ‘yes’). The study will be rated as low quality if 2 or more of the critical questions are answered ‘no’ and/or if ≥50% of the remaining questions are answered ‘no’. Otherwise, the study will be rated as medium quality. Judgments were made on case by case for questions answered as ‘unclear’. To note that we report these ratings as ‘quality’ ratings for consistency with the name of the tool, although here quality needs to be understood as ‘methodological quality’ as part of a risk of bias assessment.

Risk of bias assessment was done by one reviewer and checked by a second. QCC ratings are reported in the data extraction tables (Annexe B). Laboratory studies were not assessed.

A formal grading of evidence was not undertaken.

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups will be considered, where evidence is available.

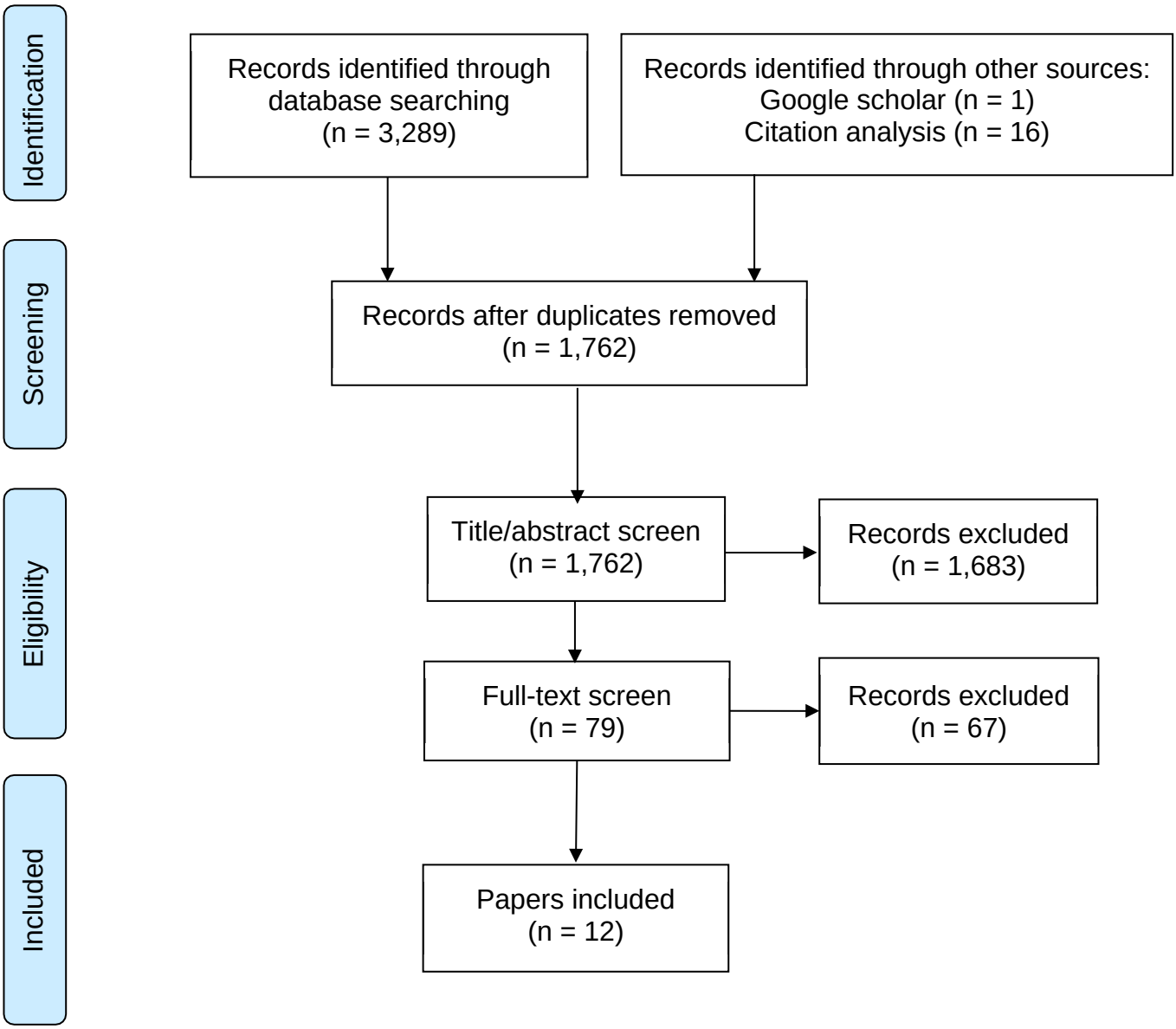

Figure A.1. PRISMA diagram

Figure A.1. PRISMA diagram alt text

A PRISMA diagram showing the flow of studies through this review.

From the original literature search (search conducted between 26 March 2020 and 17 March 2021), there were n = 12 papers included in the review.

From identification of studies via databases and registers, n = 3,306 records identified from databases.

From these, n = 1,544 duplicate records were removed before screening. This left n = 1,762 records screened, of which n = 1,683 were excluded, leaving n = 79 papers sought for retrieval. All identified reports were retrieved.

Of these n = 79 papers, n = 67 were excluded. This left n = 12 papers to be included in the review.

Annexe B. Data extraction

Table B.1 Studies reporting on risk of transmission

Reference	Study design	Methods	Main findings (relevant to this review)	Risk of bias
Aquila and others, 2020 (12)	**Study design**: case series **Objective**: to evaluate COVID-19 transmission risk to autopsy staff and the persistence of the virus in the dead body **Settings**: post-mortem/autopsy facility, Italy **Study period**: not reported **Participants** - n=8 forensic staff: • n=4 performed autopsy (higher risk exposure) • n=4 collected swabs (lower risk exposure) - n=29 deceased persons with confirmed or suspected COVID-19: • n=20 confirmed cases: 12 males; mean age: 81.3 years • n=9 suspected cases:6 males; mean age: 55.6 