NHS National Services Scotland

Evidence Tables

Transmission Based Precautions Definitions Literature Review

Version 1.0

19 August 2024

ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

Version history

This literature review will be updated in real time if any significant changes are found in the professional literature or from national guidance/policy.

Version	Date	Summary of changes
1.0	19 August 2024	N/A

Contents

Introduction

All studies which are critically appraised as part of the literature review are given a grade of evidence based on the SIGN 50 methodology grading system (SIGN, 2004), which allows scientific studies to be assessed for quality using a number of reviewing forms (available from the SIGN website).

The main conclusions from the studies are summarised along with a brief description of the study quality in an Evidence Table. Studies, which have sufficient quality and specifically answer a defined research question are grouped together to enable formation of a "considered judgment" based on this information. This "considered judgment" is then used as the basis for formulation of recommendations in a separate Considered Judgement Form.

This system allows formulation of recommendations supported by good quality observational studies in the case when RCTs are not available for practical or ethical reasons, as is generally found in infection control literature.

Grades of evidence

The following grades were given to the papers included in this evidence table:

Grade	Description
1++	High quality meta analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1-	Meta analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort studies. High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, for example case reports, case series
4	Expert opinion

Research questions for evidence table

1. What is the current definition of contact transmission?
2. What is the current definition of droplet transmission?
3. What is the current definition of airborne transmission?
4. How are infectious agents released into the air of the health and care environment from the respiratory tract?
5. Can person-to-person transmission of infection be defined beyond the current categories of contact, droplet and/or airborne?
6. What are Transmission-based Precautions (TBPs)?
7. When should TBPs be applied?
8. Are there reported occurrences of pathogen transmission which do not align with their currently assigned transmission modes?
9. What factors should be considered when determining whether to discontinue TBPs?

Question 1: What is the current definition of contact transmission?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

[NC] = no citations.

Direct contact transmission is defined as microorganisms being “transferred from one infected person to another person without a contaminated intermediate object or person”. Examples given with citations.

- Blood-containing body fluids contact with mucous membranes.
- Blood-containing body fluids contact with broken skin.
- Transfer of scabies mites.
- Transfer of herpes simplex virus (HSV) via contact with herpes whitlow.

Assessment of evidence
Indirect contact transmission is defined as involving “the transfer of an infectious agent through a contaminated intermediate object or person.” Examples given with citations. • Transfer via healthcare worker (HCW) hands. • Patient care devices. • Shared toys. • Inadequately cleaned/sterilised instruments. Examples given: Herpes simplex virus, RSV, *S. aureus*. “Although contaminated clothing has not been implicated directly in transmission, the potential exists for soiled garments to transfer infectious agents to successive patients.” [NC] “Contact precautions for pathogens that have been implicated in transmission through environmental contamination (e.g., VRE, *C difficile*, noroviruses and other intestinal tract pathogens; RSV)”.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Commission on Safety and Quality in Healthcare. Standard and transmission-based precautions and signage.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
2022. Date accessed: 7 September 2022.					
Assessment of evidence					
"Direct transmission occurs when infectious agents are transferred from one person to another person without a contaminated intermediate object or person." "Indirect transmission involves the transfer of an infectious agent through a contaminated intermediate object (fomite) or person."					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ministry of Health New Zealand. How infectious diseases spread. Date last updated: 2021. Date accessed: 15 September 2023.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
From person to person directly through close contact. "Indirectly from an infected person to an object (such as door handles, benchtops, food) and then to another person who comes into contact with the contaminated item".					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract infections in healthcare settings. October 2016. Date accessed: 21 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Does not apply to TB, MERS-CoV or human cases of avian influenza.

Guidelines supplement but do not replace local risk assessment.

Contact transmission:

“Contact transmission may be direct or indirect. Infectious agents can be inadvertently passed directly from an infected person (for example after coughing into their hands) to a recipient who, in the absence of correct hand hygiene, may then transfer the organism to the mucous membranes of their mouth, nose or eyes.

Indirect contact transmission takes place when a recipient has contact with a contaminated object, such as furniture or equipment that an infected person may have coughed or sneezed on. In the absence of correct hand hygiene, the recipient may transfer organisms from the contaminated object to the mucous membranes of their mouth, nose or eyes”.

Assessment of evidence
Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Social Care. Infection prevention and control: resource for adult social care. 31 March 2022. Applies from: 4 April 2022. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
This information is stated to apply to England. Also stated is: “This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England.”					

Assessment of evidence
"Contact precautions – used to prevent and control infections that spread via direct contact with the person or indirectly from the person's immediate environment (including care equipment). This is the most common route of cross-infection spread". [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government, National Health and Medical Research Council. Australian guidelines for the prevention and control of infection in healthcare. 2019. Date last updated: September 2022. Date accessed: 07 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
• Most common mode of transmission. • Usually involves transmission by touch or via contact with blood or body substances.					

Assessment of evidence

- Direct or indirect: [NC]

"Direct transmission occurs when infectious agents are transferred from one person to another—for example, a patient's blood entering a healthcare worker's body through an unprotected cut in the skin." [NC]

"Indirect transmission involves the transfer of an infectious agent through a contaminated intermediate object or person—for example, a healthcare worker's hands transmitting infectious agents after touching an infected body site on one patient and not performing proper hand hygiene before touching another patient, or a healthcare worker coming into contact with fomites (e.g. bedding) or faeces and then with a patient." [NC]

"Examples […] include MROs, *Clostridioides difficile* (*Clostridium difficile* or *C. difficile*), norovirus and pathogens which cause highly contagious skin infections/infestations (for example impetigo, scabies)." [NC]

"Indirect or direct contact transmission: when a healthcare workers' hands or clothing become contaminated, patient-care devices are shared between patients, infectious patients have contact with other patients, or environmental surfaces are not regularly decontaminated." [NC]

"Putting on both gloves and gown upon entering the patient-care area helps to contain infectious agents, especially those that have been implicated in transmission through environmental contamination (e.g., *C. difficile*, norovirus and other intestinal tract pathogens, respiratory syncytial virus)".

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Infection Control Committee. Guidelines on infection control practice in the clinic	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
settings of Department of Health. Date last updated: 2019. Date accessed: 10 October 2022.					

Assessment of evidence

Setting: Hong Kong.

The following guidelines are written for staff working in outpatient settings or in healthcare settings where could have potential contact with patients, their blood or body substances." "They should be read in conjunction with other infection control guidelines/recommendations promulgated by the department".

"(C) Contact precautions apply to patients known or suspected to be infected or colonized with epidemiologically important microorganisms that can be transmitted through direct patient contact (hand or skin-to-skin contact that occurs during patient-care activities) or indirect contact of contaminated environmental surfaces or healthcare items. Examples of infections transmitted by contact route include scabies, norovirus, MRSA, VRE and seven *Clostridium difficile*".

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Transmission-based precautions for the prevention and control of infections: aide-memoire. 2022. Date accessed: 11 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Contact transmission is the spread of an infectious agent caused by physical contact of a susceptible host with people or objects."

"Direct contact transmission involves both a direct body-surface-to-body-surface contact and physical transfer of microorganisms between an infected or colonized person and a susceptible host." [NC]

"Indirect contact transmission involves contact of a susceptible host with a contaminated intermediate object (e.g., contaminated hands) that carries and transfers the microorganisms." [NC]

"Examples of pathogens that can spread via contact transmission include many gastrointestinal pathogens that cause diarrhoea, and bacteria such as *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus* and Ebola virus."

References:

WHO. Transmission-based precautions. In: Infection prevention and control [online course series]. Geneva: World Health Organization; 2021.

Assessment of evidence
WHO Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. Geneva: World Health Organization; 2014. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Centres for Disease Control and Prevention, 2007.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Occurs when microorganisms are transferred through physical contact between an infected source and a host, or through the passive transfer of the microorganisms to a host via an intermediate object."

Direct contact – "exposure occurs when the transfer of microorganisms results from direct physical contact between an infected or colonized source and a host (body surface to body surface without barriers), such as shaking hands". [NC]

Indirect contact – "involves the passive transfer of microorganisms to a host via an intermediate object, such as contaminated hands that are not cleaned between episodes of patient care, contaminated patient care equipment (e.g., commodes, wheelchairs, base of electronic thermometers, blood pressure cuffs, monitoring equipment), surfaces such as bedrails that are not appropriately cleaned and disinfected between patients, or devices that have manufacturing defects that impede appropriate reprocessing. Other inanimate objects in the patient's environment that may be involved include computers and electronic recreational devices that are not cleaned or disinfected between patients."

Examples of contact transmission pathogens:

- *C. difficile*
- Antibiotic-resistant organisms (AROs), for example, methicillin-resistant *Staphylococcus aureus* (MRSA), VRE
- viruses that cause gastroenteritis

"Contact exposure − contact exposure occurs when infectious agents are transferred through physical contact between an infected source and a host or through the passive transfer of the infectious agent to a host via an intermediate object."

"Contact transmission (direct or indirect) − contact transmission occurs when contact exposure leads to an infectious dose of viable microorganisms from an infected/contaminated source, resulting in colonization and/or infection of a susceptible host."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014. Date accessed: 7 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Contact transmission: “The spread of an infectious agent caused by physical contact of a susceptible host with people or objects. [NC]

- Direct contact transmission involves both a direct body-surface-to-body-surface contact and physical transfer of microorganisms between an infected or colonized person and a susceptible host. [NC]
- Indirect contact transmission involves contact of a susceptible host with a contaminated intermediate object (e.g., contaminated hands) that carries and transfers the microorganisms.”

Under section entitled ‘Contact Precautions’:

“In addition to transmission by large droplets, some common respiratory pathogens (e.g. parainfluenza and respiratory syncytial virus) can be transmitted through contact – particularly by hand contamination and self-inoculation into conjunctival or nasal mucosa.” [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Frequently asked questions (FAQs) about enhanced barrier precautions in nursing homes. 2022. Date accessed: 26 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Contact precautions: • Multidrug-resistant organisms (MDROs). • *C. difficile*, scabies, norovirus.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: transmission based precautions. 2008. Date last updated: 2015. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Contact Precautions are required for patients known or suspected to be infected or colonised with microorganisms that can be transmitted by direct contact or through the patients' secretions or bodily fluids; i.e. contact which occurs when performing patient-care activities that require touching the patients skin, secretions or bodily fluids; or indirect contact i.e. touching potentially contaminated environmental surfaces or equipment in the patients environment. Examples include *Staphylococcus aureus* (MSSA or MRSA), Vancomycin resistant *enterococci* (VRE), *Clostridium difficile* infection (CDI) and scabies."					

Question 2: What is the current definition of droplet transmission?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

[NC] = no citations.

Centers for Disease Control and Prevention (CDC) state that droplet transmission is technically a form of contact transmission.

Droplet transmission defined as

- “respiratory droplets carrying infectious pathogens [that] transmit infection when they travel directly from the respiratory tract of the infectious individual to susceptible mucosal surfaces of the recipient, generally over short distances”

Assessment of evidence

- and that “respiratory droplets are generated when an infected person coughs, sneezes, or talks or during procedures such as suctioning, endotracheal intubation, cough induction by chest physiotherapy and cardiopulmonary resuscitation”.

CDC authors state that evidence for droplet transmission comes from:

- outbreak reports
- experimental studies
- aerosol dynamics information

- CDC suggest that there is evidence of the nasal mucosa, conjunctivae and less often the mouth being susceptible portals of entry for respiratory viruses.
- Authors state that “droplets traditionally have been defined as being >5μm in size.”
- Authors suggest that one way in which droplet transmission can be distinguished from airborne transmission is through examination of evidence for transmission over certain distances. “The maximum distance for droplet transmission is currently unresolved, although pathogens transmitted by the droplet route have not been transmitted through the air over long distances, in contrast to the airborne pathogens discussed below.”
- Area of risk for droplet transmission has been cited as <3ft around the infected individual based on epidemiologic and simulated studies.
- Donning masks, using this distance as a trigger, has prevented transmission, but no citations are provided.
- “Influenza viruses are transmitted primarily by close contact with respiratory droplets”.
- “Acquisition of Influenza by healthcare personnel has been prevented by Droplet Precautions, even when positive pressure rooms were used in one centre”.

Assessment of evidence
• "Organisms transmitted by the droplet route do not remain infective over long distances, and therefore do not require special air handling and ventilation." • Authors provide examples of pathogens transmitted via the droplet route: *Bordetella pertussis*, influenza virus, adenovirus, rhinovirus, *Mycoplasma pneumonia*, SARS-CoV, group A streptococcus, and *Neisseria meningitides*. • Droplet precaution pathogens "do not remain infectious over long distances in a healthcare facility, special air handling and ventilation are not required to prevent droplet transmission." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Commission on Safety and Quality in Healthcare. Standard and transmission-based precautions and signage. 2022. Date accessed: 7 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Droplet precautions, in addition to standard precautions, are used to prevent transmission of infectious agents spread through respiratory droplets (i.e. droplets >5microns in size). These are generated by a patient who is coughing, sneezing, or talking. Transmission via					

Assessment of evidence
droplets requires close contact as the droplets do not remain suspended in the air, and generally only travel short distances. Therefore, special air handling and ventilation are not required." "Droplets can contaminate horizontal surfaces close to the source patient, and the hands of healthcare workers can become contaminated through direct contact with those surfaces." Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract infections in healthcare settings. October 2016. Date accessed: 21 September 2022.	Expert opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Does not apply to TB, MERS-CoV or human cases of avian influenza.					

Assessment of evidence
Guidelines supplement but do not replace local risk assessment. "Droplet transmission • Droplets greater than five microns in size may be generated from the respiratory tract during coughing, sneezing or talking. • If droplets from an infected person come into contact with the mucous membranes (mouth or nose) or surface of the eye of a recipient, they can transmit infection. • These droplets remain in the air for a short period and travel one to two metres, so physical closeness is required for transmission." Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sehulster LM, Chinn RYW, Arduino MJ, et al. Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Advisory Committee (HICPAC). Chicago IL: American Society for Healthcare Engineering/American Hospital Association; 2003. Date last updated: 2019. Date accessed: 30 September 2022.					

Assessment of evidence

Experts involved in this document were staff members from the CDC and HICPAC. Their affiliations: Division of Healthcare Quality Promotion National Center for Infectious Diseases; HICPAC Advisor; Division of Bacterial and Mycotic Diseases National Center for Infectious Diseases; Division of Parasitic Diseases National Center for Infectious Diseases; Division of Oral Health National Center for Chronic Disease Prevention and Health Promotion. With liaison members from Association for Professionals in Infection Control and Epidemiology (APIC), Association of periOperative Registered Nurses (AORN), U.S food and drug administration, American health care association, U.S. Centers for Medicare and Medicaid Services, Society for Healthcare Epidemiology of America (SHEA) and Advisory Committee for the Elimination of Tuberculosis (ACET).

“Viruses whose major mode of transmission is via droplet contact rarely have caused clusters of infections in group settings through airborne routes”.

Assessment of evidence
Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Social Care. Infection prevention and control: resource for adult social care. 31 March 2022. Applies from: 4 April 2022. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
This information is stated to apply to England. Also stated is: “This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England.”

Assessment of evidence
"Droplet precautions – used to prevent and control infections spread over short distances (at least 3 feet or 1 metre) via larger droplets from the respiratory tract of one individual directly into the eyes, nose, or mouth of another individual. Droplets enter the upper respiratory tract". Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lemass H, McDonnell N, O'Connor N. et al. Infection prevention and control for primary care in Ireland: a guide for general practice. 2013. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Opinion of SARI Infection and Control Subcommittee following a review of the scientific literature and an extensive consultation exercise". No details on review of consultation provided. No citations provided.					

Assessment of evidence
"Droplet precautions: Should be used for infections such as influenza and meningococcal meningitis which can be transmitted by droplets that are generated by the patient during coughing, sneezing, talking, or while performing cough-inducing procedures, e.g., sputum induction, administration of aerosolised medications, airway suctioning and during treatment of lesions/abscesses when aerosolisation of drainage fluid is anticipated."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government, National Health and Medical Research Council. Australian guidelines for the prevention and control of infection in healthcare. 2019. Date last updated: September 2022. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

- "Can occur when an infected person coughs, sneezes or talks, and during certain procedures." [NC]
- "Droplets are infectious particles larger than 5 microns in size." [NC]
- "Respiratory droplets transmit infection when they travel directly from the respiratory tract of the infected person to susceptible mucosal surfaces (nasal, conjunctival or oral) of another person, generally over short distances." [NC]
- "Droplet distribution is limited by the force of expulsion and gravity and is usually no more than 1 metre." [NC]
- "Examples […] include influenza virus and *Neisseria meningitidis* (meningococcal infection)." [NC]

"Droplet transmission: when healthcare workers' hands become contaminated with respiratory droplets and are transferred to susceptible mucosal surfaces such as the eyes; when infectious respiratory droplets are expelled by coughing, sneezing or talking, and come into contact with another's mucosa (eyes, nose or mouth), either directly or via contaminated hands." [NC]

"As these microorganisms do not travel over long distances, special air handling and ventilation are not required." [NC]

"Infectious agents for which droplet precautions are indicated include influenza, norovirus, pertussis, meningococcus." [NC]

"Droplets: Small particles of moisture generated when a person coughs or sneezes, or when water is converted to a fine mist by an aerator or shower head. These particles, intermediate in size between drops and droplet nuclei, can contain infectious microorganisms and tend to quickly settle from the air such that risk of disease transmission is usually limited to persons in close proximity (e.g. at least 1 metre) to the droplet source." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Infection Control Committee.	Expert opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Guidelines on infection control practice in the clinic settings of Department of Health. Date last updated: 2019. Date accessed: 10 October 2022.					

Assessment of evidence

Setting: Hong Kong.

“The following guidelines are written for staff working in outpatient settings or in healthcare settings where could have potential contact with patients, their blood or body substances.” “They should be read in conjunction with other infection control guidelines/recommendations promulgated by the Department”.

“(B) Droplet Precautions Apply to patients known or suspected to be infected with a pathogen that can be transmitted by droplet route. Droplet precautions prevent the spread of organisms that are transmitted by large droplet particles (larger than 5 micrometres in size). These particles do not remain suspended in the air for extended periods of time, and usually do not travel beyond several feet (usually 1 metre or lesser) from the patient. These droplets are generated when the patient coughs, talks, or sneezes. Examples of infections transmitted by droplet route include influenza, Group A streptococcus, pertussis and rubella.”

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Transmission-based precautions for the prevention and control of infections: aide-memoire. 2022. Date accessed: 11 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Droplet transmission is the spread of an infectious agent caused by the dissemination of droplets. Droplets are primarily generated from an infected (source) person during coughing, sneezing and talking. Transmission occurs when these droplets that contain microorganisms are propelled (usually <1m) through the air and deposited on the conjunctivae, mouth, nasal, throat or pharynx mucosa of another person. Most of the volume (>99%) comprises large droplets that travel short distances (<1m) and do not remain suspended in the air. Thus, special air handling and ventilation are not required to prevent droplet transmission."

"Examples of pathogens that spread via droplet transmission include seasonal influenza virus, *Corynebacterium diphtheriae* (pharyngeal diphtheria), *Neisseria meningitidis* (meningococcal meningitis), *Yersinia pestis* (pneumonic plague), rubella virus (German measles), and *Bordetella pertussis* (pertussis)."

References:

WHO. Transmission-based precautions. In: Infection prevention and control [online course series]. Geneva: World Health Organization; 2021.

Assessment of evidence
WHO. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. Geneva: World Health Organization; 2014. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Centres for Disease Control and Prevention, 2007.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Association of periOperative registered nurses. Guideline quick view: transmission-based precautions. AORN Journal, 2019;109(4): 529-536.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Suspected or proven infections transmitted by respiratory droplets (ie, large particle droplets that are > 5μm) that are generated by a patient who is coughing, sneezing, or talking." [NC] Droplet precautions for patients who are "known or suspected to have infections transmitted by respiratory droplets (e.g., adenovirus, group A Streptococcus, influenza, *Neisseria meningitides*, *Bordetella pertussis*, rhinovirus)." Under droplet precaution section, guidelines state that respirators should be used for AGPs "on patients with suspected or proven infections transmitted by respiratory aerosols (e.g., severe acute respiratory syndrome, avian influenza, pandemic influenza, viral hemorrhagic fevers)."					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"…may occur when droplets that contain microorganisms are propelled a short distance (i.e., within 2 metres) through the air and are deposited on the mucous membranes of a host. Droplets may also contaminate the immediate environment when they settle on surfaces and may contribute to contact transmission".

Within the droplet exposure and transmission section - "large aerosol particles (i.e., greater than 10µm in diameter) will fall to the surface in a few seconds, and droplet exposure can only occur if the source and host are in close proximity (within two metres)." [NC]

Within the droplet exposure and transmission section - "some microorganisms expelled in large droplets are very fragile and do not survive outside the human host or on surfaces (e.g., *Bordetella pertussis*, meningococcus)." [NC]

Assessment of evidence
Examples of droplet transmitted pathogens: RSV, influenza, parainfluenza, rhinovirus, adenovirus, rubella, mumps and *Bordetella pertussis.* “Droplet − solid or liquid particles suspended in the air, whose motion is governed principally by gravity and whose particle size is greater than 10μm. Droplets are generated primarily as the result of an infected source coughing, sneezing or talking”. “Droplet exposure − droplet exposure may occur when droplets that contain an infectious agent are propelled a short distance (i.e., within two metres) through the air and are deposited on the mucous membranes of the eyes, nose or mouth of a host.” “Droplet nucleus − a droplet nucleus is the airborne particle resulting from a potentially infectious (microorganism-bearing) droplet from which most of the liquid has evaporated, allowing the particle to remain suspended in the air (Note: Droplet nuclei can also be found in aerosols however, their motion is controlled by physical parameters including gravity and air currents).” “Droplet transmission − transmission that occurs when the droplets that contain microorganisms are propelled a short distance (within two metres) through the air and are deposited on the mucous membranes of another person, leading to infection of the susceptible host. Droplets can also contaminate surfaces and contribute to contact transmission.”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
2014. Date accessed: 7 November 2022.					

Assessment of evidence

"Droplet transmission: the spread of an infectious agent caused by the dissemination of droplets. Droplets are primarily generated from an infected (source) person during coughing, sneezing and talking." [NC] "Transmission occurs when these droplets that contain microorganisms are propelled (usually <1m) through the air and deposited on the conjunctivae, mouth, nasal, throat or pharynx mucosa of another person." [NC] "Most of the volume (>99%) comprises large droplets that travel short distances (<1m) and do not remain suspended in the air." [NC] "Thus, special air handling and ventilation are not required to prevent droplet transmission."

"Apply standard, contact and droplet precautions at initial evaluation of a paediatric patient presenting with a suspected ARI during the peak season of certain viruses (e.g., croup and parainfluenza, acute bronchiolitis, and respiratory syncytial virus). Modify isolation precautions according to the specific diagnosis."

Under section entitled 'Droplet Precautions':

- "Respiratory pathogens that are transmitted through large droplets include adenovirus, avian influenza A(H5N1), human influenza and SARS-CoV." [NC]

Under section entitled 'Contact Precautions':

- "In addition to transmission by large droplets, some common respiratory pathogens (e.g., parainfluenza and respiratory syncytial virus) can be transmitted through contact – particularly by hand contamination and self-inoculation into conjunctival or nasal mucosa." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ministry of Health New Zealand. How infectious diseases spread. Date last updated: 2021. Date accessed: 15 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Through the air as droplets or aerosol particles (airborne).

“Some infections are spread when an infected person talks, coughs or sneezes and the small droplets they produce contain germs. The droplets travel a short distance before falling. The droplets may be breathed in by people who are near, or may fall and contaminate an object or surface. Spread can also occur by touching the nose or mouth with hands contaminated by the droplets. Examples of diseases spread by droplet:

- common cold
- influenza (the flu)
- COVID-19.”

Manatū Hauora Ministry of Health is the chief steward of the health system, leading health across the New Zealand Government. Authors and their affiliations not provided.

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: transmission based precautions. 2008. Date last updated: 2015. Date accessed: 6 September 2022	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Droplet precautions are required for patients known or suspected to be infected with microorganisms transmitted by droplets. Droplets can be generated by coughing, sneezing, talking or during the performance of procedures (e.g., nebulisation). Examples include pertussis, influenza, rubella and mumps."					

Question 3: What is the current definition of airborne transmission?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

[NC] = no citations.

In this Centers for Disease Control and Prevention (CDC) guidance, the term 'Airborne Precautions' has been supplemented with the term 'Airborne Infection Isolation Room (AIIR)'.

Modes of transmission vary by organism with some being transmitted by more than one route: some are transmitted primarily by direct or indirect contact (examples given), others by the droplet (examples given) or airborne routes – example given: *M. tuberculosis*.

Assessment of evidence
The CDC suggest that airborne pathogens are delineated by their ability to precipitate person-to-person transmission following distant contact and the need for enhanced ventilation when attempting to contain/remove the pathogen from the air: “Airborne transmission occurs by dissemination of either airborne droplet nuclei or small particles in the respirable size range containing infectious agents that remain infective over time and distance (e.g., spores of Aspergillus spp., and *Mycobacterium tuberculosis*). Microorganisms carried in this manner may be dispersed over long distances by air currents and may be inhaled by susceptible individuals who have not had face-to-face contact with (or been in the same room with) the infectious individual. Preventing the spread of pathogens that are transmitted by the airborne route requires the use of special air handling and ventilation systems (e.g., AIIRs) to contain and then safely remove the infectious agent. Infectious agents to which this applies include *Mycobacterium tuberculosis*, rubeola virus (measles), and varicella-zoster virus (chickenpox).” – General terminology used, for example ‘time and distance’ and ‘long distance’. Use of term ‘inhalational transmission’, defining transmission mode based on effective precautions (droplet precautions/ultraviolet (UV) lights) – “However, inhalational transmission could not be excluded in an outbreak of influenza in the passengers and crew of a single aircraft. Observations of a protective effect of UV lights in preventing influenza among patients with tuberculosis during the influenza pandemic of 1957-’58 have been used to suggest airborne transmission.” “In contrast to the strict interpretation of an airborne route for transmission (i.e., long distances beyond the patient room environment).” “Airborne Precautions are recommended for preventing airborne transmission of measles and varicella-zoster viruses” SARS and smallpox “could be transmitted through the airborne route”. “Droplet nuclei: Microscopic particles < 5µm in size that are the residue of evaporated droplets and are produced when a person coughs, sneezes, shouts, or sings. These particles can remain suspended in the air for prolonged periods of time and can be carried on normal air currents in a room or beyond, to adjacent spaces or areas receiving exhaust air.” [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Commission on Safety and Quality in Healthcare Standard and transmission-based precautions and signage. 2022. Date accessed: 7 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Airborne precautions, in addition to standard precautions, are used to prevent transmission of infectious agents that are disseminated through airborne droplet nuclei and remain infective over time and distance. These agents may be inhaled by individuals who have not had face-to-face contact with, or been in the same room as, the infectious individual. Airborne droplet nuclei can also be generated through aerosol-generating procedures (AGPs), such as intubation, suctioning, bronchoscopy, or the use of nebulisers." Limitations: • No citations given.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ministry of Health New Zealand. How infectious diseases spread. Date last updated: 2021. Date accessed: 15 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Other infections are spread when an infected person talks, breathes, coughs or sneezes tiny particles that contain germs into the air. These are called small particle aerosols. Since these aerosol particles are tiny, they can stay suspended in the air for hours and be breathed in by other people. Examples of aerosol spread: • chickenpox • measles • TB". Manatū Hauora Ministry of Health is the chief steward of the health system, leading health across the New Zealand Government. Authors and their affiliations not provided. No citations given.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract infections in healthcare settings. October 2016. Date accessed: 21 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Does not apply to TB, MERS-CoV or human cases of avian influenza.

Guidelines supplement but do not replace local risk assessment.

“Airborne transmission – aerosols are smaller than the droplets described above and can remain in the air for longer and, therefore, potentially transmit infection by mucous membrane contact or inhalation”.

Limitations:

- No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sehulster LM, Chinn RYW, Arduino MJ, et al. Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Chicago IL: American Society for Healthcare Engineering/American Hospital Association; 2003. Date last updated: 2019. Date accessed: 30 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
Experts involved in this document were staff members from the CDC and HICPAC. Their affiliations: Division of Healthcare Quality Promotion National Center for Infectious Diseases; HICPAC Advisor; Division of Bacterial and Mycotic Diseases National Center for Infectious Diseases; Division of Parasitic Diseases National Center for Infectious Diseases; Division of Oral Health National Center for Chronic Disease Prevention and Health Promotion. With liaison members from Association for Professionals in Infection Control and Epidemiology (APIC), Association of periOperative Registered Nurses (AORN), U.S food and drug administration, American health care association, U.S. Centers for Medicare and Medicaid Services, Society for Healthcare Epidemiology of America (SHEA) and Advisory Committee for the Elimination of Tuberculosis (ACET). “Respiratory infections can be acquired from exposure to pathogens contained either in droplets or droplet nuclei.” “The spread of airborne infectious diseases via droplet nuclei is a form of indirect transmission. Droplet nuclei are the residuals of droplets that, when suspended in air, subsequently dry and produce particles ranging in size from 1–5μm. These particles can: a. contain potentially viable microorganisms, b. be protected by a coat of dry secretions, c. remain suspended indefinitely in air, and d. be transported over long distances.” [NC] “The microorganisms in droplet nuclei persist in favorable conditions (e.g., a dry, cool atmosphere with little or no direct exposure to sunlight or other sources of radiation). Pathogenic microorganisms that can be spread via droplet nuclei include *Mycobacterium tuberculosis*, VZV, measles virus (i.e., rubeola), and smallpox virus (i.e., variola major).” “The spores of Aspergillus fumigatus have a diameter of 2–3.5μm, with a settling velocity estimated at 0.03 cm/second (or about 1 meter/hour) in still air. With this enhanced buoyancy, the spores, which resist desiccation, can remain airborne indefinitely in air currents and travel far from their source.” “The factors facilitating airborne distribution of these viruses in an infective state are unknown, but a presumed requirement is a source patient in the early stage of infection who is shedding large numbers of viral particles into the air.” [NC]

Assessment of evidence
References: Garner JS. Hospital Infection Control Practices Advisory Committee. Guideline for isolation precautions in hospitals. Infect Control Hosp Epidemiol. 1996;17:53–80. Schaal KP. Medical and microbiological problems arising from airborne infection in hospitals. J Hosp Infect 1991;18 (Suppl A):451–9. Streifel AJ. Design and maintenance of hospital ventilation systems and prevention of airborne nosocomial infections. In: Mayhall CG, ed. Hospital epidemiology and infection control, 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 1999:1211–21.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Social Care. Infection prevention and control: resource for adult social care. 31 March 2022. Applies from: 4 April 2022. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
This information is stated to apply to England.					

Assessment of evidence
Also stated is: “This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England.” “Airborne precautions – used to prevent and control infections spread without necessarily having close contact with the person via aerosols (smaller than droplets) from the respiratory tract of one individual directly into the eyes, nose, or mouth of another individual. Aerosols enter the lower respiratory tract”. Limitations: • No citations.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lemass H, McDonnell N, O’Connor N. et al. Infection prevention and control for primary care in Ireland: a guide for general practice. 2013. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
"Opinion of SARI Infection and Control Subcommittee following a review of the scientific literature and an extensive consultation exercise" No details on review of consultation provided. No citations provided. "Airborne Precautions: Should be used for infections that can be transmitted by very small respiratory particles that remain suspended in the air e.g. infective pulmonary or laryngeal TB."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government, National Health and Medical Research Council Australian guidelines for the prevention and control of infection in healthcare. 2019. Date last updated: September 2022. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
• .May occur via particles containing infectious agents that remain infective over time and distance." [NC] • "Small-particle aerosols (often smaller than 5 microns) are created during breathing, talking, coughing or sneezing and secondarily by evaporation of larger droplets in conditions of low humidity." [NC] • "Aerosols containing infectious agents can be dispersed over long distances by air currents (e.g., ventilation or air conditioning systems) and inhaled by susceptible individuals who have not had any contact with the infectious person." [NC] • "These small particles can transmit infection into small airways of the respiratory tract." • "An example of infectious agents primarily transmitted via the airborne route are *M. tuberculosis* and rubeola virus (measles)." [NC] Use term 'primarily' for airborne pathogen examples. Vague terms such as "remain infective over time and distance". Suggestion of evaporation of larger droplets only in environments of low humidity. "Airborne transmission: when attending healthcare workers or patients inhale small particles that contain infectious agents." [NC] "Aerosols: Microscopic particles <5µm in size that are the residue of evaporated droplets and are produced when a person coughs, sneezes, shouts, or sings. These particles can remain suspended in the air for prolonged periods of time and can be carried on normal air currents in a room or beyond, to adjacent spaces or areas receiving exhaust air." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Infection Control Committee. Guidelines on infection control practice in the clinic settings of	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health. Date last updated: 2019. Date accessed: 10 October 2022.					
Assessment of evidence					
Setting: Hong Kong. “The following guidelines are written for staff working in outpatient settings or in healthcare settings where could have potential contact with patients, their blood or body substances.” “They should be read in conjunction with other infection control guidelines/recommendations promulgated by the Department”. “Airborne precautions prevent diseases that are transmitted by airborne droplet nuclei (5 micrometres or smaller in size) containing microorganisms that can remain suspended in the air for long period of time or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air current within a room or over a long distance. Examples of airborne infections are pulmonary tuberculosis, chickenpox and measles.” Limitations: • No citations provided.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Transmission-based precautions for the prevention and control of infections: aide-memoire. 2022. Date accessed: 11 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Airborne transmission is the spread of an infectious agent caused by the dissemination of droplet nuclei that remain infectious when suspended in air over long distances and time. Airborne transmission can be further categorized into obligate or preferential airborne transmission.

- Obligate airborne transmission refers to pathogens that are transmitted only by deposition of droplet nuclei under natural conditions (e.g., pulmonary tuberculosis).
- Preferential airborne transmission refers to pathogens that can initiate infection by multiple routes, but are predominantly transmitted by droplet nuclei (e.g., measles and chickenpox).
- Opportunistic airborne transmission refers to agents that naturally cause disease through other routes, but under special circumstances may be transmitted via fine particle aerosols."

"Examples of pathogens that spread via airborne transmission are *Mycobacterium tuberculosis* (tuberculosis), varicella zoster virus (Herpes zoster/ shingles), rubeola virus (measles)."

Assessment of evidence
"Current WHO list of aerosol-generating procedures: tracheal intubation, non-invasive ventilation (e.g., BiLevel positive airway pressure, continuous positive airway pressure), tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy, sputum induction by using nebulized hypertonic saline, dentistry and autopsy procedures". **References:** WHO. Transmission-based precautions. In: Infection Prevention and Control [online course series]. Geneva: World Health Organization; 2021. WHO. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. Geneva: World Health Organization; 2014. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Centres for Disease Control and Prevention; 2007.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Manatū Hauora Ministry of Health. Infection prevention and control: overview of infection prevention and control practices in health and disability care settings. Date last updated: 21 July 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 12 October 2022.					
Assessment of evidence					
“Airborne Precautions Airborne Precautions are required when interacting with people known or suspected to have diseases spread by very small particles that can suspend in the air and can be inhaled into the lungs.” [NC]					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Association of periOperative registered nurses. Guideline Quick View: Transmission-Based Precautions. 2019. AORN Journal, 109: 529-536.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
“the airborne route (i.e., small particles or droplet nuclei < 5μm in size).” [NC]					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Airborne transmission may occur when viable microorganisms contained in aerosolized secretions from an infected source are propelled a short (i.e., within two metres) or long (i.e., greater than two metres) distance through the air are inhaled, come into contact with receptors in a susceptible host's airway, overcome host defences and cause disease."

For transmission of infection to occur: [NC]

- Pathogen in particles must be remain viable in the air for prolonged period of time.
- Susceptible host must be exposed to a sufficient concentration (infectious dose).
- The appropriate receptors for the infectious agents must be present at the site of exposure.

Assessment of evidence
"Examples of pathogens spread by the airborne route: Varicella zoster virus, *Mycobacterium tuberculosis*, rubeola virus (measles), smallpox and monkeypox." "Measles transmission has been reported up to 90 minutes after the index case has left the room." Infections transmitted via the airborne route; measles, respiratory (including laryngeal or pleuropulmonary) TB, smallpox, monkeypox, varicella, disseminated zoster. [NC] "Aerosols − Solid or liquid particles suspended in the air, whose motion is governed principally by particle size, which ranges from 10μm–100μm. (Note: Particles less than 10μm [i.e., droplet nuclei] can also be found in aerosols; however, their motion is controlled by other physical parameters)." "Airborne exposure − Exposure to aerosols capable of being inhaled." "Airborne transmission − Transmission of microorganisms via inhalation of aerosols that results in an infection in a susceptible host."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 November 2022					
Assessment of evidence					
Airborne transmission: “The spread of an infectious agent caused by the dissemination of droplet nuclei that remain infectious when suspended in air over long distances and time”. [NC] “Airborne pathogens are transmitted through inhalation of droplet nuclei that remain infectious over a long distance (e.g., >1m), and require special air handling.”					

Question 4: How are infectious agents released into the air of the health and care environment from the respiratory tract?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Gregson FKA, Shrimpton AJ, Hamilton F, et al. Identification of the source events for aerosol generation during oesophagogastroduodenoscopy. Gut. 2022;71:871-878.	Observational air sampling study.	**Level 3**	Particles produced during conscious oesophagogastroduodenoscopy (OGD).	Tidal mouth breathing, nasal breathing and voluntary coughing of same patients.	Particle counts (baseline of tidal breathing and voluntary coughs). Events which occurred during procedure with time stamps, for example, endoscope insertion, coughing and so on. Lengths of time for different events.

Assessment of evidence

Setting: UK, operating theatre (25 air changes per hour (ACH)).

This study carried out in an operating theatre in the UK suggests that evoked coughing during conscious OGD generates significantly more total aerosols (0.3-10μm) than volitional coughing (number and mass) and creates significantly higher peaks. The study also suggests that conscious OGD without cough events does not generate more aerosols (0.3-10μm) than mouth breathing (p=0.17), that nasal breathing produces significantly less aerosols than mouth breathing and that the procedural origin of particles during an OGD is induced coughing rather than scope insertion or removal.

Assessment of evidence
Limitations: • Particles lost to impact in 1m tubing. • Patients are healthy and may not represent those with infection. • Specific to conscious sedation. • Only 15 subjects (nine for volitional and procedural cough comparison). • Typing error – two different values for peak count of voluntary cough reported (2330 and 2320). • Comparison to forced volitional coughing not natural coughing. • Particles not infectious virus. • Lack of detail for specific staff numbers/activity during procedure or baseline readings—"The number of staff in the room and their movement were kept to a minimum throughout the study to minimise extrinsic and artefactual aerosol generation."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Johnson TJ, Nishida RT, Sonpar AP, et al. Viral load of SARS-CoV-2 in droplets and bioaerosols directly captured during breathing, speaking and coughing.	Observational air sampling study.	**Level 3**	RNA detection via air sampling with assessment of viability and examination of relationship between viral load of air samples and viral load of naso-	N/A	Viability of samples. RNA viral load of samples (copies/ml). NP swab results from participants. Correlation between viral load in NP swab

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sci Rep. 2022;12(1):3484.			pharyngeal (NP) swabs.		and viral load of air samples.