years	**Outcomes** - Number of positive COVID-19 tests from autopsy staff - Number of positive COVID-19 tests from the deceased at different time intervals post-mortem **Exposure** - Exposure of autopsy staff to the body of deceased persons with confirmed or suspected COVID-19 - Length of time between death and post-mortem swab collection **Preventive measures** - PPE: staff wore triple layer of PPE including FFP-3 mask, disposable nitrile gloves, suit, full face shield, shoe covers - Autopsy suite: autopsy staff had a vaporised chlorine bath on entry and exit, hand sanitisation on exit - Body bag: double body bag used **Sample collection** - Staff: nasopharyngeal swabs collected 7 and 15 days after last autopsy performed - Cadavers: • Naso-oropharyngeal swabs collected at 2, 4, 6, 12 and 24 hours since death, and during autopsy if performed (n=20 confirmed; n=9 suspected) • endobronchial swabs during autopsy (24h post-mortem) were performed (n=5 confirmed; n=9 suspected) **Testing method** - RT-PCR (Ct values >40 deemed negative) - Viral culture test: not conducted	**Risk of transmission results** (autopsy staff) - All forensic staff group (n=8) tested negative for SARS-CoV-2 at 7- and 15-days post autopsy performed/samples analysed **Post-mortem results** (deceased persons) Naso-oropharyngeal swabs: - Suspected group (n=9): all swabs negative - Confirmed group (n=20): 11 positive, 9 negative - Persistence over time after death in the 11 positive cases: • 2h – 10 positive (90.9%) • 4h– 10 positive (90.9%) • 6h – 9 positive (81.8%) • 12h - 7 positive (63.6%) • 24h - 9 positive (81.8%) - 2 cases had false negative swabs at 2, 4 and 6 hours after death but positive swabs at 12 and 24 hours (and endobronchial swabs were positive) Endobronchial swabs (24h post-mortem): - Suspected group (n=9): all swabs negative - Confirmed group (n=20): 2 positive, 3 negative - In one of the negative cases all swabs up to 6 hours after death were positive (negative at 12 and 24 hours) - No significant association between comorbidities and post-mortem time persistence in either confirmed or suspected groups	**Study design**: descriptive study, no control group **Other bias**: small sample size; information bias (no demographical information provided for autopsy staff) **QCC rating:** high

Basso and others, 2020 (13)	**Study design**: case series **Objective**: to evaluate the risk of COVID-19 transmission to autopsy staff from post-mortem examination **Settings**: autopsy suite, pathology units, Padua, Italy	**Outcomes** - Number of positive COVID-19 tests from autopsy staff - Number of positive COVID-19 tests from the deceased at autopsy	**Risk of transmission results** (autopsy staff) - None of the staff developed symptoms of COVID-19 at a median of 16 days after post-mortem examination - Nasopharyngeal swabs were all negative **Post-mortem results** (deceased persons) - Time between death and post-mortem examination: between 1 and 6 days (median = 3) - Endobronchial swabs all positive (22/22)	**Study design:** descriptive study, no control group **Other bias:** small sample size; information bias (lack of detail on when staff were given swabs and no demographical information provided for autopsy staff)

Reference	Study design	Methods	Main findings (relevant to this review)	Risk of bias
	Study period: February to April 2020 **Participants** - n=8 autopsy staff • n=3 performed autopsy (2 pathologists, 1 technician) • n=5 carried out post-mortem examinations (3 pathologists and 2 technicians) - n=22 deceased persons defined as 'COVID-19 cases' (no information on ante-mortem testing): 15 male; mean age = 80.6 ± 8.4 years (range = 61 to 96)	**Exposure** - Exposure of autopsy staff to the body of deceased persons with confirmed COVID-19 **Preventive measures** - PPE: 3 pairs of surgical gloves, shoe covers, head cover, Tyvek chemical protection coverall, leg covers, FFP3, goggles, impermeable gown/apron - Autopsy suite: ventilation system, pressure-negative environment, HEPA filters; 'filter room' where operators were disinfected and removed PPE - Body bag: double body bag, procedure performed in inner bag, outer bag wiped with disinfectant before leaving suite **Sample collection** - Staff: nasopharyngeal swab, periodically - Cadavers: endobronchial swab and lung samples (as well as other tissue samples), during autopsy **Testing method** - RT-PCR (Ct threshold for negative results not reported) - Viral culture test: for one lung sample (6 days post-mortem)	- Live virus culture of the lung sample was positive (1/1, 6 days post-mortem)	**QCC rating:** low
Hirschbuhl and others, 2020 (14)	**Study design:** case series **Objective**: to evaluate the risk of COVID-19 transmission to autopsy staff **Settings:** University Medical Center Augsburg, Germany **Study period**: 4 April to 28 April 2020 **Participants** - n=4 autopsy staff - n=17 deceased persons with confirmed COVID-19	**Outcomes** - Number of positive COVID-19 tests from autopsy staff - Number of positive COVID-19 tests from the deceased at autopsy **Exposure** - Exposure of autopsy staff to the body of deceased persons with confirmed COVID-19 **Preventive measures** - PPE: surgical scrub suit, rubber boots, hat, goggles, visor, FFP3, waterproof gown, forearm protection, plastic apron, glass fibre reinforced cut resistant gloves, double surgical gloves - Autopsy suite: whole-room ventilation **Sample collection** - Staff: oropharyngeal swabs and blood sample on 8 and 11 May 2020	**Risk of transmission results** (autopsy staff) - All autopsy staff repeatedly tested negative for COVID-19 and did not develop any symptoms - Serological tests were also negative **Post-mortem results** (deceased persons) - 16 out of 17 cases were positive for COVID-19 in at least one site tested	**Study design:** descriptive study, no control group **Other bias:** small sample size; information bias (not enough information on exposure risk of autopsy staff and no demographical information provided for autopsy staff) **QCC rating:** low