Assessment of evidence

Setting: Canada. Mask sampling (setting not relevant).

Due to limitations, this small observational study can only demonstrate that SARS-CoV-2 viral RNA can be detected in air samples (0.3-10µm) (from 17 participants) and in the 0.65-7µm size range (four participants). Viable virus was also shown to be disseminated into the immediate environment via coughing (two participants).

Limitations:

- Sampling set up changed throughout study resulting in small sample sizes for specific processes.
- According to Figure 1b, viral RNA appears to have been detected in samples from a non-infected subject. “One set of field blanks (denoted by triangles) was gathered from a hospital inpatient not infected with SARS-CoV-2.” This is not addressed by the authors.
- Results from hospitalized patients combined with results from community patients – effect on NP swab and air sample viral load correlation unknown.
- Flow rates from samplers provided but sampling times not provided so cannot ascertain viral load of specific air volume.
- No correlation statistics provided for nasal swab and air sample RNA values.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Shrimpton AJ, Brown JM, Cook TM, et al. Quantitative evaluation of aerosol generation from upper airway suctioning assessed during tracheal intubation and extubation sequences in anaesthetized patients. Journal of Hospital Infection. 2022;124:13-21.	Observational air sampling study.	**Level 3**	Primary: Upper airway suctioning at different stages of surgical procedure (pre and post intubation, pre and post extubation). Secondary: Face mask ventilation, intubation, extubation.	Tidal breathing and volitional coughing.	Peak and mean particle counts (0.3-10µm). Events which were time stamped during continuous sampling.
Assessment of evidence					
Setting: UK, operating room theatre (25 ACH). This study provides evidence that the procedure of upper airway suctioning for conscious, sedated or sedated and intubated patients does not appear to generate more particles of 0.3-10µm than breathing (p=.029, <.0001). Power calculations were not based on the interventions of face mask ventilation of sedated patients or intubation under sedation, however, this study also suggests that these procedures may not generate more 0.3-10µm particles than breathing (p= .0002 for both).					

Assessment of evidence
Peak particle counts produced during breathing were significantly higher than those produced during upper airway suctioning of conscious, sedated or sedated and intubated patients (p<.0001). Limitations: • Lack of detail on staff/patient presence during background readings • Not infectious particles • Reasonably small sample size but power calculations conducted (although specific to upper airway suctioning) • Non-infectious patients • Some intubations involved unique events, for example, erroneous intubation of oesophagus before successful intubation of trachea

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lindsley WG, Blachere FM, Beezhold DH, et al. Viable influenza A virus in airborne particles expelled during coughs versus exhalations. Influenza and Other Respiratory Viruses. 2016;10(5):404-413.	Observational air sampling study.	**Level 3**	The production of aerosol particles containing viable influenza A virus by infected people during forced coughs. Three simulated coughs.	The production of aerosol particles containing viable influenza A virus by infected people during forced exhalations. Three exhalations (as much and as rapidly as possible).	Results of NP/oropharyngeal (OP) swabs. Positivity +/- of aerosol samples.

Assessment of evidence
Setting: US. This limited observational study demonstrates that viable Influenza A is disseminated into the air via three forced coughs (28 of 53, 53% infected persons) and three forced deep exhalations (22 of 52, 42% of infected persons) and that there appears to be no significant difference in rates of positive air samples for these two differing activities (p=.2207). However, this study has limited applicability due to it being very specific to young, otherwise healthy individuals who had been experiencing symptoms for two days on average before sampling, specific to Influenza A strain of that season, and its specificity and artificial nature of respiratory processes measured. Strengths of randomised order of respiratory events and lab confirmed infection. Limitations: • Simulated cough with mouth sealed around mouthpiece may not mimic in vivo scenario • Exhale as much and as rapidly as possible with mouth sealed around mouthpiece may not mimic in vivo scenario • Specific to younger, healthier patients • Unclear if powered adequately

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Kulkarni H, Smith CM, Lee DDH, et al. Evidence of Respiratory Syncytial Virus Spread by Aerosol. Time to	Observational air sampling study.	**Level 3**	Air samples surrounding 18 RSV infected children/infants in hospital cubicles.	Eight infants in control group (hospitalised but no respiratory problems).	Presence of virus in air samples 1m from patients' heads and for some subjects, 2hrs post discharge.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Revisit Infection Control Strategies? Am J Respir Crit Care Med. 2016; 194(3):308-316					Quantity of viable virus in air samples (PFU/L of air). Size range of particles of positive air samples (µm).

Assessment of evidence

Setting: UK, hospital paediatric ward cubicles (6 ACH) and paediatric ICU cubicles (10 ACH).

This study demonstrates that viable RSV virus can be detected in the air 1m from infected, hospitalized infant/child patients within the particle size range of approx. 0.65-10µm. With viable samples detected in particles of <4.7µm in size and in the 0.65-1.1µm range. Unfortunately, it is unclear what specific procedures were ongoing during time of sampling. This study also demonstrates that two hours following discharge of three patients from cubicles with six ACH, viable virus was still detectable in the air, although reduced. It is unclear what procedures these patients underwent.

Limitations:

- Cannot use data from patients cared for in open bays. Table 3 demonstrates presence of other RSV positive patients in bay when taking samples from index patients.
- Unclear as to procedures patients underwent. Three patients on ventilation. Seven on nasal cannula O_2. Authors report open suctioning of ventilated patients.
- Specific to hospitalized infants/children later in the course of infection (mean of 7.9 days of symptoms).
- Unclear as to nature of symptoms and positivity of staff/visitors.
- Very wide confidence intervals.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sheikh S, Hamilton FW, Nava GW, et al. Are aerosols generated during lung function testing in patients and healthy volunteers? Results from the AERATOR study. Thorax. 2022; 77(3):292-294.	Observational air sampling study.	**Level 3**	Standardised spirometry (Vyntus spirometer, Vyaire with single use bacterial filters). Peak flow assessments with bacterial filter. Peak flow assessment without bacterial filter. Fractional exhaled nitric oxide (FE_{NO}) assessments (NIOX device, Aerocrine).	Breathing. Speaking. Voluntary coughing.	Mean total particle counts per sample – Geometric mean number concentration/cm3 (0.5µm-20µm). Mean peak particle counts per sample – geometric mean number concentration/cm3 (0.5µm-20µm).

Assessment of evidence

Setting: UK, laminar flow theatre air supply rate of 1200 m^3/s (500-650 ACH).

This observational air sampling study carried out in a laminal flow theatre in the UK suggests that for healthy volunteers (n=33) and patients with reduced lung function (but no viral infection, n=10), standard spirometry (with a filter) and peak flow measurements (with a filter) do not on average produce higher peak particle counts (0.5-20µm) than forced coughing. Compared to a filtered peak flow, voluntary cough mean peak particle counts were 18 times higher in volunteers and 145 times higher in patients (both p=<0.01). Compared to spirometry (with a filter) voluntary cough mean peak particle counts were 56 times higher in volunteers and 22 times higher in patients with lung disease (both p=<0.01). Authors also reported that they did not identify any significant particle production, above background levels, from the FE_{NO} device. There are a number of significant limitations that must be considered in relation to this study. They include a small

Assessment of evidence
sample size with lack of power calculation and lack of reporting on particle size distributions and how this may differ between lung function tests and/or respiratory events. Limitations: • No randomization of respiratory events/lung function tests. • No subjects infected with respiratory viral pathogens. • Fairly small sample sizes. • Voluntary/forced coughs may not represent in vivo coughing. • No particle sizes. • Particles of sizes 0.5-20μm (incorporating larger droplets). • Cannot ascertain the size profile of particles produced and how it differs between procedures/respiratory activities. • Unknown effect of high air change per hour canopy environment.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Murr AT, Nicholas R, Lenze BS. et al. Quantification of Aerosol Concentrations During Endonasal Instrumentation in the Clinic Setting.	Observational air sampling study.	**Level 3**	Measurement of aerosol particle concentrations (number and size of particles) during patient procedures: diagnostic nasal endoscopies and	Baseline. Pre-procedure and post-procedure.	Mean particle concentration per cubic foot. Particle size distribution (0.3, 0.5, 1, 2.5, 5, and 10 μm).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
The Laryngoscope. 2021;131:1415–1421.			nasal endoscopies with debridement's in an outpatient clinic.		Linear regression model was used for direct comparison of effect with different instrument types.

Assessment of evidence

Setting: US, non-negative pressure single room at an outpatient clinic with unknown ACH.

This small observational study involving 30 patients (2 paediatric), suggests a significant increase when comparing pre-procedure measures to post procedure measures following nasal endoscopy with debridement when using cold instrumentation (p=0.005) and during suction use (p=0.001). Also suggested is a significant increase in aerosol particle concentration when comparing baseline and pre-procedure levels (non-negative pressure single room at an outpatient clinic with unknown ACH (p=0.041)). This study possesses several limitations and may not fully generalize to UK health and care settings.

Limitations:

- Small sample size.
- May not fully generalize as carried out in local commercial buildings (although clinics, not a clinical setting).
- May not generalize to UK health setting.
- ACH not provided.
- Time between sample measurements ranged for 2-5 seconds – effect of accumulating particles possible.
- Unclear if door is closed when procedure carried out (likely to be the case) to be comparable with baseline conditions.
- Type and number of sampling interruptions not recorded.
- Lack of information on participant characteristics.

Assessment of evidence
• Only two paediatric patients, results may not generalize to this population. Results in paper not reporting on this cohort separately. • No apparent waiting for return to baseline. Excluded in relation to airway suctioning findings only as cannot ascertain precise location of respiratory tract suctioning and findings may reflect aerosol build up over procedure period as suctioning not sampled as an isolated event.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Graziani F, Izzetti R, Lardani L, et al. Experimental evaluation of aerosol production after dental ultrasonic instrumentation: an analysis on fine Particulate Matter Perturbation. Int. J. Environ. Res. Public Health. 2021;18:3357.	Observational air sampling study.	**Level 3**	Investigation of the pattern of production, diffusion, and persistence of aerosols as measured through the analysis of particle concentration produced during ultrasonic instrumentation.	Samples taken at baseline, before instrumentation, after instrumentation, and at 15-minute time points after procedure up to 120-minutes.	Particle number concentration (Pnum) per size of particle, 0.3, 0.5, 1.0, 3.0, 5.0, and 10.0 µm). Linear regression of Pnum over time (up to 120 minutes).
Assessment of evidence					
Setting: Italy, two dental operating rooms (no ventilation).					

Assessment of evidence
This small observational study involving eight patients, suggests when performing supragingival ultrasonic scaling on the buccal surfaces of the anterior upper and lower teeth on adults in a non-ventilated dental operating room, significant increases in particle numbers of particles sized 0.5µm and 1µm are seen (p=<0.05). Differences in particle number concentration over time are assessed. 0.5µm particles had returned to baseline levels by 60 minutes post instrumentation, 1µm at 45 minutes, 3µm at 15 minutes and particles of size 5µm and 10µm dropped below baseline levels during or just after instrumentation up until 105 minutes afterwards. Particles of 0.3µm in size appeared to not have returned to baseline levels by 105 minutes post-instrumentation. Limitations: • Small sample size. • May not generalize to UK. • Baseline measures taken at initial registration, unclear what this is and if baseline measures were true representation. • Steps involved in the procedure not provided. • Limited information on patient characteristics.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Gaeckle NT, Lee J, Park Y. et al. Aerosol generation from the respiratory tract with various modes of oxygen delivery.	Observational sampling study.	**Level 3**	The concentration of aerosol particles in the 0.37 to 20-µm size range arising from the respiratory tract of healthy participants during breathing, talking, and coughing while	Comparison of particle sizes and number when receiving different oxygen modalities.	Particle concentration (cm^{-3}). Geometric mean diameter (the exponential and logarithmic mean) (µm).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
American Journal of Respiratory and Critical Care Medicine. 2020; 202(8).			receiving oxygen by various modes of delivery.		

Assessment of evidence

Setting: US, negative pressure operating room (15 ACH).

This study involved 10 healthy participants and assessments of particle production during varying respiratory activities, oxygen delivery (non-humidified nasal cannula at 4L/min and non-humidified face mask at 15L/min), non-invasive ventilation (NIPPV 12/5 cm H2O and 20/10 cm H2O) and high flow nasal oxygen use (10L/min, 30L/min and 50L/min). The study found the median particle concentration (per cm^3) was 0.068 (IQR 0.046-0.091) for normal breathing, 0.071 (IQR 0.056-0.104) for talking, 0.105 (IQR 0.080-0.115) for deep breathing and 0.138 (IQR 0.098-0.191) for forced coughing. The median particle concentration was calculated from samples collected repeatedly at one second intervals for 100 seconds (for normal breathing, talking and deep breathing) and 20 seconds (for deep coughs).

The study suggests neither the median particle number nor size of particles, significantly changed with any oxygen modality tested. This was the case during normal breathing, talking, deep breathing, and forced coughing. At 5cm from source, the median of mean particle diameter was 1.48µm (IQR 1.22-1.54) for normal breathing, 1.00µm for deep breathing (IQR 0.98-1.14), 1.28µm (IQR 1.14-1.43) for talking, and 1.03µm (0.94-1.46) for forced coughing. These data were attained using an aerodynamic particle spectrometer (APS) which could measure particles from 0.53-20µm in size. Residual background particles were seen to be significantly larger than particles sampled from participants (p=<0.05). Significant differences between adjusted (for multiple comparisons) geometric mean diameters (µm) were identified when comparing normal breathing and deep breathing, normal breathing and coughing with use of 4min/L nasal cannula and normal breathing vs deep breathing with 30min/L high nasal flow cannula. The study is limited by its small sample size and other potential confounding factors such as unknown ventilation and number of (if any) personnel present.

Assessment of evidence
Limitations: • Room parameters not controlled or measured. • Did not consider air currents. • No mention of doors opening, movement during procedure, number of personnel in room/PPE worn. • One result is reported as “There were some conditions in which cough and deep breathing produced significantly smaller particles than normal breathing,” this is too vague to extract any information . • No mention of rest periods between measurements. • Specific to patient population. • The paper states that in regards to deep breathing, the use of HFNC with flow >30 L/min or NIPPV significantly decreased particle concentration when compared with breathing room air – based on unadjusted analysis. However, this finding is not supported with quantitative/ statistical values. • The paper states coughing produced a higher number of particles than the other manoeuvres tested and was the only manoeuvre to significantly increase measured particle number above the background room concentration. However, no statistical data to support.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Asadi S, Wexler AS, Cappa CD et al. Aerosol emission and superemission during human	Experimental air sampling study.	**Level 3**	Particle Counts	Speaking four different languages, speaking at different volumes and performing different breathing patterns.	Particle emission rate (particles/second). Particle size distribution (mean

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
speech increase with voice loudness. Nature Scientific Report. 2019; 9(1):2348.					geometric diameter µm). Volume amplitude (dB). Square root mean amplitude (A_{rms}).

Assessment of evidence

Setting: California, US. Air sampling using a funnel positioned 7.5cm from participant in an indoor environment.

This study involved participants carrying out experiments: voicing ‘a’ sounds; reading aloud the ‘rainbow passage’; reading aloud ‘the little princess chapter in English translation, Spanish, Mandarin or Arabic; and alternating four breathing patterns at three different amplitudes. An aerodynamic particle sizer collected particles using a funnel. The study was carried out in an indoor ‘controlled’ environment where the temperature ranged 20-25 degrees Celsius and humidity in hood ranged from 45% to 80%.

This study investigated particle emission rates and mean particle sizes when performing different speech or breathing exercises with 48 healthy volunteers. The study identified that in this small cohort of healthy participants, particle emission rates generally appeared to be significantly higher for speech activities than nose or mouth breathing activities (p=<0.05). Particle emission rate appeared to increase with increasing speech volume, but particle size distribution was independent of language spoken or loudness. Certain individuals appeared to emit far more particles than others. The study’s main limitation was small sample sizes within individual experiments involving 10-30 participants.

Limitations:

- Specific to healthy cohort.
- No information on ventilation.
- No statistical testing for differences in patient characteristics .

Assessment of evidence
• Gender and age – stated “no obvious trend” in differences, however only considered for one experiment (the rainbow passage). • Large variation in humidity conditions. • stated no significant impact on results of humidity and temp, provided in sup data but appears to only have been considered for one of the experiments (the little princess). • statistical analysis methods do not allow for comparisons with significance testing. • General particles, not infectious patients or particles. • Particle rate emission data presented in box plot graphs, difficult to obtain values from.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Akin H, Karabay O, Toptan H, et al. Investigation of the presence of SARS-CoV-2 in aerosol after dental treatment. International Dental Journal. 2022:211-215	Observational air sampling.	**Level 3**	The presence of SARS-CoV-2 in aerosol and COVID-19 contamination distance during ultrasonic scaling and tooth preparation. Impact of suction (medium or high) was also investigated.	Use of medium or high suction. Distances of petri dishes to head of patient.	Detection of SARS-CoV-2 through RT-PCR. Ct Values.

Assessment of evidence

Setting: Turkey, operating room.

This small observational study involving 24 patients identified the presence of SARS-CoV-2 RNA using settle plates at distances 0.9m, 1.2m, 2.53m and 3.1m from the patient's head during a dental procedure with medium suctioning. This study is limited by its small sample size, lack of healthcare worker (HCW) testing for COVID-19 and uncertainty regarding 30 minute 'fall out' time.

Limitations:

- Small sample size.
- Three times more males in study than females (six vs 18).
- Study carried out in Turkey, may not generalize to UK health and care settings.
- Time between procedures not provided.
- Movements prior to procedure (by investigators/ clinicians) not disclosed.
- No testing of clinicians and investigators for COVID-19.
- Date of diagnosis and procedure provided, unknown patient stage of infection.
- Simulation aspect of procedure (cannot be extracted from results), does not represent conditions in practice.
- May be variation in pressure applied/ suction by dental unit during procedures as the study identifies the limitation that only one dental unit was used, which is attached to nine additional dental units using the same suction system and no evaluation was made as to if sufficient pressure is supplied when all are in use.
- Unknown environmental conditions such as temperature, humidity, ventilation, air changes.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Dudding T, Sheikh S, Gregson F, et al. A clinical observational analysis of aerosol emissions from dental procedures. PLoS One. 2022;17(3): e0265076.	Observational air sampling study.	**Level 3**	Aerosol numbers generated during 15 different periodontal, oral surgery and orthodontic procedures for human subjects.	Manikin head measurements used as a control to ascertain contribution of patient derived particles.	Total and mean procedure aerosol number concentration (dN*/dLog(Dp)/cm^3). Time stamped events. Particle size distributions. *Mean aerosol number concentration.

Assessment of evidence

Setting: UK, enclosed room (three air purification units, closed external vents).

This study was carried out in an enclosed room in the UK involving 41 patients. It suggests that certain dental procedures do not significantly contaminate the air with particles (0.5-20µm in size) greater than low background levels (0.18 (+/- SD 0.12 particles cm^3). In this study, median total aerosol numbers for certain procedures* appeared to be higher than baseline peak forced cough measurements, however the source/nature of these particles is unknown. This study also supports the concept that particles (of sizes 0.5-20µm) produced during ultrasonic scaling, 3-in-1 syringe use (air + air/water) and surgical drilling may be largely or wholly instrument, rather than patient, derived. Whereas high and slow speed drilling appeared to have different size distributions compared to the phantom head measurements potentially suggesting a non-instrumental source of particles, however, this is based on weak evidence and this study cannot be used in isolation to confirm this hypothesis.

*Surgical drilling, ultrasonic scaling, 3 in 1 air, 3 in 1 air/water, slow speed and high speed drilling.

Assessment of evidence
Limitations: • Forced volitional coughs used as baseline. • Compared to manikin head with “the assumption that if the distributions were the same, all aerosol detected from the patient during the procedure could be explained by the non-salivary contaminated instrument source”. • No power calculations. Small sample sizes for specific procedures (surgical drilling n=7). • Lack of inter-procedure consistency, for example, ultrasonic scaling could mean RSD of specific quadrant or full mouth supragingival scaling. • Cannot ascertain infectiousness/viability of particles. • Baseline measurements do not appear to have been collected at the same distance from source as procedural measurements. • Specific suctioning parameters. • Not necessarily a measurement of ‘inhalable aerosols’ – 0.5-20µm.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Fabian P, McDevitt JJ, DeHaan WH, et al. Influenza virus in human exhaled breath: an observational study.	Observational air sampling study.	**Level 3**	Particle counts and sizes in exhaled breath of infected influenza patients (n=10 subjects).	N/A	Particle counts in exhaled breath of infected influenza patients (n=10 subjects). Particle size distribution (0.3-5µm) in exhaled

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
PLoS One. 2008;3(7): e2691.					breath of influenza infected patients (n=10 subjects).

Assessment of evidence

Setting: Hong Kong.

This small observational study involving 10 patients was carried out in three clinics in China. The study demonstrates wide inter-subject variability for particle production by influenza A and B infected patients. Particle counts ranged from 67 to 8,500 particles per litre of air, during five minutes of breathing sampling. Mask sampling.

Limitations:

- Small sample sizes.
- Selection bias for symptomatic persons who presented for medical care.
- Cannot link RNA detection to specific particle sizes.
- Authors conclude that “influenza virus RNA is contained in fine particles because over 87% of the exhaled particles were under 1μm and less than 0.1% were larger than 5μm.” However, they later gone on to state that their sampling method would likely not capture particles of >5μm due to mask/tubing impaction therefore creating sampling bias.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Alsved M, Nygren D, Thuresson S, et al. SARS-CoV-2 in Exhaled Aerosol	Observational air sampling study.	**Level 3**	SARS-CoV-2 RNA aerosol-positive cases when	SARS-CoV-2 RNA aerosol-negative cases when	Transmission rates in households of index case.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Particles from COVID-19 Cases and Its Association to Household Transmission Clin Infect Dis. 2022; 75(1):50-56			breathing, singing and talking.	breathing, singing and talking.	Days since symptom onset. Reported symptoms. Viral load of NP and salivary swabs. Respiratory activity performed during sampling (breathing, singing, talking).

Assessment of evidence

Setting: Sweden, funnel sampling in mobile van.

This limited observational study with small sample sizes suggests that, as days from symptom onset increase, likelihood of detecting SARS-CoV-2 RNA in exhaled breath decreases (OR 0.55 [0.30–1.0], p=.049). There was a higher fraction of positive aerosol samples from singing, 42% (16/38), and from talking, 30% (11/37), than from breathing, 8% (3/38) (p=0.001 and p=0.019 respectively) In this study, RNA was detected in samples from small particle size bins (1–4 μm and <1μm). Cases reporting cough were more likely to have positive aerosol samples (OR 13, [1.4–120] p=0.02) and aerosol-positive cases were more likely to have lower Ct-values (higher viral load) in NP samples than aerosol-negative cases (p=0.02).

This study cannot be used in isolation to support precautions based on NP swab viral loads, days since symptom onset or respiratory activity due to small sample sizes but may contribute to a wider evidence base – more research is needed. This study does demonstrate that SARS-CoV-2 can be detected in small particles at a short range.

Assessment of evidence
Limitations: • Specific to symptomatic participants. • Specific to strain (22 cases had alpha variant). • Order of respiratory activities does not appear to have been randomized. • Samples not established to be viable/infective. • Small sample sizes, likely underpowered (n=38, 19 positive COVID-19, 19 negative COVID-19).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Fennelly K, Jones-Lopez EC, Ayakaka I, et al. Variability of infectious aerosols produced during coughing by patients with pulmonary tuberculosis. Am J Respir Crit Care Med. 2012;186(5):450-457.	Observational air sampling study.	**Level 3**	Collection of aerosols using a cough aerosol sampling system to quantify and establish their size from patients with active pulmonary TB performing voluntary coughing. Evaluating factors associated with cough aerosol production.	Clinical and demographic factors of patients .	Colony forming units (CFU). Particle size distribution (µm).

Assessment of evidence

Setting: Uganda. Mouthpiece sample collection.

This study involving 112 participants was carried out at a hospital in Uganda, sampling room is not defined. The study suggests patients with suspected tuberculosis and positive sputum acid-fast bacteria (AFB) can produce positive culturable cough aerosols. However, the majority of sputum AFB smear–positive patients (69%) did not produce culturable cough aerosols and none of the sputum AFB-negative/culture positive patients produced positive cough aerosols. The majority (96.4%) of particles collected measured between 0.65 and 4.7μm.

Limitations:

- Study carried out 18-20 years ago may be outdated.
- May not generalize to Scottish health and care setting.
- HIV testing voluntary therefore results including analysis/ comparisons of HIV patients not included in this appraisal as may be inaccurate.
- Grade of extent of disease subjective as decided based on radiograph by one clinician.
- Treatment for patients was offered, MDR-TB treatment provided when medicines became available, unclear at what stage of study treatment began, in total 97/101 treated however due to likelihood of differences in time of treatment available, potential for only a proportion of participants being treated introducing variation.
- Forced cough may not mirror natural coughing processes.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Fabian P, Brain J, Houseman EA, et al.	Observational air sampling study.	**Level 3**	Quantification of general particles exhaled by participants on day	Compared particle production rates with	Breath particle concentrations over time.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Origin of exhaled breath particles from healthy and human rhinovirus-infected subjects. Journal of Aerosol Medicine and Pulmonary Drug Delivery. 2011;24(3).			five of infection with human rhinovirus (HRV).	breathing manoeuvres.	Particle concentrations (particle count divided by 0.3 seconds inhalation/ exhalation volume). Size distribution (µm).

Assessment of evidence

Setting: US.

This study carried out in US involved 19 participants, the study investigated exhaled particles of participants with human rhinovirus (HRV) infection (day five of infection). In this cohort, 25% of subjects were classed as high particle producers (>500 particles/L of air). The majority of exhaled particles were between 0.3 and 0.499µm with particles >3µm rarely detected. No samples from HRV subjects were positive for HRV due to either not being produced or too low numbers for detection, however HRV samples included as controls were detected. Mouthpiece sampler.

Limitations:

- Small sample size.
- Intrasubject variability not accounted for (7 asthmatics, 12 no asthmatics).
- RSV patients results specific to those under 25, minimum age not provided.
- Severity of symptoms unknown.
- For HRV participants, large range in breaths per minute of individuals.

Assessment of evidence
• No statistical testing to establish if any variations between participants are significant. • Specific to subjects five days post inoculation.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Fleischer M, Schumann L, Hartmann A, et al. Pre-adolescent children exhibit lower aerosol particle volume emissions than adults for breathing, speaking, singing and shouting. J R Soc Interface. 2022.	Observational air sampling study.	**Level 3**	This study aimed to determine the cumulative particle emission rate for 15 pre-adolescent children. Assessed: • Breathing at rest (30s) • Speaking (30s) • Singing (30s) • Shouting (10s) Each activity above repeated five times.	Compared to 15 adults.	Emission rate (PM) = computed based on the measured particle concentration and the volume flow through the filter fan unit (particles/sec). Particle volume rate: values taking into account the average size of each measurement channel (0.4, 0.75, 2.0, 4.0, 7.5, 17.5 µm) and assuming a spherical geometry. Max sound pressure levels.

Assessment of evidence
Setting: Berlin University, Germany, clean room with positive pressure (15 Pa). This study involved 30 participants, (15 children between six and 10 years old and 15 adults). Children appear to produce lower particle numbers per second when breathing, speaking and singing compared to adults but the inter-subject variation is so large that this cannot be accepted as a general rule. Emission rates during shouting were similar for adults and children with children producing louder shouts and particles of greater volume. In general, speaking appears to produce more particles than breathing and singing/shouting produces more particles than speaking. Median emission rates for different activities are given but without standard deviations or ranges. Limitations: • To estimate droplet size at mouth, assumptions made regarding droplet content, time in tube and degree of evaporation in relation to room humidity. • Unclear how many room changes per hour. • Unnatural effect of Filter fan unit drawing air towards sampler. • Particles lost before sampling at 810mm distance. • Specific to individuals without respiratory infection. • Median values are presented without standard deviations or ranges. • Tests of significance are not provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Gohli J, Anderson AM, Brantsaeter AB, et al.	Observational air sampling.	**Level 3**	Presence of viral RNA and viable virus in air samples at differing distances	N/A	Viral RNA concentrations in air samples.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Dispersion of SARS-CoV-2 in air surrounding COVID-19-infected individuals with mild symptoms. Indoor Air. 2022 Feb;32(2).			from infected subjects.		Total aerosol particle counts in air samples. RNA detection in oronasopharyngeal samples. Results of viral culturing. Participant symptoms, days since symptom onset and reason for original test. Talking time during sampling in minutes. Frequency of other activities whilst sampling (mild and severe coughing, laughing, sneezing).
Assessment of evidence					
Setting: Norway, naturally vented room with single ventilation shaft.					

Assessment of evidence
This observational study carried out in Norway with 14 participants can only indicate that SARS-CoV-2 RNA can be detected in air at 1m and 2m from infected subjects who are mildly symptomatic at 2-15 days since symptom onset (mean – 6 days, median – 5 days, data missing for three subjects) whilst talking for 15 minutes. RNA was detected at 4m from a zone which hosted eight infected subjects for approx. 2 hours and 40 minutes. Limitations: • Small sample sizes. • Most test subjects were at the end of the first week of symptoms. • 4m positive sample was collected during a session where eight test subjects were inside the testing room for approximately 15–20 minute each. • Unclear room parameters. • Set up of sampling equipment may have physically blocked exhaled air. • Unclear which subjects had which specific symptoms.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Hamilton FW, Gregson FKA, Arnold DT, et al. Aerosol emission from the respiratory tract: an analysis of aerosol generation	Observational air sampling study.	**Level 3**	To characterise aerosol emission from high-flow nasal oxygen (HFNO) and continuous positive airway pressure (CPAP) and	N/A	Speaking and Breathing - average number concentration of aerosol produced during the activity (particles/cm^3/s).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
from oxygen delivery systems. Thorax. 2022; 77(3):276-282.			compare with breathing, speaking and coughing.		Coughing - peak number concentration (particles/cm^3/s).
Assessment of evidence					
Setting: UK, ultraclean laminar flow theatre for healthy volunteers sampling and infectious disease ward for COVID-19 infected patients. This study carried out in the UK, performed air sampling on healthy volunteers (n=25) and COVID-19 infected patients (n=8). The study demonstrates that small particle sizes of 0.5-1.5µm are produced at close range (10cm) during speech and forced coughing. It also demonstrates via repeated measurements that there can be significant intrasubject variability regarding forced coughs (n= six subjects). There appears to be differences in aerosol production by differing HFNO equipment. Finally, it suggests that for the specific HFNO equipment used, a significant proportion of aerosols generated was from the equipment itself as: • "the size distribution of aerosol was not consistent with aerosol from the respiratory tract". • "aerosol was emitted [from the HFNO equipment] even when the machine was unattached to the patient,". • the addition of a filter reduced particle production to 0.006cm-3 when breathing, however based on one subject. This is lower than the mean breathing measurement results for healthy volunteer group. However, further research amongst multiple subjects is needed to confirm this theory. Limitations: • Voluntary coughs from healthy volunteers. • "Background aerosol concentration of infectious ward rooms was significantly higher than in the operating theatres precluding reliable measurements of breathing and speaking."					

Assessment of evidence
• Coughing results from healthy volunteers versus infected patient cannot reliably be compared due to differences in setting and small sample sizes (wide inter-subject variability). • Did not appear to randomize respiratory activities. • Unclear application of background counts (subtracted or used for comparison?). • Unclear how many different volunteers provided samples, for example, “Table 1 describes the number of times each activity was performed, and on how many volunteers, alongside aerosol emission for each activity. The number of activities does not match the number of participants, as some volunteers (n=6) repeated the assessments on a different day to check repeatability, and some measurements were only performed on certain participants.” For example, in Table 1 it states that 25 measurements were conducted but was this with 25 different volunteers? – Authors contacted, issue resolved. • Unclear as to presence in room during baseline measurements but this does not preclude comparison of respiratory activities, for example, breathing compared to CPAP. • Unclear ‘return to baseline’ period. Participants stepped away from funnel. • No sample size/power calculations. • Specific to CPAP equipment and setting (non-humidified 15cm H_2O pressure).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Simonds AK, Hanah A, Chatwin M, et al. Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. Health Technology Assessment 2010; 14(46):131–172.	Observational air sampling study.	**Level 3**	Non-invasive ventilation (VPAP ST III (ResMed UK Ltd, Abingdon, UK) bilevel positive pressure ventilator set in spontaneous timed mode) 20 mins for both types. Oxygen therapy (via 60% venti-mask for 20 mins for healthy and coryzal subjects. 24% oxygen via Venturi mask for 20 mins for chronic lung disease patients) Nebuliser treatment (4ml, time unclear) Chest physiotherapy (for chronic lung disease patients, 10 mins).	Baseline measurement pre-intervention (tidal breathing and coughing) compared to intervention measurement.	Particle size (0.3-10µm). Particle concentration per m^3. Decay in particles over time after ceasing intervention. Impact of modifying non-invasive ventilation (NIV) circuit.

Assessment of evidence
Setting: London, UK, standard single-bedside room at a hospital, no ventilation system or external window. This observational study involved healthy subjects (n=12), patients with coryzal symptoms (n=11) and CLD patients with acute respiratory infection (ARI) exacerbations (n=21). Particle production during various procedures was compared to baseline particle counts which involved subjects breathing and coughing. The study suggests that NIV using a vented mask produces a significant increase in large particles (>10μm) at source, both in CLD patients (p=.042) and possibly in subjects with coryzal symptoms (p=.044) but not in healthy individuals (p=.379). At a 1m distance, NIV using a vented mask produced a significant increase in particles in the following size ranges 3-5μm (p=.047) and 5-10μm (p=.018) for coryzal patients but not healthy or CLD patients. In contrast to the vented mask NIV, no significant increase in any particle size ranges (0.3-10μm) at source or at 1m was seen with use of the non-vented exhalation filter NIV circuit which suggests that the filter is a useful particle dissemination mitigation measure. Chest physiotherapy performed on CLD patients created an increase in large particles (>10μm) next to the subjects' face (p=0.003), but no significant increase was seen at 1m. Oxygen therapy did not increase particle count in any size range for any subject group. Nebulised saline increased particle counts in the following size range categories for all subject groups: 0.3-0.5, 0.5-1, 1-3 and 3-5μm at the subjects' face and 1m away. Nebulised saline increased particle counts in the following size range categories for healthy subjects: 5-10, >10μm at subject's face but not at 1m. Nebulised saline did not increase particle counts of 5-10 or >10μm at 1m away for any subject group. Particles contaminated with respiratory secretions, or of respiratory tract origin, cannot be distinguished from those produced by the nebuliser itself although authors reported that size distributions did not align with the profile of particles of respiratory tract origin. This study's main limitations include small sample sizes, absence on reporting of activity during 40-min baseline sampling period where participants were asked to do "a series of spontaneous coughs" whilst wearing and not wearing a surgical mask as well as unknown room parameters such as temperature, humidity, air flows and background particle counts. Limitations: • Small sample sizes within each group. • Position of D2 (1m), height from floor not provided. • 40 mins between interventions to allow for background particles to fall to baseline, unknown if this is sufficient time. • Variation in diagnosis, indication for admission, and the study interventions applied to those in patient's category.

Assessment of evidence
• 1 patient in coryzal category did not have modified NIV or nebulization as interventions. • Only those in patient groups received physiotherapy. • Likely to be variation in number of coughs and force of coughs of patients. • Mean age of patients group slightly higher. • no randomisation to sampling conditions/intervention. • Background particle levels not taken. Background levels may have been too high to reliable detect aerosol generation above it. • Mean particle counts used rather than mean peak counts. • Did provide subject characteristics but did not evaluate effect of missing data on stats. • Unclear as to temp, humidity and ventilation of settings.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lindsley WG, Blachere FM, Thewlis RE, et al. Measurements of Airborne Influenza Virus in Aerosol Particles from Human Coughs. PLos ONE. 2010;5(11).	Observational air sampling study.	**Level 3**	The amount and size of airborne particles containing influenza virus that are produced by patients when they cough.	N/A	Detection of influenza RNA. Viable influenza virus. Size distribution of particles µm.

Assessment of evidence

Setting: US.

This observational study was carried out in the US and involved 58 volunteers. This study suggests influenza RNA and viable influenza virus can be detected from cough aerosols when coughing directly into a mouthpiece following deep inhalation. The study also reports that 65% of influenza viral RNA was found in particles <4μm in diameter. Sampler with mouthpiece.

Limitations:

- Mix methods for assessing if participants were infected with influenza virus.
- Not all participants were infected with influenza.
- Infectious period or time from symptoms not provided.
- Sampling at close range using mouthpiece, may not reflect real life situation.
- Strain of virus not determined.
- Reasons for only sampling cough aerosols for 48 out of 58 volunteer subjects not provided.
- Reason for only sampling 30 nasopharyngeal swabs using viral plaque assays and 20 cough aerosols using viral plaque assays not provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Killingley B, Greatorex J, Cauchemes S, et al. Virus shedding and environmental deposition of novel A	Observational study with air sampling.	**Level 3**	Air sampling and viability for influenza virus.	Symptom score and viral shedding. Mean shedding duration for those on antivirals vs those not.	Virus shedding (nose swab) and environmental deposition (fomites and air) as measured

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
(H1N1) pandemic influenza virus: interim findings. Health Technology Assessment. 2010; 14(46):237-354.				Comparing particle counts at distances 3ft vs 7ft.	by PCR and virus culture techniques. Particle size distribution (µm). Daily symptom scores. Medication logs.

Assessment of evidence

Setting: UK. Samples taken in care and community settings.

This observational study was carried out in the UK, the study suggests H1N1 influenza RNA can be detected in particle size ranges <1, 1-4, and 4µm within the air at approximately 0.9m from infected subjects (based on three subjects). Subjects ranged between 3-4 days post symptom onset at time of sampling.

Limitations:

- Subjects were not stationary during air sampling “though they were asked to remain in the same position if they could”, distance from the subject to the sampler may have varied.
- Proportion of subjects had antiviral medication (54%), although the influence of this was explored.
- More than one infected persons in room at time of air sampling on occasion – excluded these subjects (n=2) from conclusions.
- No baseline measurements or settle time allowed for air sampling.
- Very small sample size.
- Unclear what activities were being undertaken or procedures performed during sampling.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Fennelly KP, Martyny JW, Fulton KE, et al. Cough-generated aerosols of Mycobacterium tuberculosis: a new method to study infectiousness. American Journal of Respiratory and Critical Care Medicine. 2004;169.	Observational air sampling study.	**Level 3**	Isolation and quantification of viable *M. tuberculosis* from aerosols of patients coughing into a chamber.	N/A	Number of culturable isolates. Size distribution (µm). Cough frequency during 5-minute sampling window.

Assessment of evidence

Setting: Colorado, US, negative pressure isolation room (6 ACH).

This observational study was carried out in the US within a negative pressure isolation room with six ACH, the study used a cough aerosol sampling system via tubing and involved 16 participants. The study suggests viable *M. tuberculosis* can be isolated and cultured from the cough exhalations of infected participants. Production of culturable aerosol was associated with lack of treatment in the preceding week(s) (Fisher's exact test; p =0.007). The study also suggests the majority (90%) of particles released appear to be within the sizes ranging from 0.65 to 3.3µm. Sampling via tubing.

Limitations:

- Small sample size (n=8).
- Unknown number of persons in room during 5-min prior sampling of ambient air.