Reference	Study design	Methods	Main findings (relevant to this review)	Risk of bias
		Cadavers: nasopharyngeal, tracheal and bronchial swabs during autopsy **Testing method** - RT-PCR (Ct threshold not reported) - Viral culture test: not conducted - Serological testing (staff only)		
Alishaq and others, 2021 (11)	**Study design:** prevalence study **Objective:** to evaluate COVID-19 infection rates among mortuary and cemetery workers and the risk factors associated with infection **Settings:** mortuaries and cemeteries in Qatar **Study period**: 10 March to 6 October 2020 **Participants** - All workers invited to participate: • n=47 mortuary workers: median age 39 years (IQR 30-51); 41 males (87.2%) • n=81 cemetery workers: median age 38 years (IQR 30.5-49), 67 males (82.7%)	**Outcome** - Number of positive COVID-19 tests from mortuary and cemetery staff **Exposure** - Exposure of mortuary and cemetery staff to the body of deceased persons with confirmed COVID-19 **Preventive measures** - Staff followed a specific protocol for handling bodies of the deceased, including PPE, the use of 2 body bags, cleaning the environment, social distancing, quick burial **Sample collection and testing method** - Nasopharyngeal swabs (RT-PCR): collected in July for cemetery workers and September for mortuary workers (Ct threshold not reported) - Serological testing: blood sample, collected in September for all workers - Environmental sample (RT-PCR): collected from mortuary and cemetery sites, including outer surfaces of body bags (Ct threshold not reported) **Data source:** demographic and clinical data obtained by structured questionnaires and interviews **Statistical analysis:** multivariable logistic regression to calculate odd ratios (OR)	**Mortuary workers** - Nasopharyngeal swab: • 7/47 positive (14.9%) • median Ct for positive samples: 24.82 (IQR: 17.85, 31.79) - Blood sample: • 8/32 positive (25.0%), of which 6 were also RT-PCR positive • median antibody titre for positive samples: 22.25 (IQR: 6.97, 62.48) - n=9 tested positive (RT-PCR or serologic test), of which: • 5 (55.6%) had contact with a living COVID-19 confirmed case; 4 (44.4%) did not • 3 (33.3%) were asymptomatic **Cemetery workers** - Nasopharyngeal swab: • 5/76 positive (6.6%) • median Ct for positive samples: 27.17 (IQR: 14.73, 39.62) - Blood sample: • 22/64 (34.4%) positive, of which 3 were also RT-PCR positive • median antibody titre for positive samples: 64.8 (IQR: 13.33, 106.75) - n=24 tested positive (PCR or serologic test), of which: • 1 (4.2%) had no contact with living COVID-19 confirmed cases 23 (95.8%) were unsure • 20 (83.3%) were asymptomatic - Factors associated with infection include: • age (<30 years): OR 4.9; 95% CI 1.7–14.6 • contact with a living COVID-19 case: OR 4.7; 95% CI 1.7–13.3 • symptoms within previous 2 weeks: OR 9.0; 95% CI 1.9–42.0 - Factors not associated include shared accommodation, mortician vs. non-mortician, cemetery vs. mortuary - 45 environmental samples (mortuary n=15, cemetery n=30). All samples negative or had a Ct value above 35	**Study design:** no control group **Other bias:** information bias (not enough information for work exposure risk, including preventive measures and recall bias for possible contact with COVID-19 confirmed case); unclear generalizability as characteristics of workers and working condition may be different in other countries. **QCC rating:** medium