Assessment of evidence
• Variation in cough frequency (mean of 76.5 coughs [IQR 32–113]). • No collation of CFUs isolated in other stages (sizes) for the remaining 10%. • Participants directly coughing into a chamber via tubing, which does not reflect real life scenario.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Shankar SN, Witanachchi CT, Morea AF, et al. SARS-CoV-2 in residential rooms of two self-isolating persons with COVID-19. J Aerosol Sci. 2022; 159.	Observational air sampling study.	**Level 3**	Detection of SARS-CoV-2 RNA and viable virus in air samples at set distances from isolating volunteers. Sizes of particles in air samples associated with viral RNA detection.	N/A	Viral quantification in air samples via Cq values and SARS-CoV-2 GE/cm^3 of air. Presence of RNA in size fractionated samples at set distances from subjects. Results of viral culture analysis.

Assessment of evidence
Setting: US, residential setting. This observational study involving two participants and carried out in the UK within theatre rooms (ventilation rate and humidity levels unknown), indicates that SARS-CoV-2 viral RNA can be detected in the air at distances of 2.2m from infected subjects in particle sizes of less than 1µm. However, due to some unreported aspects and small sample size this study should be interpreted with caution. Limitations: • Rate of air changes and humidity levels of rooms unknown. • Unclear if volunteers maintained distance from samplers although set sampling periods (1.5-2hrs) with knowledge of study so deemed unlikely. • Very small sample size.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Shrimpton AJ, Gregson FKA, Brown JM, et al. A quantitative evaluation of aerosol generation during supraglottic airway insertion and removal. Anaesthesia. 2021; 76.	Observational air sampling study.	**Level 3**	Real-time measures of aerosol generation with an optical particle sizer in a working operating theatre environment (during supraglottic insertions and removals).	The measured levels with those generated by a volitional cough, the patient's own breathing and background levels.	Median concentration of aerosol particles (particles.l^{-1}) during certain procedures. Size distribution of particles (µm).

Assessment of evidence

Setting: UK, hospital theatre rooms.

This observational study carried out in operating theatres at a hospital in Bristol, UK investigated real-time measures of aerosol generation with an optical particle sizer when performing supraglottic airway insertion and removal and compared this to baseline measures (the patient's own breathing) and an investigators series of coughs. During insertion, aerosol concentration did not significantly differ to tidal breathing or baseline measurements. During removal, aerosol concentration did not significantly differ to tidal breathing, however size distribution profiles are not compared.

Limitations:

- Size distributions provided as line graph, unclear.
- Small sample size (n=12).
- 4.3 second lag between the funnel and the particle sizer.
- Potential confounding effects from:
    - "Some had a short period of facemask ventilation immediately before supraglottic airway insertion (n = 3). The majority also had a period of manual ventilation to confirm airway patency after supraglottic airway insertion (n = 8)."
    - "Only one cough was noted during the removal sequences, this occurred with the anaesthetic facemask tightly applied to the patient by the anaesthetist and no increase in aerosol was detected."
    - Duration of background reading not known.
    - Unknown fallow time if any/required between experiments .
    - No comparison apparent of aerosol concentration during removal with background measurements.
    - Lack of participant characteristics, for instance, unknown why undergoing this procedure, their health status, demographics.
    - Differences in procedural events for 12 subjects.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sajgalik P, Garzona-Navas A, et al. Characterization of Aerosol Generation During Various Intensities of Exercise. Education and Clinical Practice. 2021; 160(4).	Observational air sampling study.	**Level 3**	Investigating aerosol generation during varying levels of exercise of healthy volunteers.	Comparison with timepoint zero (baseline) and other levels of exercise.	Particle concentration (per litre). Size distributions of particles (µm). Patient measurements: VO2, respiratory exchange ratio, and ventilation data (expressed both as minute volume in liters per minute and cumulative ventilation in liters).
Assessment of evidence					
Setting: US, non healthcare setting – use of Colorado altitude airtight tent. This observational study carried out in a non-healthcare setting within Colorado, US suggests a significant increase in the mean of particles in size ranges measured by Fluke sampler: >0.3 µm; 0.3-1µm; 1-5 µm, and measured by P-Trak sampler in a single channel measuring 0.02-1µm with increased intensity of exercise amongst eight healthy volunteers. For all three locations (side, back and anterior) of PTrak samplers, a significant increase in particle concentrations was seen when comparing beginning of exercise (zero minutes) with 75% of predicted heart rate reserve (HRR), 100% HRR and cool down). This was also seen with Fluke particle classes which increased					

Assessment of evidence
significantly above the end of resting breathing value at 50%, 75%, 100% HRR and in cool down, but not at 25% HRR. All increases were significant at p=<0.05. The study is limited by its small sample size and lack of generalizability to real life scenarios. Limitations: • Small sample size (n=8). • Experimental set up using tent, may not generalize to real life scenarios. • General particles, cannot indicate infectivity. • Colorado Altitude tent used was airtight but had several sealable entry points that might allow air exchange with the non-HEPA filtered room air surrounding the tent. • Study states “P-Trak and Fluke particle counters are not intended for precise quantification (accurate to +15%),”. • Levels of exercise and timepoints based on percentage of an estimated heart rate reserve (from prediction for age group). • Unknown if increased particles are arising from exhalation or skin particles/clothing abrasion.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract	Expert opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
infections in healthcare settings. 2016. Date accessed: 21 September 2022.					

Assessment of evidence

Does not apply to TB, MERS-CoV or human cases of avian influenza.

Guidelines supplement but do not replace local risk assessment.

“Aerosol generating procedures (AGP) are considered to have a greater likelihood of producing aerosols compared to coughing for instance.” [NC]

“From the available literature* and incorporating UK expert opinion, the following procedures are considered likely to generate aerosols capable of transmitting respiratory pathogens when undertaken on patients with an RTI:

- intubation, extubation and related procedures; for example, manual ventilation and open suctioning
- cardiopulmonary resuscitation
- bronchoscopy (unless carried out through a closed circuit ventilation system).
- surgery and post-mortem procedures in which high-speed devices are used
- dental procedures
- non-invasive ventilation (NIV) e.g., bilevel positive airway pressure ventilation (BiPAP)
- continuous positive airway pressure ventilation (CPAP)
- high frequency oscillatory ventilation (HFOV)

Assessment of evidence
• induction of sputum". *Ref to WHO 2007 guidance Infection prevention and control of epidemic- and pandemic- prone acute respiratory disease in health care "Certain other procedures/equipment may generate an aerosol from material other than patients' secretions but are NOT considered to represent a significant infectious risk. Procedures in this category include: • obtaining diagnostic nose and throat swabs • administration of pressurised humidified 02 • administration of medication via nebulisation". [NC] "During nebulisation, the aerosol derives from a non-patient source (the fluid in the nebuliser chamber) and does not carry patient derived viral particles. If a particle in the aerosol coalesces with a contaminated mucous membrane, it will cease to be airborne and therefore will not be part of an aerosol." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Yip L, Finn M, Granados A, et al. Influenza virus RNA recovered from droplets and droplet nuclei emitted by adults in an acute care setting.	Observational air sampling study.	**Level 3**	Determining the distribution of viral RNA by particle size and distance in an inpatient setting and establish whether influenza virus RNA could be recovered from HCWs' breathing zones.	Air sample results with clinical characteristics and patient demographics.	Positivity of air samples for influenza. Size distribution (µm). Activities of HCWs via questionnaire. Time spent in participants rooms, during aerosol

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
J Occup Environ Hyg. 2019; 16(5):341-348.			The study also sought to identify host determinants for the recovery of viral RNA from the air.		generating procedures and caring for other patients with acute respiratory symptoms.

Assessment of evidence

Setting: Canada, acute teaching hospital and long term care facility. Single rooms (4-6 ACH).

This observational study was carried out at an acute care teaching hospital in Canada on patients (n=16) in isolation rooms on droplet precautions and HCWs (n=7) caring for them. The study suggests influenza virus A H1N1 and H3N2 is detectable in the air in sizes <1 µm, 1-4 µm and >4 µm. Influenza virus RNA was detected at 2m and from the corridor (exact distance from patient not provided). There was no detection of influenza B and only 1/7 HCWs breathing zones were positive for influenza A (H1N1). Findings should be interpreted with caution due to the potential for an unclear source and distance as well as a lack of an appropriate control and potential for confounding factors, for instance, unrestricted visitors, no HCW testing.

Limitations:

- No restrictions on patient, visitor or HCW activity when sampling.
- Controls were carried out during end of flu season, unknown if there were positive patients for influenza when air sampling in corridors occurred. May not be an appropriate control.
- No baseline measures taken.
- Specific to certain strains of influenza.
- Variation in samplers for HCWs and patients.

Assessment of evidence
• During HCW sampling, they performed usual activities during their shift including caring for patients with confirmed influenza (participating in study). • Questionnaire used to ascertain time spent in participants rooms, during aerosol generating procedures and caring for other patients with acute respiratory symptoms. (Recall bias). • No association reported for relative humidity but no reports for temperature. • No testing of HCWs. • Unknown size of particles detected in samples collected by PFTE filters. • Proportions of patents at teaching hospital or long-term care facility not provided. • Variation of locations of sampling, for instance, ED, inpatient units and critical care. • No specific information regarding stage of infection or time since last positive test. • “particles <1µm were recovered on a 3µm pore size”.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Shrimpton AJ, Brown JM, Gregson FKA, et al. A quantitative evaluation of aerosol generation during manual facemask ventilation.	Observational air sampling study.	**Level 3**	Assessment of risk from facemask ventilation for aerosol generation compared with patients own tidal breathing and volitional coughs.	Particle numbers compared with tidal breathing and volatile coughing.	Particle size, concentration and mass (within the size range 300 nm to 10 µm in diameter). Median particle concentration vs background

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Anaesthesia. 2022; 77:22-27.					concentrations and vs tidal breathing. Peak particle concentrations vs particle counts during a cough.

Assessment of evidence

Setting: theatres at a UK hospital (25 ACH).

This observational study investigates risk from facemask ventilation for aerosol generation compared with patients own tidal breathing and volitional coughs. The study has some limitations, namely a small sample size of 11 patients.

This study suggests, in this cohort, spontaneous quiet tidal breathing produces significantly greater median particle concentration levels when compared with background levels (p=0.002). The median particle concentration detected during 60 seconds of facemask ventilation without a leak was not significantly different to background levels. During facemask ventilation with a leak, this was significantly higher (around five-fold) than background levels (p=0.019) and significantly lower than spontaneous tidal breathing levels (p=0.002). This study also identified that the majority of particles produced by participants performing volitional coughs (86.5%) were <1µm.

Limitations:

- Small sample size (n=11).
- May be variation in head position of participants.
- Background aerosol production measured by directing sampling funnel away from patients whilst prep was being carried out for induction of anaesthesia.

Assessment of evidence
• Variation in surgeries being carried out, would require different prep times and varied number of staff present as well as impact of different background measurement parameters (prep type, number of staff etc.) Also need to consider effect of varying comorbidities. • Purposeful airway leak generated in some patients, not all. • Lack of information regarding participants, for instance, reason for surgery, co-morbidities. • Volitional coughs may not mirror natural process.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Campiti VJ, Ye MJ, Sharma D, et al. Aerosol generation during myringotomy with tympanostomy tube insertion: implications for otolaryngology in the COVID-19 era. Otolaryngol Head Neck Surg. 2021; 65(4):532-535.	Observational air sampling study.	**Level 3**	Aerosol generation during myringotomy and tympanostomy tube (MT) insertion.	Baseline (60 seconds following induction of general anaesthesia via mask ventilation but prior to insertion of the myringotomy knife. "Tonsillectomy with monopolar electrocautery (n = 4) from separate cases served as a positive control."	Particle concentration (particles/cm^3) in three size categories (0.3 to <0.9, 0.9 to <2.69 and 2.69 to 10µm).

Assessment of evidence
Setting: US, single operating theatre (20 ACH). This study is limited by a small sample size and specific paediatric population, however, it does suggest that myringotomy and tympanostomy tube insertion with suction, does not generate significant numbers of particles above baseline levels in the 0.3-10μm size range. Tonsillectomy with monopolar electrocautery appears to produce aerosols (0.3-10μm) above baseline level but again this is based on a very small sample size. Further research is needed. Limitations: • Baseline measurements may not mirror procedural activity – authors theorized that reduction in particle counts may have been due to "dissipation of particles generated by movement while setting up for the procedure." Or perhaps it was due to suctioning. Suctioning parameters/settings not reported. • Unclear how many patients involved in study (only nine ears figure reported). • Patient characteristics not reported.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Bischoff WE, McNall RJ, Blevins MW, et al. Detection of Measles Virus RNA in Air and Surface Specimens in a Hospital Setting.	Observational air sampling study.	**Level 3**	The detection of measles (MeV) in the air, on surfaces and on respirators used by HCWs during routine care of a patient hospitalized with measles.	N/A	Particle size distribution (μm). Samples positive for MeV. MeV RNA (copies/ cm^2).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Journal of Infectious diseases. 2016; 213(4):600-603.					

Assessment of evidence

This observational study was carried out in a single negative pressure isolation room at a tertiary hospital in the US (6 air changes per hour). The study is limited by its sample size, only reporting on one patient with measles, with air sampled day five post rash onset (18 days post-exposure). The study detected MeV RNA in particles <4.7μm at four and eight ft from the patient's head. Particle size distribution changed with proximity to the patient's head with a greater proportion of smaller particles (<4.7μm) detected at four and eight feet from patient's head and a greater proportion of larger particles (>4.7μm) detected "close to patient's head". Of the 134 HCW respirator samples, four were RNA positive, all were worn on day six after rash onset and distances from source were not controlled.

Limitations

- Small sample size (n=1).
- HCW testing not carried out.
- Samples taken from 18 days after exposure (5 days after rash onset). Measles infectivity period is usually around four days before through to four days after rash onset.
- Particle detection >4.7μm at vague distance "close to patient head".
- May not generalize to UK health and care setting as carried out at U.S hospital.
- Patient on contact and aerosol precautions, presume no visitors but not stated.
- Unknown what type of samples were cultured.
- No sequencing to match to the patient was performed.
- Unknown if respirators worn in other areas (or around another measles positive care in the hospital).

Assessment of evidence
• Number of particles per size category not provided, only higher-level info.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Mürbe D, Kriegel M, Lange J, et al. Aerosol emission in professional singing of classical music. Sci Rep. 2021; 11(1).	Observational air sampling study.	**Level 3**	The number and size distribution of small particles emitted by professional singers.	Experiment I Comparison between five replications of each activity: (a) Breathing through the mouth (50sec). (b) Reading a standardized text (50sec). (c) Singing a line of a four-part choral movement (50sec). Experiment II Singing a sustained vowel (/aː/) at three loudness conditions (5 replications). (a) piano (10sec).	Particle emission rate (particles per second). Decibels for sound pressure level (dB SPL).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
				(b) mezzo-forte (10sec). (c) forte (10sec).	

Assessment of evidence

Setting: Berlin, Germany. 'Clean room' conditions.

The study suggests that particle emission rates for particles of size 0.3-25µm, are significantly higher for speaking compared to breathing (p=<0.001) and for singing (p=<0.001) compared to speaking. It also suggests that as volume increases so does particle emission rate. There is large inter-subject variation regarding particle emission rates when breathing, speaking or singing. The majority of particle sizes at 0.81m from the subject are <5µm in size. However, as this study is likely underpowered, more research is needed.

Limitations:

- Small sample size.
- Measured emission rates may be lower than true rates due to influence of baffle plates.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Subat YW, Guntupalli SK, Sajgalik P, et al. aerosol generation during peak flow testing: clinical	Observational air sampling study.	**Level 3**	Quantification and characterization of aerosol generation during peak flow testing.	Five different peak flow meters (continuous sampling for three exhalations) for each PFM compared to baseline of quiet	Mean cumulative particle counts per cm^3.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
implications for COVID-19. Respir Care. 2021; 66(8):1291-1298				breathing for one minute.	

Assessment of evidence

Setting: particle free lab space.

This study suggests, based on five different peak flow meters, but a very small sample size of five healthy volunteers, that peak flow testing generates significantly greater numbers of small aerosols (0.02-1µm) than tidal breathing (p=0.01).

Limitations:

- Healthy respiratory emissions may not reflect those from persons with respiratory infection.
- Return to baseline between each set of PFM measurements is reported but how this was established is unclear.
- Non-randomisation of PFM meters.
- Small sample size, no power calculations.
- Specific to three expiratory flow measurements.
- Unclear if sampling times were comparable? One minute for tidal breathing, how long for performance of three peak flow tests?
- Measurements also taken in clinical area with 15 ACH, authors state the following:
    - “Although all peak flow meters measured increased mean particle concentrations compared to masked and unmasked tidal breathing, the differences were small when compared to the mean particle concentrations found in the ambient clinical environment.” “Given the small relative increase in particle generation recorded in this study, we have transitioned our infection control practices to droplet precautions”.

Assessment of evidence
○ This is a flawed conclusion as the particle sources are different. An increase of small particles during peak flow measurement compared to breathing could be significant as it represents respiratory fluid dissemination no matter the level of ambient background particles. Background particles could be derived from respiratory fluids of healthy individuals, clothing, fabrics, hair and so on.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Wainwright CE, France MW, O'Rourke P, et al. Cough-generated aerosols of Pseudomonas aeruginosa and other Gram-negative bacteria from patients with cystic fibrosis. Thorax. 2009; 64:926-931.	Observational air sampling study.	**Level 3**	To determine the concentration and particle size distribution of cough aerosols containing culturable *P. aeruginosa* and other Gram-negative bacteria from children and adults with cystic fibrosis (CF). The study also aimed to determine whether concentrations of cough aerosols detected were related to clinical	Voluntary coughing with tidal breathing with and nebulised hypertonic saline. Clinical parameters.	Sputum microbiology (12 months prior to study and day 23 of study). Aerosol microbiology (total count (total sum of *P aeruginosa* or *B cepacia* complex colonies counted) of CFUs of identified bacteria). Particle size distribution, where counts from stages 4-6 were termed as small aerosol fraction (<3.3µm).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
			parameters and clonality of *P aeruginosa* strains.		

Assessment of evidence

Setting: Australia.

This observational air sampling study aimed to determine the concentration and particle size distribution of cough aerosols containing culturable *P. aeruginosa* and other Gram-negative bacteria from children and adults with CF. The study also aimed to determine whether concentrations of cough aerosols detected were related to clinical parameters and clonality of *P. aeruginosa* strains. Sampling via mouthpiece.

On the day of the study, 23 patients provided sputum samples, 21 cultured *P. aeruginosa* and one cultured *B. cenocepacia*, six also cultured *S. aureus*. All 28 patients recruited (26 *P. aeruginosa* isolated; one with no *P. aeruginosa* isolated; one with *B. cenocepacia* isolated) provided a cough sample. Of these, 25/28 had cough aerosols that grew *P. aeruginosa*. Overall, 20/21 patients who cultured *P. aeruginosa* in their sputum also cultured *P. aeruginosa* of similar genotype in their cough samples. *B. cenocepacia* was cultured from the cough sample provided by the patient with *B. cenocepacia* isolated from their sputum. This study demonstrates that *P. aeruginosa* can be cultured from samples collected following five minutes of forced coughing (20 of 21 patients with a positive sputum sample for *P. aeruginosa* of a similar genotype) and breathing.

25/28 subjects had cough aerosols that grew *P. aeruginosa*, one subject cultured *B. cenocepacia* and two subjects had no Gram-negative bacteria cultured. There was wide variation in corrected total count of CFUs from generated aerosols among subjects. A significant correlation was identified with total count of CFUs from sputum and total corrected count of CFUs from voluntary coughing. Positive cough aerosol sampling system (CASS) aerosol cultures were identified in 3/7 subjects performing tidal breathing.

In 16/101 air samples, unique strains of *P. aeruginosa* were cultured, not matching any isolates from CASS or sputum. Five samples (from four patients) with AES2 strain of *P. aeruginosa* were also identified in sputum and cough aerosols of these four subjects. Positive air

Assessment of evidence
samples were reportedly associated with high concentration in cough aerosols. However, this finding is limited by potential confounding factors such as personnel (if any) in the room not provided, variation in air exchange rates, and it is unknown if doors/ windows open. 71.8% of particles containing culturable aerosol isolated from voluntary coughing were <3.3µm. Settle plates had an average of six CFU. Identified was a significantly lower mean total corrected count during tidal breathing compared with voluntary coughing (p=0.001). Comparisons made with tidal breathing should be interpreted with caution due to a small sample size (n=7) of subjects in this category. Forced expiratory volume in one second (FEV1) was significantly correlated with the total corrected count from the voluntary cough aerosol and with the corrected small aerosol fraction (p=0.019 and p=0.018, respectively). Limitations: • Study funded by hospital in which investigation was carried out. • Likely to be variation between patients in terms of strength of coughs (subjective assessment of strength). • Small sample size of subjects performing tidal breathing (n=7). • Variation in type of equipment used for maximum expiratory pressure measurements between paediatrics and adults. • Exact timepoints of centrifugal testing not provided. • One subject had no comparison (performed voluntary cough only). • Unclear on “afferent limb equipment” definition not provided. • No p value given for tidal breathing compared with hypertonic saline.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Chia PY, Coleman KK, Tan YK, et al.	Observational air sampling study.	**Level 3**	Presence of viral RNA in air	N/A	SARS-CoV2 RNA detection in specific air sample particle

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients . Nat Commun. 2020; 11(1).			surrounding infected patients. Specific particle size ranges associated with positive samples.		size ranges (<4µm, 1-4µm and <1µm). RNA copies per m^3 air sampled.

Assessment of evidence

Setting: Singapore, airborne infection isolation rooms (12 ACH).

This limited study included only three patients placed within airborne infection isolation rooms. The study indicates that SARS-CoV-2 viral RNA can be detected at 1m from symptomatic patients (cough) within particles of 1-4µm and >4µm at day five of illness.

Limitations:

- Very small sample size.
- Discrepancies in sampling methods for the three patients. Patient one had samples taken at 1m and 2.1m but patients two and three only at 1m.
- One patient spoke on phone during sampling.
- Authors report no AGPs undertaken but AGP list not defined.
- No reported testing of visitors/staff and no indication as to traffic of other persons during sampling.
- PCR samples taken ‘within 72hrs’ of air sampling unclear as to exact NP viral load on day of sampling.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Choukri F, Menotti J, Sarfati C, et al. Quantification and spread of *Pneumocystis jirovecii* in the surrounding air of patients with pneumocystis pneumonia. Clin Infect Dis. 2010; 51(3):259-265.	Observational air sampling study.	**Level 3**	Detection of Pneumocystis jirovecii in the surrounding air of infected patients with assessment of detection at increasing distances and fungal burden in air (copies/m^3).	Fungal air burdens at 1m, 3m, 5m and 8m.	DNA copies per m^3 of sampled air. Qualitative result of detection/no detection at specific distances.

Assessment of evidence

Setting: Paris, France. Open ward ICU and “conventional patient rooms” with “no negative pressure or laminar flow”.

This study was carried out at two hospitals in Paris and involved air sampling in association with 19 patients. The study suggests that *Pneumocystis jirovecii* DNA can be detected in the air at 8m from infected patients. It also suggests that fungal burden in the air decreases with increasing distance from the source.

There were patients for whom no DNA was detected at 1m with similar days from diagnosis/treatment to those with positive 1m samples, suggesting the influence of other patient/environmental/sampling factors.

Limitations:

- Unclear why 21 from original 40 figure were not included in study.
- Specific to hospitalized patients.

Assessment of evidence
• 12 of 19 patients had already received treatment 1–9 days before air samples could be collected. • Small sample size. • Unclear if entrance/corridor/ICU ward samples were only derived from patient of interest. • Unclear treatments or symptoms. • Unclear if patients remained at specified distance.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ong SWX, Tan YKT, Tan BH, et al. Lack of viable severe acute respiratory coronavirus virus 2 (SARS-CoV-2) among PCR-positive air samples from hospital rooms and community isolation facilities. Infection Control & Hospital Epidemiology. 2021:1-6.	Observational air sampling study.	**Level 3**	Isolation of SARS-CoV-2 from air samples obtained from rooms of patients early in their illness. Viability was assessed in a subset of samples.	N/A	SARS-CoV-2 RNA. Viral culture of SARS-CoV-2 Size fractioning (particles less than <4.34µm).

Assessment of evidence
Setting: Singapore, airborne-infection isolation rooms (AIIRs) 12 ACH (specific to hospital AIIRs setting, community centre had natural ventilation). Singapore This observational study carried out in AIIRs at the National Centre of Infectious Diseases in Singapore, attempted to detect viable SARS-CoV-2 from air samples taken in rooms housing positive COVID-19 patients (n=19). The study identified six out of 12 rooms with positive samples, in four of which, samples were restricted to particles sized <4.34µm. Positive samples were detected at a distance of 1m from patients' heads. No viable SARS-CoV-2 was detected through virus cultures. Most patients (63.2%) were symptomatic on day of sampling. Limitations: • Small sample size (n=19). • Study may not generalize to UK health and care setting. • Unknown temperature and humidity of sampling rooms. • Duration of air sampling not provided. • Predominantly males in study. • Influence (if any) from doors opening, HCWs/ researchers/ visitors unknown. • Not all patients were symptomatic therefore, unable to say results were found within early stages of infection. • Some patients may no longer be infectious if sampling occurred within seven days of testing positive. • Community isolation facility findings excluded due to unclear distance to source.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Binder RA, Alarja NA, Robie ER, et al. Environmental and aerosolized SARS-CoV-2 among hospitalized COVID-19 patients. Oxford University Press for the Infectious Diseases Society of America. 2020.	Observational air sampling.	**Level 3**	Assessing aerosol and environmental samples for SARS-CoV-2 RNA and viability from hospitalized patients (suspected/ confirmed COVID-19) and their close contacts.	N/A	SARS-CoV-2 RNA in samples (Saliva, NP, rectal, aerosols). Viability. Size distribution: >4μm, <4μm.

Assessment of evidence

Setting: US.

This observational study was carried out at a hospital in North Carolina on patients in single-occupancy rooms with suspected or confirmed COVID-19 early in the pandemic (early 2020). Aerosol sampling detected SARS-CoV-2 RNA in samples from three patients. Positive samples were detected in sizes <4 and >4 μm at distances up to ~2.2m. Patients had variation in their symptoms, with the patient producing RNA positive particles >4μm having symptoms of runny nose, fever and headache. Other patients had cough, fatigue and difficulty breathing. No viable SARS-CoV-2 RNA was detected. The study is limited by its lack of information regarding procedures being carried out, HCWs/ visitors/ researchers present, as well as its small sample size and lack of HCW testing. Approx. 14 ACH (taken from empty room in hospital).

Limitations:

- Specific to dominant strain at time of study (early in pandemic, may not generalize).

Assessment of evidence
• Self-reporting of patient's characteristics, such as pre-existing illnesses (recall bias). • Wide range in day of enrolment post symptom onset (1-34), some patients may not be infectious. • Small sample size of patients completing both follow-ups (n=6). • Type of procedures carried out not mentioned. • Visitors not reported on. • No HCW sampling. • PPE worn unknown. • May be conflict of interest with funding. • May not generalize to UK health and care settings. • Unclear where close contacts were located during follow-up visits, no mention of aerosol samples from close contacts, only positivity for SARS-CoV-2 RNA of the samples they provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Dinkele R, Gessner S, McKerry A, et al. Aerosolization of Mycobacterium tuberculosis by tidal breathing.	Observational air sampling study.	**Level 3**	To assess the dominant source of *Mycobacterium tuberculosis* (Mtb) aerosols relating to respiratory manoeuvre.	Tidal breathing. Coughing. Forced vital capacity (FVC).	Particle counts* (33 patients). *1) the total number of particles collected (particle count). 2) the average number of particles produced per

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Am J Respir Crit Care Med. 2022; 206(2):206-216.					manoeuvre (particles/ manoeuvre). 3) the estimated total number of particles produced (total particles). Particle size distribution (proportion of particle count in one of five size bins, 0.5–1µm, 1–1.5µm, 1.5–2µm, 2–5µm and >5µm) (33 patients). Viable bacilli numbers ascertained via fluorescence microscopy visualisation CO^2 concentration (32 patients)

Assessment of evidence

Setting: South Africa, primary health care facility.

This study presents the concept that particle numbers generated during coughing, breathing and FVC manoeuvres of TB infected patients, may not correlate with Mtb count production. In their study cohort, tidal breathing produced significantly less Mtb per breath compared to a single FVC manoeuvre or cough (2.6 fold higher (p= 0.009) and 3.2-fold (p= 0.00185) respectively), however, the average number of Mtb bacilli per particle, was lower for a single cough (0.3 fold change p= 0.009) or FVC manoeuvre (0.09 fold change p= 0.00185) than a single breath. Breathing is an ongoing, repeated daily activity compared to coughing which is sporadic. Within this study cohort, one minute of tidal breathing generated more bacilli than a single cough or FVC manoeuvre and following five minutes of sampling, all three manoeuvres returned similar rates of positivity (65-70%) for Mtb (15 coughs/15 FVC manoeuvres/5 mins of tidal breathing). Samples taken using cone collector.

Limitations:

- Respiratory manoeuvre order was not randomized.
- Manoeuvres, CO_2 and particle count data not recorded for every participant. This may skew data especially if exclusion/drop out of high particle/Mtb producers.
- FVC and cough samples excluded if fewer than two peaks in particle counts were detected above the background (trend to exclude those with lower particle count production).
- Spontaneous coughs occurred during tidal breathing sampling in (33%) of participants which may affect results although authors performed analysis to mitigate this limitation.
- Forced coughs may not mirror natural cough activity.
- Caution when using particle size distribution data as do not know contribution from background particles/particles of non-respiratory activity origin, however, sampling cone used with directional air flow.
- Specific to TB and symptomatic patients.
- No sample size calculations.

Assessment of evidence
• Limited patient demographic data given. • Participants were excluded from Mtb count/particle analysis based on zero Mtb count – "To examine the relationship between particle numbers and the aerosolization of Mtb bacilli, the relative abundance of Mtb bacilli per particle was calculated for all three maneuvers. Participants with a zero count for Mtb were excluded from this analysis." Analysis based on 19 FVC samples, 21 Tidal breathing samples and 20 cough samples.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Wood ME, Stockwell RE, Johnson GR et al. Face masks and cough etiquette reduce the cough aerosol concentration of Pseudomonas aeruginosa in people with cystic fibrosis. ORCID. 2018; 197(3):348-355.	Observational air sampling study.	**Level 3**	This study aims to compare the effectiveness of face masks and cough etiquette, however the study does investigate presence of bacteria in aerosols generated from tidal breathing. Therefore, methods and results from this aspect of the study are reported here. Other information is out with the scope of this review.	Comparison with clinical, demographic, and microbiological parameters.	Sputum microbiology (CFU/ml). Log transformed sputum *P. aeruginosa* counts % of culturable particles <4.7 µm Aerosols containing viable *P. aeruginosa.* Genotyping of aerosol samples to sputum cultures.

Assessment of evidence
Setting: Brisbane, Australia. This observational study carried out in Australia on CF patients with chronic *P. aeruginosa* demonstrates aerosol samples containing viable *P. aeruginosa* are detected at 2m when the patient is coughing (uncovered). Genomic sequencing linked 16/19 aerosol samples to the patient's sputum. *S. maltophilia* was detected in the aerosols of patients with isolated *S. maltophilia* in their sputum, however this did not appear to be analysed through genomic sequencing. The study identified 71% of culturable particles were ≤4.7µm and there was a statistically significant association between log-transformed sputum *P. aeruginosa* counts and total aerosol load (p=0.01). Validated closed wind tunnel system for sampling. Limitations: • Specific to adults (≥18 years) with CF and chronic *P. aeruginosa* infection. • 20 min rest period between manoeuvres, unknown if this time is long enough for particles to return to baseline. • May be variation between patient coughs as number of coughs/ induced coughing/ force of coughs not mentioned or recorded. • Lack of information regarding the setting, for instance, the tunnel and its air changes, temp, humidity.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Wilson NM, Marks GB, Eckhardt A, et al. The effect of respiratory activity, non-invasive respiratory support and facemasks on	Observational air sampling study.	**Level 3**	Aimed to measure the size, total number and volume of all human aerosols exhaled during respiratory activities and therapies.	Compared emissions between one minute of: quiet breathing (through nose or mouth), talking loudly (alphabet repeat),	Fold differences between geometric means of activities/ therapies. Average total number of particles.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
aerosol generation and its relevance to COVID-19. Anaesthesia. 2021; 76(11):1465-1474.				shouting (short sentence repeat), forced expiratory manoeuvres (six – one every 7-8secs), exercise (pedal exerciser, set to mid-load to achieve ~ 70% of maximal estimated heart rate), and coughing (six volitional – one every 7-8secs) With three respiratory therapies: high-flow nasal oxygen (delivered via ventilator, temp 33°C, FiO2 of 0.25) 20, 40 and 60 L/min during breathing,	Estimated total volumes per particle bin size.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
				60L/min during talking, FEVs and exercise, single circuit non-invasive positive pressure ventilation (NIPPV) (all exhaled gas directly enters the sampling cone via an unfiltered outlet), and dual circuit NIPPV (gas leaves the circuit at a distant location with HEPA filter and gases sampled in the cone represent leakage from the skin-mask interface or the anti-asphyxia valve) For both types of NIPPV pressures delivered were (peak inspiratory/peak expiratory): 5/5,	

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
				10/10, 15/10, 20/10 and 25/10 cmH2O during quiet breathing, and 20/10 cm H2O during exercise.	

Assessment of evidence

Setting: Australia.

This study involving 10 healthy participants was carried out in Australia. This study suggests that talking, shouting and exercise produce more particles than quiet breathing and that volitional coughs or FEVs produce more particles than quiet breathing. Respiratory therapies appear to increase particle production for quiet breathing but not to the same degree as increased respiratory exertion such as talking, shouting, coughing, exercise or FEV manoeuvres. There was large inter-subject variability in particle numbers released across all activities. When considering particle numbers, particles <5μm appear to make up >92%, but when considering particle volumes <5μm make up 5.9-34.9% for breathing, talking, shouting and coughing, with coughing producing the greatest proportion. Novel chamber with cone collector.

Limitations:

- Small sample size.
- During visual assessments using e-cigarette smoke (suppl. info) it is clear that significant under sampling of coughs may have occurred due to backwards movement of aerosols away from sampler. This suggests an overall issue with under sampling which is perhaps exacerbated by increased forward pressure/exhalation. The reduced particle counts seen with respiratory therapies during coughing, talking, shouting and exercise (but not breathing) may be a reflection of aerosol redirection and not true reduction.
- Authors suggest that exertional respiratory activities mimic respiratory illness.
- Volitional/forced coughs may not mirror natural events.

Assessment of evidence

• Healthy subjects without respiratory infection.
• 1 minute of breathing, talking, shouting compared to approx. 45 seconds of coughing/FEVs.
• Data does not appear to have been analysed based on paired analysis.
• Following measurements not taken:
  ○ Exercise, coughing, forced expiration or coughing for high-flow nasal oxygen (HFNO) at 20 or 40L/min.
  ○ Shouting for HFNO.
  ○ Exercise for NIPPV at setting other than 20/10.
  ○ Coughing, forced expiration, coughing or shouting for NIPPV.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Santarpia JL, Herrera VL, Rivera DN, et al. The size and culturability of patient-generated SARS-CoV-2 aerosol. J Expo Sci Environ Epidemiol. 2022; 32(5):706-711.	Observational air sampling study.	**Level 3**	Presence of virus in size-fractioned aerosols from COVID-19 infected patients.	N/A	Aerosol size distributions. Presence of viral RNA in specific particle size ranges (PCR, western blot and electron microscopy). Quantity of viral RNA in samples (copies/L of air).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
					Viability of RNA positive samples.

Assessment of evidence

Setting: US, two wards and six rooms (where some rooms negatively pressured and some rooms single occupancy).

This study carried out in the US indicates that viable SARS-CoV-2 virus can be detected in particles <1µm in size, in the vicinity of COVID-19 infected patients.

Limitations:

- Specific to circulating strain at time/location.
- Specific to hospitalized patients.
- Errors in text, early description states six patients of five rooms but later six rooms are reported on and supplementary data suggests involvement of seven patients.
- Data given re: days post positive test but not post symptom onset.
- One room had two patients, unclear if second occupant had COVID-19.
- Unclear definitive source of particles.
- Distance to sampler stated to be ‘at least 1m’ but not defined or consistent.
- Limited reporting of patient characteristics.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Jones-Lopez EC, Namugga O, Mumbowa F, et al. Cough aerosols of Mycobacterium tuberculosis predict new infection: a household contact study. American Journal of Respiratory and Critical Care Medicine. 2013;187.	Observational air sampling study.	**Level 3**	Study carried out aerosol sampling of TB patients coughing at close range to establish the CFU of culturable *M. tuberculosis*. Study investigated factors associated with household contact tuberculin skin test (TST) conversion.	N/A	Aerosol status divided into three groups: aerosol negative; low aerosol (1–9 CFU); and high aerosol (>10 CFU). Individuals dwellings were assessed for individual contact, time, crowding, and ventilation conditions. TST conversion in contacts. Factors associated with TST conversion in contacts through adjusted and unadjusted analysis. (unadjusted and adjusted odds ratio with 95% CI).

Assessment of evidence
This observational study, carried out in Uganda, suggests that 45% of TB patients produce culturable *M. tuberculosis* when coughing into tubing connected to a sampler. Of these patients, 19% produced low aerosols (1-9CFUs) and 26% produced high aerosols (>10CFUs). Sputum-positive AFB smear grade does not appear to be associated with high aerosol producers, although no statistical analysis was carried out on this. Aerosol sampling into tubing. This study suggests there is significantly greater odds (OR 4.81 [95% CI 1.20–19.23] p=0.03) of infection with TB if housed with a high-aerosol producing TB index case (defined as producing >10 CFUs). Limitations: • Less generalizable, only included TB patients with more advanced disease. • Variation in crowdedness of households, however controlled for in adjusted multivariate analysis. • Not controlled environment, likely to have differing levels of contact with TB case, however partially controlled for in adjusted multivariate analysis. • Strength of cough not measured, therefore inferences on variation in CFUs, or high/ low aerosols produced and cough peak flow rates should be treated with caution. • Forced cough may not represent real-life cough. • Appears researcher present when sampling, however not confirmed, no information on PPE, background particle levels. • Temp and humidity recorded but not provided in results. • May not generalize to UK health and care setting. • Unknown if any household contacts were immunocompromised or had had a previous TB infection. • “infected contacts at highest risk of developing active TB disease and secondary TB suspects were referred for evaluation and treatment.” Unclear at what stage this was carried out, may have been during study period. • Have not compared secondary case infection rate based on index cases who had or had not started treatment.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Frealle E, Valade S, Guigue N. et al. Diffusion of Pneumocystis jirovecii in the surrounding air of patients with Pneumocystis colonization: frequency and putative risk factors. Medical Mycology. 2017;55:568-572.	Observational air sampling – Brief Report.	**Level 3**	Detection of *P. jirovecii* in air samples collected from the rooms occupied by patients colonized with Pneumocystis (at distances 1m and 5m) and analysis of underlying factors that could favour Pneumocystis excretion.	N/A	Pneumocystis DNA loads (copies/µl) in respiratory samples Genotypes of Pneumocystis in respiratory and aerosol samples.

Assessment of evidence

Setting: France, patient rooms (windows/ doors closed), unknown ACH.

This brief report carried out at two university hospitals in France included a total of 17 patients. The study demonstrates *P. jirovecii* can be detected in rooms of patients colonized with Pneumocystis up to 1m from the patients' head. Of the patients with positive air samples, two had an autoimmune disease and one had a hematologic disease.

Limitations:

- No information regarding temperature, humidity, ventilation of patient rooms being sampled.
- Genotyping of other stains not provided.
- Personnel, visitors or HCWs presence in rooms before, during sampling unknown.

Assessment of evidence
• Duration of sampling unknown. • May not generalize to UK health and care setting. • Small number of positive samples. • Small sample size per sampling location. • Brief report, lacking detailed description.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ferroni A, Werkhauser-Bertran A, Le Bourgeois M, et al. Bacterial contamination in the environment of hospitalised children with cystic fibrosis. Journal of Cystic Fibrosis. 2008:477-482.	Observational air sampling study.	**Level 3**	"Air and surface samples at particular times of the day from locations most frequented by these children during their hospital stay: clinical wards, school, leisure centre and the respiratory functional explorations (RFE) unit. Environmental pathogenic bacteria were compared to the respiratory	N/A	Airborne bacteria (CFU per m^3 of air). Positive air sample for *P. aeruginosa* and *S. aureus*. Bacterial resistance. Genomic analysis of bacteria in air samples and sputum.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
			bacteria of CF patients." Only air samples taken in the rooms of CF children three times a day before and after cleaning/ patient activities were of interest and are reported in this appraisal.		

Assessment of evidence

Setting: France, described as "closed environment".

This observational air sampling study carried out at a hospital in France involved children with cystic fibrosis colonized with *P. aeruginosa*, *S. aureus* or both. Air sampling of bedrooms housing the children was carried out three times a day (in the morning at wake-up, after physiotherapy and after cleaning of the rooms at mornings end). The study demonstrates that *P. aeruginosa* and *S. aureus* can be cultured from air samples in rooms of patients colonized with these bacteria. In 6/12 positive P. aeruginosa samples, air samples matched genetically to the patient's sputum sample. No statistical comparisons were made between the different times of sampling. Results should be interpreted with caution as no distances to the sampler were provided, amongst other limitations.

Limitations:

- Large range in number of samples taken per patient.
- Fallow times/ measure of returning to baseline prior to testing the same room housing a new patient not stated.
- Duration of sampling not provided.

Assessment of evidence
• No distance of air sampler to patient given. • Different strains of *P. aeruginosa* identified on six occasions to the strain in the patients' sputum sample, potential for carrying aerosols longer distances, potential for cross contamination or lab error for instance not identified within sputum? • Funding and conflicts of interest not stated. • May not generalize to UK health and care setting. • Patient characteristics and demographics not provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
UK Health Security Agency. Ventilation to reduce the spread of respiratory infections, including COVID-19: Guidance on the ventilation of indoor spaces to reduce the spread of respiratory infections, including coronavirus (COVID-19).	Expert opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
4 March 2021. Date last updated: 2 August 2022. Date accessed: 7 October 2022.					

Assessment of evidence

"When someone with a respiratory viral infection breathes, speaks, coughs or sneezes, they release small particles (droplets and aerosols) that contain the virus which causes the infection. These particles can be breathed in or can come into contact with the eyes, nose, or mouth. The particles can also land on surfaces and be passed from person to person via touch."

"While larger droplets fall quickly to the ground, aerosols containing the virus can remain suspended in the air for some time, including after an infected person has left the area. In poorly ventilated rooms the amount of virus in the air can build up, increasing the risk of spread, especially if there are lots of infected people in the room. The risk of airborne transmission is increased when occupants in an enclosed space are participating in energetic activity, such as exercising, or when they are shouting, singing or talking loudly."

"Bringing fresh air into a room and removing older stale air that contains virus particles reduces the chance of spreading respiratory infections. The more fresh air that is brought inside, the quicker any airborne virus will be removed from the room."

"Ventilation does not prevent the spread of respiratory infections through close contact and is only one of the actions you can take to live safely with respiratory infections, including COVID-19."

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
The American Society of Heating, Refrigerating and Air-Conditioning Engineers. ASHRAE position document on infectious aerosols. 2022. Date accessed: 15 November 2022. Expires October 23, 2025.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
This position document written by The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) states to "express the views of the Society on specific issues" to "provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy". "All people, whether infected or not, release droplets of respiratory fluid (mucus, sputum, or saliva) spanning a wide range of sizes during such respiratory activities." [NC] "Some droplets are so large that they cannot remain suspended for more than a few seconds in the expired jet. Some droplets are small enough to be considered aerosol particles (aerosols) that can remain suspended in the air for an extended period." NC					

Assessment of evidence
“Under all but the most humid conditions, the smallest droplets rapidly evaporate, leaving behind solid or semisolid residue consisting of nonvolatile components of the respiratory fluid. If a person is infected, their respiratory droplets and aerosols may carry pathogens and may be infectious.” [NC] “The concentration of aerosols decreases with distance. As infectious aerosols move through a space, they may lose infectivity over time. The risk of transmission also increases with the duration of exposure”. “Exhalations release droplets spanning a wide range of sizes, including those small enough to be considered aerosols. The number, size, and velocity of these droplets and aerosols vary widely by individual, type of respiratory activity and/or metabolic intensity, the volume of vocalization, and stage of disease if the person is infected. Speaking loudly, singing, and deeper breathing associated with physical activity and the like increase the number and speed of droplets and aerosols discharged into the air”. “Mechanisms of Transmission of Infectious Aerosols An infectious aerosol is a collection of pathogen-laden particles in the air. Typically, infectious aerosols are released by an infected person as part of respiratory activities such as breathing, talking, singing, coughing, and sneezing”. [NC] **References:** Buonanno G, Morawska L and Stabile L. Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: Prospective and retrospective applications. Environment International. 2020; 145:106112. Coleman K, Tay DJW, Tan KS, et al.* Viral Load of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in Respiratory Aerosols Emitted by Patients With Coronavirus Disease 2019 (COVID-19) While Breathing, Talking, and Singing. Clinical Infectious Diseases. 2021; 74(10):1722–1728. Pöhlker ML, Krüger OO, Förster JD, et al. Respiratory aerosols and droplets in the transmission of infectious diseases. ArXiv Preprint ArXiv. 2021:2103.01188. Tomisa G, Horváth A, Farkas Á, et al.** Real-life measurement of size-fractionated aerosol concentration in a plethysmography box during the COVID-19 pandemic and estimation of the associated viral load. Journal of Hospital Infection. 2021; 118:7–14. Wang CC, Prather KA, Sznitman J, et al. Airborne transmission of respiratory viruses. Science. 2021; 373(6558).

Assessment of evidence
*Included in TBP review **Excluded from TBP review

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Coleman KK, Tay DJW, Tan KS, et al. Viral load of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in respiratory aerosols emitted by patients with coronavirus disease 2019 (COVID-19) while breathing, talking, and singing. Clin Infect Dis. 2022; 74(10):1722-1728.	Observational air sampling study.	**Level 3**	To determine viral loads and viability of virus within coarse (>5μm) and fine (≤5μm) respiratory aerosols produced when breathing, talking, and singing.	30 minutes of breathing. 15 minutes of talking. 15 minutes of singing. Patients with detectable viral RNA in breath. Patients without detectable viral RNA in breath.	Viral RNA in coarse (>5μm) and fine (<5μm) particles. Patient demographics (for example, days since illness onset). Result of viral culturing (fine particle samples only).
Assessment of evidence					
Setting: Singapore, National Centre for Infectious Diseases (unknown room parameters).					

Assessment of evidence
This study carried out in Singapore involved 22 patients with RT-PCR confirmed COVID-19. The study demonstrates that viral RNA can be detected in particles <5μm in size, at close range, to COVID-19 positive patients during 30 minutes of breathing, 15 minutes of talking and 15 minutes of singing. Certain individuals appear to aerosolize higher viral loads than others with 2 of 22 participants (sampled on day three of illness) accounting for 52.4% of the total viral load captured, however this may be linked to timing of sampling/stage of infection. Mixed results were observed for viral loads produced by differing respiratory activities. Seven participants emitted more virus from talking than singing. This study also suggests that the majority of virus emitted by COVID-19 positive individuals is found within the fine particle fraction as, overall, aerosols <5μm constituted 85% of the viral load detected - however, due to study limitations further research is needed to validate this finding. Limitations: • No randomization of measured respiratory activities. • Coarse fraction samples were not cultured as the impaction method was not designed for culture analysis. • Was there a key difference in the ability/propensity to detect virus in fine particle versus coarse? • Two participants (4 and 22) observed to be coughing during sampling. • Specific to the dominant circulating strain of the time/area. • Small sample size. • Specific to young male population. • Clinical CT values are from day of diagnosis not day of sampling. • No evidence of repeated sampling. • Sampling methods validated using inert particles and influenza.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Mürbe D, Kriegel M, Lange J, et al. Aerosol emission of adolescents voices during speaking, singing and shouting. PLoS One. 2021; 16(2).	Observational air samplings study.	**Level 3**	Particle count emission rates, particle size distributions and sound volume levels of adolescents.	Speaking (30s) repeated five times. Singing (30s) repeated five times. Shouting (10s) repeated five times. Sustained phonation at two different volumes (piano and forte).	Particle emission rates (P/s). Maximum sound pressure levels (db SPL). Percentage of total particle counts which fall within specific particle size fraction groups (0.3-0.5, 0.5-1.0, 1.0-3.0, 3.0-5.0, 5.0-10.0, 10.0-25.0µm) (%).

Assessment of evidence

This German study of a small cohort (n=8) suggests that around 99% of particles emitted by adolescents during speaking, singing or shouting are <5µm in size. Singing appears to produce significantly more particles than speaking (p=<0.001) and shouting more than speaking (p=<0.001). In this cohort there appeared to be a weak positive correlation between sound volume and particle emission rates and high inter-subject variability in particle production. NB: Makes reference to ISO 21501-4.

Limitations:

- Small sample size.
- Specific to 13–15-year-olds.
- Unclear if use of baffle plates is appropriate (no citations provided to justify use of baffle plates).

Assessment of evidence
• Unclear if subjects present for baseline measurements. • Margin of error for particle counters based on size. • Authors report large inter-subject variability but do not provide enough data level detail to confirm this. • No respiratory infection in subjects. • Unclear correlation between particle numbers/sizes and viral load emitted/infective potential.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Gregson FKA, Watson NA, Orton CM, et al. Comparing aerosol concentrations and particle size distributions generated by singing, speaking and breathing. Aerosol Science and Technology. 2021; (55)6:681-691.	Observational air sampling study.	**Level 3**	Aerosol concentrations and particle size distributions of professional singers.	Five repetitions of: Breathing (in through nose, out through mouth) (10s), Breathing (in through nose, out through nose) (10s), Singing single note at different pitches (10s), Singing at different loudness (20s), Speaking,	Particle number concentration (cm^3) over one second interval. Particle mass concentration ($\mu g.m^3$) over one second interval. Particle size distribution (dN/dlog (Dp)*. Vocalisation loudness dBA. *dN (or ΔN) is the number of particles

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
				Speaking at different loudness (20s), Singing a single note at different loudness (10s), Three repetitions of cough.	in the range (total concentration) and dlog(Dp) (or ΔlogDp) is the difference in the log of the channel width. Authors report aerosol concentrations from 51 size bins, ranging from 0.523 to 20μm in diameter. Single coughs compared to one second of other respiratory activity.
Assessment of evidence					
Setting: UK, operating theatre with laminar flow ventilation (500-600ACH). This study suggests that singing and speaking at loud volumes generates significantly more particle mass than breathing (24-36 times more) but p-values are not given. Median particle number concentration for both singing and speaking increased by a factor of 10–13 as loudness increased from 50–60 dBA to 90–100 dBA. It also suggests that loud singing generates more particles than speaking. Steep increases (20-30-fold) were observed in mass concentration with increases in loudness for speaking and singing (p=<0.001). This study suggests that at the quietest volume (50–60 dBA), neither singing (p=0.19) nor speaking (p=0.20) was significantly different in numbers of particles produced compared to breathing. There appear to be specific individuals who produce higher numbers of particles during					

Assessment of evidence
respiratory activity compared to others. Generally size distributions for speaking, singing and breathing were similar but with speaking and singing on average generating larger particles than breathing. It also suggests that coughing produces more particles (8.6 times more) and greater particle mass concentration (4.8 times more) than speaking at a moderate volume for 20 seconds (70-80dB). Also identified was wide inter-subject variability for cough results, particle concentration per cough ranged from 0.22 to 41 particles/cm^3. Limitations: • Collection within a funnel does not replicate dilution that would arise with spread of respiratory emissions. • Particles may be lost to tubing. • Particles may be lost to backward motion. • Relatively small sample size with no power calculations (effect could be significant considering wide inter-subject variation in particle production numbers). • Not all participants provided samples for all tests/parameters. • Many missing p values.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lednicky JA, Lauzard M, Fan ZH, et al. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients.	Observational air sampling study.	**Level 3**	Presence of viable SARS-CoV-2 virus in air surrounding COVID-19 infected patient(s).	N/A	Results of air sample testing: RT-qPCR (Ct values, Genome Equivalents/L of air), Virus culture.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Int J Infect Dis. 2020;100:476-482.					Results of air sample and clinical culture genome sequence matching.

Assessment of evidence

Setting: Florida, US, single hospital room with curtain dividing two inpatients (6 ACH).

This study was carried out at a hospital in Florida, US. The study involved two COVID-19 infected patients within a single hospital room with a curtain dividing the two inpatients. The study suggests that small amounts of viable SARS-CoV-2 virus can be detected in the air up to 4.8m from an infected patient.

Limitations:

- Does not comment on movement of patients.
- Unclear as to patients' stages of infection/symptomatic status at time of sampling.
- Unclear as to contribution to sample by single or both patients.
- Does not report on visitors, staff movements.
- Authors report no AGPs but do not specify AGP definition/list or medical procedures undertaken.
- Low viral counts detected in air (this could be due to a number of factors, for example, patient stage of infection, lack of symptoms, particle production characteristics of patient, inadequacy of sampling equipment, mishandling of samples etc.).
- Specific to COVID-19 strain infecting involved patients.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Kim UJ, Lee SY, Lee JY, et al. Air and environmental contamination caused by COVID-19 patients: a multi-center study. J Korean Med Sci. 2020; 35(37).	Observational air sampling study.	**Level 3**	Presence of SARS-CoV-2 viral RNA at 2m from COVID-19 infected, hospitalized patients.	N/A	Presence of SARS-CoV-2 viral RNA in air samples via PCR.

Assessment of evidence

Setting: South Korea, proportion of patients in negative pressure rooms.

This limited study carried out across four hospitals in South Korea included eight patients, the study suggests that SARS-CoV-2 viral RNA is not detectable in the air at 2m from hospitalized COVID-19 infected patients, although first air sampling session for some patients could have been conducted seven days post symptom onset. This study is limited by its small sample size and variation in room conditions, for instance, some rooms had no negative air pressure, others had 15 ACH.

Limitations:

- Very small sample size.
- Specific to strain of COVID-19 infecting patients.
- Unclear when clinical respiratory samples were taken – were patients infected during sampling process?
- Unclear if distance to sampler was maintained.

Assessment of evidence
• Were the patients symptomatic at time of sampling?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Yan J, Grantham M, Pantelic J. Infectious virus in exhaled breath of symptomatic seasonal influenza cases from a college community. PNAS. 2018; 115(5):1081-1086.	Observational air sampling study.	**Level 3**	"Characterizing influenza virus in exhaled breath from community-acquired influenza cases during natural breathing, prompted speech, coughing, and sneezing, and assess the infectivity of naturally occurring influenza aerosols".	N/A	For NP swabs, course aerosol, and fine aerosols: "Infectious Virus (positive culture passage)", Positive quantitative cultures (fluorescent focus units (FFUs)), Geometric mean and range, Positive RNA copies, Geometric mean, Associations of shedding with patient characteristics.

Assessment of evidence
This observational study carried out in the US involved volunteers between ages 19-21. The study suggests positive infectious influenza virus and quantitative cultures samples can be detected in fine aerosols (>0.05-<5μm). Both coarse and fine aerosol samples had

Assessment of evidence
detectable viral RNA. Cough frequency was significantly associated with increased fine-aerosol (p=<0.0001) and course aerosol RNA shedding (p=<0.01). Vaccinations for influenza given the previous and current year appeared to have a significant association with greater finer-aerosol RNA shedding. This study is limited by its lack of clarity, potential for inclusion of the same participant on more than one occasion, lack of standardisation of cough frequency and no. of samples per patient. Sampling via cone. Limitations: • No info on setting/ room of sampling, for instance, temp, humidity, no. of personnel present. However, cone sampling performed so not as important. • Considerable variation in cough frequency amongst participants. • Results are specific to age groups 19-21 with high asthma prevalence, not generalizable to all population. • Not carried out in a clinical setting, may not generalize to health and care settings. • Coarse aerosol particles “not assayed”, reason not provided. • Results are not presented per participant sampled, potential for same participant producing numerous positive samples. • No. of samples from each participant does not appear to be standardized.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Bischoff WE, Wallis ML, Tucker BK, et al. "Gesundheit!" sneezing, common colds, allergies, and	Observational air sampling study.	**Level 3**	To determine the impact of sneezing on the airborne dispersal of *S. aureus* bacteria.	Non-sneezing and histamine induced sneezing sessions. With or without rhinovirus infection.	Results of *S. aureus* quantitative swabbing tests (nasal, pharynx, axillae skin, skin of

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Staphylococcus aureus dispersion. J Infect Dis. 2006;194(8):1119-26.					palms of hands, skin of groin). Number of sneezes, coughs, nose blows, talking, and unusual activities performed by participant during sampling personnel. Dispersal of airborne bacteria—such as *S. aureus*, CoNS, and other bacteria—at the individual level over the course of 16 consecutive days, in colony-forming units per cubic meter per minute (CFU/m^3/min). Molecular typing.
Assessment of evidence					
This study was carried out in North Carolina, US and involved 11 medical and undergraduate students. This study, although specific to a small group of young persons, suggests that the mean number of *S. aureus*, in the nose or pharynx, does not change significantly after rhinovirus exposure (IRR, 1.02; p=0.888) but that sneezing significantly increases the amount of *S. aureus* bacteria disseminated into the					

Assessment of evidence

air from the respiratory tract from nasally colonized patients, although wide inter-subject variability was observed (<1 to 279 CFU of *S. aureus*/m^3/min during sneezing sessions).

Limitations:

- Sneezing and non-sneezing sessions do not appear to be randomised.
- Small sample sizes (no sample size calculations).
- Specific to younger population.
- How was chamber cleared between sampling sessions/participants?
- Unclear as to delineation between 'first group' and 'latter group' ("Five volunteers dispersed 160 CFU of *S. aureus*/m^3/min, whereas the remaining 6 volunteers did not expel >5 CFU of *S. aureus*/m^3/min. This is likely explained by the higher frequency of sneezing in the first volunteer group, in which an average of 6.5 sneezes/session was seen, compared with 3.8 sneezes/session in the latter group (p=<0.05)". However, in an earlier section it is reported that "number of sneezes during histamine induced sneezing sessions was not statistically significant before or after rhinovirus infection (p=0.2622)".
- Unclear reporting: "Given that 2.83 CFU of *S. aureus*/m^3/min were recovered per sneeze, ~23 CFU/m^3/min were expelled into the air by 1 sneeze".
- Authors suggest that the presence of respiratory allergies leads to an increase in airborne *S. aureus* during sneezing, however, unclear how many subjects were considered to have allergies and how many were not.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Bischoff WE, Bassetti S, Bassetti-Wyss B. et al. Airborne dispersal as a novel transmission	Observational Air Sampling.	**Level 3**	Analysis of airborne dispersal of coagulase-negative staphylococci (CoNS) with a	Comparisons between: Baseline (pre-exposure to RSV) vs	Viable particles by impact on agar plates CFU/m^3/min. Incidence rate ratio

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
route of coagulase-negative - staphylococci: interaction between negative-staphylococci and rhinovirus infection . Infection Control and Hospital Epidemiology. 2004.			rhinovirus infection. Investigated at the same time as analysis of dispersal of *S. aureus* with a rhinovirus investigation.	post rhinovirus exposure . Condition I (own clothing) vs condition II (sterile clothing including sterile, waterproof surgical gown over the street clothes, sterile gloves, shoe covers, and a bouffant cap).	Particle sizes (<5µm, >5µm).

Assessment of evidence

Setting: US, airtight chamber with HEPA filter.

This study carried out in the US involved 12 participants. The study suggests CoNS bacteria can be detected in the air at sizes <5µm in this cohort in an airtight chamber built around a class II biosafety hood. The study also suggests sterile clothing (including sterile, waterproof surgical gown over the street clothes, sterile gloves, shoe covers, and a bouffant cap) significantly reduces CoNS CFU/ m^3/min in the air, when compared with subject's own clothing ($p<0.0001$). "However, there was no significant impact on the dispersal of CoNS by adding a mask to the surgical gown […] ($p= 0.433$)." The study is limited by its small sample size of 12 participants co-colonized with *S. aureus* and specificity to young predominantly male, adults.

Limitations:

- Small sample size (n=12).
- Specific to young adults (av. 24 range 20-37).
- Uncontrolled coughing and sneezing events, will have varied in no. from participant and session.

Assessment of evidence
• No defined distance from samplers. • Carried out in US. • Controlled environment of sealed small chamber, built around the front glass of a class II biosafety hood – may not generalise out with this set-up. • Vague description of how they calculated the estimate time point of maximum spread, for instance, did they use data from the cold symptom scoring, were the two participants with no symptoms included in this? • Specific to participants co-colonised with *S. aureus.* • Statistical testing of all three conditions together. • No statistical testing of just condition one and condition two separately to see if significant increase with baseline and exposure. • Unclear on what day of infection air sampling was carried out.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sawano M, Takeshita K, Ohno H, et al. RT-PCR diagnosis of COVID-19 from exhaled breath condensate: a clinical study.	Observational air sampling.	**Level 3**	"to clarify changes in RNA load in EBC overtime following disease onset".	N/A	Viral load in EBC samples (copies/mL). Viral load compared with patient characteristics. Detection rate of viral RNA.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
J. Breath Res. 2021;15.					

Assessment of evidence

This study carried out in Japan involved 48 participants. The study demonstrates SARS-CoV-2 RNA can be detected from breath condensate of hospitalized COVID-19 infected patients. The study suggests that there may be a significant association between SARS-CoV-2 RNA viral load in exhaled breath condensate (EBC) of hospitalised COVID-19 infected patients and the need for mechanical ventilation (p=<0.05). Significantly higher detection rates of viral RNA were associated with a need for oxygen administration (p=<0.01), a need for mechanical ventilation (p=0.04), presence of a cough (p=<0.01), presence of a fever (p=0.01) or being less than three days from symptom onset (p=<0.01).

Limitations:

- Delay in EBC sampling caused variation in sample collection after onset (range 9-16 days).
- Specific to hospitalized patients.
- Unknown strain infecting patients, early in pandemic.
- Variation in duration and volume of sample.
- 15 positive EBC samples collected from 12 patients, number of repetitions of sampling not provided.
- Environmental conditions not provided.
- Disease onset not defined or reported. Unable to make inferences on day of infection.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

“Research has demonstrated that both droplet and airborne-sized particles can be found in the air at close proximity (up to two metres) to a coughing/sneezing source. [citations provided] In addition, a portion of larger particles (droplets) may desiccate (and so become smaller) while in the air and become, in effect, droplet nuclei.” [NC]

“Particles with a diameter of 1 µm to 10 µm may penetrate as far as the alveolar ducts (i.e., beyond the vocal cords), but may also be deposited at any point in the respiratory tract”. [NC]

Guidance cites Roy and Milton (2004) when discussing inhalable fraction of particle sizes.

“variety of [particle] sizes are expelled from the human airway during coughing, sneezing, talking and medical procedures.” [NC]

“size of […] particles and […] distance they will be propelled is dependent on the force generated by the individual or the procedure.” [NC]

Assessment of evidence
“Large particles (greater than 10 μm) will fall quickly (in a few seconds) to the ground.” “smaller particles may remain suspended for a significantly longer time: tens of seconds for a droplet 10 μm in diameter and minutes or hours for small droplet nuclei.” [NC] “The particles that remain aloft for minutes or hours (less than 10 μm in diameter) can be carried by air currents over a measurable distance, including beyond the room, and are considered to represent an airborne exposure.” [NC] “Droplets are generated naturally from an infected source, primarily during coughing, sneezing or talking, or artificially through AGMPs.” “Aerosol-generating medical procedures may also result in the generation of smaller infectious droplets that can travel farther than those generated spontaneously from patients.” [NC] “The coughs and sneezes of some individuals (e.g., young children or frail elderly) may not be forceful enough to propel droplets as far as two metres.” “Aerosols containing viable microorganisms are generated naturally from an infected source during coughing, sneezing and talking, or artificially through AGMPs.” [NC] “Aerosol-generating medical procedures are medical procedures that can generate aerosols as a result of artificial manipulation of a person’s airway.” [NC] “The risk of infection transmission may increase during AGMPs because of the potential to generate a high volume of respiratory aerosols that may be propelled over a longer distance than that involved in natural dispersion patterns. These procedures include: • Intubation and related procedures (e.g., manual ventilation, open endotracheal suctioning) • Cardiopulmonary resuscitation • Bronchoscopy • Sputum induction • Nebulized therapy

Assessment of evidence
• Non-invasive positive pressure ventilation (continuous or bilevel positive airway pressure)".

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Gralton J, Tovey ER, McLaws ML, et al. Respiratory virus RNA is detectable in airborne and droplet particles. J Med Virol. 2013; 85(12):2151-2159.	Observational air sampling study.	**Level 3**	Determination of the size of particles carrying respiratory viral RNA during coughing and breathing in symptomatic children and adults.	Breathing for 10 minutes. Forced coughing 10 times. Adult vs child. Asthmatic vs non-asthmatic. Type of respiratory infection.	Presence of respiratory infection viral RNA in size fractionated breath or cough samples. >7 µm (Stage 1), >4.7 to <7 µm (Stage 2), >3.3 to <4.7 µm (Stage 3), >2.1 to <3.3 µm (Stage 4), >1.1 to <2.1 µm (Stage 5), >0.65 to <1.1 µm (Stage 6).
Assessment of evidence					
Setting: Sydney, Australia, infectious diseases ward with non-isolation rooms.					

Assessment of evidence

This study carried out in an infectious diseases ward in Sydney Australia involved 12 adults and 41 children (median age 6.8, SD 3 years). The study shows that the viral RNA (specific to the strains of parainfluenza and rhinovirus which infected this cohort) were detectable in small particle size fractionated samples (0.65-1.1µm) during breathing for 10 minutes and during 10 forced coughs. It is unclear what proportion of individuals with confirmed respiratory infection expelled RNA positive samples as there is no baseline figure established through swab results/lab testing. There was no significant difference (p=0.712) in viral RNA detection in breath samples compared with cough samples but amount of virus is not quantified.
 	
Limitations:
• Infection not laboratory confirmed in children. Based on symptom scores over previous 24hrs from validated questionnaire (3 mild symptoms or two moderate).
• Not a completely validated sampling system: “A punctured section of the tube is contained by a disposable plastic bag. This modification accommodates changes in input airflow produced on breathing and coughing and prevents any fluctuation to sampling airflow (28 l/min) drawn through the six-stage Andersen Sampler”.
• Forced cough may not mirror natural coughing process.
  • Breathing into sampler between coughs may confound results.
  • A mixture of respiratory infections with especially small sample sizes for RSV and Influenza A.
  • Specific to hospitalized children.
  • Particles will be lost to impaction in other areas of equipment/nasal exhalation.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Wood ME, Stockwell RE, Johnson GR, et al. Cystic fibrosis pathogens survive for extended periods within cough-generated droplet nuclei. Thorax. 2019; 74(1):87-90.	Observational air sampling study.	**Level 3**	Assessment of the "physical properties and survival of common non-*Pseudomonas aeruginosa* CF pathogens generated during coughing." Coughing samples at 2m and 4m (comfortable strength and frequency for five minutes). Coughing samples at 5-,15- and 45-minute time delays post-production (coughing for two minutes).	N/A	Results of cough aerosol culturing in CFUs. Results of sputum sample culturing in CFUs. Culturable bacteria in size fractionated samples at different distances and following different lengths of time.
Assessment of evidence					
This study, carried out in Brisbane, Australia involved 30 CF patients. The study suggests culturable gram-negative bacteria and *S. aureus* (matched to patient sputum samples) was detected in the cough aerosols of CF patients. It was detected at 4m from the source. Sampling via mouthpiece.					

Assessment of evidence
Bacteria from aerosols produced at source were cultured from <4.7µm size fractionated samples and were culturable 45 minutes post-production. This study suggests that there may be a correlation between bacterial sputum and aerosol concentrations for Gram-negative bacteria (GNB) species (r=0.50, p=0.035) and *S. aureus* (r=0.66, p=0.005). Limitations: • Presentation of results often unclear as authors switch between reporting on specific organisms and participants, for example, Table 1 denotes presence and CFUs of organism types detected at certain distances/times not based on number of participants. • How was the apparatus treated between sampling periods (decontamination protocols)? • Specific to young CF patients. • Forced coughs may not mirror natural coughing episodes. • No reports of positive or negative controls. • Presence of bacteria does not directly indicate infectivity/infectious risk. • Drum impedes natural settling of bacteria/particles. • Don't know what specific GNB or *S. aureus* strains were detected at 2m/4m, or at 5/15/45minutes.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Stockwell R, Chin M, Johnson GR, et al. Transmission of bacteria in bronchiectasis and chronic obstructive	Observational air sampling study.	**Level 3**	The study "sought to determine if (i) patients with bronchiectasis or COPD can produce cough aerosols	N/A	Patient respiratory function (FEV1 and FVC). Cultures of *P. aeruginosa* (CFU) in sputum and aerosols

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
pulmonary disease: low burden of cough aerosols. Respirology. 2019; 24:980-987.			containing *P. aeruginosa* and (ii) if respiratory infections with shared *P. aeruginosa* strains occur in patients with bronchiectasis and chronic obstructive pulmonary disease (COPD) attending a centre that is co-located with a large adult CF centre." Part (ii) of the study was genotyping, this is omitted from this appraisal with exception of matching patients to aerosol samples, due to lack of epidemiological information to link these patients.		Genotyping *of P. aeruginosa* cough aerosols.

Assessment of evidence
This study, carried out in Brisbane, Australia, demonstrates *P. aeruginosa* can be cultured in cough aerosols from patients with positive *P. aeruginosa* sputum samples and bronchiectasis or COPD. It also demonstrates *P. aeruginosa* can be detected at 2m and 4m. However, the clinical disease (bronchiectasis and/or COPD) of these patients is unknown, affecting generalizability. Viable *P. aeruginosa* containing aerosols were detected at 15 minutes when suspended in a sealed rotating drum (a "duration rig"). Viable *P. aeruginosa* was not detected at 5- or 45- minutes, again it is unclear which specific patients produced these results. Low CFUs were detected, and genotyping of paired sputum and cough aerosol samples were genetically indistinguishable. Sampling within "two validated cough rigs". Limitations: • Duration rig represents experimental conditions, may not generalize to in vivo situation. • Small sample size n=20, as low as 16, • Specific to older adults on average 62-63 years old. • Specific to clinically stable participants with bronchiectasis or COPD previously positive with *P. aeruginosa* in sputum. • Unclear if patients with bronchiectasis and/or COPD had the positive samples at 4m.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
infections in health care. 2014. Date accessed: 7 November 2022.					

Assessment of evidence

"High-risk aerosol-generating procedures: Aerosols are produced when an air current moves across the surface of a film of liquid, generating small particles at the air–liquid interface. The particle size is inversely related to the velocity of air. Therefore, if a procedure causes air to travel at high speed over the respiratory mucosa and epithelium, the production of aerosols containing infectious agents is a potential risk. An aerosol-generating procedure is defined as any medical procedure that can induce the production of aerosols of various sizes, including droplet nuclei." [NC]

"Infectious respiratory aerosols: Respiratory aerosols that contain infectious particles. Aerosol size is determined by the force and pressure involved in the generation of the particles. The final size depends on the nature of the fluid containing the organisms, the force and pressure at emission, the initial size of the aerosol, environmental conditions (e.g., temperature, relative humidity and airflow), the time spent airborne, and the size of the organisms within a droplet. The distance travelled and the length of time particles remain suspended in the air is determined by the types of organism, particle size, settling velocity, relative humidity and airflow. Large particles typically remain suspended in the air for a limited period of time and settle within 1 m (3 feet) of the source. Smaller particles evaporate quickly; the resulting dried residues settle from the air slowly, and remain suspended in the air for variable lengths of time. The definitions and classification of the different types of infectious respiratory aerosols are evolving, and the implications for IPC measures are not yet clear. However, for the purpose of this document, infectious respiratory aerosols are classified into:

- droplets – respiratory aerosols > 5 μm in diameter; and
- droplet nuclei – the residue of dried respiratory aerosols (≤ 5 μm in diameter) that results from evaporation of droplets coughed or sneezed into the atmosphere or by aerosolization of infective material." [NC]

Assessment of evidence
“The spread of an infectious agent caused by the dissemination of droplets. Droplets are primarily generated from an infected (source) person during coughing, sneezing and talking. Transmission occurs when these droplets that contain microorganisms are propelled (usually <1m) through the air and deposited on the conjunctivae, mouth, nasal, throat or pharynx mucosa of another person. Most of the volume (>99%) comprises large droplets that travel short distances (<1m) and do not remain suspended in the air.” [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Kim SH, Chang SY, Sung M, et al. extensive viable middle east respiratory syndrome (MERS) coronavirus contamination in air and surrounding environment in MERS isolation wards. Clin Infect Dis. 2016;63(3):363-369. Please note, further information obtained from authors reply to letter:	Observational air samplings study.	**Level 3**	Detection of virus in environmental samples via PCR, immunofluorescence assay and electron microscopy.	N/A	Presence of viral RNA via PCR of air samples. Presence of viable virus in air samples via immunofluorescence assay and electron microscopy visualisation.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Kim SH, Sung M, Min JY. Reply to Kerkhove et al and Oh. Clinical Infectious Diseases. 2016; 63(8):1143–1144.					

Assessment of evidence

Setting: South Korea, two hospitals, hospital A rooms ≥12 ACH, hospital B not reported.

This study, carried out at two hospitals in South Korea involved three patients, the study demonstrates that viable MERS-CoV virus could be detected in air samples surrounding positive patients, however, distance to sampler was not controlled and contribution to sample from others cannot be ruled out.

Limitations:

- Virus in air could have represented re-aerosolization rather than direct emission from respiratory tract.
- Very small patient cohort.
- Patients in late stage of infection (16-22 days post symptom onset).
- Specific to hospitalized patients.
- Cannot know if patient three was still PCR positive at time of sampling.
- Cannot know if patients were still infectious at time of sampling.
- Distance to sampler somewhat vague and not controlled apart from for patient three who was bed bound although unclear medical procedures/care activities.

Assessment of evidence
• Potential AGPs performed during/not long before sampling. • Virus in samples not quantified. • No information regarding symptoms of patients.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Killingley B, Greatorex J, Digard P, et al. The environmental deposition of influenza virus from patients infected with influenza A(H1N1)pdm09: Implications for infection prevention and control. Journal of infection and public health. 2016; 9(3):278-288.	Observational air sampling study.	**Level 3**	Influenza A (H1N1) - Assessing presence and quantity of viral DNA and viable virus in air samples around infected patients with search for correlation between nasal viral load and viral DNA presence in air.	N/A	Quantification of viral load of patient nares samples. (copies/ml) Quantification of viral load in air surrounding infected patients (copies/ml). Correlation between nares and air sample viral loads. Results of viral culturing with immunofluorescence assay. Presence and quantification of viral DNA in size

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
					fractionated samples (<1, 1-4 and >4µm).

Assessment of evidence

Setting: UK, community and hospital (hospital rooms/community bedrooms).

This study, carried out in the community and hospitals in the UK involved 12 participants. The study demonstrates that Influenza viral DNA can be detected in size fractionated samples <1µm, 1-4µm and >4µm, in the air, at 1m from the subject and detected in particles of sizes 1-4µm at 2m, however, inferences regarding distance cannot be stated with certainty.

Limitations:

- Variable volume of air sampled based on differing sampling time periods (1-3h) and at differing approx. distances.
- Some contradictory information (“Subjects were targeted on the basis of a positive rapid test” however authors state later that “eight [of 12] were rapid antigen test positive”.
- Unclear as to ACH of room, air flow.
- Maintenance of distance to sampler not guaranteed/confirmed.
- Unknown contribution of visitors/residents/staff and what activities were undertaken by subjects, medical procedures undergone.
- Subjects PCR positive but unknown if still infectious (those who had positive air samples were 3-4 days into their illness).
- Specific characteristics only provided for those with positive air samples not whole 12-person cohort.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Engel T, Erren E, Vanden Driessche K, et al. Aerosol Transmission of Aspergillus fumigatus in Cystic Fibrosis Patients in the Netherlands. Emerging Infectious Diseases. 2019 ;25(4):797-799.	Observational air sampling study.	**Level 3**	Examination of culturable A. fumigatus in CF cough aerosols.	N/A	Bacterial species present on cough plates. Presence of A. fumigatus on agar plates (CFUs up to max. 20).

Assessment of evidence

This study, carried out in the Netherlands involving 15 patients with Cystic Fibrosis (CF), demonstrates viable *A. fumigatus* can be detected on agar plates when coughed on by CF patients colonized with A. fumigatus at a distance of 5cm. Genotyping of sputum samples from the patient and their cough plate samples confirmed identical genotypes.

Limitations:

- Small sample size (n=15).
- No CFU data provided (only counted up to max 20).
- Very close range (5cm).
- Voluntary cough may not mirror natural process.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Bioaerosols: An airborne dispersion of particles containing whole or parts of biological entities, such as bacteria, viruses, dust mites, fungal hyphae, or fungal spores. Such aerosols usually consist of a mixture of mono-dispersed and aggregate cells, spores or viruses, carried by other materials, such as respiratory secretions and/or inert particles. Infectious bioaerosols (i.e., those that contain biological agents capable of causing an infectious disease) can be generated from human sources (e.g., expulsion from the respiratory tract during coughing, sneezing, talking or singing; during suctioning or wound irrigation) […] Bioaerosols include large respiratory droplets and small droplet nuclei".					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Chan SM, Ma TW, Chong MK, et al. A proof of concept study: esophagogastroduodenoscopy is an aerosol-generating procedure and continuous oral suction during the procedure reduces the amount of aerosol generated. Gastroenterology. 2020; 159:1949–1951.	Observational air sampling.	**Level 3**	Establish if Esophagogastroduodenoscopy (EGD) produces aerosols by comparing baseline levels of particle counts with levels during the procedure.	Baseline particle counts to during procedure particle counts.	Particle counts (cubic feet (dCF)). Associations with use of sedation, dental sucker and log (dCF).
Assessment of evidence					
This study carried out in a procedural room with six ACH in a hospital in Hong Kong, involved 93 patients undergoing EGD. The study suggests that compared to baseline measurements, particle counts during the EGD procedure, in the size ranges 0.3-10 µm, are significantly raised (p=<0.001 to <0.02). The study also suggests the use of a “dental sucker” significantly reduces the number of particles sized 0.3-10µm expelled during the procedure when compared to baseline (p=<0.001, p=<0.001, p=<0.001, p=0.02, p=<0.01, and p=0.046, respectively). Patient sedation appeared to have no significant effect on particle counts. This study is limited by its short time period for baseline measurements (at least one minute) and lack of information regarding staff presence, activity etc. during measurements.					