Table B.2. Laboratory studies reporting on infectivity of body samples

Reference	Study design	Testing method and timing	Main findings (relevant to this review)
Beltempo and others, 2021 (16)	**Objective**: to evaluate if SARS-CoV-2 RNA is persistent in post-mortem nasopharyngeal swabs from a COVID-19 patient 35 days after death **Setting:** local crematorium, Aosta, Italy **Study period:** 17 March to 22 April 2020 **Participants** - n=1 deceased person with confirmed COVID-19 (positive RT-PCR ante-mortem): male; 60 years old, several comorbidities - Body refrigerated at 4°C between death and preparation for cremation	**Sample location** - Nasopharyngeal and oropharyngeal swabs **Time of sample collection** - 35 days after death - Samples taken and tested same day as extraction from refrigerator **Testing method** - RT-PCR (Ct threshold for negative results not reported) - Viral culture test: not conducted	- SARS-CoV-2 RNA was present in the swab samples - No additional information provided (for example, Ct values not reported)
Casagrande and others, 2021 (20)	**Objective:** to evaluate the presence of SARS-CoV-2 in corneas of deceased patients with confirmed COVID-19 **Setting**: Institute of Forensic Medicine, Hamburg, Germany **Study period:** 20 March to 14 May 2020 (autopsies) **Participants** - n=11 deceased persons with confirmed COVID-19: 9 male; mean age: 68.5 ± 18.8 years (no info on pre-existing conditions) - No specific minimum viral load needed for inclusion but patients with high viral load (>10^4 copies per cell) were primarily selected - Bodies stored at 4°C until autopsy	**Sample location** - Throat swabs - Conjunctiva swab, corneal discs sample, AH (aqueous humor) samples, VH (vitreous humor) samples, venous blood samples **Time of sample collection** - Mean (SD) post-mortem interval: 2.7 (1.7) days - Conjunctival swabs taken before autopsy - Cornea separated during autopsy **Testing method** - RT-PCR (reported as copies per/ml) - Viral culture test: virus isolation in cell cultures completed corneal disc samples	**RT-PCR results** - 10/11 had at least one positive sample - 8/10 had positive throat swabs - 5/11 had positive conjunctival swabs (of which 1 had negative swab throat) - 6/11 had positive cornea samples (all 6 had positive throat swabs), of which: • 4/6 also had positive conjunctival swabs • 1/3 had positive AH samples • 3/5 had positive VH samples • 4/5 had positive blood samples (viremia) - 5/9 had positive blood samples (viremia) (all 5 had positive throat swabs) Viral culture cell results - Virus isolation was unsuccessful in all cornea samples
Dell'Aquila and others, 2020 (17)	**Objective:** to evaluate the presence of SARS-CoV-2 during a post-mortem examination using swabs **Setting:** Rome, Italy **Study period:** not reported (from April 2020) **Participants** - n=12 deceased persons with confirmed COVID-19 (ante-mortem swabs: 11/12 positive; 1/12 inconclusive but post-mortem swabs positive): 4 males; average age: 82.3 (54 to 93) years	**Sample location** - Nasopharyngeal, tracheal and lung swabs **Time of sample collection:** at autopsy - Average time between ante-mortem and post-mortem swab: 21.16 days (8 to 39 days) - Average time between death and autopsy swabbing: 43.92 hours (12 to 120 hours) - Refrigerated at -20C after collection - Accepted by the microbiology laboratory 3 to 310 hours after collection **Testing method** - RT-PCR (Ct values >40 deemed negative) - Viral culture test: not conducted	**Initial post-mortem results** - 9/12 had at least 1 post-mortem nasopharyngeal or tracheal swab test positive for SARS-CoV-2 (including for nasal swab collected 120h post-mortem); median Ct for positive swabs: 28.5 (IQR 26.0-31.0) - 5/12 had a positive lung swab **Time-persistence results** - Correlation between negativity of lung swabs and number of days elapsed from antemortem swabs (R^2 = 0.9633, r = −0.9815, p< .001) - Correlation between positive result from other swabs in aggregate and number of days since antemortem swabs (R^2= 0.9502, r= −0.9748, p< .001) - No relationship found between swab result and the time from collection or before acceptance in the microbiology laboratory