Assessment of evidence
Limitations: • No patient characteristics or demographic info, may be significant differences/ comorbidities. • Variation in reason for surgeries. • Potential confounding factors - no. of personnel in the room, opening/ closing of doors, movement during baseline. • Lack of info on air sampler such as flow rate, and so on. • Small sampling time for baseline measurement (at least one minute prior). • p-values for dCF in each size range not reported, only a range "(p=<0.001 to <0.02)".

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Milton DK, Fabian MP, Cowling BJ, et al. Influenza virus aerosols in human exhaled breath: particle size, culturability, and effect of surgical masks. PLoS Pathog. 2013; 9(3)..	Observational air sampling study.	**Level 3**	This study sampled exhaled breath of volunteers with PCR confirmed Influenza to establish no. copies of viral RNA of particles >5µm and <5µm as well as viability of particles <5µm.	N/A	No. copies viral RNA for coarse particles (>5µm) and fine particles (<5µm). Viable virus in fine-particle fraction.

Assessment of evidence

This study, carried out in Massachusetts, US, demonstrates influenza RNA can be detected in particles sized <5μm and >5μm. In this cohort, fine fraction particles (<5μm) contained more viral copies than coarse particles (>5μm) (8.8-fold more [95% CI 4.1 to 19]). Coarse and fine fraction copy numbers were significantly correlated (r=0.60, p=<0.0001). The study also identified viable influenza viral RNA in the fine particle range, produced by two participants with the highest numbers of viral RNA copies, viability testing was not attempted for coarse particles. Sampling via cone.

The study suggests with increase in time since onset of symptoms, viral copy number declines for both coarse fraction particles (6.0-fold drop with each additional day since onset in the number of virus copies detected [95% CI 1.7 to 21-fold]) and fine particles (2.4-fold drop with each additional day since onset in the number of virus copies detected [95% CI 1.1 to 5.1-fold]).

The study suggests viral load in nasopharyngeal swab specimen is not associated with that in coarse or fine particle samples. Both asthma and having a fever were significantly associated with lower fine fraction copy numbers (p=0.029 and p=0.014, respectively). This study is limited by its small sample size and lack of information regarding duration between participant sampling.

Limitations:

- Did not look at viability of coarse particle samples.
- Small sample size (37 volunteers analysed).
- Unknown time period between participants, potential for particles to remain from previous participant.
- Forced coughs may not represent real life scenario (normal coughs).
- One participant reported to have frequent natural coughs this may make their data different to others, potentially non-comparable number of coughs.
- Specific to Influenza and strains of cohort.
- Young cohort.
- Missing p-values.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Viklund E, Kokelj S, Larsson P, et al. Severe acute respiratory syndrome coronavirus 2 can be detected in exhaled aerosol sampled during a few minutes of breathing or coughing. Influenza Other Respi Viruses. 2022;16:402–410.	Observational air sampling study.	**Level 3**	Particle concentrations, particle size distribution and detection of SARS-CoV-2 RNA in exhalations of COVID-19 positive individuals.	Control subjects (no COVID-19 infection suspected). Breathing manoeuvres. Aerosol positive (RNA) and negative individuals.	NP swab viral loads (PCR Ct values). Aerosol sample viral loads (Ct values). Patient characteristics and symptoms. SARS-CoV-2 RNA positivity of aerosol samples. Particle counts (number exhaled particles per breath, kn*). * Knudsen number used for particle count (kn). Particles per breath in kn.
Assessment of evidence					
This observational air sampling study was carried out in Sweden and involved 25 subjects with COVID-19 infection. The study shows that SARS-CoV-2 RNA can be detected in exhaled particles of <5μm in size when breathing, coughing and performing a deep exhalation/rapid inhalation manoeuvre. It also reports that for this small, specific cohort, there was no association between number of exhaled particles (<5μm) and either aerosol sample positivity or aerosol viral load. Subjects with COVID-19 appeared to exhale less particles than healthy					

Assessment of evidence
controls during normal breathing and airway opening breaths (p=0.008 and 0.001 respectively), but not during coughing (p=0.151). There was also no association found between the viral loads of NP swabs and aerosol samples. This study also demonstrates wide inter-subject particle production variability as two individuals produced a very high number of particles during coughing compared to other subjects. Particle size assessment demonstrated that this increase was largely attributable to particles of size 0.4-1.1µm. Particle numbers per cough ranged from 0.9-217.4 for COVID-19 infected individuals. Sampling via mouthpiece. Limitations: • No p-value given for reported lack of association between particle counts and aerosol sample positivity. • Small sample size. • Specific to young, symptomatic individuals. • Specific to COVID-19 strain in this cohort. • Lack of modelling for age/lung capacity in assessment for difference between particle production between healthy and infected participants. • Forced coughs may not mirror natural processes.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Knibbs LD, Johnson GR, Kidd TJ, et al. Viability of Pseudomonas aeruginosa in cough aerosols generated	Observational air sampling study.	**Level 3**	This study attempts to understand *P. aeruginosa* aerosol duration of viability and distances viable cough aerosols can travel.	*P. aeruginosa* aerosol sampled at distances one, two and four meters from source and at five-, 15- and 45- minutes post-production.	*P. aeruginosa* concentrations (CFU/ml). No. of subjects with isolated *P. aeruginosa* at distances of 1, 2 and

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
by persons with cystic fibrosis. Thorax. 2014; 69(8):740-5.				Size fractionated samples - small (2.1–3.3, 1.1–2.1 and 0.65–1.1 µm) and large (>7, 4.7–7.0 and 3.3–4.7µm).	4m and following five-, 15- and 45-minutes. CFU counts of *P. aeruginosa* per large fraction and small fraction. Inter-subject heterogeneity (total viable *P. aeruginosa* cultured).

Assessment of evidence

This observational study carried out in Australia on CF patients with chronic *P. aeruginosa* reported that cough aerosol samples containing viable *P. aeruginosa* were detected from all patients.

The study identified that aerosol samples containing viable *P. aeruginosa* were detected at 4m in 17 of 18 patients (94%) and at all distances (1m, 2m and 4m) in 16 of 18 participants when the patient is (forced) coughing for five minutes into an airtight 'rig' set up to provide controlled conditions. CFU counts significantly decreased with increasing distance (p=0.001), this was the case for 'small' (p=0.005) and 'large' (p<0.001) fraction particles.

Within the rotational 'rig', following two minutes of forced coughing, aerosol samples (both large and small) containing *P. aeruginosa* remained viable for a duration of 45 minutes from 14 of 18 participants (78%). A significant decrease is seen in CFU counts with increasing duration (p=0.046). This was the case for small (p=0.031) but not large fraction aerosols.

Viable *P aeruginosa* isolates were cultured from particles <3.3µm.

Assessment of evidence
Limitations: • Potential for missing some *P aeruginosa* isolates, presumptive screening prior to RT PCR. • Likely to be variation between patients in terms strength of coughs (subjective assessment of strength). • Small sample size (19 CF patients, 10 healthy controls). • Specific to those (>12 years) with CF and chronic *P. aeruginosa* infection. • Discrepancy with no. of patients included in analysis vs no. recruited of CF patients. Paper states there are 19 patients with CF, 18 providing sputum and one providing a cough swab. Their results are presented out of 18. Unknown if one patient dropped out, was not sampled, or if the patient with the cough swab is not included in analysis and why.

Question 5: Can person-to-person transmission of infection be defined beyond the current categories of contact, droplet and/or airborne?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Infection Control – How Infections Spread. 2016. Date accessed: 11 April 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Contact moves germs by touch (example: MRSA or VRE). For example, healthcare provider hands become contaminated by touching germs present on medical equipment or high touch surfaces and then carry the germs on their hands and spread to a susceptible person when proper hand hygiene is not performed before touching the susceptible person." "Sprays and splashes occur when an infected person coughs or sneezes, creating droplets which carry germs short distances (within approximately 6 feet). These germs can land on a susceptible person's eyes, nose, or mouth and can cause infection (example: pertussis or meningitis)." "Close range inhalation occurs when a droplet containing germs is small enough to breathe in but not durable over distance." "Inhalation occurs when germs are aerosolized in tiny particles that survive on air currents over great distances and time and reach a susceptible person. Airborne transmission can occur when infected patients cough, talk, or sneeze germs into the air (example: TB or					

Assessment of evidence
measles), or when germs are aerosolized by medical equipment or by dust from a construction zone (example: *Nontuberculous mycobacteria* or aspergillus)." "Sharps injuries can lead to infections (example: HIV, HBV, HCV) when bloodborne pathogens enter a person through a skin puncture by a used needle or sharp instrument."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed 06/09/2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
[NC] = no citations					

Assessment of evidence

The Centers for Disease Control and Prevention (CDC) acknowledge that certain pathogens can be spread by more than one of the defined routes (direct/indirect, droplet or airborne) and use the word 'primarily' when assigning an example to a give route.

- Issues with at risk 'droplet transmission' zone of <3ft: experimental studies with smallpox and investigations during the global SARS outbreaks of 2003 suggest droplets could spread 6ft or more– authors do not clarify what they mean by 'droplet'.
- Authors state that distance of droplet travel is likely dependent on "velocity and mechanism by which respiratory droplets are propelled from the source, the density of respiratory secretions, environmental factors such as temperature and humidity, and the ability of the pathogen to maintain infectivity over that distance".
- Due to factors described above, "distance of ≤3 feet around the patient is best viewed as an example of what is meant by 'a short distance from a patient' and [authors state that it] should not be used as the sole criterion for deciding when a mask should be donned to protect from droplet exposure." Authors state that donning a mask within 6-10ft/entry to patient room may be prudent and that consideration of whether the pathogen is emerging/highly virulent, should be taken into consideration. Authors highlight that more research on droplet transmission is needed.

SARS-CoV:

- In Appendix A, CDC outline that airborne precautions for SARS-CoV are "preferred" but that droplet precautions can be used if AIIR is unavailable. They state that aerosol generating procedures and "supershedders" present the highest risks for transmission via small droplet nuclei and large droplets.
- In the main body of text authors state that "the relative contribution of potential modes of transmission [for SARS-CoV] is not precisely known." They state that there is "ample evidence for droplet and contact transmission, however, opportunistic airborne transmission cannot be excluded".
- Authors state that "exposure to aerosol generating procedures (e.g., endotracheal intubation, suctioning) was associated with transmission of infection to large numbers of healthcare personnel outside of the United States. Therefore, aerosolization of small infectious particles generated during these and other similar procedures could be a risk factor for transmission to others within a multi-bed-room or shared airspace".

Assessment of evidence

- Review concluded that greatest risk is to those in close contact, not properly trained in infection prevention and control (IPC) measures, do not consistently use PPE and that N95 respirators may offer improved protection to those performing aerosol generating procedures (AGPs) and/or high-risk activities.
- Authors note that transmission to healthcare workers (HCWs) was not reported in Vietnam with inconsistent IPC measures (including PPE) suggesting other factors may play important role (e.g., severity of disease, frequency of high risk exposures/events, environmental features).

"Droplet nuclei, particles arising from the desiccation of suspended droplets" have been associated with airborne transmission and are cited to be <5μm in size but this is "a reflection of the pathogenesis of pulmonary tuberculosis which is not generalisable to other organisms."

"Observations of particle dynamics have demonstrated that a range of droplet sizes, including those with diameters of 30μm or greater, can remain suspended in the air".

The CDC use language which indicates their acknowledgement of certain pathogens propensity to be transmitted via one route more often than others. When describing RSV, authors state that "although respiratory syncytial virus may be transmitted by the droplet route, direct contact with infected respiratory secretions is the most important determinant of transmission and consistent adherence to Standard plus Contact Precautions prevents transmission in healthcare settings". It is thus suggested by authors that if a pathogen can be controlled through mitigation of its predominant transmission routes, provision of IPC measures for all possible routes may not be required.

In contrast to the above, for smallpox, CDC authors state that evidence suggests that "under unusual circumstances" variola virus (smallpox) can be "transmitted over long distances through the air" and that "droplet and contact routes are the more frequent routes of transmission for smallpox" yet airborne-infection isolation rooms (AIIRs) are recommended for this pathogen.

This guidance has a significant section on "small particle aerosol transmission of agents that are most frequently transmitted by the droplet route".

Assessment of evidence

- "For certain other respiratory infectious agents, such as influenza and rhinovirus, and even some gastrointestinal viruses (e.g., norovirus and rotavirus) there is some evidence that the pathogen may be transmitted via small-particle aerosols, under natural and experimental conditions. Such transmission has occurred over distances longer than 3 feet…"
- However, although authors outline airborne transmission characteristics, they further clarify that these transmission events happened.
- "within a defined airspace (e.g., patient room), suggesting that it is unlikely that these agents remain viable on air currents that travel long distances."
- They also state that "AIIRs are not required routinely to prevent transmission of these agents." Is this why they are not considered to be airborne pathogens?

"In contrast to the strict interpretation of an airborne route for transmission (i.e., long distances beyond the patient room environment), short distance transmission by small particle aerosols generated under specific circumstances (e.g., during endotracheal intubation) to persons in the immediate area near the patient has been demonstrated." [NC]

"Aerosolized particles <100μm can remain suspended in air when room air current velocities exceed the terminal settling velocities of the particles."

"Although the most frequent routes of transmission of noroviruses are contact and food and waterborne routes, several reports suggest that noroviruses may be transmitted through aerosolization of infectious particles from vomitus or fecal material. It is hypothesized that the aerosolized particles are inhaled and subsequently swallowed."

"Roy and Milton proposed a new classification for aerosol transmission when evaluating routes of SARS transmission:

1. obligate: under natural conditions, disease occurs following transmission of the agent only through inhalation of small particle aerosols (e.g., tuberculosis)
2. preferential: natural infection results from transmission through multiple routes, but small particle aerosols are the predominant route (e.g., measles, varicella)

Assessment of evidence

3. opportunistic: agents that naturally cause disease through other routes, but under special circumstances may be transmitted via fine particle aerosols."

"This conceptual framework can explain rare occurrences of airborne transmission of agents that are transmitted most frequently by other routes (e.g., smallpox, SARS, influenza, noroviruses)."

Consider transmission modes with inclusion of person-to-person or environment-to-person. "Some airborne infectious agents are derived from the environment and do not usually involve person-to-person transmission." For example, aerosolization and inhalation of finely milled powdered preparation of anthrax from surfaces. Environmental fungi (for example, Aspergillus spp.) may cause disease in immunocompromised patients who inhale aerosolized (for example, via construction dust) spores. *Legionella* transmitted via common aerosol source. Contaminated food, water or medications.

Other transmission modes: Vector borne transmission, percutaneous exposure to contaminated blood, transfusion, transplantation, xenotransplantation.

"A Protective Environment refers to isolation practices designed to decrease the risk of exposure to environmental fungal agents in allogeneic HSCT patients."

Cough etiquette is outlined as a standard precaution, however, is it not more in line with the description of TBPs. Placing masks on coughing patients, education relating to cough etiquette.

In Appendix A authors outline that transmission modes were assigned based on consultation of infectious disease manuals and textbooks and the published literature was searched for evidence of person-to-person transmission in healthcare and non-healthcare settings. "Criteria used to assign Transmission-Based Precautions categories follow:

- A Transmission-Based Precautions category was assigned if there was strong evidence for person-to-person transmission via droplet, contact, or airborne routes in healthcare or non-healthcare settings and/or if patient factors (e.g., diapered infants, diarrhoea, draining wounds) increased the risk of transmission i.e., not based on evidence of SICPs not being sufficient to prevent transmission
- Transmission-Based Precautions category assignments reflect the predominant mode(s) of transmission

Assessment of evidence
• If there was no evidence for person-to-person transmission by droplet, contact or airborne routes, Standard Precautions were assigned • If there was a low risk for person-to-person transmission and no evidence of healthcare associated transmission, Standard Precautions were assigned • Standard Precautions were assigned for bloodborne pathogens". Part 1: General discussion on scientific data regarding transmission of infectious agents. Part 2: General infection control principles/procedures (waste, cohorting, patient transport, patient placement, prevention of needlestick injuries and so on) with considerations for specific patient symptoms, pathogens, hygiene practices, but with occasional links back to precaution categories (for example, single room are always indicated for patients placed on airborne precautions and preferred for those on droplet/contact precautions but provides other considerations such as personal hygiene practices, prioritisation based on immune status, draining wounds, indwelling devices). Part 3: Precautions (standard, transmission and protective environment). Part 4 – Outlines recommendations. Presence of pathogens but not considered a transmission mode: "The finding of large numbers of Ebola viral particles in the skin and the lumina of sweat glands has raised concern that transmission could occur from direct contact with intact skin though epidemiologic evidence to support this is lacking." "Aspergillus spp. have been recovered from hospital water systems, the role of water as a reservoir for immunosuppressed patients remains uncertain." Section on 'Infectious agents of special infection control interest for Healthcare Settings': MDROs, *C. difficile,* Prions, SARS, Monkeypox, Haemorrhagic fever viruses, noroviruses. Adaptation of transmission prevention guidelines based on healthcare setting. Population characteristics (immunocompromised, indwelling devices, breaches in natural barriers, behavioural differences) intensity of care, exposure to environmental sources, length of stay, frequency of interaction with staff/other patients/visitors, resources. ICUs, burn units, paediatrics, long term care, cystic fibrosis centres.

Assessment of evidence
Protective environment/considerations based on vulnerability: staggered approach to reception using beepers for cystic fibrosis (CF) patients, increased cleaning to minimise dust collection, visitor screening. “A protective environment: a protective environment is designed for allogeneic HSCT patients to minimize fungal spore counts in the air and reduce the risk of invasive environmental fungal infections”. “it has been advised that severely immunocompromised patients wear a high-efficiency respiratory-protection device (e.g., an N95 respirator) when they leave the Protective Environment” when construction/renovation/dust generating activities are ongoing.” 1. “HEPA filtration of incoming air; 2. directed room air flow; 3. positive room air pressure relative to the corridor; 4. well-sealed rooms (including sealed walls, floors, ceilings, windows, electrical outlets) to prevent flow of air from the outside; 5. ventilation to provide >12 ACH; 6. strategies to minimize dust (e.g., scrubbable surfaces rather than upholstery and carpet, and routinely cleaning crevices and sprinkler heads); and 7. prohibiting dried and fresh flowers and potted plants in the rooms of HSCT patients.” “Standard Precautions are intended to be applied to the care of all patients in all healthcare settings, regardless of the suspected or confirmed presence of an infectious agent.” Standard precautions include respiratory hygiene/etiquette. During periods of increased respiratory infection prevalence offer masks to coughing patients and any symptomatic persons with, encourage physical distancing of >3ft. May want to recommend year-round for ease. Patient placement is not only based on precautions, for instance, routes of transmission of the known or suspected infectious agent. Formal Recommendation: • Risk factors for transmission in the infected patient

Assessment of evidence
• Risk factors for adverse outcomes resulting from an HAI in other patients in the area or room being considered for patient-placement • Availability of single-patient rooms • Patient options for room-sharing (e.g., cohorting patients with the same infection) Category II". [NC] Under airborne precautions recommendations section (page 90) pathogen specific guidance is given negating the functionality of an airborne precautions bundle. What is meant by airborne in this statement – "Although SARS-CoV is transmitted primarily by contact and/or droplet routes, airborne transmission over a limited distance (e.g., within a room), has been suggested, though not proven. This is true of other infectious agents such as influenza virus and noroviruses."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Sehulster LM, Chinn RYW, Arduino MJ, et al. Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Advisory Committee (HICPAC). Chicago IL: American Society for Healthcare Engineering/American Hospital Association; 2003. Date last updated: 2019. Date accessed: 30 September 2022.					

Assessment of evidence

Experts involved in this document were staff members from the CDC and HICPAC. Their affiliations: Division of Healthcare Quality Promotion National Center for Infectious Diseases; HICPAC Advisor; Division of Bacterial and Mycotic Diseases National Center for Infectious Diseases; Division of Parasitic Diseases National Center for Infectious Diseases; Division of Oral Health National Center for Chronic Disease Prevention and Health Promotion. With liaison members from Association for Professionals in Infection Control and Epidemiology (APIC), Association of periOperative Registered Nurses (AORN), U.S food and drug administration, American health care association, U.S. Centers for Medicare and Medicaid Services, Society for Healthcare Epidemiology of America (SHEA) and Advisory Committee for the Elimination of Tuberculosis (ACET).

CDC gives examples of what microorganisms they suggest are associated with airborne transmission and the reports of these occurring in healthcare settings. Colum for “under investigation” shows there is uncertainty, and the CDC are recognising this. Within “under investigation” column, “Pneumocystis carinii” is listed for Fungi, “n/a” is stated for both Bacteria and Viruses.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Government of Canada. Pathogen risk assessment. Last modified: 29 September 2021. Date accessed: 3 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Present a pathogen risk assessment with multiple sections, for example, severity of disease caused, whether certain specific populations are at increased risk of morbidity/mortality, whether pre and/or post exposure treatments are available and the likelihood of human-to-human transmission by direct or indirect contact.

For each transmission mode the user is asked to describe the likelihood of transmission: none, low/unlikely, moderate/possible, high/preferred route or unknown. Transmission modes presented include ingestion, injection, arthropod vectors, contact with intact skin, contact with mucous membranes or damaged skin, inhalation (large or small droplet aerosols, spores), exposure to animals via direct/indirect contact.

The user is then asked to use a second list to identify modes of transmission and their likelihood: - however it is unclear where inhalation would fit into this categorisation.

“Direct Contact (Casual): None; Low, unlikely; Moderate, possible; High, preferred route; Unknown

Direct Contact (Intimate): None; Low, unlikely; Moderate, possible; High, preferred route; Unknown

Indirect Contact (Fomites): None; Low, unlikely; Moderate, possible; High, preferred route; Unknown

Indirect Contact (Vectors): None; Low, unlikely; Moderate, possible; High, preferred route; Unknown”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government, National Health and Medical Research Council. Australian Guidelines for the Prevention and Control of Infection in Healthcare. 2019. Date last updated: September 2022. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"single-patient rooms are also an effective precaution to prevent droplet and airborne transmission of infection, and can also protect immunocompromised patients." [NC]

Table A2.5 presents the different transmission route terms used for different pathogens: (great variation can be observed)

- Contact with blood or body substances (mucosal, parenteral) either directly or indirectly.
- Aerosols.
- Airborne.

Assessment of evidence
• Faecal-oral route; Ingestion of contaminated water and food. • Contact. • Contact, ingestion. • Contact; droplet; inhalation; contaminated fomites. • Vertical. • Droplet. • Contact (skin to skin). • Contaminated medicines. • Transmitted by animal bites, scratches, or by contamination of mucous membranes or broken skin. • Droplet. • Droplet (respiratory secretions). • Contact (droplet in certain circumstances) (Norovirus, also states droplet precautions based on risk assessment). • Not fully known, presumed contact, droplet and airborne. (MERS) • Contact (both direct & indirect). • Airborne droplets.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
The American Society of Heating, Refrigerating and Air-Conditioning Engineers. ASHRAE Position Document on Infectious Aerosols. 2022. Date accessed: 15 November 2022. Expires: 23 October 2025.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

This position document written by The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) states to "express the views of the Society on specific issues" to "provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy".

"Transmission of infection is a complex process; the risk of disease is determined by numerous factors that have considerable and uncertain variability including the characteristics of the pathogen concerned, the infectiousness of the host, the media through which the infectious agent passes from source to new host, and the immune response of the new host (Noakes and Sleigh 2009)."

"Traditional definitions of "airborne" and "droplet" transmission have been shown to be misleading, and revised definitions of transmission routes are more closely aligned with the actual mechanisms by which pathogens are transferred from one person to another" [NC]

Assessment of evidence
“These revised routes are (1) inhalation of aerosols, (2) spray of large droplets, and (3) touching a contaminated surface. The first supplants the traditional airborne route, which was assumed to apply only at long distance, while the second and third correspond to the traditional droplet and fomite (or contact) routes.” [NC] “To facilitate readability and understanding, this committee agreed to leverage recently proposed terminology.” “Inhalation of infectious aerosols can cause infection, though the risk of infection of any individual is a function of the infectivity of the particular organism, its ability to remain infectious in air, the exposed person’s susceptibility to infection, the number of particles inhaled, the amount of infectious virus in the inhaled particles, where the particles are deposited along the respiratory tract, and other factors.” [NC] “In the past, the transmission of most respiratory pathogens was thought to be associated primarily with larger droplets, of concern only to people at close range to an infected person.” [NC] “It is now clear that transmission of COVID-19 and other respiratory infections is likely dominated by inhalation of infectious aerosols both at close range and long range (Wang et al. 2021)” “Pathogen-carrying droplets and aerosolized particles that fall to a surface can be a source of infection through touch and subsequent touching of the eyes or nose or through reaerosolization (or resuspension) followed by inhalation.” [NC] “persistence of various infectious pathogens in aerosols may be affected by environmental conditions, including temperature and humidity (Tang 2009).” “Different pathogens respond differently to varying temperature and humidity conditions. Therefore, attempting to modify risk through these mechanisms is problematic.” [NC] **References:** Noakes CJ and Sleigh PA. Mathematical models for assessing the role of airflow on the risk of airborne infection in hospital wards. Journal of the Royal Society Interface. 2009; 6(suppl_6):S791–S800. Tang JW. The effect of environmental parameters on the survival of airborne infectious agents. Journal of the Royal Society Interface. 2009; 6(suppl_6):S737–S746.

Assessment of evidence
Wang CC, Prather KA, Sznitman J, et al. Airborne transmission of respiratory viruses. Science. 2021; 373(6558).

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Health Protection Agency. Prevention and control of infection in care homes - an information resource. 2013 Date accessed: 10 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
This expert opinion is described as “An information resource to assist staff in taking all reasonable steps to protect residents and staff from acquiring infections and prevent cross infection; and to provide information and guidance on infection prevention and control that will assist managers in undertaking risk assessments and in developing policies” which applies only to England. Target audience for these guidelines “Care Trust CEs, GPs, Communications Leads, Consultants in Communicable Disease Control, Community Infection Control Nurses, Health Protection Nurses, Care Home Managers, Care Quality Commission”. “Method of spread or mode of transmission If hands come into contact with these the micro-organisms may be carried from one person to another unless the hands are properly decontaminated. Some micro-organisms may be spread in the air. The viruses that are responsible for colds and influenza are found in

Assessment of evidence
nasal secretion, saliva and sputum. Coughing or sneezing near another person may pass on these viruses in the droplets or aerosol produced. Touching your face will contaminate your hands with these viruses. Modes of transmission include: • aerosol; • droplet; • faecal–oral; • direct contact (person-to-person), often by contaminated hands; • indirect contact (food, water, fomites [inanimate objects], the environment); • blood and body fluid; and • insects and parasites.” In a later table (Appendix 2), varying terminology is used for “mode of transmission” per specific disease or causative organisms. Modes of transmission listed in table include: • “food, • person-to-person • hand-to-mouth • pet faeces • airborne • contact with rash • environmental contamination

Assessment of evidence
• direct contact with lesions • directed contact with discharge • water • from pets • droplet • direct contact with infectious secretions • Contact with infected blood or other body fluids • Sexual transmission • Contact with saliva • Direct and indirect contact • Airborne during bed making • Airborne if ‘open’ case (sputum smear positive) otherwise not infectious • Person-to-person (close contact) • Water or food contaminated by infected water • Usually reactivation (of chickenpox) • Direct contact with rash” There is some inconsistency with the modes listed above, for example the use of “airborne” in the table and the use of “aerosol” in the list. Limitations: • Specific to care homes.

Assessment of evidence
• No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Social Care. Infection prevention and control: resource for adult social care. 31 March 2022. Applies from: 4 April 2022. Date accessed: 5 October 2022,	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Also stated is: “This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England.” “Extra precautions are categorised according to the way the pathogen spreads, noting that some pathogens are spread by multiple routes. The 3 categories are: • Contact precautions…					

Assessment of evidence

- Droplet precautions…
- Airborne precautions…"

"These categories help identify the additional precautions which may include isolation and additional PPE depending on the pathogen."

Define these as "extra precautions".

Also stated is: "This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England."

"An assessment of a person's risk of infection should be carried out before they start using the service and should be kept under review for as long as they use the service. The assessment should contribute to the planning of the person's care and should determine whether any extra IPC precautions are required, such as whether they need to isolate or whether workers need to wear additional personal protective equipment (PPE). The assessment should include all factors which place the person at a higher risk of catching or spreading infection and may include:

- Symptoms:
    - History of current diarrhoea or vomiting
    - Unexplained rash
    - Fever or temperature
    - Respiratory symptoms, such as coughing or sneezing
- Contact:
    - Previous infection with a multi-drug resistant pathogen (where known)
    - Recent travel outside the UK where there are known risks of infection
    - Contact with people with a known infection

Assessment of evidence

• Person risk factors:
  ○ Vaccination status which will assist assessment of their susceptibility to infection and allow protective actions to be taken when necessary
  ○ Wounds or breaks in the skin
  ○ Invasive devices such as urinary catheters
  ○ Conditions or medicines that weaken the immune system
• Environmental risk factors, such as poor ventilation in the care setting”
Limitations:
• This information is stated to apply to England.
• No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
2013. Date last updated: November 2016 Date accessed: 1 November 2022					

Assessment of evidence

"Source control measures − Methods to contain infectious agents from an infectious source, including signage, separate entrances, partitions, triage/early recognition, AIIRs, diagnosis and treatment, respiratory hygiene (including masks, tissues, hand hygiene products and designated handwashing sinks), process controls for AGMPs and spatial separation."

Aerosol-generating medical procedures (AGMPs) – "medical procedures that can generate aerosols as a result of artificial manipulation of a person's airway." "AGMPs associated with a documented increased risk of TB or SARS transmission: Intubation and related procedures (e.g., manual ventilation, open endotracheal suctioning); cardiopulmonary resuscitation; bronchoscopy; sputum induction; nebulized therapy; non-invasive positive pressure ventilation (continuous or bi-level positive airway pressure)." [NC]

"There is debate about whether other medical procedures result in the generation of aerosols through cough induction and lead to transmission of infection. However, there is no published literature that documents the transmission of respiratory infections (including TB, SARS and influenza) by these methods. Examples of these procedures include: high-frequency oscillatory ventilation; tracheostomy care; chest physiotherapy; nasopharyngeal swabs, nasopharyngeal aspirates." [NC]

"Environmental factors are controlled in AIIRs to minimize the transmission of infectious agents that are usually transmitted from person to person by droplet nuclei associated with coughing or aerosolization of contaminated fluids." [NC]

"Routes of transmission of infectious agents (microorganisms) are conventionally categorized into five routes: contact, droplet, airborne, common vehicle* and vectorborne." [NC]

*Common vehicle relates to a single contaminated source such as food, multi-dose vials, IV fluids or equipment.

Assessment of evidence
“Transmission of microorganisms in health care is increased by the presence of patients who visibly soil the environment or cannot maintain appropriate hygiene, including respiratory hygiene; patients who are cognitively impaired; patients with uncontained secretions or excretions; patients with wound drainage that cannot be contained by a dressing; patients with fecal incontinence if stools cannot be contained in incontinence products or infant diapers; and those with viral respiratory or gastrointestinal infections, especially infants.” • Human sources. • Animal sources. • Environmental sources. “contact with an infected source or a contaminated environment (physical or passive, face-to-face contact or close contact (within two metres of an infected coughing source) and when a susceptible host inhales a microorganism (as an aerosol or droplet).” Exposure to particles diagram (Figure 2). Probability of airborne exposure to an infectious aerosol is influenced by: [NC] • proximity of infected source and host • particle sizes which contain the infectious agent • infectious agent viability • concentration of virus in particles • concentration of particles in the room • relative humidity • air flow direction • ACH of room

Assessment of evidence

Between concept of droplet and/or contact transmission - “Other infectious agents, especially respiratory viruses (e.g., RSV, influenza, parainfluenza and rhinovirus) that are expelled in large droplets, remain viable in droplets that settle on objects in the immediate environment of the patient and survive long enough on surfaces to be picked up on the hands of patients or HCWs”.

AGMPs have been associated with increased risk of SARS or TB transmission – cited 2007 WHO guidance on epidemic and pandemic infection control for acute respiratory infections.

Common vehicle transmission: “a single contaminated source, such as food, multi-dose vials, intravenous fluids or equipment, which serves to transmit infection to multiple hosts.”

Vector-borne transmission: “transmission by insect vectors”

Control measures to prevent exposure or transmission may differ according to:

- specific microorganism
- patient condition (young children, incontinent adults and cognitively impaired individuals, copious respiratory secretions or frequent cough and are unable to perform self-care)
- situation
- procedure (AGMPs have been shown to increase the transmission of TB and SARS
- care setting

As part of PCRA:

- What contact is the HCW going to have with the patient?
- What task(s) or procedures(s) is the HCW going to perform? Is there a risk of splashes/sprays?
- If the patient has diarrhea, is he/she continent? If incontinent, can stool be contained in an adult incontinence product?
- Is the patient able and willing to perform hand hygiene?

Assessment of evidence
• Is the patient in a shared room? Single rooms are prudent for: • “patients who visibly soil the environment or who cannot maintain appropriate hygiene, including respiratory hygiene. • patients with uncontained secretions or excretions. • patients with wound drainage that cannot be contained by a dressing. • patients with faecal incontinence if stools cannot be contained in incontinent products or infant diapers.” - demonstrates IPC interventions based on symptoms rather than pathogen/transmission route. “Fomites − Inanimate objects in the environment that may become contaminated with microorganisms and serve as vehicles of transmission.”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 November 2022.					

Assessment of evidence

Aerosol-generating procedures associated with increased risk of pathogen transmission: Medical procedures that have been reported to be aerosol-generating and consistently associated with an increased risk of pathogen transmission (Annex A).

“Airborne transmission can be further categorized into obligate or preferential airborne transmission.

- Obligate airborne transmission refers to pathogens that are transmitted only by deposition of droplet nuclei under natural conditions (e.g., pulmonary tuberculosis).
- Preferential airborne transmission refers to pathogens that can initiate infection by multiple routes, but are predominantly transmitted by droplet nuclei (e.g., measles and chickenpox).”

“Although knowledge of transmission modes is ever-evolving, current evidence indicates that the primary mode of transmission of most acute respiratory diseases is through droplets, but transmission through contact (including hand contamination followed by self-inoculation) or infectious respiratory aerosols at short range can also happen for some pathogens in particular circumstances.” [NC]

Incidence, distribution and outcomes of respiratory infection disease vary according to:

- “environmental conditions (e.g., air pollutants, household crowding, humidity, hygiene, season and temperature);
- availability and effectiveness of medical care and infection prevention and control (IPC) measures to contain spread such as vaccines, access to health-care facilities, and isolation capacity;
- host factors such as age, cigarette-smoking, host ability to transmit infection, immune status, nutritional status, prior or concurrent infection with other pathogens, and underlying medical conditions; and
- pathogenic characteristics, including modes of transmission, transmissibility, virulence factors (e.g., genes encoding toxins) and microbial load (inoculum size)”.

Assessment of evidence

"Human-to-human transmission of SARS occurs mainly through droplets or direct contact, although transmission through infectious respiratory aerosols of various sizes may occur at short range."

Airborne transmission is further classified as obligate or preferential:

- "obligate airborne transmission applies to agents naturally transmitted exclusively through droplet nuclei deposited in the distal part of the lung (e.g., *Mycobacterium tuberculosis* causing pulmonary TB)"
- "preferential airborne transmission applies to pathogens (e.g., measles) that are transmitted by droplet nuclei deposited in the airways but can also be transmitted by other routes."

"Transmission of droplet nuclei at short range may also occur with SARS-CoV, human influenza, and perhaps with other viral respiratory infections, during special circumstances; for example:

- performance of aerosol-generating procedures associated with pathogen transmission in rooms that are inadequately ventilated;
- and lack of adequate use of PPE (e.g., as happened with SARS)."

"This type of transmission has been referred to as opportunistic airborne transmission, and does not involve transmission over long distances as obligate and preferential airborne transmission do."

Under section of 'Airborne Precautions', separate list of precautions given for opportunistic pathogens:

"For most diseases that can be opportunistically transmitted through droplet nuclei, Droplet Precautions should be added to Standard Precautions during routine patient care. Take additional measures during aerosol-generating procedures associated with increased risk of pathogen transmission." [NC]

- Use medical mask (surgical or procedural) when working within 1m of the patient.
- When performing AGPs "associated with pathogen transmission, use a particulate respirator that is at least as protective as a NIOSH-certified N95, EU FFP2 or equivalent, and wear gloves, gowns and eye protection (e.g. goggles)." And use "adequately ventilated single rooms".

Assessment of evidence
• 1m spacing between patients. • Single rooms and cohorting. • “Airborne Precaution rooms are not obligatory. If they are available, prioritize them for patients with airborne-transmitted diseases”. • Limit patient movement. • Masks for patients outside room/area. “When a novel ARI is identified and the mode of transmission is unknown, it may be prudent to implement the highest level of IPC precautions whenever possible (including the use of particulate respirators), until the mode of transmission has been clarified.”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Ministry of Health New Zealand. How infectious diseases spread. Date last updated: 2021. Date accessed: 15 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
“Germs can spread from person to person through: • The air as droplets or aerosol particles					

Assessment of evidence
• Faecal-oral spread • Blood or other body fluids • Skin or mucous membrane contact • Sexual contact Some infections can be spread in more than one way” Each of the above explained in more detail in text. Germs can get into the body via: • mouth (eating, drinking, breathing) • skin (cuts and grazes) • eyes • genitals.

Question 6: What are Transmission Based Precautions?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Infection control basics – transmission-based precautions. 2016. Date accessed: 24 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

No citations or evidence accompany these recommendations.

“Transmission-Based Precautions are the second tier of basic infection control and are to be used in addition to Standard Precautions”.

Contact precautions are shown to include:

- Patient isolation.
- Use PPE - gloves and gown.
- Limit movement/transportation of patients but, if necessary, follow specific protocols (e.g. donning clean PPE, covering/containing infected/colonised areas of patients body).
- Use disposable/dedicated pieces of equipment where possible.

Assessment of evidence
• Prioritise cleaning/disinfection of the rooms - “ensuring rooms are frequently cleaned and disinfected (e.g., at least daily or prior to use by another patient if outpatient setting) focusing on frequently-touched surfaces and equipment in the immediate vicinity of the patient.” Droplet precautions are shown to include: (accompanying poster also recommends covering eyes, which is not included in the main text) • Source control (mask on patient) (type of mask not specified). • Patient isolation. • Instruct patients to follow Respiratory Hygiene/Cough Etiquette recommendations. • Use PPE - Don mask (type of mask not specified). • Limit movement/transportation of patients. Airborne precautions are shown to include: • Source control (mask on patient) (type of mask not specified). • Patient isolation in ‘airborne infection isolation room’. • “Restrict susceptible healthcare personnel from entering the room”. • Use PPE – use “a fit-tested NIOSH-approved N95 or higher level respirator”. • Instruct patients to follow Respiratory Hygiene/Cough Etiquette recommendations. • Limit movement/transportation of patients “Healthcare personnel transporting patients who are on Airborne Precautions do not need to wear a mask or respirator during transport if the patient is wearing a mask and infectious skin lesions are covered.” • “Immunize susceptible persons as soon as possible following unprotected contact with vaccine-preventable infections (e.g., measles, varicella or smallpox).”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centers for Disease Control and Prevention and Healthcare Infection Control Practices Advisory Committee. Consideration for use of enhanced barrier precautions in skilled nursing facilities. 2021. Date accessed: 12 January 2023.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Enhanced Barrier Precautions were a specific PPE based strategy introduced by Centers for Disease Control and Prevention (CDC) in 2019 – glove and gown use.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Frequently asked questions (FAQs) about enhanced barrier precautions in nursing homes. 2022. Date accessed: 26 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Enhanced Barrier Precautions:

- "Enhanced Barrier Precautions are an infection control intervention designed to reduce transmission of multidrug-resistant organisms (MDROs) in nursing homes."
- "Standard Precautions still apply while using Enhanced Barrier Precautions. For example, if splashes and sprays are anticipated during the high-contact care activity, face protection should be used in addition to the gown and gloves."
- "Enhanced Barrier Precautions require the use of gown and gloves only for high-contact resident care activities (unless otherwise indicated as part of Standard Precautions)."
- "Residents are not restricted to their rooms and do not require placement in a private room. Enhanced Barrier Precautions also allow residents to participate in group activities."

Assessment of evidence
Contact Precautions: • Require the use of gown and gloves on every entry into a resident's room, regardless of the level of care being provided to the resident. • Dedicated equipment (for example, stethoscope and blood pressure cuff). • Placed in a private room. When private rooms are not available, residents with the same pathogen may be roomed together. • Restricted to their rooms except for medically necessary care, including restriction from participation in group activities.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: transmission based precautions. 2008. Date last updated: 2015.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 12 January 2023.					

Assessment of evidence

"Transmission based precautions are additional measures focused on the particular mode of transmission and are always in addition to standard precautions. They are grouped into categories according to the route of transmission of the infectious agent."

"Transmission based precautions are categorised by the route of transmission of the infections agent"

"In addition to standard precautions and appropriate PPE […] the following will be required for all patients who require transmission based precautions:"

"Contact precautions:

- Single room, cohort with same infection
- Isolation notice should be displayed
- Advise all staff of the necessary precautions
- Masks not normally indicated unless risk of splash
- Limit movement of patient from the room to essential purposes only
- If transfer/movement is necessary, notify the receiving department/IPC team in advance"

"Droplet precautions:

- Single room, cohort with same infection
- No special air handling and ventilation required
- Isolation notice should be displayed

Assessment of evidence
• Advise all staff of the necessary precautions • Wear a fluid shield mask when working within one metre of the patient until no longer infectious • Limit movement of patient from the room to essential purposes only • If transfer/movement is necessary, place a surgical fluid shield mask on the patient • If transfer/movement is necessary, notify the receiving department/IPC team in advance” “Airborne precautions: • Negative pressure isolation room (where available) • Doors and windows must remain closed • Patient must remain in the room • Isolation notice should be displayed • Advise all staff of the necessary precautions • FFP3 respirator mask must be worn for confirmed or suspected MDR or XDR-TB • Susceptible, non-immune persons should not enter the room of patients with measles or chicken pox • Limit movement of patient from the room to essential purposes only • If transfer/movement is necessary, place a surgical fluid shield mask on the patient • If transfer/movement is necessary, notify the receiving department/IPC team in advance”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
[NC] = no citations, [NG] = no grading. The CDC outline three transmission routes: • Contact transmission (direct and indirect). • Droplet transmission. • Airborne transmission. Modes of transmission vary by type of organism. Some pathogens may be transmitted by more than one route.					

Assessment of evidence
Infection is the result of a complex interrelationship between host and infectious agent. Affected by pathogenicity, virulence, antigenicity, infectious dose, mechanism of disease production, route of exposure, susceptibility of host to infection etc. “There are three categories of Transmission-Based Precautions: Contact Precautions, Droplet Precautions, and Airborne Precautions”. “When used either singly or in combination, they are always used in addition to Standard Precautions.” Airborne Precautions: Formal Recommendations – • Single patient rooms indicated – airborne infection isolation rooms (AIIRs). • Keep patient door closed [NC, NG]. • AIIR with at least six air changes per hour (ACH) (existing) or 12ACH (new facility) [NC, NG]. • Direct exhaust of air to outside or HEPA filtration of air that’s recirculated back into the room [NC, NG]. • Monitor air pressure of AIIR daily with visual indicators (e.g., smoke tubes, flutter strips), regardless of the presence of differential pressure sensing devices (e.g., manometers) [NG]. • Patient wears surgical mask out with AIIR if tolerated (ambulatory care). • Placed in AIIR as soon as possible [NC]. • Once the patient leaves, the room should remain vacant for the appropriate time, generally one hour, to allow for a full exchange of air (ambulatory care). • Non-immune HCWs should not enter room of patients with Measles, Varicella, Disseminated Zoster or Smallpox if other immune staff are available. • Wear a fit tested National Institute for Occupational Safety and Health (NIOSH)-approved N95 or higher respirator for respiratory protection when entering the room of a patient with suspected or confirmed: infectious pulmonary TB, infectious laryngeal TB,

Assessment of evidence
infectious TB skin lesions with procedures that would aerosolise particles e.g. irrigation, incision and drainage, whirlpool treatments, smallpox. Masks/isolation extended to persons accompanying patient if symptomatic (ambulatory care): Formal recommendations – • Limiting transport [NC]. • Appropriate barriers on patient consistent with route and risk of transmission, for example, mask or impervious dressings. • HCWs transporting patient with airborne precautions do not need to wear mask or respirator if patient is wearing mask and infectious lesions are covered [NC]. Notification of those in area that patient is being transferred to. Dedicated non-critical medical equipment. “Healthcare personnel caring for patients on Airborne Precautions wear a mask or respirator, depending on the disease-specific recommendations […] that is donned prior to room entry.” Formal recommendation – • “No recommendation is made regarding the type of personal protective equipment (i.e., surgical mask or respiratory protection with a N95 or higher respirator) to be worn by susceptible healthcare personnel who must have contact with patients with known or suspected measles, chickenpox or disseminated herpes zoster. (Unresolved issue)”. “Airborne infection isolation room (AIIR): Formerly, negative pressure isolation room, an AIIR is a single-occupancy patient-care room used to isolate persons with a suspected or confirmed airborne infectious disease. Environmental factors are controlled in AIIRs to minimize the transmission of infectious agents that are usually transmitted from person to person by droplet nuclei associated with coughing or aerosolization of contaminated fluids. AIIRs should provide negative pressure in the room (so that air flows under the door gap into the room); and an air flow rate of 6-12 ACH (6 ACH for existing structures, 12 ACH for new construction or renovation); and direct exhaust of air from the room to the outside of the building or recirculation of air through a HEPA filter before returning to circulation”.

Assessment of evidence

Droplet Precautions:

Formal recommendations –

- Single patient rooms preferred [NC] otherwise prioritise patients who have excessive cough and sputum production [NC].
- Cohorting of patients with same pathogen if no single rooms.
- >3ft spatial separation between beds of those who are not/are infected/colonised, draw privacy curtain.
- Limiting transport [NC].
- Appropriate barriers on patient consistent with route and risk of transmission, for example, mask or impervious dressings [NC].
- No mask required for those persons transporting patients on droplet precautions [NC].

Notification of those in area that patient is being transferred to.

Dedicated non-critical medical equipment.

>3ft separation between beds with divider curtains.

Formal Recommendations –

- Mask for HCWs in close contact with infected patients (usually donned on entry).
- “No recommendation for routinely wearing eye protection (e.g., goggle or face shield), in addition to a mask, for close contact with patients who require Droplet Precautions.” [NC] (Unresolved issue).

For patients with suspected or proven SARS, avian influenza or pandemic influenza other guidance is recommended.

Mask for patient when out with room and should follow respiratory hygiene.

Contact Precautions:

Formal Recommendations –

Assessment of evidence

- Single patient rooms preferred otherwise prioritise patients with conditions that may facilitate transmission, for example, stool incontinence, draining wounds. [NC]
- Cohorting of patients with same pathogen if no single rooms.
- Limiting transport [NC].
- Appropriate barriers on patient consistent with route and risk of transmission, for example, mask or impervious dressings [NC].

Notification of those in area that patient is being transferred to.

Dedicated non-critical medical equipment.

Formal recommendations –

- >3ft spatial separation between beds of those who are not/are infected/colonised, draw privacy curtain [NC].
- Upon entry “gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient’s environment”.
- Upon entry, a gown “for all interactions that may involve contact with the patient or potentially contaminated areas in the patient’s environment”.

Don PPE on room entry and doff before exit.

Formal recommendation –

- “Ensure that rooms of patients on Contact Precautions are prioritized for frequent cleaning and disinfection (e.g., at least daily) with a focus on frequently-touched surfaces (e.g., bed rails, overbed table, bedside commode, lavatory surfaces in patient bathrooms, doorknobs) and equipment in the immediate vicinity of the patient”.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Enhanced barrier precautions. Date accessed: 6 September 2022.	Expert opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Poster. Enhanced barrier precautions involve hand hygiene before entering and on leaving residents room as well as wearing gloves and a gown for “high contact resident care activities”.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Commission on Safety and Quality in Healthcare. Standard and transmission-based precautions and signage. 2022.	Expert opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 September 2022.					

Assessment of evidence

"There are three types of transmission-based precautions: contact, droplet and airborne precautions."

"The key elements of applying contact precautions are:

- Use of appropriate personal protective equipment, such as aprons, gowns, and gloves.
- Patient placement (for example, single room cohorting).
- Minimising patient movement".

"When used as part of transmission based precautions, PPE services as a barrier to specific means of transmission of infectious agents"

"The key elements of applying droplet precautions are:

- Use of appropriate personal protective equipment (surgical mask always required, apron, gown, gloves, and protective eyewear as appropriate)
- Patient placement
- Minimising patient transfer or transport."

"The key elements of applying airborne precautions are:

- Use of appropriate personal protective equipment, particularly correctly fitted particulate filter respirators (PFRs), such as P2 and N95
- Patient placement (e.g., use of negative pressure rooms)
- Minimising patient movement."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Strengthening infection prevention and control in primary care. A collection of existing standards, measurements and implementation resources. 2021. Date accessed: 7 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Taken from the glossary section.

“Transmission-based precautions:

Additional measures focused on the particular mode of transmission of the microorganism (contact, droplet, or airborne) and always used in addition to standard precautions. They are grouped into categories according to the route of transmission of the infectious agent. Transmission-based precautions should be applied when caring for patients with known infection, patients who are colonized with an infectious organism, and asymptomatic patients who are suspected of/under investigation for colonization or infection with an infectious microorganism.”

Assessment of evidence
References: Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: transmission based precautions. 2008 [updated 2015, accessed 2021 August 23].

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract infections in healthcare settings. October 2016. Date accessed: 21 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Does not apply to TB, MERS-CoV or human cases of avian influenza. Guidelines supplement but do not replace local risk assessment. For respiratory infections droplet and contact precautions should be used in combination. Droplet precautions:					

Assessment of evidence
• Single room or cohorting (prioritise single room for patients with cough). • 1m between patients. • Screens or curtains between beds. • Negative pressure rooms not needed. • Signage to indicate cohort/isolation area. • Limit patient movement out with room/area. • Patient wears surgical mask outside room. • Staff wear face masks whilst transporting (if patient is not wearing mask). • Airborne precautions for aerosol generating procedures (AGPs). • Respiratory hygiene/cough etiquette. • Surgical face mask for staff who have close contact with infected patient (within 2m). • Eye protection is advisable where there is assessed to be a risk of eye exposure to infectious sprays. Contact precautions: • All staff should wear a plastic apron and gloves. • Dedicated patient care equipment (where it cannot be dedicated it must be cleaned appropriately between patients). • Rooms of patients with infection are cleaned daily, and are prioritised. • For frequently touched surface cleaning (for example, over-bed tables, lockers, lavatory surfaces in patient bathrooms, door knobs and equipment in the immediate vicinity of the patient) three times a day and immediately if visibly contaminated. • All frequently touched surfaces and all horizontal surfaces should be decontaminated after any AGP.

Assessment of evidence

- Keep the patient environment clean and clutter free.
- Use disposable cleaning materials in accordance with local policy.
- Carry out terminal cleaning of all isolation/cohort rooms following the local infection prevention and control policy on terminal decontamination.
- Follow local policy for safe handling of contaminated linen.

Limitations:

No citations for all above points.

Some points above constitute standard infection control precautions (SICPs) and/or do not belong in the contact precautions dedicated section.

Airborne precautions:

Only refers to AGPs as guidance for TB, MERS-CoV and human cases of avian influenza is specific to be elsewhere.

AGPs:

- A fit tested FFP3 respirator (EN149:2001), fluid repellent gown, gloves and eye protection, for example, goggles or full face visor, should be worn.
- Well-ventilated single rooms with door shut.
- Only if essential and only essential personnel present.
- Limited visitors.
- “Visitors should be made aware of the risks and be offered PPE as recommended for staff.”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M. et al. Management of multidrug-resistant organisms in healthcare settings. 2006. Date last updated: 2017. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Expert opinion piece provided by CDC with HICPAC. Author affiliations provided covering wide representation in infection control. "Contact precautions are intended to prevent transmission of infectious agents, including epidemiologically important microorganisms, which are transmitted by direct or indirect contact with the patient or the patient's environment. A single patient room is preferred for patients who require Contact Precautions. When a single-patient room is not available, consultation with infection control is necessary to assess the various risks associated with other patient placement options (e.g., cohorting, keeping the patient with an existing roommate)."					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government National Health and Medical Research Council. Australian guidelines for the prevention and control of infection in healthcare. 2019. Date last updated September 2022. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"In healthcare settings, the main modes for transmission of infectious agents are contact (including bloodborne), droplet and airborne."

"The modes of transmission vary by type of organism. In some cases the same organism may be transmitted by more than one route (e.g. norovirus, influenza and respiratory syncytial virus (RSV) can be transmitted by contact and droplet routes)."

"Transmission-based precautions should be tailored to the particular infectious agent involved and its mode of transmission. This may involve a combination of practices."

"Contact precautions are used when there is known or suspected risk of direct or indirect contact transmission of infectious agents that are not effectively contained by standard precautions alone".

Assessment of evidence
“Droplet precautions are used for patients known or suspected to be infected with agents transmitted over short distances by large respiratory droplets”. “Airborne precautions are used for patients known or suspected to be infected with agents transmitted person-to-person by the airborne route”. TBPs generally tend to involve: • “dynamic risk assessment in the pre-hospital (emergency) setting to anticipate and communicate the potential need for transmission-based precautions on patient arrival”. • “allocating a single room inclusive of bathroom facilities and closing door to patient with a suspected or confirmed infection (isolation)”. • “placing patients colonised or infected with the same infectious agent and antibiogram in a room together (cohorting)”. • “wearing specific personal protective equipment”. • “providing patient-dedicated equipment”. • “using sodium hypochlorite or an appropriate Therapeutic Goods Administration-listed hospital-grade disinfectant with specific claims”. • “using specific air handling techniques”. • “restricting the movement of both patients and healthcare workers.” Formerly known as additional precautions. “A single-patient room is recommended for patients who require contact precautions.” “single-patient rooms are also an effective precaution to prevent droplet and airborne transmission of infection.” “Rooms with ensuites and anterooms are preferred.”

Assessment of evidence
“Anterooms increase the effectiveness of single-patient rooms by reducing the potential escape of airborne infectious particles in the corridor.” “Other points relevant to patient placement include the following: keep patient notes outside the room, keep patient bedside charts outside the room, disinfect hands upon leaving room and after writing in the chart, keep doors closed where safe to do so (this may not be possible for patients requiring high visualisation), make sure rooms are clearly signed.” “when working with patients who require contact precautions, healthcare workers should: put on gloves and gown upon entry to the patient-care area, ensure that clothing and skin do not contact potentially contaminated environmental surfaces, remove gown and gloves and perform hand hygiene before leaving the patient-care area.” Contact precautions should be used in addition to standard precautions. CPs involve use of appropriate personal protective equipment (PPE), special handling of equipment, patient placement and minimising patient transfer or transport. Example of TBP: “When the presence of *C. difficile* or non-enveloped viruses is known or suspected, use of alcohol-based hand rubs alone may not be sufficient to reduce transmission of these organisms”. “Putting on both gloves and gown upon entering the patient-care area helps to contain infectious agents, especially those that have been implicated in transmission through environmental contamination (e.g. *C. difficile*, norovirus and other intestinal tract pathogens, respiratory syncytial virus).” Applied in addition to standard precautions. “The combination of measures used in transmission-based precautions depends on the route(s) of transmission of the infectious agent involved”. • “continued implementation of standard precautions • appropriate use of personal protective equipment (PPE) (including gloves, apron or gowns, surgical masks or P2 respirators, and protective eyewear) • patient-dedicated equipment

Assessment of evidence
• allocation of single rooms or cohorting of patients • appropriate air handling requirements • enhanced cleaning and disinfecting of the patient environment • restricted transfer of patients within and between facilities." Contact – conditional recommendation for hand hygiene, PPE and dedicated patient care equipment. Droplet – conditional recommendation for "surgical mask […] when entering a patient-care environment", good practice statement for single patient room. Airborne – conditional recommendation for "correctly fitted P2 respirator is worn when entering the patient-care area", good practice statement for "negative pressure room (Class N/Type 5) with bathroom facilities or in a room from which air does not circulate to other areas."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lemass H, McDonnell N, O'Connor N. et al. Infection prevention and control for primary care in Ireland: a guide for general practice. 2013.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 October 2022.					

Assessment of evidence

"Opinion of SARI Infection and Control Subcommittee following a review of the scientific literature and an extensive consultation exercise".

"Transmission Based Precautions are Contact, Droplet and Airborne Precautions".

"Recommended Measures for Patients that Require Transmission Based Precautions. Patient placement. If possible, symptomatic patients who present a risk of droplet transmission e.g., influenza, or airborne transmission e.g., TB should be placed in a dedicated waiting area, away from other patients. If a dedicated waiting area is not available then these patients should be placed at least one meter away from other patients if possible. Consider provision of a surgical mask for patients requiring droplet and airborne precautions to wear while in the practice. Have appropriate PPE readily available for any practice staff that require it. Once the patient leaves, clean and decontaminate equipment and the environment as appropriate (refer to decontamination guideline)".

Limitations:

- No details on review of consultation provided.
- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Infection Control Committee. Guidelines on infection control	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
practice in the clinic settings of department of health. Date last updated: 2019. Date accessed: 10 October 2022.					

Assessment of evidence

Setting: Hong Kong.

“The following guidelines are written for staff working in outpatient settings or in healthcare settings where could have potential contact with patients, their blood or body substances.” “They should be read in conjunction with other infection control guidelines/recommendations promulgated by the Department”.

“The first tier Standard Precautions are the minimum infection prevention practices that apply to all patient care in all healthcare settings, regardless of their diagnosis. The second tier Transmission-Based Precautions are extra steps to follow for illnesses that are caused by certain germs.”

“Transmission-Based Precautions are used empirically, according to the clinical syndrome and the likely etiologic agents at that time.”

“There are three categories of Transmission-Based Precautions include: (1) Airborne Precautions, (2) Droplet Precautions, and (3) Contact Precautions. For some diseases that may have multiple routes of transmission, a combination of Transmission-Based Precautions may be used. Whether used singly or in combination, Transmission-Based Precautions are always used in addition to Standard Precautions.”

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization Transmission-based precautions for the prevention and control of infections: aide-memoire. 2022. Date accessed: 11 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"Transmission-based precautions are used in addition to standard precautions for patients with known or suspected infection or colonization* with transmissible and/or epidemiologically significant pathogens*. The type of transmission-based precautions assigned to a patient depends on the transmission route of the microorganism: contact, droplet, or airborne." *Colonization occurs when microorganisms are present on a host individual but the individual does not show clinical symptoms or findings of an active disease. A colonized individual can transmit infectious microorganisms to other individuals. Limitations: • No citations provided.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Manatū Hauora Ministry of Health. Infection prevention and control: overview of infection prevention and control practices in health and disability care settings. Date last updated: 21 July 2022. Date accessed: 12 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"Transmission-Based Precautions

Transmission-Based Precautions are a secondary set of infection prevention and control practices. They are used in addition to Standard Precautions for patients who may be infected or colonised with infectious pathogens, specifically to prevent transmission of infections.

Transmission-Based Precautions are – contact, droplet and airborne."

Limitations:

- No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Association of periOperative registered nurses. Guideline Quick View: Transmission-Based Precautions. AORN Journal. 2019; 109:529-536.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Contact precautions – gown and gloves for contact with patient, care equipment and environmental surfaces. Additional steps for transportation of pts under contact precautions, for example, notifying persons of incoming contact precautions patient, contain and cover the infected or colonized areas of the patient's body. Single room isolation if possible, at least 3ft away from other patients if possible. Enhanced environmental cleaning following the care of patients who are known to be infected or colonized with MDROs. Specific cleaning equipment may be necessary, for example "Environmental Protection Agency-registered disinfectant that is effective against *C. diff* spores during cleaning following the care of patients diagnosed with or suspected to have a *C. diff* infection." Dedicated patient care equipment. Instruction to visitors regarding hand hygiene, glove and gown use.

Droplet precautions – don surgical mask upon room entry. A respirator for performing AGPs. Additional steps for transportation of pts under droplet precautions e.g. A mask for patients being transported but no mask for those transporting patient, notifying persons of incoming DP patient, instruct patient to follow respiratory/cough etiquette. Single room isolation, at least 3ft away from other patients. Instruct visitors regarding hand hygiene and mask use. "Special air handling and ventilation are not required as part of droplet precautions."

Airborne precautions – don respirator upon room entry. Additional steps for transportation of pts under airborne precautions, for example, notifying persons of incoming airborne precautions patient, a mask for patient, instruct patient to follow respiratory/cough etiquette, cover skin lesions associated with "varicella or smallpox or draining skin lesions caused by tuberculosis before patient transport", transport staff

Assessment of evidence
need not wear a mask or respirator if patient is wearing a mask. Airborne infection isolation room. Postpone elective surgery until patient no longer infectious. “If surgery cannot be postponed, schedule the surgery at the end of the day and with the minimum number of perioperative personnel present.” If AIIRs are not available, “supplemental air-cleaning technologies (e.g., portable high-efficiency particulate air filtration, ultraviolet germicidal irradiation) [may be] necessary.” Use bacterial filters on endotracheal tube or exhalation breathing circuit. “Following cough-inducing procedures (e.g., intubation, extubation, bronchoscopy) in the OR, restrict room access until 99% of airborne particles have been removed from the air (e.g., 15 air exchanges per hour for 28 minutes).” “Wear respiratory protection if entering a room before 99% of the airborne contaminants are removed” Instruct visitors regarding hand hygiene and mask use. Limitations: • No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada.. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 1 November 2022.					

Assessment of evidence

Referred to as ‘routine practices’ and ‘additional precautions’.

Respiratory hygiene should be implemented across continuum of care (for instance, considered routine or standard precaution). [NC]

“Some infections may need a combination of additional precautions (contact, droplet, airborne), since some microorganisms can be transferred by more than one route.” [NC]

“The application of routine practices continues even with the application of additional precautions.” [NC]

“Additional precautions − Extra measures, when routine practices alone may not interrupt transmission of an infectious agent. They are used in addition to routine practices (not in place of), and are initiated both on condition/clinical presentation (syndrome) and on specific etiology (diagnosis).”

“Mode of transmission − Mechanism by which an infectious agent is spread (e.g., by contact, droplets or aerosols).”

“Transmission − The process whereby an infectious agent passes from a source and causes infection in a susceptible host.”

Droplet:

- From 1999 to 2013 guidance, the recommendation for “spatial separation between a patient with a suspected or confirmed droplet transmissible respiratory infection who is coughing (infected source) and another patient without that infection (susceptible host) [changed] from one metre to two metres. When using a risk assessment, one metre may be sufficient for young children and others whose cough is not forceful enough to propel the droplets as far as two metres.” [NC]
- Patients can remove their mask when in their own room.
- Patients with acute respiratory symptoms should be placed in a single room/have a separate waiting area/in multi-bed room separated by curtain.

Assessment of evidence

- “Healthcare workers who are not immune to mumps or rubella should not provide direct care for patients with these infections.”
- Single room with dedicated toilet and sink is preferable especially where it is difficult to maintain 2m distancing. Room door may remain open.
- Cohorting for same micro-organism is acceptable.
- If cohorting is not possible, privacy curtains between beds should be closed. If cohorting is not possible, avoid placement of patient under droplet precautions with patients who are at high risk of complications. Patients should be at least 2m apart.
- Spacing between infant stations to minimize opportunities for droplet contact.
- Patient should perform hand hygiene before leaving their room.
- Patient should wear a mask if tolerated during transport. Transport personnel should wear facial protection if the patient cannot follow respiratory hygiene.
- “Facial protection (i.e., masks and eye protection, or face shields, or masks with visor attachment) should be worn:
    - for care of patients with symptoms of acute respiratory viral infection,
    - when within two metres of patient who is coughing at the time of interaction, or
    - if performing procedures that may result in coughing
- For care of patients with rubella or mumps, facial protection is not needed if the healthcare worker is immune”.
- Education of patients, visitors and families.
- Number of visitors should be minimised.
- For visitors: exceptions to the need for facial protection include the following:
    - For patients with suspected or confirmed Haemophilus influenzae type B infection, visitors should wear facial protection only if they will have extensive close contact with children <5 years of age.

Assessment of evidence

  - For patients with rubella or mumps, facial protection is not needed if the visitor is immune. Non-immune visitors should only enter the room when it is absolutely necessary; if they enter the room, they should wear facial protection.

- For long term care facility (LTCF): restriction of group activities whilst symptomatic.
- For ambulatory care: Separate waiting rooms**.**
- Home care: screening prior to home visits**.**
- Home care: deferred routine care during acute respiratory symptoms.

Airborne:

- "Specifics related to airborne precautions are that only immune HCWs work with patients infected with chickenpox or measles and that airflow is controlled." [NC]
- Airborne infection isolation room – "ventilation systems provide adequate rates of air exchange and appropriate pressure differentials to maintain direction of flow.
- "There is time needed before the room is safe for a new patient or staff to enter without a respirator" [NC]
- Designed for patients suspected or confirmed to have an infection transmitted by the airborne route – airborne infection isolation rooms (AIIRs) with negative pressure. [NC]
- "Patients should be directed to put on a mask, if tolerated (not a respirator), when not in an airborne infection isolation room"
- "Patients known or suspected to have an airborne infection should be placed directly into an airborne infection isolation room with the door closed and with exhaust vented to the outside or filtered through a high-efficiency particulate filter if recirculated."
- Strategies to reduce aerosol generation during aerosol-generating medical procedures (AGMPs) for patients with suspected or confirmed TB, SARS, emerging pathogen for which transmission characteristics are not yet known and viral hemorrhagic fevers (VHFs).
  - Limit numbers of persons present**.**

Assessment of evidence

  - Performed in AIIRs.
  - Respirators should be worn by all personnel.
  - Appropriate ventilation.
  - Closed endotracheal suction systems.
  - Bacterial filters on endotracheal tubes.
- AIIR with separate in-room toilet, sink and bathing facility for the patient, and a designated handwashing sink for healthcare workers.
- Patients known to be infected with the same virus (measles or varicella) may share a room.
- Patients with tuberculosis should not share rooms, as strains and levels of infectivity may be different.
- Patient restricted to room**.**
- A mask (not a respirator) should be placed on the patient (if tolerated) when the patient leaves the room.
- Immune healthcare workers do not need respirators when caring for patients known or suspected to have measles (rubeola), varicella (chickenpox) or disseminated zoster.
- Gloves should be worn by non-immune healthcare workers caring for patients with varicella or disseminated zoster.
- For varicella: Susceptible personnel and visitors should not enter the room. If exceptional circumstances make this necessary, they should wear a respirator and gloves.
- Respirators for:
  - respiratory TB
  - vaccine preventable airborne infections (for instance, varicella, measles) to which they are not immune.
  - monkeypox

Assessment of evidence

  - smallpox
  - AGMPs on patients with signs and symptoms of severe acute respiratory syndrome, VHFs or with a respiratory pathogen for which transmission characteristics are not yet known.

- Respirators for “when infectious tuberculosis skin lesions are present and procedures that would aerosolize viable tubercle bacilli organisms (e.g., irrigation) are performed.”
- Education of patients, visitors and families.
- For TB visitors should be restricted to immediate family or guardian**.** Restricted visiting for all other airborne infections.
- If the patient needs oxygen, a filtered oxygen mask should be used.

Contact:

- “In situations of continued transmission of certain microorganisms (e.g., norovirus, rotavirus*, C. difficile*) use of specific disinfectant products may need to be considered. In outbreak situations or when there is continued transmission, rooms of *C. difficile* infection patients should be decontaminated and cleaned with chlorine-containing cleaning agents (at least 1,000 ppm) or other sporicidal agents.”
- “Gloves are used for all care of patients on contact precautions”. [NC]
- “Gowns are used for contact precautions if direct contact of clothing with the patient or with contaminated environmental surfaces is anticipated.” Authors cite evidence of gowns becoming contaminated with MRSA, VRE or *C. difficile* following care of an infected/colonised patient.
- Contact precautions include hand hygiene with specific recommendation for soap and water instead of ABHR during outbreaks or in settings with high transmission of norovirus or *C. difficile* infection or with suspected or documented exposure to *B. anthracis* contaminated items.
- Patients requiring contact precautions should have single room, dedicated toilet, dedicated patient sink and dedicated staff sink. Prioritise patients with incontinence, uncontained secretions, wound drainage, cognitive impairment.

Assessment of evidence
• LTCF: Decisions regarding cohorting and participation in group activities should be made based on a case-by-case basis (infection risk factors). • LTCF/home care: Participation in group activities should not be restricted if wound drainage/diarrhoea is contained. • Cohorting for same micro-organism is acceptable. • If cohorting is not possible, privacy curtains between beds should be closed. • If cohorting is not possible, avoid placement of patient under contact precautions with patients who are at high risk of complications or conditions which many facilitate transmission, for example, open wounds. • During transportation draining wounds should be contained, infected areas should be covered. Areas to which the patient is being transferred should be informed of necessary precautions, waiting periods outside of room should be minimised. • PPE for contact precautions should be provided out with patient's room/area**.** • Gloves should be worn for entry to the patients room. • Long sleeved gown should be worn if it is anticipated that clothes or forearms will be in contact with the patient, their equipment, environmental surfaces, and so on. • Data are inconclusive on the need for masks for CPs, apart from their need when caring for patients with MRSA. • LTCF/home care: Gloves should be worn for direct contact with patient or environmental surfaces. • Cohorting/dedicated use of patient care equipment • Additional cleaning measures or frequency may be warranted in situations where continued transmission of specific infectious agents is noted (for example, *C. difficile*, norovirus and rotavirus). • The efficacy of disinfectants being used should be assessed and if indicated, a more effective disinfectant should be selected. • All horizontal and frequently touched surfaces should be cleaned at least twice daily and when soiled.

Assessment of evidence

- Precautions discontinued or patient moved: terminal cleaning with changing of privacy curtains and cleaning and disinfection or changing of string/cloth call bells or light cords should be done.
- Education of patients, visitors and families.
- Number of visitors should be minimised.
- Patient should perform hand hygiene before leaving their room.

General:

- "Additional precautions are specific to the care setting (e.g., acute care, ambulatory care, prehospital care, LTC, and home care)".
- Additional precautions are conventionally divided into contact precautions, droplet precautions and airborne precautions.
- Priority for single room allocation for those requiring additional precautions.
- AIIRs should be used for performing AGMPs on patients with TB, SARS, viral hemorrhagic fever and respiratory infection with an emerging pathogen for which transmission routes are not yet fully known. [NC]
- "When additional precautions are necessary, patients should leave their rooms for medically necessary purposes only. Communication between the transporting area and the receiving area is important to ensure consistency of precautions and to decrease unnecessary waiting time in public areas. Source control measures (e.g., requesting that the patient perform hand hygiene before leaving their room, cover skin lesions, wear a mask) should be applied." [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Implementation of personal protective equipment (PPE) use in nursing homes to prevent spread of multidrug resistant organisms (MDROs). Date last updated: 12 July 2022. Date accessed: 7 November 2022.					

Assessment of evidence

"This document is intended to provide guidance for PPE use and room restriction in nursing homes for preventing transmission of MDROs".

"For the purposes of this guidance, the MDROs for which the use of EBP applies are based on local epidemiology. At a minimum, they should include resistant organisms targeted by CDC but can also include other epidemiologically important MDROs."

"Contact Precautions are one type of Transmission-Based Precaution that are used when pathogen transmission is not completely interrupted by Standard Precautions alone. Contact Precautions are intended to prevent transmission of infectious agents, like MDROs, that are spread by direct or indirect contact with the resident or the resident's environment." [NC]

"Contact Precautions require the use of gown and gloves on every entry into a resident's room. The resident is given dedicated equipment (e.g., stethoscope and blood pressure cuff) and is placed into a private room. When private rooms are not available, some residents (e.g.,

Assessment of evidence
residents with the same pathogen) may be cohorted, or grouped together. Residents on Contact Precautions should be restricted to their rooms except for medically necessary care and restricted from participation in group activities." [NC] Because Contact Precautions require room restriction, they are generally intended to be time limited and, when implemented, should include a plan for discontinuation or de-escalation." [NC] "Enhanced Barrier Precautions expand the use of PPE and refer to the use of gown and gloves during high-contact resident care activities that provide opportunities for transfer of MDROs to staff hands and clothing. MDROs may be indirectly transferred from resident-to-resident during these high-contact care activities." Citations are individual papers from 2011-2018.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014. Date accessed: 7 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
Airborne precaution room: “A room with high ventilation rate and controlled direction of airflow that can be used to contain airborne infections and ARIs caused by a novel agent with the potential to pose a public health risk. An Airborne Precaution room can be naturally or mechanically ventilated.” “Such a room is equivalent to the ‘airborne infection isolation room’ described by the CDC.” “Measures designed to minimize the risk of transmission of infections.” Isolation precautions are separated into standard and additional precautions. Standard Precautions – “these should always be in place for all patient care”; and Additional precautions – “these are required in particular circumstances and comprise Contact, Droplet and Airborne Precautions.” Under section entitled “Droplet Precautions”: Medical mask when working within 1m of patient, advisable when entering patients room. Single rooms or cohorting: • Spatial separation between patients of at least 1m. • Limit patient movement. • Patient wears medical mask when outside room. Under section entitled “Contact Precautions”: • Gloves when entering patient room. • Gown when entering patient room (apron alone not appropriate). • Dedicated patient equipment. • Single rooms or cohorting. • Limit patient movement. Under section entitled “Airborne Precautions”:

Assessment of evidence
• N95 respirator or equivalent when entering room/area. • Airborne precaution room.. • If single rooms not available, cohorting • Use appropriate PPE for AGPs. • Limit patient movement, patient wears medical mask outside of room. Airborne precautions: “Adequate environmental ventilation is especially important to reduce the transmission of pathogens that are transmitted through the airborne route (e.g., pulmonary TB, measles and chickenpox).” [NC] Contact precautions: “For infectious agents that spread by contact, important environmental control methods include cleaning and disinfection of contaminated surfaces and inanimate objects.” [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: isolation of patients. 2008.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date last updated: 2015. Date accessed: 13 September 2022.					

Assessment of evidence

Source Isolation

- "Source isolation can be achieved by nursing the patient in a single room or a negative pressure isolation room/unit with an ensuite toilet. Inclusion of a ventilation system distinguishes an isolation room from a single room. Isolation is usually carried out in a single (preferably en-suite) room with hand washing facilities and with the door kept closed."
- "The type of IPC precautions required for a patient in source isolation will depend on the mode of transmission of the organism causing the illness i.e. airborne, droplet, contact, or standard."

Protective Isolation:

- "Many infections acquired by immunocompromised patients are endogenous infections (An infection caused by an infectious agent that is already present in the body, but has previously been inapparent or dormant), however transmission of infection from other patients, staff or the environment can be a risk and therefore extra precautions are required."
- "Patient's requiring protective isolation should be nursed in a single room. Where possible this room should have an ante-room, positive pressure ventilation and Hepa filtered air. The room should have an en-suite and hand washing facilities and the doors(s) should be kept closed at all times. For maximum effect, only one of the doors in the ante-room should be open at any time when entering or leaving the cubicle."

Question 7: When should TBPs be applied?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Infection control basics - transmission-based precautions. 2016. Date accessed: 24 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Transmission based precautions are “to be used in addition to Standard Precautions for patients who may be infected or colonized with certain infectious agents for which additional precautions are needed to prevent infection transmission.” “Use Contact Precautions for patients with known or suspected infections that represent an increased risk for contact transmission.” “Use Droplet Precautions for patients known or suspected to be infected with pathogens transmitted by respiratory droplets that are generated by a patient who is coughing, sneezing, or talking.” “Use Airborne Precautions for patients known or suspected to be infected with pathogens transmitted by the airborne route (e.g., tuberculosis, measles, chickenpox, disseminated herpes zoster)”. Limitations: • No citations or evidence accompany these recommendations.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention and Healthcare Infection Control Practices Advisory Committee. Consideration for use of enhanced barrier precautions in skilled nursing facilities. 2021. Date accessed: 24 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
In 2021, Centres for Disease Control and Prevention (CDC) and Healthcare Infection Control Practices Advisory Committee (HICPAC) produced a white paper to consider the use of enhanced barrier precautions (EBPs) beyond multi-drug resistant organism (MDRO) risk especially those "pathogens that affect every nursing home in the United States such as *S. aureus* (both methicillin sensitive and resistant)." EBPs should be applied to "certain residents during specific high-contact resident care activities associated with MDRO transmission***" "EBPs* may be applied (when Contact Precautions do not otherwise apply) to residents with any of the following: • Wounds or indwelling medical devices**, regardless of MDRO colonization status					

Assessment of evidence

- Infection or colonization with an MDRO."

CDC and HICPAC advise that expansion of use of EBPs for 'high contact resident care activities, wounds and indwelling medical devices' is based on:

- Recognition that standard precautions […] often have not been successfully implemented in nursing home settings.
- Contact precautions […] are considered stigmatizing to residents.
- Nursing homes are unable to routinely identify colonised residents or unaware of their MDRO status.

To support their recommendation for routine glove or gown use for residents with indwelling devices, CDC and HICPAC cite a 2015 randomised clinical trial by Mody et al., which apparently showed that "routine use of EBP among residents with indwelling medical devices reduced acquisition of MDROs including methicillin-resistant *S. aureus*, and reduced catheter-associated urinary tract infections."

To support their recommendation for routine glove/gown use for residents with wounds and/or indwelling devices, CDC and HICPAC cite a 2020 quasi-experimental study by Lydecker et al., where "routine use of EBP during high-risk care of residents with wounds or indwelling medical devices was associated with a significant decrease in acquisition and transmission of both methicillin-susceptible and methicillin-resistant *S. aureus*."