Reference	Study design	Testing method and timing	Main findings (relevant to this review)
Heinrich and others, 2021 (15)	**Objective:** to evaluate the stability and infectivity of COVID-19 in nasopharyngeal mucosa after death **Setting:** Hamburg, Germany **Study period:** 22 March to 1 May 2020 **Participants** - n=79 deceased persons with confirmed COVID-19 (positive ante-mortem swabs)	**Sample location** - Nasopharyngeal swabs and pharyngeal tissue **Time of sample collection** - Initial post-mortem test (n=79): at admission (median post-mortem interval: 17.8h; 2.7 to 482.6h) - Time-persistence (n=11): at 0, 12, 24, 36, 48, 60, 72, 96 and 168 hours after admission (median post-mortem interval: 5.7h; range 2.9-32.0h; IQR 6.9h) - Virus culture (n=6): time points not specified (post-mortem interval range: 5.67 to 35.75h) **Testing method** - RT-PCR (Ct values >50 deemed negative) - Viral culture test: virus isolation in cell cultures for pharyngeal tissue	**Initial post-mortem results** (n=79) - All swabs were positive - Event of death had no effect on viral load (Wilcoxon test for paired data: U = -5, p= 0.85) - No correlation between post-mortem interval and viral load (Spearman correlation: R = -0.07, p= 0.5) **Time-persistence results** (n=11) - Swabs positive at all time points - Median Ct at admission = 29.52 (range 15.2-50.0; IQR 22.5) - Viral load (Ct) was consistent at all time points (apart from 4 samples from 2 patients which were considered deviations in sample collection) - If excluding the 4 negative samples, viral load increases overtime (0.6% per hour) but the estimate was not statistically significant (p=0.58) **Viral culture results** (n=6) - Virus isolation was successful in 4 out of 6 cases in pharyngeal tissue (live virus was detected up to 35.8 hours after death)
Plenzig and others, 2021 (18)	**Objective**: to determine COVID-19 duration/ infectivity in deceased patient's swabs and samples **Setting:** Germany **Study period**: missing **Participants** - n=4 deceased persons with confirmed COVID-19 (3 ante-mortem positive swab, one tested 2 days post-mortem): 3 males; mean age: 81 years (range: 65 to 88 years) - Stored at 6-8ºC within 12 to 24 hours after death	**Sample location** - Swabs: perioral (skin surrounding the mouth), both palms and inner elbows, oropharyngeal, trachea and both lungs - Tissues: brain, heart, lungs, liver, spleen, pancreas, kidneys, adrenal glands, thyroid glands, paratracheal lymph nodes, small intestine and colon **Time of sample collection** - Post-mortem interval (PMI) 1, 4, 9, 17 days for case 1, 2, 3, and 4 respectively (number of samples not reported) - Samples stored at -8°C, thawed before preparation **Testing method** - RT-PCR (Ct threshold for negative results not reported) for elbow and palm swabs and most tissue samples - Viral culture test: cytopathogenic effect (CPE) assessed for all samples daily (up to 7 days)	**RT-PCR** - Case 1 (1 day PMI) positive for palm swabs (Ct: 35.55 and 31.87) - Cases 2, 3 and 4 negative for all swab locations - To note that lung tissues were positive for all 4 cases (Ct between 14.96 and 34.46) but that lung swabs were not tested **Cell culture** - Case 2 (4 days PMI) CPE for oropharynx and trachea swabs, and right and left lung swabs and tissues (negative for all other swabs and tissues) - Case 4 (17 days PMI; case was in advanced decomposition) CPE for perioral and trachea swabs, and right and left lung swabs and tissues (negative for all other swabs and tissues) - Cases 1 and 3 no CPE in any samples - The duration of COVID-19 illness was 2 and 11 days for case 2 and 4 before death, compared to > 19 days for 1 and 3
Prasad and others, 2021 (22) PREPRINT (v1; 19 February 2021)	**Objective**: to detect SARS-CoV-2 in autolysed samples from an exhumed decomposed body **Setting**: India **Study period:** not reported **Participants**	**Sample location** - Naso-oropharyngeal and visceral swabs from lung, intestine, liver, and kidney **Time of sample collection** - Swab collected: 15 days after burial and tested 21 days later **Testing method** - RT-PCR 3 times with 3 different kits (Genes2Me, Q-line molecular, Meril) (Ct values >40 deemed negative)	- Naso-oropharyngeal samples were RT-PCR positive: • Genes2Me kit (E, N, RdRP and RNase P genes): Ct values of 27.1, 25.3, 25.8 and 34.0 respectively • Q-line kit (ORF1ab and N genes): Ct values of 28.8 and 29.4 respectively • Meril kit (ORF1ab and N gene): Ct values of 31.5 and 31 respectively