"nursing facilities may consider placing residents with known MDRO colonization on EBP to control MDRO transmission, if Contact Precautions do not apply." Based on context, contact precautions routinely appear to apply to 'novel or targeted' MDROs, this guidance recommends expansion of EBPs to non-novel and non-targeted MDROs.

*Gloves and gowns as defined by CDC in 2019.

**examples of indwelling medical devices include central line, urinary catheter, feeding tube, and tracheostomy/ventilator.

***examples of high contact resident care activities include dressing, bathing/showering, transferring, providing hygiene, changing linens, changing briefs or assisting with toileting, device care or use, and wound care.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Frequently asked questions (FAQs) about enhanced barrier precautions in nursing homes. 2022. Date accessed: 26 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Enhanced Barrier Precautions:

- Specific to long-term care facilities (LTCFs) and nursing homes.
- “expand the use of gown and gloves beyond anticipated blood and body fluid exposures.”
- “focus on use of gown and gloves during high-contact resident care activities that have been demonstrated* to result in transfer of MDROs to hands and clothing of healthcare personnel, even if blood and body fluid exposure is not anticipated.”
- “recommended for residents known to be colonized or infected with a MDRO as well as those at increased risk of MDRO acquisition (e.g., residents with wounds or indwelling medical devices).”
- “Changing linen is considered a high contact resident care activity”.

Assessment of evidence
• "could be considered for additional environmental services or housekeeping responsibilities that involve extensive contact with the resident or the resident's environment." *"through hundreds of observations of care in nursing homes" Contact precautions for a resident with a MDRO: • Recommended if the resident has acute diarrhoea, draining wounds, or other sites of secretions or excretions that are unable to be covered or contained or • for a limited period of time during a suspected or confirmed MDRO outbreak investigation. • If neither of above are met and no other indications for contact precautions (CPs), EBPs can be used • Gowns and gloves should be worn by environmental services (EVS) personnel when cleaning and disinfecting the rooms of residents on CPs. CPs: • MDROs • *Closridioides difficile*, scabies, norovirus MDROs targeted by CDC: Pan-resistant organisms: • Carbapenemase-producing carbapenem-resistant *Enterobacterales*, • Carbapenemase-producing carbapenem-resistant *Pseudomonas*, • Carbapenemase-producing carbapenem-resistant *Acinetobacter baumannii*, and • *Candida auris.*

Assessment of evidence
Additional epidemiologically important MDROs: • Methicillin-resistant *Staphylococcus aureus* (MRSA), • ESBL-producing *Enterobacterales,* • Vancomycin-resistant *Enterococci* (VRE), • Multidrug-resistant *Pseudomonas aeruginosa*, • Drug-resistant *Streptococcus pneumoniae.*

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Preventing infections in healthcare. 2020. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"CDC recommends the use of Contact Precautions in inpatient acute care settings for patients known to be colonized or infected with epidemiologically important multidrug-resistant organisms (MDROs) including MRSA."					

Assessment of evidence
“Based on the current evidence, CDC continues to recommend the use of Contact Precautions for MRSA-colonized or infected patients. CDC will continue to evaluate the evidence on Contact Precautions as it becomes available. In addition, CDC continues to work with partners to identify and evaluate other measures to decrease transmission of MDROs in healthcare settings.”

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: transmission based precautions. 2008. Date last updated: 2015. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
“Transmission based precautions should be applied when caring for:					

Assessment of evidence

- Patients with known infection
- Patients who are colonised with an infectious organism
- Asymptomatic patients who are suspected of/under investigation for colonisation or infection with an infectious microorganism.

Transmission based precautions are categorised by the route of transmission of the infectious agent:

Contact Precautions are required for patients known or suspected to be infected or colonised with microorganisms that can be transmitted by direct contact or through the patients secretions or bodily fluids; i.e. contact which occurs when performing patient-care activities that require touching the patients skin, secretions or bodily fluids; or indirect contact i.e. touching potentially contaminated environmental surfaces or equipment in the patients environment.

- Examples include *Staphylococcus aureus* (MSSA or MRSA), Vancomycin resistant enterococci (VRE), *Clostridium difficile* infection (CDI) and scabies.

Droplet Precautions are required for patients known or suspected to be infected with microorganisms transmitted by droplets. Droplets can be generated by coughing, sneezing, talking or during the performance of procedures (e.g., nebulisation).

- Examples include pertussis, influenza, rubella and mumps.

Airborne Precautions are required for patients known or suspected to be infected with microorganisms that can be transmitted to other patients/staff via the airborne route, for example, in dust.

- Examples include Tuberculosis, chickenpox and measles.

Note: Some diseases have multiple routes of transmission and more than one Transmission-Based Precautions category may be used, for example Multi-drug resistant microorganisms such as Multi-drug resistant tuberculosis (MDR-TB) and Human respiratory syncytial virus (RSV). When used either singularly or in combination, they are always used in addition to Standard Precautions."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

[NG] = no grading, [NC] = no citations.

“Transmission-Based Precautions are for patients who are known or suspected to be infected or colonized with infectious agents, including certain epidemiologically important pathogens, which require additional control measures to effectively prevent transmission.”

Formal recommendation –

- “In addition to Standard Precautions, use Transmission-Based Precautions for patients with documented or suspected infection or colonization with highly transmissible or epidemiologically-important pathogens for which additional precautions are needed to prevent transmission”.

Assessment of evidence
“Since the infecting agent often is not known at the time of admission to a healthcare facility, Transmission-Based Precautions are used empirically, according to the clinical syndrome and the likely etiologic agents at the time, and then modified when the pathogen is identified or a transmissible infectious etiology is ruled out.”
“Transmission-Based Precautions are used when the route(s) of transmission is (are) not completely interrupted using Standard Precautions alone.” [NC]
“Contact Precautions are intended to prevent transmission of infectious agents, including epidemiologically important microorganisms, which are spread by direct or indirect contact with the patient or the patient’s environment”. [NC]
“Contact Precautions also apply where the presence of excessive wound drainage, fecal incontinence, or other discharges from the body suggest an increased potential for extensive environmental contamination and risk of transmission.” [NC]
Contact precautions for pathogens that have been implicated in transmission through environmental contamination (for example, VRE, *C. difficile*, noroviruses and other intestinal tract pathogens; respiratory syncytial virus (RSV)).
“Droplet Precautions are intended to prevent transmission of pathogens spread through close respiratory or mucous membrane contact with respiratory secretions”. [NC]
Infectious agents for which droplet precautions are required include “*B.pertussis*, Influenza, Adenovirus, Rhinovirus, *N. Meningitides* and group A streptococcus (for the first 24 hours of antimicrobial therapy)”. [NC]
“Airborne Precautions prevent transmission of infectious agents that remain infectious over long distances when suspended in the air (e.g., rubeola virus [measles], varicella virus [chickenpox], *M. tuberculosis*, and possibly SARS-CoV)”
“Transmission-Based Precautions must be implemented while test results are pending based on the clinical presentation and likely pathogens.”
Modifications should be made based on settings: for example, for home care airborne infection isolation rooms (AIIRs) will not be available, other residents need not wear PPE if in regular contact with patient.
Contact precautions for those colonised/infected with MDROs in acute care settings and LTCFs where continued transmission is evident.

Assessment of evidence
Formal recommendations – • Use Contact Precautions as recommended in Appendix A for patients with known or suspected infections or evidence of syndromes that represent an increased risk for contact transmission. [NC, NG] • "Use Droplet Precautions […] for patients known or suspected to be infected with pathogens transmitted by respiratory droplets (i.e., large-particle droplets >5µm in size) that are generated by a patient who is coughing, sneezing or talking". • "Use Airborne Precautions […] for patients known or suspected to be infected with infectious agents transmitted person-to-person by the airborne route (e.g., M tuberculosis, measles, chickenpox, disseminated herpes zoster." Under droplet precautions section: • For patients with suspected or proven SARS, avian influenza or pandemic influenza other guidance is recommended.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Commission on Safety and Quality in Healthcare. Standard and transmission-based precautions and signage. 2022. Date accessed: 7 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
"In certain situations, the use of standard precautions alone may not be enough to limit the spread of infection. When this occurs, transmission-based precautions are required." "Those patients who require transmission-based precautions, due to a known or suspected infection". "One or more types of transmission-based precautions may be required, depending on how an infection is spread between people." "Contact precautions, in addition to standard precautions, are used for infectious agents that may be transmitted by direct or indirect contact with the patient or the patient's environment." Limitations: • No citations given.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health, Social Services and Public Safety (NI). The Northern Ireland regional infection prevention and control manual: isolation of patients. 2008. Date last updated: 2015.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 6 September 2022.					

Assessment of evidence

"Isolation precautions should be used for patients who are either known or suspected to have an infectious disease, are colonised or infected with a multi-resistant organism or who are particularly susceptible to infection."

1. " Source Isolation aims to confine the infectious agent and prevent its spread from one patient to another. (Source isolation was previously known as 'barrier nursing')."
2. "Protective Isolation aims to protect an immunocompromised patient who is at high risk of acquiring micro-organisms from either the environment or from other patients, staff or visitors.

It is important that standard IPC precautions are implemented at all times and all patients must be assessed on admission to ensure that they are placed in appropriate isolation if necessary. Patients with certain conditions must be isolated immediately for example:

- Diarrhoea and/or vomiting
- Undiagnosed rashes and fevers
- Known Carbapenem Producing *Enterobacteriaceae* (CPE) patients/carriers
- Suspected or confirmed Group A streptococcal infection (i.e., necrotizing fasciitis)
- Patients shedding Meticillin-resistant *staphylococcus aureus* (MRSA), Glycopeptide-resistant enterococci (GRE)
- Patients admitted from a hospital outside NI who may be infected/colonised with resistant micro-organisms
- Bacterial meningitis"

Source isolation

- "Occasionally cohort nursing (placing the patient in a room/bay area with other patients who are infected or colonised with the same microorganism), may be considered. Cohorting should only be done as a last resort and on the advice of the local IPC team/PHA. If

Assessment of evidence
cohorting patients, a dedicated team of staff should care for these patients; however this can only be implemented if sufficient staff are available." Protective isolation • "…in some cases, if an immunocompromised patient has a concurrent communicable disease, source isolation may be required and positive pressure ventilation may be inappropriate – these patients should be discussed with the IPC Team/Microbiologist/Clinician." "Patients should remain in isolation whilst they remain symptomatic; a risk assessment should be undertaken to ascertain if and when isolation precautions can be relaxed."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract infections in healthcare settings. October 2016. Date accessed: 21 September 2022.	Expert opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
Does not apply to TB, MERS-CoV or human cases of avian influenza. Guidelines supplement but do not replace local risk assessment. “When standard infection control measures alone are insufficient to interrupt transmission, additional transmission-based precautions are indicated.” [NC] “Interrupting transmission of a respiratory pathogen requires more than one category of respiratory precautions, including: • The use of droplet and contact precautions at all times • The addition of airborne precautions while undertaking an aerosol-generating procedure (AGP)” [NC] Droplet precautions – “to minimise transmission of respiratory pathogens from infected patients via droplets to susceptible persons.” [NC] Contact precautions – “to prevent transmission of infection by contact with the patient or the patient’s environment”. [NC] Airborne precautions – “designed to prevent transmission of infectious agents via particles which remain suspended in the air.” [NC] For respiratory infections droplet and contact precautions should be used in combination.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M. et al. Management of multidrug-resistant organisms in healthcare settings. 2006.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date last updated: 2017. Date accessed: 5 October 2022.					

Assessment of evidence

Expert opinion piece provided by CDC with the HICPAC. Author affiliations provided covering wide representation in infection control.

“HCP caring for patients on Contact Precautions should wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient’s environment.” [NC]

“The necessary duration of Contact Precautions for patients treated for infection with an MDRO, but who may continue to be colonized with the organism at one or more body sites, remains an unresolved issue. Patients may remain colonized with MDROs for prolonged periods; shedding of these organisms may be intermittent, and surveillance cultures may fail to detect their presence.”

“Three studies evaluated the use of gloves with or without gowns for all patient contacts to prevent VRE acquisition in ICU settings. Two of the studies showed that use of both gloves and gowns reduced VRE transmission while the third showed no difference in transmission based on the barriers used”.

“Contact precautions are intended to prevent transmission of infectious agents, including epidemiologically important microorganisms which are transmitted by direct or indirect contact with the patient or the patient’s environment.”

Recommendations:

“V.A.5.c. Use of Contact Precautions

V.A.5.c.i. In acute-care hospitals, implement Contact Precautions routinely for all patients infected with target MDROs and for patients that have been previously identified as being colonized with target MDROs (e.g., patients transferred from other units or facilities who are known to be colonized). Category IB

V.A.5.c.ii. In LTCFs,

Assessment of evidence

- Consider the individual patient's clinical situation and prevalence or incidence of MDRO in the facility when deciding whether to implement or modify Contact Precautions in addition to Standard Precautions for a patient infected or colonized with a target MDRO. Category II
- For relatively healthy residents (e.g., mainly independent) follow Standard Precautions, making sure that gloves and gowns are used for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes/bags. Category II
- For ill residents (e.g., those totally dependent upon healthcare personnel for healthcare and activities of daily living, ventilator-dependent) and for those residents whose infected secretions or drainage cannot be contained, use Contact Precautions in addition to Standard Precautions. Category II
- For MDRO colonized or infected patients without draining wounds, diarrhea, or uncontrolled secretions, establish ranges of permitted ambulation, socialization, and use of common areas based on their risk to other patients and on the ability of the colonized or infected patients to observe proper hand hygiene and other recommended precautions to contain secretions and excretions. Category II

V.A.5.d**.** In ambulatory settings, use Standard Precautions for patients known to be infected or colonized with target MDROs, making sure that gloves and gowns are used for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes and bags. Category II

V.A.5.e. In home care settings

- Follow Standard Precautions making sure to use gowns and gloves for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes and bags. Category II

V.A.5.i. Patient placement in hospitals and LTCFs

V.A.5.i.1. When single-patient rooms are available, assign priority for these rooms to patients with known or suspected MDRO colonization or infection. Give highest priority to those patients who have conditions that may facilitate transmission, e.g., uncontained secretions or excretions. Category IB

Assessment of evidence
V.A.5.i.2. When single-patient rooms are not available, cohort patients with the same MDRO in the same room or patient-care area. Category IB V.A.5.i.3. When cohorting patients with the same MDRO is not possible, place MDRO patients in rooms with patients who are at low risk for acquisition of MDROs and associated adverse outcomes from infection and are likely to have short lengths of stay. Category II".

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Social Care. Infection prevention and control: resource for adult social care. 31 March 2022. Applies from: 4 April 2022. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
This information is stated to apply to England. Also stated is: "This resource contains general infection prevention and control (IPC) principles to be used in combination with advice and guidance on managing specific infections. It is for those responsible for setting and maintaining standards of IPC within adult social care in England."

Assessment of evidence

"Standard precautions alone may not be sufficient to prevent the spread of infection. There is a need to assess any additional measures needed when a person is suspected or known to have an infection. Additional precautions are based on:

- which pathogen is causing the suspected or known infection or colonisation
- how the pathogen is spread
- the severity of the illness
- where the person is supported or cared for
- the procedure or task being undertaken

Identifying people who have an infection, and the pathogen causing it, is essential to ensure appropriate support is provided to minimise the risk of spreading it to others".

"An assessment of a person's risk of infection should be carried out before they start using the service and should be kept under review for as long as they use the service. The assessment should contribute to the planning of the person's care and should determine whether any extra IPC precautions are required, such as whether they need to isolate or whether workers need to wear additional personal protective equipment (PPE). The assessment should include all factors which place the person at a higher risk of catching or spreading infection and may include:

- Symptoms:
  - History of current diarrhoea or vomiting
  - Unexplained rash
  - Fever or temperature
  - Respiratory symptoms, such as coughing or sneezing
- Contact:
  - Previous infection with a multi-drug resistant pathogen (where known)
  - Recent travel outside the UK where there are known risks of infection
  - Contact with people with a known infection

Assessment of evidence

• Person risk factors:
  ○ Vaccination status which will assist assessment of their susceptibility to infection and allow protective actions to be taken when necessary
  ○ Wounds or breaks in the skin
  ○ Invasive devices such as urinary catheters
  ○ Conditions or medicines that weaken the immune system
• Environmental risk factors, such as poor ventilation in the care setting”
 	
Limitations:
• No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Lemass H, McDonnell N, O’Connor N. et al. Infection prevention and control for primary care in Ireland: a guide for general practice. 2013. Date accessed: 7 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
"Opinion of SARI Infection and Control Subcommittee following a review of the scientific literature and an extensive consultation exercise". "While the implementation of Standard Precautions can minimise the transmission of infection within the general practice setting, some patients suspected or known to be colonized with transmissible infections require additional precautions know as Transmission Based Precautions. Standard Precautions must be applied in addition to Transmission Based Precautions." Limitations: • No details on review of consultation provided. • No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government. National Health and Medical Research Council Australian guidelines for the prevention and control of infection in healthcare. 2019. Date last updated: September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 October 2022.					

Assessment of evidence

- "where standard precautions may not be sufficient on their own". [NC]
- "used in the event of an outbreak (e.g. gastroenteritis), to assist in containing the outbreak and preventing further infection." [NC]
- "used in addition to standard precautions, where the suspected or confirmed presence of infectious agents represents an increased risk of transmission." [NC]
- "particularly important in containing multi-resistant organisms". [NC]

"Contact precautions are used when there is known or suspected risk of direct or indirect contact transmission of infectious agents that are not effectively contained by standard precautions alone". [NC]

"Droplet precautions are used for patients known or suspected to be infected with agents transmitted over short distances by large respiratory droplets". [NC]

"Airborne precautions are used for patients known or suspected to be infected with agents transmitted person-to-person by the airborne route". [NC]

Example of transmission based precaution: "When the presence of *C. difficile* or non-enveloped viruses is known or suspected, use of alcohol-based hand rubs alone may not be sufficient to reduce transmission of these organisms". [NC]

- "Putting on both gloves and gown upon entering the patient-care area helps to contain infectious agents, especially those that have been implicated in transmission through environmental contamination (e.g., *C. difficile*, norovirus and other intestinal tract pathogens, respiratory syncytial virus)."

Conditional recommendation: "It is suggested that contact precautions, in addition to standard precautions, are implemented in the presence of known or suspected infectious agents that are spread by direct or indirect contact with the patient or the patient's environment." – Low certainty of evidence. Cite expert opinion of CDC, Siegel et al, 2007 guidance. Authors state that "There is supportive

Assessment of evidence
evidence and a strong theoretical rationale to support the use of contact precautions for patients known or suspected to be infected with an infectious agent spread via the contact route. This intervention is also supported by work, health and safety principles." Authors also state that "The benefits of using contact precautions clearly outweigh any undesirable effects." [Only one citation provided]. • "in the presence of suspected or known infectious agents that represent an increased risk of transmission." [NC] • "to reduce further transmission opportunities that may arise due to the specific route of transmission of a particular pathogen." [NC] • "While it is not possible to prospectively identify all patients needing transmission-based precautions, in certain settings recognising an increased risk warrants their use while confirmatory tests are pending." [NC] Conditional recommendation: "It is suggested that droplet precautions, in addition to standard precautions, are implemented for patients known or suspected to be infected with agents transmitted by respiratory droplets that are generated by a patient when coughing, sneezing or talking." – Low certainty of evidence. Cite expert opinion of CDC, Siegel et al, 2007 guidance. Authors state that "There is supportive evidence and a strong theoretical rationale for the use of droplet precautions for patients known or suspected to be infected with agents transmitted by respiratory droplets. This intervention is also supported by work, health and safety principles." Authors also state that "The benefits of using droplet precautions […] clearly outweigh any undesirable effects." [Only one citation provided]. • "Droplet precautions are intended to prevent transmission of infectious agents spread through close respiratory or mucous membrane contact with respiratory secretions" [NC] Recommended: "It is recommended that airborne precautions, in addition to standard precautions, are implemented in the presence of known or suspected infectious agents that are transmitted person-to-person by the airborne route." – Moderate certainty of evidence. Cite expert opinion of CDC, Siegel et al, 2007 guidance and Public Health Agency of Canada. Authors state that "The benefits of implementing airborne precautions for patients known or suspected to be infected with infectious agents transmitted person-to-person by the airborne route clearly outweigh any undesirable effects." Conditional recommendation: "It is suggested that contact precautions be considered for all patients colonised or infected with a multi-resistant organism (MRO) where there is anticipated patient and/or environmental contact, including: • performing hand hygiene and putting on gloves and gowns before entering the patient-care area

Assessment of evidence

- using patient-dedicated or single-use non-critical patient-care equipment
- using a single-patient room or, if unavailable, cohorting patients with the same strain of MRO in designated patient-care areas (upon approval from the healthcare facility's Infection Control Team)
- ensuring consistent cleaning and disinfection of surfaces in close proximity to the patient and those likely to be touched by the patient and healthcare workers

Authors cite CDC guidance, Management of Multidrug-Resistant Organisms in Healthcare Settings (2006) stating that “the quality of evidence is low, and there is significant variability amongst results regarding both the benefits and harms of contact precautions for MROs.”

Conditional recommendation:

- “Benefits outweigh harms for the majority, but not for everyone. The majority of patients would likely want this option”.
- “there are two fundamental reasons for a [conditional] recommendation: i) the evidence is low quality, so it’s hard to be sure of the right course of action OR ii) there is a fine balance between benefits and harms of treatment alternatives. Other drivers for [conditional] recommendations are variability in patients values and preferences or issues related to resource-use, feasibility, or equity.” In general users should ‘think twice’ when applying conditional recommendations. “For example, patients’ values and preferences, comorbitities, polypharmacy, burden of medical care, or personal limitations may result in the alternative course of action being the preferred option.”

Recommended:

- “Benefits outweigh harms for almost everyone. All or nearly all informed patients would likely want this option”.
- “A strong recommendation essentially means "just do it" and there is good reason to believe all informed patients would want this option. The evidence should be of high/moderate quality, but in some instances you can issue strong recommendations based on low/very low quality evidence.”

Assessment of evidence
References: Ontario Agency for Health Protection and Promotion and Provincial Infectious Diseases Advisory Committee. Best practices for infection prevention and control programs in Ontario: in all health care settings. 3rd ed. Toronto, Ontario: Queen's Printer for Ontario; 2012. Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Centers for Disease Control and Prevention. 2007 [updated May 2022, accessed 6 September 2022].

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Health Protection Agency. Prevention and control of infection in care homes - an information resource. 2013. Date accessed: 10 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
This expert opinion is described as "An information resource to assist staff in taking all reasonable steps to protect residents and staff from acquiring infections and prevent cross infection; and to provide information and guidance on infection prevention and control that will assist managers in undertaking risk assessments and in developing policies" which applies only to England.

Assessment of evidence
Target audience for these guidelines “Care Trust CEs, GPs, Communications Leads, Consultants in Communicable Disease Control, Community Infection Control Nurses, Health Protection Nurses, Care Home Managers, Care Quality Commission”. • “Residents who are vomiting should be kept in a single room, as long as symptoms persist. Most acute diarrhoeal infection is caused by viruses, for example, norovirus also known as the ‘winter vomiting disease’ due to its seasonality and typical symptoms.” • “If a resident is discharged from hospital within 48 hours of the last symptoms of diarrhoea and vomiting every effort should be made to care for them in a single room with a dedicated toilet and appropriate precautions until they have been clear of symptoms for 48 hours.” • “Most respiratory infections are spread through the air as well as through close contact, so the residents should be nursed in a single room during the acute illness, particularly if they are coughing and sneezing.” • “Because colonisation can be very long-term, it is not necessary to isolate residents known to be colonised with antibiotic-resistant bacteria.” Limitations: • Specific to care homes. • No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Transmission-based precautions for the prevention and	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
control of infections: aide-memoire. 2022. Date accessed: 11 October 2022.					
Assessment of evidence					
“Transmission-based precautions must be started as soon as a patient presents with symptoms (e.g. fever, new cough, vomiting, diarrhoea). There is no need to wait for test results.” “Transmission-based precautions are used in addition to standard precautions for patients with known or suspected infection or colonization1 with transmissible and/or epidemiologically significant pathogens. The type of transmission-based precautions assigned to a patient depends on the transmission route of the microorganism: contact, droplet, or airborne.” Limitations: • No citations provided.					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Association of periOperative registered nurses. Guideline quick view: transmission-based precautions.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
AORN Journal. 2019; 109:529-536.					

Assessment of evidence

Contact precautions should be applied for patients who are known to be colonized or infected with pathogens transmitted by contact (for example. multidrug resistant organisms [MDROs], *C. difficile*). Don gown/gloves upon entry and discard upon exit.

Droplet precautions for patients who are "known or suspected to have infections transmitted by respiratory droplets (e.g., adenovirus, group A *Streptococcus*, influenza, *Neisseria meningitides*, *Bordetella pertussis*, rhinovirus)." Under droplet precaution section, guidelines state that respirators should be used for AGPs "on patients with suspected or proven infections transmitted by respiratory aerosols (e.g., severe acute respiratory syndrome, avian influenza, pandemic influenza, viral hemorrhagic fevers)."

Airborne precautions should be applied "when providing care to patients who are known or suspected to be infected with pathogens that are transmitted by the airborne route (i.e., small particles or droplet nuclei < 5μm in size)." For pts with "suspected or proven infections transmitted by the airborne route (e.g., *Mycobacterium tuberculosis* [TB], rubeola virus [measles], varicella-zoster virus [chickenpox], disseminated herpes zoster)."

Limitations:

- No citations for above.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Precautions for preventing the transmission of	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.					
Assessment of evidence					
Contact precautions – “for microorganisms of very low infective dose or situations where heavy contamination of the patient’s environment is anticipated.” [NC] Droplet precautions – “for microorganisms primarily transmitted by the large droplet route”. [NC] Airborne precautions – “for microorganisms transmitted through the air over extended time and distance by small particles.” [NC] “Each HCW has a responsibility to perform a PCRA [point of care risk assessment] before every interaction with every patient and/or the patient’s environment, and to ensure that appropriate control measures (i.e., routine practices and, if necessary, additional precautions) are in place to prevent transmission of microorganisms.” [NC] “In addition to routine practices, precautions should be used for patients with suspected or known infections or colonization with microorganisms for which routine practices are insufficient to prevent transmission.” [NC] “Additional precautions should be used empirically, based on the patient’s condition or clinical presentation. These may need to be modified or discontinued based on the specific microorganism identified.” [NC] “Application of additional precautions may vary between acute care, LTC, ambulatory care, prehospital care and home care settings. Local epidemiology should be considered in the application of additional precautions.” [NC] “adult patients with known or suspected viral respiratory infections be placed on contact and droplet precautions” [NC]					

Assessment of evidence

Additional precautions are applied when:

- “the transmission characteristics of, or impact of, infection with a specific microorganism (e.g., microorganisms with a low infectious dose such as *Shigella* spp., or microorganisms spread by the droplet route such as respiratory syncytial virus [RSV], or epidemiologically significant microorganisms such as antibiotic resistant organisms [AROs]) or syndromes are not fully prevented by routine practices.”
- “medical procedures increase the risk of transmission of a specific infectious agent (e.g., AGMPs)”
- “the clinical situation prevents consistent application of routine practices (e.g., care of the young child, incontinent adult or cognitively impaired individual).”

Balancing risk and benefit when using TBPs – “Transmission of microorganisms in the healthcare setting cannot always be prevented, and attempts to do so would entail additional costs and restrictive measures that would interfere with the quality of life for the patient or avoidance of potentially beneficial medical procedures or interventions. Thus, IPC practices should be tailored to the level of care that is being provided and the inherent risk to the individual and the population if infection occurs. Precautions that may be justified in terms of risk–benefit in an intensive care unit (ICU) or acute care ward may not be of equal benefit or indicated for a patient in LTC.” [NC] “certain measures may need to be modified for different types of healthcare settings, based on assessment of risks and benefits. The benefit of reducing risk of transmission needs to be balanced against the cost (in quality of life, adequacy of medical care and monetary outlay) of the precautions taken to achieve this reduction in risk.” [NC]

Strategies to reduce aerosol generation:

- “for aerosol generating medical procedures AGMPs on patients with signs or symptoms of suspected or confirmed TB, SARS or respiratory infection with an emerging pathogen for which transmission routes are not yet fully known”.
- “when AGMPs are necessary on patients with viral hemorrhagic fevers”.

Assessment of evidence

Airborne precautions:

- For procedures that may aerosolize viable *tubercle bacilli* (e.g., irrigation) of non-respiratory lesions and use of oscillating saws during autopsy on patients with TB. Airborne precautions are recommended when performing these procedures on patients with suspected or confirmed TB.

Additional precautions applied "when the natural transmission characteristics of specific microorganisms: [NC]

- epidemiologically significant microorganisms including *C. difficile*
- antibiotic-resistant microorganisms
- viral gastroenteritis
- emerging respiratory infections
- or syndromes are not fully managed by routine practices." [NC]

"Additional precautions may be required when:

- medical procedures artificially increase the risk of transmission of a specific microorganism
- because of the clinical situation (e.g., care of a young child, incontinent adult or cognitively impaired individual)." [NC]

Additional precautions are "specific to the care setting (e.g., acute care, ambulatory care, prehospital care, LTC, and home care)." [NC]

"Additional precautions should be implemented as soon as disease or risk factors are suspected or identified. A confirmed diagnosis is not necessary for additional precautions to be applied." [NC]

Prior to every patient interaction, a point of care risk assessment should be conducted by healthcare staff to "determine the need for additional precautions when routine practices are not sufficient to prevent exposure" [NC]

"Additional precautions to be applied when the natural transmission characteristics of specific microorganisms (e.g., epidemiologically significant microorganisms including C. difficile, antibiotic-resistant microorganisms, viral gastroenteritis and emerging respiratory infections […] or syndromes are not fully managed by routine practices." [NC]

Assessment of evidence

"Additional precautions may be required when medical procedures artificially increase the risk of transmission of a specific microorganism or because of the clinical situation (e.g., care of a young child, incontinent adult or cognitively impaired individual)." [NC]

Epidemiologically significant organisms requiring additional precautions: [NC]

- *C. difficile.*
- Antimicrobial resistant micro-organisms.
- Viral gastroenteritis (norovirus, calicivirus, rotavirus).
- Emerging respiratory infections.

"Routine practices properly and consistently applied should prevent transmission by the contact route. For certain situations that may result in extensive contamination of the environment or for microorganisms with a very low infectious dose, contact precautions may be indicated. [NC] Contact precautions should be used for the conditions/clinical presentations and specific etiologies listed in List 3".

List 3 aligns with the more detailed Tables 4 and 5 which present symptoms and pathogen diagnoses that indicate the need for use of additional precautions. There are specific caveats for certain pathogens/symptoms, for example, contact precautions are only indicated for unknown pathogen diarrhoea if the patient is incontinent, bodily fluids cannot be contained and/or unable to comply with hand hygiene.

For the care of patients with antibiotic resistant micro-organisms in ambulatory care settings, home care or prehospital care: CPs should not be used for asymptomatic carriers (only colonised).

Droplet precautions should be used for the conditions/clinical presentations listed in List 4. List 4 aligns with the more detailed Tables 4 and 5 which present symptoms and pathogen diagnoses that indicate the need for use of additional precautions. List 4 includes "Viral hemorrhagic fevers (Crimean -Congo, Ebola, Lassa, Marburg)".

For droplet precautions, some indications may differ based on age of patient [for example epiglottitis or cellulitis in children <5 years, scarlet fever in children]

"Droplet precautions in addition to routine practices are sufficient for aerosol-generating medical procedures performed on patients on droplet precautions who have no signs or symptoms of:

Assessment of evidence
• Suspected or confirmed tuberculosis • Severe acute respiratory syndrome • Respiratory infection with an emerging pathogen for which transmission characteristics are not yet known." [NG, NC] Airborne precautions should be used for conditions/clinical presentations listed in List 5. List 5 aligns with the more detailed Tables 4 and 5 which present symptoms and pathogen diagnoses which indicate the need for use of additional precautions. "Additional precautions − Extra measures, when routine practices alone may not interrupt transmission of an infectious agent. They are used in addition to routine practices (not in place of) and are initiated both on condition/clinical presentation (syndrome) and on specific etiology (diagnosis)." As part of PCRA: • What contact is the HCW going to have with the patient? • What task(s) or procedures(s) is the HCW going to perform? Is there a risk of splashes/sprays? • If the patient has diarrhea, is he/she continent? If incontinent, can stool be contained in an adult incontinence product? • Is the patient able and willing to perform hand hygiene? • Is the patient in a shared room?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Marshall C, Richards M, McBryde E. Do active surveillance and contact precautions	Before-after study	**Level 3**	Applying contact precautions (single room isolation/cohorting with gowns and	Before (control; 21 May 2007 to 20 July 2008) vs after (intervention; 21 July	Rate of MRSA (per 1,000 at risk patient days) with an adjusted hazard ratio.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
reduce MRSA acquisition? A prospective interrupted time series. PloS one. 2013 Mar 21;8(3).			gloves) for MRSA colonised/infected patients alongside active surveillance.	2008 to 21 September 2009).	Secondary outcome: segmented regression analysis. Hand hygiene and infection control adherence

Assessment of evidence

Setting: Australia, medical-surgical ICU.

This prospective before-after study was carried out on ICU patients at a tertiary adult hospital in Melbourne, 4,317 patients admitted 4,781 times we observed between 21 May 2007 to 21 September 2009. This study provides evidence that contact precautions including gloves, gowns and isolation/cohorting of MRSA infected/colonised patients in an MRSA-endemic ICU alongside active surveillance significantly reduced the rate of MRSA acquisition (18.5 per 1,000 at risk patient days before intervention to 7.9 per 1,000 at-risk patient days after intervention) with an adjusted hazard ratio of MRSA of 0.39 [95% CI: 0.24-0.62].

Limitations:

- The time periods observed are 14 months either side of the change in policy on 21 July 2008, so may have differences in seasonal variation. However, this decision was made on the basis that a minimum of 50 events were required in the before stage for statistical power, and this was not reached at 11 months so the researchers extended the study period from 12 months to 14.
- Hand hygiene compliance was low (12-34%).
- No wash out period, but authors note change immediately after introduction of the intervention not statistically significant.
- The study was not blinded as healthcare workers were aware of patient status in the after phase, and may have also been aware in the before phase if they checked electronic records.

Assessment of evidence
• Research nurses were employed during the study period to optimize compliance, so effectiveness of contact precautions may not be generalizable where such intervention support and monitoring is not provided. • The hospital in which the study was set was MRSA endemic, so precautions may not be as effective in settings where MRSA is less prevalent. • Pre-emptive isolation of patients was not in place.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Geva A, Wright SB, Baldini LM, et al. Spread of methicillin-resistant Staphylococcus aureus in a large tertiary NICU: network analysis. Pediatrics. 2011 Nov; 128(5):e1173-80.	Cohort (retrospective)	**Level 3**	Nurse interactions in NICU setting contributing to MRSA in the presence of contact precautions and standard precautions.	Compared epoch (7/14 day time period) where there was an incident case of MRSA colonisation with an epoch were there were no newly colonised infants to identify predictors of new MRSA colonisation.	MRSA screening results (from infection-control records).
Assessment of evidence					
Setting: Massachusetts, medical center NICU. This study was carried out at a level III medical centre NICU in Massachusetts involving 3,488 infants treated in the NICU, with 2,620 infants screened for MRSA at least once. This retrospective cohort study provides some evidence that application of contact precautions					

Assessment of evidence
(gowns, gloves and “separating” colonised infants) in a NICU significantly reduced the odds of MRSA colonisation in the study population (OR: 0.65 [95% CI: 0.53-0.80]; *p*<.001). However, these findings are based on modelling (network analysis), which is defined by assumptions made by the authors and rely heavily on the accuracy of medical records and consistent adherence of contact precautions, which were not monitored. Limitations: • Describing colonised/infected infants as “separated” is vague – not clear if placed in a different room or distanced. • Patient characteristics (clinical/demographic) for whole study population, no comparison of MRSA colonised vs non-colonised patient groups to deduce if colonised infants may have been more susceptible to infection. • Did not publish data on MRSA positive patients clustering together through nursing connections. • A lot of narrative synthesis of network analysis results. • Where MRSA detected, there were higher patient/nurse ratios and average daily census counts –possible that this influenced testing/surveillance in the ward. • Adherence to contact precautions and other IPC not monitored – significant increase in risk of colonisation when patients had a direct nursing connection may be indicative of poor adherence, or staff carriers. • Epochs not the same length – 7 or 14 days. • Did not capture all healthcare worker interaction because of insufficient data for other healthcare practitioners (just nurses). • Accuracy of nurse records would have impacted whether modelling was accurate. • Excluded 16 weeks of incomplete archived patient/nursing data (technical problem with archiving system). • Graphs from exploratory analysis not published.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centres for Disease Control and Prevention. Implementation of personal protective equipment (PPE) use in nursing homes to prevent spread of multidrug resistant organisms (MDROs). Date last updated: July 12 2022. Date accessed: 07 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"This document is intended to provide guidance for PPE use and room restriction in nursing homes for preventing transmission of MDROs"
"For the purposes of this guidance, the MDROs for which the use of EBP applies are based on local epidemiology. At a minimum, they should include resistant organisms targeted by CDC but can also include other epidemiologically important MDROs."

EBPs:

"The use of gown and gloves for high-contact resident care activities is indicated, when Contact Precautions do not otherwise apply, for nursing home residents with wounds and/or indwelling medical devices regardless of MDRO colonization as well as for residents with MDRO infection or colonization".

Assessment of evidence
“Residents are not restricted to their rooms or limited from participation in group activities. Because Enhanced Barrier Precautions do not impose the same activity and room placement restrictions as Contact Precautions, they are intended to be in place for the duration of a resident’s stay in the facility or until resolution of the wound or discontinuation of the indwelling medical device that placed them at higher risk.” Within this document a table is provided for standard precautions, enhanced barrier precautions and contact precautions detailing who this applies, PPE used for situations, required PPE and room restriction: EBPs Are to be applied: “All residents with any of the following: • Infection or colonization with an MDRO when Contact Precautions do not otherwise apply • Wounds and/or indwelling medical devices (e.g., central line, urinary catheter, feeding tube, tracheostomy/ventilator) regardless of MDRO colonization status”. Suggest PPE to be used in these situations: “During high-contact resident care activities: • Dressing • Bathing/showering • Transferring • Providing hygiene • Changing linens • Changing briefs or assisting with toileting

Assessment of evidence
• Device care or use: central line, urinary catheter, feeding tube, tracheostomy/ventilator • Wound care: any skin opening requiring a dressing". Contact precautions Are to be applied: "All residents infected or colonized with a MDRO in any of the following situations: • Presence of acute diarrhea, draining wounds or other sites of secretions or excretions that are unable to be covered or contained • For a limited time period, as determined in consultation with public health authorities, on units or in facilities during the investigation of a suspected or confirmed MDRO outbreak • When otherwise directed by public health authorities All residents who have another infection (e.g., C. difficile, norovirus, scabies) or condition for which Contact Precautions is recommended in Appendix A (Type and Duration of Precautions Recommended for Selected Infections and Conditions) of the CDC Guideline for Isolation Precautions." Suggest PPE to be used in these situations: "Any room entry". "Contact Precautions are one type of Transmission-Based Precaution that are used when pathogen transmission is not completely interrupted by Standard Precautions alone. Contact Precautions are intended to prevent transmission of infectious agents, like MDROs, that are spread by direct or indirect contact with the resident or the resident's environment." [NC] Limitations: • No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014. Date accessed: 7 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

"these guidelines prioritize a syndromic and epidemiological approach for assessing risks of infection and application of additional IPC measures."