Reference	Study design	Testing method and timing	Main findings (relevant to this review)
	n=1 deceased person with confirmed COVID-19: sex and age nor reported (“in their 40s”) (Exhumed body showing signs of decomposing)	- Viral culture test: not conducted	- Lung swabs were negative, but microscopy showed cell damage caused by SARS-CoV-2 (autolytic changes).
Sawant and others, 2020 (21)	**Objective**: to analyse the prevalence of SARS-CoV-2 RNA in post-mortem ocular tissues **Setting:** US **Study period**: all testing done after 3 April 2020 **Participants** - n= 53 deceased persons with confirmed or suspected COVID-19: • Group 1: n=18 confirmed cases: median age 61 years old (17-72) • Group 2: n=13 suspected cases (signs and symptoms of COVID-19 before death), median age 59 years old (26-75) • Group 3: n=2 suspected cases (close contacts of COVID-19 cases), median age 63 years old (62-63) • Group 4: n=10 confirmed cases; median age 66 years old (46-90); 5 Caucasian, 3 Hispanic, 1 African American, 1 south Asian	**Sample location** - Groups 1 to 3: Scleral and cornea tissue samples (132 samples in total) - Group 4: 9 swabs each (1 nasopharyngeal, 2 conjunctiva, 2 anterior corneas, 2 posterior corneas and 2 vitreous); blood samples for serological testing **Time of sample collection** - No reported **Testing method** - RT-PCR (Ct values >37 deemed negative) - Viral culture test: not conducted	- Group 1: 17% positivity in sclera (6/18) and 11% in cornea samples (4/18) - Group 2: 12% positivity in sclera and 15% in cornea samples - Group 3: 0% positivity in both sclera and cornea samples - Group 4: positivity rates: • 60% for nasopharyngeal swabs (6/10) • 5% for conjunctival swabs (3/10) • 5% for anterior corneal swabs (1/10) • 25% for posterior corneal swabs (5/10) • 15% for vitreous swabs (3/10)
Skok and others, 2020 (19)	**Objective:** to assess presence of SARS-CoV-2 RNA in post-mortem swabs from various organs and correlating this with post-mortem tissue damage and viral dynamics **Setting:** Graz, Austria **Study period:** 24 March 2020 to 13 May 2020 **Participants** - n=28 deceased persons with confirmed COVID-19 (randomly selected out of the 69 patients who died of COVID-19 at the hospital): 17 male; all Caucasian; mean age: 82.9 years (range: 66 to 96): • autopsy group: n=19 • non-autopsy group: n=9 - Stored at 4°C within 2 hours after death	**Sample location** - Autopsy group: nasopharyngeal/throat, both lungs, intestine, colon, gallbladder, and cerebrospinal fluid/brain and blood swabs. - Non-autopsy group: throat swab **Time of sample collection** - First throat swabs taken at post-mortem examination/autopsy (timing not reported) - Consecutive swabs at 24-hour intervals after post-mortem examination: • 14 patients had 2nd swab (24 hours) • 9 had 3rd swab (48 hours) • 4 had 4th swab (72 hours) • 1 had 5th swab (96 hours) • 1 had 6th swab (128 hours) - Swabs from other anatomical regions were taken once at autopsy (n=19) - Swabs were stored at 2-8°C until they were transported and tested within 12 hours of arrival at the laboratory **Testing method** - RT-PCR (Ct threshold for negative results not clearly reported; might be 50) - Viral culture test: not conducted	**Initial post-mortem results** - 22/28 patients had positive 1st post-mortem throat swab (average Ct: 28.12) - Of the 6 negative, 3 had negative last ante-mortem swab, 3 were positive - 17/19 right lung swabs were positive (average Ct: 28.53) - 16/19 left lung swabs were positive (average Ct: 29.01) **Time-persistence results (throat swabs)** - When the first post-mortem swab was positive, consecutive swabs remained positive: • 2nd swab: 11/14 positive (the 3 negatives were also negative for 1st swab) • 3rd swab: 8/9 positive (the 1 negative was also negative for 2nd swab) • 4th swab: 4/4 positive • 5th and 6th swab: 1/1 positive without significant variation in Ct value (128 hours after post-mortem examination) - Differences between Ct values in ante- (27.68, SD = 5.44) and post-mortem (28.12, SD =3.92) swabs were not statistically significant. (*t*(-0.4)=76; p=0.548; independent sample *t* test)

Annexe C. Protocol

Transmission risk from the deceased: rapid review protocol

Review question

“What is the risk of COVID-19 transmission from the deceased?”

Notes:

- A scoping search was performed on 07 May 2020 using a number of existing Covid-19 review repositories plus additional resources such as PROSPERO. This scoping search was updated on 12 January 2021.
- A rapid review by Yaacoub and others “Safe management of bodies of deceased persons with suspected or confirmed COVID-19: a rapid systematic review” was identified. Their search strategy included primary and secondary evidence from COVID-19 as well as indirect evidence from systematic reviews on SARS and MERS. The cut-off date for these searches was 26 March 2020.
- The aim of this rapid review is to update the above systematic review. We will search for primary studies related to COVID-19 published since 26 March 2020.
- Due to the amount of studies being published on COVID-19 since last year, we refined the strategy by Yaacoub and others in order to reduce the number of hits.

Inclusion and exclusion criteria

	Included	Excluded
Population	• bodies of deceased persons with suspected or confirmed COVID-19 • individuals handling these bodies	
Setting	All	
Context	COVID-19 pandemic	Other infectious disease
Intervention	• handling of bodies of deceased persons with suspected or confirmed COVID-19 • any strategy to manage bodies of deceased persons	Studies looking at viral load and viral shedding will be considered only if performed on dead bodies with the aim to assess transmission risk.
Outcomes	Risk of COVID-19 transmission to the individual handling the bodies Measures: • any measures deemed appropriate to assess transmission risk will be considered	
Language	English	
Date of publication	26 March 2020 to 17 March 2021	

	Included	Excluded
Study design	• experimental or observational studies • outbreak investigation	• systematic or narrative reviews • guidelines • opinion pieces • modelling studies
Publication type	Published and pre-print	

Sources of evidence: Medline, Embase, medRxiv preprints, WHO COVID-19 Research Database

Search terms for Ovid Medline

1. (Cadaver* or Corpse* or carcass* or mortem* or cremat* or Immur* or promessi* or composting or dissolut* or grave* or tomb* or bu?ri* or bur?y* or Adipocere or ((livor or rigor or algor) adj mortis) or ((Postmortem or Post-mortem) adj change) or Cruor or Autolys?s or interment* or entombment* or sepltur* or (pass* adj away)).tw,kw.
2. ((manag* or handl* or care or caring or dead or infected or dispos*) adj3 (body or bodies)).tw,kw.
3. deceased.tw,kw.
4. Burial/
5. exp Cadaver/
6. Mortuary Practice/
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp coronavirus/
9. exp Coronavirus Infections/
10. COVID-19/
11. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
12. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
13. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
14. or/8-13
15. 7 and 14
16. limit 15 to dt=20200518-20210316
17. limit 16 to english language

Screening

Screening on title and abstract will be undertaken in duplicate by 2 reviewers for at least 10% of the eligible studies, with the remainder completed by one reviewer. Disagreement will be resolved by discussion.

Screening on full text will be undertaken by one reviewer and checked by a second.

Data extraction

Summary information for each study will be extracted and reported in tabular form. Information will include country, setting, study design, outcomes measures, results and any relevant contextual data (such as timing or level of community transmission at the time of the study). Data extraction will be undertaken by one reviewer and checked by a second.

Risk of bias assessment

Risk of bias will be assessed using the Academy of Nutrition and Dietetics quality criteria checklist (QCC) for primary research. This tool is not specific to nutrition and can be applied quickly to most study designs to consider core areas of potential bias. Risk of bias will be assessed by one reviewer and checked by a second.

Synthesis

A narrative synthesis will be provided based either on key themes (such as type of event) or based on study design.

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups will be considered, where evidence is available.

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. We do this through world-leading science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

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