Additional precautions may be needed depending on:

- "the suspected or confirmed causative agents of the ARIs;
- the presence of epidemiological and clinical clues suggesting that patients have ARIs of potential concern; and
- the types of contact and procedures that are undertaken with patients with ARIs."

"Apply Standard Precautions routinely to ALL patients in ALL health-care settings".

Assessment of evidence

- "Apply Standard and Droplet Precautions at the initial evaluation of a patient with a suspected ARI. Modify isolation precautions according to the specific diagnosis, as it becomes available."
- "Apply Standard, Contact and Droplet Precautions at initial evaluation of a paediatric patient presenting with a suspected ARI during the peak season of certain viruses (e.g., croup and parainfluenza, acute bronchiolitis, and respiratory syncytial virus). Modify isolation precautions according to the specific diagnosis."
- "Evaluate the risk to determine whether additional protective measures may be necessary; for example, when providing care for patients infected with some specific pathogens. If the patient has indications suggestive of a novel ARI with epidemic or pandemic potential and the route of transmission has not been established, add Airborne and Contact Precautions, plus eye protection, to Standard Precautions."
- Directed to Annex B 'isolation precautions'.

Advises contact, droplet and/or airborne precautions but main body of guidance contains general acute respiratory infection (ARI) recommendations divided based on 'for all ARIs', 'for ARIs of potential concern' and 'newly emerging ARIs'. "Because droplets are the major mode of transmission for most ARIs, Droplet Precautions should be applied in addition to Standard Precautions when an ARI is suspected."

ARIs of potential concern (no clear definition) → SARS, new influenza virus causing human infection, novel acute respiratory infections with potential for a high public health impact, MERS.

"Airborne Precaution rooms should be prioritized for patients with obligate (pulmonary TB) or preferential airborne infections (e.g., measles and chickenpox) and for patients infected with novel agents causing ARIs of potential concern for which there is no information on possible routes of transmission."

In Annex J, general ARI measures are provided based on:

- Measures for countries with no reported ARIs of potential concern.
- Additional measures for countries with reported ARIs of potential concern.

Assessment of evidence
Under section entitled ‘Droplet Precautions’: • “Respiratory pathogens that are transmitted through large droplets include adenovirus, avian influenza A(H5N1), human influenza and SARS-CoV.” [NC] Under section entitled ‘Contact Precautions’: • “In addition to transmission by large droplets, some common respiratory pathogens (e.g., parainfluenza and respiratory syncytial virus) can be transmitted through contact –particularly by hand contamination and self-inoculation into conjunctival or nasal mucosa.” [NC] “Previously, the association between medical procedures that are known to produce aerosols and an increased risk of pathogen transmission had not been rigorously evaluated. However, a systematic review on aerosol-generating procedures and the risk of ARI transmission has now made it easier to determine which procedures are associated with a high risk of transmission and provides a basis for recommendations.” “additional precautions in selected patients (e.g. based on the presumptive diagnosis)”.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Strengthening infection prevention and control in primary care. A collection of existing standards, measurements and	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
implementation resources. 2021. Date accessed: 7 September 2022.					
Assessment of evidence					
“Transmission-based precautions should be applied when caring for patients with known infection, patients who are colonised with an infectious organism, and asymptomatic patients who are suspected of/under investigation for colonisation or infection with an infectious microorganism.”					

Question 8: Are there reported occurrences of pathogen transmission which do not align with their currently assigned transmission modes?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Teare L, Martin N, Elamin W, et al. Acinetobacter - the trojan horse of infection control? J Hosp Infect. 2019 May; 102(1):45-53.	Outbreak Report	**Level 3**	Epidemiological and microbiological investigation of multi drug resistant *Acinetobacter baumanii* outbreak in a UK burn ICU (BICU).	N/A	Results of epidemiological time/place evaluation. Matching of clinical isolates. Results of swabbing and settle plate sampling. Results of smoke testing to establish air flows.

Assessment of evidence

Outbreak involved three patients who were colonised on admission with two strains of multi drug resistant *A. baumannii* (MDR AB) (named as Dubai strain and Mumbai strain in report) and two index cases with nosocomial infection of the 'Dubai strain'. This review focuses on transmission to the first patient, patient C, as this was hypothesised to involve air mediated person-person transmission of MDR AB.

Patients A and B (source patients) and C (index patient) were all housed in negative pressure single rooms of the burn ICU off of the same corridor. Patients A and B in rooms three and four. Patient C in room two.

There were two isolates of the outbreak strain:

Assessment of evidence

- A settle plate placed on a trolley in the corridor between BICU Rooms one and two (opposite the operating theatre); and
- A swab from the right rear wheel of a trolley housing the portable X-ray machine which was also stored in the communal corridor outside the operating theatre.

Patients A and B who carried 'the Dubai' MDR AB strain underwent surgical operations seven days before the index patient (patient C) but otherwise had no reported contact.

Limitations include an inability to rule out transmission via shared staff and thus direct/indirect contact transmission following inadequate infection prevention and control (IPC) practices (for example, hand hygiene, PPE doffing, equipment cleaning). Also transmission via inadequately cleaned surfaces in the operating theatre cannot be ruled out. Authors do not provide adequate detail on shared equipment or shared staff. Patient D was also housed in a negative pressure single room of the BICU off the contaminated corridor, and was susceptible to infection yet did not become infected. Authors theorized that this was due to reduced treatment/ use of equipment /earlier closure of wounds.

Through the circumstantial evidence of:

- A strong commitment to IPC including changing of shoes/scrubs/headwear/showering, and so on.
- Reported monitoring of compliance.
- Index patient and source patients having no reported contact.

Alongside:

- Positive corridor air samples and close to floor surfaces which matched the strain of the source/index patient.
- The single rooms having a negative pressure which should have prevented dissemination of contaminated air moving from patient rooms into the corridor.
- Smoke testing which confirmed that air flowed either directly from the operating theatre into the corridor, or into the anaesthetic room and then into the corridor.

Assessment of evidence
Authors hypothesized contamination of equipment stored in the corridor by air flowing from the positive pressure theatre and consequent indirect equipment derived contact transmission and/or direct contamination of the air of the patient rooms from the theatre via the corridor. This study presents evidence which may indicate the possibility of air mediated MDR *A. baumanii* transmission to and from an immunocompromised patient but cannot be used in isolation to support a redefining of *A. baumanii* as a person-person air mediated transmitted pathogen, however - a precautionary principle could be prudent. Further evidence is needed.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Jung J, Lee J, Jo S, et al. Nosocomial outbreak of COVID-19 in a Hematologic Ward. Infect Chemother. 2021 Jun ;53(2):332-341.	Outbreak Report	**Level 3**	Outbreak investigation reported with hypothesis for long range air mediated transmission presented.	N/A	Results of epidemiological time/place investigations. Case/staff interviews. Examination of CCTV footage. Contact tracing with PCR testing. Whole genome sequencing.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
					Simulation of air flow (not included in appraisal).

Assessment of evidence

Findings:

Three patients (cases four, eight and nine) and two caregivers (cases two and three) shared a room (Room 36) with the hypothesised index patient. One caregiver (case five) “was close contact to cases” of Room 36. Case six was in a separate room but used the shared bathroom 40 mins after index case.

Case seven was in a single isolation room with a separate bathroom and did not use the shared bathroom.

Case seven’s room door was open on two occasions following the use of the adjacent shared bathroom by Case six.

“There was unintended negative pressure (-1.5 Pa) [in patient sevens room (Rm 1)] due to an imbalance of the air supply and ventilation system.”

Poor ventilation in adjacent shared bathroom due to a dysfunctional air-exhaust.

However, Case seven did visit shared utility room and shared this room with Case two for 30s whilst they both wore masks.

But all other patients/caregivers (n=73) who used the utility room (and were not one of the other cases who had close contact/shared a room with the index patient) did not test positive for COVID-19.

Whole genome sequencing (WGS): all but one strain were 100% identical. One sample had a difference of one nucleotide.

Limitations:

- Authors do not comment on shared HCWs/equipment.
- Cannot rule out infection from contaminated surfaces in shared utility room.

Assessment of evidence
• Scenario may be specific to highly immunocompromised patients. Based on circumstantial evidence and WGS this study presents evidence which may indicate the possibility of long range air-mediated transmission of COVID-19 to and from an immunocompromised patient – although transmission via indirect contact cannot be ruled out and more detail on shared healthcare staff/equipment is desirable. Further evidence is needed.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Goldberg L, Levinsky Y, Marcus N, et al. SARS-CoV-2 infection among health care workers despite the use of surgical masks and physical distancing-the role of airborne transmission. Open Forum Infect Dis. 2021 Jan 27; 8(3).	Outbreak Report	**Level 3**	Hypothesis of 'airborne' transmission of COVID-19 due to failure of physical distancing and mask wearing to mitigate spread (small particles, remain in air, transmission over long distances).	N/A	Date of contact/interaction with index family (mother and/or child). Nature of contact/interaction. Results of COVID-19 tests for contacts. Dates of positive tests and any associated symptoms. Patient/HCW reported actions.

Assessment of evidence
Setting: Israel, general paediatric ward. Circumstantial evidence suggests transmission of COVID-19 infection to healthcare workers (HCWs) who wore masks and did not have direct/indirect contact with the index patient but fomite transmission and/or close staff interaction cannot be ruled out with significant limitations of lack of sequence data and timing of wider staff/family/contact testing. Limitations: • Cannot rule out fomite transmission. • Lack of detail regarding timing of testing ward staff/patients as well as testing of staff family/contacts. • No WGS to link cases. • Self-reported compliance with mask use. • Staff interaction post exposure to ‘index family’ not described. • Cannot ascertain quality of facemasks. • Cannot guarantee physical distancing between patients’ mother and other persons in room.

Question 9: What factors should be considered when determining whether to discontinue TBPs?

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Jimenez A, Fennie K, Munoz-Price LS, et al. Duration of carbapenemase-producing enterobacteriales carriage among ICU patients in Miami, FL: a retrospective cohort study. Am J Infect Control. 2021 Oct; 49(10):1281-1286.	Retrospective cohort study	**Level 3**	N/A	N/A	N/A

Assessment of evidence

- A retrospective cohort study among patients admitted between January 2012 and December 2016 to ICUs of four hospitals which assessed time to clearance of multi-drug resistant organism (MDRO) colonisation/infection with consideration of risk factors for extended colonisation/infection.
- "Rectal and tracheal aspirate (ventilated patients) cultures were collected upon admission to the ICU and weekly thereafter until discharge or transfer out of the ICU."
- Patients included if they received their first ever recorded positive result as part of this initial/admission screening.

Assessment of evidence

- "A patient was considered CPE cleared when he/she had two or more negative surveillance cultures from the initial source (rectal or respiratory), and other CPE were not isolated from any other clinical cultures." If clinical culture was initial trigger – a negative sample was required from the same associated site.
- "Patients included in the final analysis [n=75] were followed for a median time of 83 days (IQR, 36-241 days) and a maximum of 1,754 days (58 months)."
- "The median time from first detection to last CPE positive culture was 24 days (Range, 0-1,252)."
- "Overall median time for clearance was 80 days (Range, 16-457). Of the 25 cleared patients, 15 (60%) cleared within 3 months, 19 (76%) within 6 months, 22 (88%) within one year, and all 25 by 15 months."
- "Recurrence was detected in 8 (32%) of the cleared patients; the median time to recurrence was 40 days (Range, 10-671 days)."
- Selection bias (excluded those patients who did not have more than one follow up screen/sample).
- "In our cohort, we found that 21 of the cases never demonstrated positive results in rectal surveillance cultures but did show positive results from respiratory specimens."
- Patients were followed up until they met the definition of clearance or for "patients with prolonged carbapenemase-producing *Enterobacteriales* (CPE) carriage were censored when last seen in any of the system facilities or at the end of the study period." Significant limitation – follow up time varied between patients.

Regardless of limitations the following conclusions can be drawn:

- Recurrence is an issue.
- Establishing clearance time for some pathogens can be challenging due to wide variability.
- Can be challenging to establish when colonisation initially occurred - to then evaluate clearance time.
- Clinical site of sampling may affect results.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Centers for Disease Control and Prevention. Frequently asked questions (FAQs) about enhanced barrier precautions in nursing homes. 2022. Date accessed: 26 August 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

- Suggestion that if less impaction on patient activity/interaction with staff/visitors precautions can be implemented for longer.

Stopping enhanced barrier precautions:

- Usually for duration of stay, especially for MDROs where a negative test is not necessarily indicative of clearance.
- Resolution of the wound.
- Removal of indwelling device that placed them at high risk.

Stopping contact precautions:

- Should be time limited and, when implemented, should include a plan for discontinuation or de-escalation.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Jiwani RA, Mao Y, Pona A, et al. Discontinuation of transmission precautions for COVID-19 patients: polymerase chain reaction diagnostics, patient delays, and cycle threshold values. Infect Dis Clin Pract (Baltim Md). 2021 Sep; 29(5):e287-e293.	Retrospective cohort study	**Level 3**	Retrospective chart review	N/A	Length of stay. Days in isolation unit. Symptom history. PCR test results. Date appropriate for discharge or isolation discontinuation based on a symptom-based strategy.
Assessment of evidence					
Setting: US, hospitalized patients within the Vidant Health system. 34 COVID-positive hospitalized patients who had repeated PCR tests >3 days from their first positive test result. Retrospective patient record assessment to evaluate the impact of a test-based strategy for discontinuation of COVID-19 transmission precautions. Evidence of patients testing positive via PCR test after a previously negative test Evidence of patients testing positive 30 days or more post symptom onset (n= 6/34).					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Richey LE, Oh Y, Tchamba DM, et al. When should contact precautions be discontinued for patients with methicillin-resistant Staphylococcus aureus? Am J Infect Control. 2017; 45(1):75-76.	Prospective cohort study	**Level 3**	Study aimed to determine "the proportion of patients known to be MRSA positive who remained positive more than a year after their initial positive culture, and to identify characteristics that would predict positivity."	N/A	N/A

Assessment of evidence

Setting: US

Active surveillance (on admission and weekly) for patients, during study period (October 2010 to March 2014), known to have been colonized or infected with methicillin-resistant *S. aureus* (MRSA) for at least one year. This resulted in inclusion of 408 patients who had their initial MRSA diagnosis 416-5,668 days before their admission screen.

Assessed risk factors associated with persistent carriage: age, sex, hospitalization within the past year, presence of a wound or foreign body, receipt of antibiotics at the time of active surveillance culture (ASC), hemodialysis, and residence in a group setting – not addressed further due to bias of differing lengths of time since diagnosis and concept that sicker patients may have been hospitalised more recently/frequently with greater opportunity to pick up MRSA positivity.

Of 408 patients with a minimum year long history of MRSA:

Assessment of evidence
• 67 were positive on admission. • Of 181 who were re-screened, eight were positive following this second test. • Of 173 who were screened a third time, six were positive following this third test. The number of days between first-known positive MRSA culture to admission ASC was associated with lower risk for having MRSA detected during the study (odds ratio [OR], 0.99; 95% confidence interval [CI], [0.99-1.00]; p = 0.03). Having an admission screen performed more than five years since the first known positive MRSA culture was associated with lowest risk (OR, 0.45; [95% CI, 0.25-0.79]; p = 0.005). 144 patients had their admission screen done more than five years from their first known MRSA-positive culture and just over 4% were positive during the study period. Evidence of recurrence and/or unreliable test results. A single admission screen of those diagnosed with MRSA colonisation/infection >1y ago, missed 3.4% of cases. Patients testing positive for MRSA five years after initial diagnosis.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health England. Infection control precautions to minimise transmission of acute respiratory tract	Expert opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
infections in healthcare settings. October 2016. Date accessed: 21 September 2022					

Assessment of evidence

[NC] = no citations.

Does not apply to TB, MERS-CoV or human cases of avian influenza.

Guidelines supplement but do not replace local risk assessment.

“The infectious period (or period of communicability) […] varies by pathogen and by individual.”

“For many acute respiratory viral infections the infectious period is unknown; for practical purposes it is often assumed to equate to the duration of symptoms.” [NC]

“In general, infectiousness is greatest in the early stages of infection.” [NC]

“The infectious period for influenza is thought to be from about one day before the onset of symptoms until 3−5 days later.” [NC]

“Children, immunocompromised individuals and seriously ill people may remain infectious for a longer period, and action should be considered to minimise prolonged shedding of influenza virus by patients with risk factors.” [NC]

“Patients with pertussis infection may be infectious until three weeks after the onset of the paroxysmal phase of the disease.” [NC]

“As a general rule, the duration of isolation precautions for hospitalised patients should be continued for 24 hours after resolution of fever and respiratory symptoms.” [NC]

“For prolonged illness with complications such as pneumonia, control measures should be used during the duration of acute illness until symptoms and signs of respiratory disease have resolved.” [NC]

Assessment of evidence
“In some circumstances, testing for viral persistence may be helpful to ascertain whether isolation needs to be continued.” [NC] “Immunosuppressed patients may remain infectious for a longer time period, particularly respiratory viral infections.” [NC] “The decision to discontinue isolation should be based on assessment of the patient’s clinical condition and, where available, testing for persistence of virus should be considered.” [NC]

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. management of multidrug-resistant organisms in healthcare settings. 2006. Date last updated: 2017. Date accessed: 5 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
Expert opinion piece provided by CDC with the Healthcare Infection Control Practices Advisory Committee (HICPAC). Author affiliations provided covering wide representation in infection control.					

Assessment of evidence
"The 1995 HICPAC guideline for preventing the transmission of VRE suggested three negative stool/perianal cultures obtained at weekly intervals as a criterion for discontinuation of Contact Precautions." "There is a paucity of information in the literature on when to discontinue Contact Precautions for patients colonized with a MDR-GNB, possibly because infection and colonization with these MDROs are often associated with outbreaks" [NC]. "In general, it seems reasonable to discontinue Contact Precautions when three or more surveillance cultures for the target MDRO are repeatedly negative over the course of a week or two in a patient who has not received antimicrobial therapy for several weeks, especially in the absence of a draining wound, profuse respiratory secretions, or evidence implicating the specific patient in ongoing transmission of the MDRO within the facility." [NC] Recommendations: "V.A.5.e. In home care settings V.A.5.h. * Discontinuation of Contact Precautions. No recommendation can be made regarding when to discontinue Contact Precautions. Unresolved issue (See Background for discussion of options)."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Australian Government, National Health and Medical Research Council. Australian guidelines for the prevention and control of	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
infection in healthcare. 2019. Date last updated: September 2022. Date accessed: 7 October 2022.					
Assessment of evidence					
“Transmission-based precautions remain in effect for limited periods of time until signs and symptoms of the infection have resolved, or according to recommendations from infection control professionals specific to the infectious agent”. [NC] Table A2.5 outlines the category of precautions that should be undertaken as well as their duration based firstly on syndrome/condition and secondly by pathogen/organism. Table A2.5 demonstrates that multiple categories of precautions may need to be implemented until the cause of the condition is established or illness ceases, for example, regarding Meningitis, standard and droplet precautions should implemented. “If cause of meningitis is bacterial, S + D precautions can be ceased after 24 hours of antibiotic treatment is complete. If cause of meningitis is viral, use standard precautions.” Examples of different transmission based precaution (TBP) ceasing criteria, for example, duration of illness, until all lesions dry and crusted over, until off antimicrobial treatment and culture negative, 24 hours after symptoms cease, until 24 hours after initiation of effective therapy, for seven days after onset of jaundice; for duration of hospitalisation for children <3 years etc. [NC]					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Department of Health and Health Protection Agency. Prevention and control of infection in care homes - an information resource. 2013. Date accessed: 10 October 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

This expert opinion is described as “An information resource to assist staff in taking all reasonable steps to protect residents and staff from acquiring infections and prevent cross infection; and to provide information and guidance on infection prevention and control that will assist managers in undertaking risk assessments and in developing policies” which applies only to England.

Target audience for these guidelines “Care Trust CEs, GPs, Communications Leads, Consultants in Communicable Disease Control, Community Infection Control Nurses, Health Protection Nurses, Care Home Managers, Care Quality Commission”.

In a table (Appendix 2) they provide a “period of infectivity” description per specific diseases or causative pathogens. Period of infectivity differs greatly and in specificity between diseases or causative pathogens, with some specific to a period of time after symptoms have passed and some before symptom onset.

Examples include:

- “Not infectious”.
- “Until treated”.

Assessment of evidence
• “While diarrhoea persists”. • “Infectious for 1–2 days before the onset of symptoms and 6 days after rash appears or until lesions are crusted (if longer).” • “Until lesions crusted”. • “Until 48 hours after treatment”. • “Variable, but unlikely to infect others by 48 hours after diarrhoea stops unless poor hygiene/ Incontinent. ” • “Incubation period of 14–17 days. (range 14 – 21). Individuals are infectious from about one week before, and at least four days after, the onset of the rash. ” • “For life”. • “While symptomatic”. Demonstrates the complexity in infectious periods and difficulty in defining discontinuation criteria. Limitations: • Specific to care homes. • No citations provided.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Banach DB, Bearman G, Barnden M. SHEA expert guidance: duration of contact precautions for acute-care settings. Infection Control & Hospital Epidemiology. 2018; 39(2).	Expert opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence

Expert opinion document written by authors consisting of current (at the time) and past members of the Society for Healthcare Epidemiology of America (SHEA) Guidelines Committee (GLC). Document references “Handbook for SHEA-Sponsored Guidelines and Expert Guidance Documents”, in 2015 (accessed 2017), this is a living document with no version control. Therefore, cannot be assessed as a guidance document.

Define special topic expert guidance (EG) documents as “developed to address areas of relatively narrow scope that lack the level of evidence required for a formal guideline but are important for the provision of safe and effective healthcare. As such, systematic grading of evidence level is not provided for individual recommendations. Each EG is based on a synthesis of limited evidence, theoretical rationale, current practices, practical considerations, the opinion of the writing group, and consideration of potential harms where applicable.”

Articles collected between 1 January 1990 and 1 April 2016. Screened by two reviewers. The EG was also informed by a survey of the SHEA Research Network (SRN). “Consensus around each recommendation was reached through anonymous rating and comment period. This EG was reviewed and approved by the SHEA Guidelines Committee, the SHEA Publications Committee, and the SHEA

Assessment of evidence

Board of Trustees. This EG was endorsed by the Association for Professionals in Infection Control and Epidemiology (APIC), the Society of Hospital Medicine (SHM), and the Association of Medical Microbiology and Infectious Disease Canada (AMMI Canada)."

Respondents to the SRN: "healthcare epidemiologist (75.3%), infection committee chair (54.6%), and infection preventionist (26%). These individuals indicated that they are involved in patient care (40.3%), teaching (40.3%), clinical research (31.2%), and administration (18.9%)" from "60.5% were academic medical centers, 18.4% were community teaching hospitals with academic affiliations, and 7.9% were community hospitals with no academic affiliations."

Purpose of document:

- "This expert guidance document (EG) provides recommendations regarding discontinuation of contact precautions (CP) at the individual patient level in acute-care hospitals employing CP for 1 or more of the following organisms: methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Clostridium difficile*, and multidrug-resistant *Enterobacteriaceae* (MDR-E), including carbapenem-resistant *Enterobacteriaceae* (CRE) and extended-spectrum β-lactamase (ESBL)–producing organisms."
- Rationale provided (with citations or results of SRN where applicable) for each set of recommendations per organisms as well as background information on current recommendations of discontinuation, duration and size of colonisation for each organisms.

Recommendations –

MRSA:

1. "If a hospital uses CP for patients previously colonized or infected with MRSA, we recommend establishing a policy for the discontinuation of CP for MRSA."
2. "For patients not on antimicrobial therapy with activity against MRSA, we recommend negative screening cultures to guide decisions about discontinuation of CP. The optimal number of negative cultures needed is unclear, though 1–3 negative cultures are often used. The anterior nares are a common site of culture sampling, though the literature is unclear regarding the optimal site and the role of extra-nasal sampling."

Assessment of evidence

3. “For high-risk patients, such as those with chronic wounds or patients from long-term care facilities, we recommend extending CP from the last MRSA-positive culture, prior to assessing for CP discontinuation.”
4. “Outside an outbreak setting, if a facility’s endemic rates of MRSA infection are low, the hospital may consider the alternative approach of using CP for patients with active MRSA infection for the duration of the index admission and discontinuing CP on hospital discharge. In adopting this approach, a hospital should monitor facility MRSA infection rates, maximize and consider monitoring use of standard precautions, and minimize patient cohorting to avoid intrafacility transmission. If the hospital’s MRSA infection rates increase, the hospital should transition to a screening culture–based approach for discontinuation of CP”.

Vancomycin-Resistant Enterococci (VRE):

1. “If a hospital uses CP when caring for patients colonized or infected with VRE, we recommend establishing a policy for discontinuation of CP for VRE.”
2. “We recommend that following treatment of VRE infection, the hospital use negative stool or rectal swab cultures to guide decisions about the discontinuation of CP. The optimal number of negative cultures needed is unclear, though 1–3 negative cultures, each at least 1 week apart if multiple cultures are obtained, are often used.”
3. “Hospitals should consider extending CP prior to assessing for CP discontinuation in VRE infected patients who are (1) highly immunosuppressed, (2) receiving broad spectrum systemic antimicrobial therapy without VRE activity, (3) receiving care in protected environments (e.g,, burn units, bone marrow transplant units, or settings with neutropenic patients), or (4) receiving care at institutions with high rates of VRE infection.”
4. “Outside an outbreak setting and if facility endemic rates of VRE infection are low, the hospital may consider the alternative approach of using CP for patients with active VRE infection for the duration of the index admission and discontinuation of CP on hospital discharge. In adopting this approach, hospitals should monitor VRE infection rates, maximize and consider monitoring use of standard precautions, and minimize patient cohorting to avoid intrafacility transmission. If institutional VRE infection rates increase, the hospital should transition to a screening culture–based approach for discontinuation of CP.”

Assessment of evidence

Multidrug-Resistant *Enterobacteriaceae* (MDR-E):

1. "If a hospital uses CP for patients infected or colonized with MDR-E (ESBL-E and/or CRE), we recommend establishing a policy for discontinuation of CP for MDR-E that includes the following:
    a) Maintaining CP for ESBL-E and CRE for the duration of the index hospital stay when infection or colonization with these bacteria is first detected.
    b) Considering discontinuation of CP on a case-by-case basis, taking into account the following criteria: (1) at least 6 months have elapsed since the last positive culture; (2) presence of a clinical infection and ongoing antibiotic use, where discontinuation of CP should be discouraged in the setting of suspected or known infection with ESBL-E or CRE, and concurrent broad spectrum antibiotic use that may select for these organisms; and (3) procurement of an adequate number of screening samples, with at least 2 consecutive negative rectal swab samples obtained at least 1 week apart to consider an individual negative for ESBL-E or CRE colonization."
2. "We recommend that for extensively drug-resistant *Enterobacteriaceae*, such as carbapenemase-producing CRE, or *Enterobacteriaceae* with very limited treatment options (susceptible to ≤2 antibiotic classes used to treat that organism), hospitals should maintain CP indefinitely."

C. difficile:

1. "We recommend that patients with *C. difficile* infection (CDI) receive care with CP for at least 48 hours after resolution of diarrhea."
2. "Hospitals should consider extending CP through the duration of hospitalization if elevated rates of CDI are present despite appropriate infection prevention and control measures."
3. "At this time, insufficient evidence exists to make a formal recommendation as to whether patients with CDI should be placed on CP if they are readmitted to the hospital."

General Screening or molecular testing as methods:

"Microbiological Screening and Molecular Testing. At this time, insufficient evidence exists to make a formal recommendation supporting the use of molecular testing for the purpose of discontinuation of CP for MDROs.

Assessment of evidence
Rationale. While we assume that polymerase chain reaction (PCR) tests perform with superior sensitivity compared to culture, due to lack of high-quality studies at this time, we cannot definitively ascertain the impact of molecular methods on informing the duration of colonization and guiding decisions about CP." Limitations: • "Although the organisms addressed are frequently encountered in other settings (e.g., nursing homes, long-term acute-care facilities, rehabilitation centers, outpatient medical care settings), additional considerations may affect the application of these recommendations outside the acute-care hospital environment."

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Association for Professionals in Infection Control and Epidemiology. Guide to infection prevention in emergency medical services. 2013.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
"The purpose of this guide is to provide Emergency Medical Services (EMS) system responders and their organizations with a practical resource to infection recognition and prevention in the EMS environment. This guide contains current information, recommendations, regulations, resources, program examples, and forms to utilize in the EMS system responder setting."					

Assessment of evidence
No methods provided as to how evidence was obtained for formulating this guide. Authors affiliations are varied including: representation from fire department; professors in biosecurity and emergency medicine; medical/ clinical coordinators; and an EMS program manager. Duration of a work restriction (and definition of this) per disease/problem is provided in Table 2.2 of these guidelines. These are given a category (IA, IB, II). Duration varies greatly with disease/problem, examples include: • "Until discharge ceases" (conjunctivitis). • "Until symptoms resolve" (diarrheal disease). • "Until antimicrobial therapy completed and 2 cultures obtained 24 hours apart are negative" (diphtheria) . • "Until 7 days after onset of jaundice" (hepatitis A) • "Until lesions heal" (herpes simplex) • "From beginning of catarrhal stage through 3rd week after onset paroxysms or until 5 days after start of effective antimicrobial therapy" (pertussis active). • "Until 5 days after start of effective antimicrobial therapy" (pertussis post exposure). "Category IA - Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies. Category IB - Strongly recommended for all hospitals and reviewed as effective by experts in the field and a consensus of Hospital Infection Control Practices Advisory Committee members on the basis of strong rationale and suggestive evidence, even though definitive scientific studies have not been done. Category II - Suggested for implementation in many hospitals. Recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretic rationale, or definitive studies applicable to some but not all hospitals. No recommendation; unresolved issue - Practices for which insufficient evidence or consensus regarding efficacy exists." Source of this table is stated to be a CDC guideline in 1998:

Assessment of evidence
Bolyard EA, Tablan OC, Williams WW, et al. Guideline for infection control in healthcare personnel. Hospital Infection Control Practices Advisory Committee [published correction appears in Infect Control Hosp Epidemiol 1998 Jul;19(7):493]. *Infect Control Hosp Epidemiol*. 1998;19(6):407-463.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Public Health Agency of Canada. Routine Practices and additional precautions for preventing the transmission of infection in healthcare settings. 2013. Date last updated: November 2016. Date accessed: 1 November 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Assessment of evidence
[NC] = no citation. “The HCW is responsible for:

Assessment of evidence

- ensuring patients are not subjected to unnecessary additional precautions
- ensuring that precautions are reviewed daily, adjusted if indicated by new information and discontinued when no longer indicated". [NC]

The organisation is responsible for "identifying the person responsible for modifying or discontinuing precautions". [NC]

Contact precautions should be discontinued after signs and symptoms of the infection have resolved or as per the pathogen specific recommendations. "The duration of precautions should be determined on a case-by-case basis when patient symptoms are prolonged or when the patient is immune suppressed. The patient with persistent symptoms should be re-evaluated for underlying chronic disease. Repeated microbiological testing may be warranted."

"There are insufficient data at present on which to base recommendations for discontinuation of precautions for patients colonized with antibiotic-resistant microorganisms. Decisions should be made locally, taking into consideration the specific microorganisms, the patient population and local experience with duration of colonization. These policies should be updated as data become available."

For home care (contact precautions): precautions should be discontinued when the patient is asymptomatic.

Droplet precautions should be discontinued after signs and symptoms of the infection have resolved or as per the disease-specific recommendations in Table 5. Duration of precautions should be determined on a case-by-case basis when patient symptoms are prolonged or when the patient is immune suppressed. The patient with persistent symptoms should be re-evaluated for underlying chronic disease. Repeat microbiological testing may sometimes be warranted.

For varicella: The patient should remain in the room until all lesions have crusted. "Exposed susceptible contacts should be placed in single airborne infection isolation room from seven days after the first possible exposure until 21 days after the last exposure."

For measles: the patient should remain in the room until four days after onset of rash or for the duration of illness, if immunocompromised. Exposed susceptible contacts should be placed in single airborne infection isolation rooms from five days after the first possible exposure until 21 days after the last exposure, regardless of vaccine administration.

Airborne precautions should be discontinued after signs and symptoms of the infection have resolved or as per the disease-specific recommendations in Table 5.

Assessment of evidence
Handling the deceased: “airborne precautions should be continued for the handling of a patient with infectious respiratory tuberculosis, measles or varicella until appropriate time has elapsed to remove airborne contaminants in the room.” “Sufficient time should be allowed for the air to be free of aerosolized droplet nuclei before housekeeping performs terminal cleaning, or the housekeeper should wear a respirator.” Tables 4 and 5 outline possible influential factors regarding discontinuation of TBPs: duration of symptoms, following specific period of treatment/anti-microbial therapy, negative test/culture results, a certain number of consecutive negative tests/culture results, until infection ruled out, duration of drainage, until normal stools, while lesions present, a certain number of days following onset of a specific symptom, until all lesions are dry, until organism cleared, cultures from specific body sites are negative, during hospitalisation, specific number of days since last exposure, unknown, negative cultures from specific time periods (morning), while viable micro-organisms are in drainage, until a certain age, for example, one year old, until drainage resolved or contained by dressings. Many entries are blank.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
World Health Organization. Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014.	Expert Opinion	**Level 4**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Date accessed: 7 November 2022.					
Assessment of evidence					
“Additional precautions for patients with all ARIs should be maintained for the duration of symptomatic illness (rather than various durations depending on the pathogen and patient information, as was previously recommended)”. [NC] For all acute respiratory infections (ARIs): “Always implement Standard Precautions. Implement additional IPC precautions at the time of admission, and continue for the duration of symptomatic illness, modifying according to the pathogen and patient information. Do not routinely use laboratory tests to determine the duration of IPC precautions, as there is no evidence that this is effective”. SARS: “The duration of infectivity for SARS is not well defined. Although it has been reported that conversion to a negative reverse transcriptase-polymerase chain reaction (RT-PCR) may take a long time (median 30 days, longest 81 days), the clinical and epidemiological significance of this conversion is not known. In studies in Hong Kong SAR, China, no SARS-CoV could be cultured from clinical samples once the infected patients became asymptomatic.”					

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Theodore DA, Greendyke WG, Miko B, et al. Cycle thresholds among solid organ transplant recipients testing positive for SARS-CoV-2.	Retrospective observational study	**Level 3**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Transplantation. 2021; 105(7):1445-1448.					

Assessment of evidence

This retrospective observational study aimed to address the gap in knowledge regarding removal of transmission-based precautions when treating solid organ transplant (kidney, liver, lung, heart) patients who were SARS-CoV-2 positive. The study was undertaken by reviewing medical records (specifically cycle threshold (Ct) of E-gene from PCR tests) of patients admitted to Columbia University Medical Centre, New York, US between 13 March and 15 May 2020.

All patients were tested on admission and then again at the discretion of clinical staff and a test-based strategy for discontinuation of precautions was implemented throughout the study period. Ct<40 was considered positive, and clinical characteristics were recorded for patients with Ct<34 at day 20 after symptom onset (after first positive test for asymptomatic patients).

Sixty patients were identified during the study period. Of the 47 patients that had a test collected on or after day 20, 23 were positive for SARS-CoV-2. OF these 23 patients, only 17 had tests with E-gene Ct available. Ten of these 17 patients had E-gene Ct values <34. Across these ten patients, three had persistent symptoms, six had improved symptoms, and one developed symptoms after day 20 and these resolved while they remained positive.

While no specific indications for removal of contact precautions are provided by this study, its findings do highlight that discontinuation of contact precautions may need to differ between patient groups.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Morone G, Palomba A, Iosa M, et al. Incidence and persistence of viral shedding in COVID-19 post-acute patients with negativized pharyngeal swab: a systematic review. Front Med. 2020;7.	Systematic Review	**Level 1+**	N/A	N/A	N/A

Assessment of evidence

This systematic review pooled 55 studies (37/55 studies reported continuous values and thus were included in statistical analysis) suggesting COVID-19 viral shedding, defined as the duration of positivity (days since symptom onset or first positive test to last available positive test), may be determined from respiratory or faecal samples. However, the duration times vairy depending on the sample type, with faecal samples more likely to have a longer duration. Duration of positivity appears to be significantly associated with disease severity, which could pose as a potential indicator for viral shedding. This study also suggests children may shed COVID-19 for longer than adults.

In summary, in the context of COVID-19, factors to consider for determining viral shedding may be disease severity and age (adults or child), with acknowledgement that different sample types (respiratory and faecal) may have an impact on this.

Limitations:

- No I^2 statistic provided to establish heterogeneity between studies.
- No funnel plot analysis for publication bias, although study acknowledges potential for this in discussion.

Assessment of evidence
• Viral RNA detection in majority of studies, opposed to viable RNA, making assumption shedding means infectious. • Likely to be heterogeneity in parameters to define duration of infection, for instance, one negative test or two consecutive negative tests. • May not generalise to UK health and care setting, no studies from UK included, studies conducted mainly in China.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Siegel JD, Rhinehart E, Jackson M, et al. 2007 guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Date last updated: May 2022. Date accessed: 6 September 2022.	Expert Opinion	**Level 4**	N/A	N/A	N/A
Assessment of evidence					
“Transmission-Based Precautions remain in effect for limited periods of time (i.e., while the risk for transmission of the infectious agent persists or for the duration of the illness”. [NC]					

Assessment of evidence

"For most infectious diseases, this duration reflects known patterns of persistence and shedding of infectious agents associated with the natural history of the infectious process and its treatment."

"For some diseases (e.g., pharyngeal or cutaneous diphtheria) Transmission-Based Precautions remain in effect until culture or antigen-detection test results document eradication of the pathogen".

"For other diseases, (e.g., *M. tuberculosis*) state laws and regulations, and healthcare facility policies, may dictate the duration of precautions."

"In immunocompromised patients, viral shedding can persist for prolonged periods of time (many weeks to months) […] therefore, the duration of contact and/or droplet precautions may be prolonged for many weeks."

MDROs:

It may be prudent to assume that MDRO carriers are colonised permanently as:

- Even though MRSA has an effective decolonization regimen there is evidence that carriers of MRSA, "who have negative nasal cultures after a course of systemic or topical therapy, may resume shedding MRSA in the weeks that follow therapy."
- The CP discontinuation criteria for VRE of three negative stool cultures, obtained at weekly intervals, may fail to detect colonization that can persist for >1 year.
- "available data indicate that colonization with VRE, MRSA, and possibly MDR-GNB, can persist for many months, especially in the presence of severe underlying disease, invasive devices, and recurrent courses of antimicrobial agents."

"an interval free of hospitalizations, antimicrobial therapy, and invasive devices (e.g., 6 or 12 months) before reculturing patients to document clearance of carriage may be used."

Formal Recommendations:

- "Extend duration of Transmission-Based Precautions, (e.g., Droplet, Contact) for immunosuppressed patients with viral infections due to prolonged shedding of viral agents that may be transmitted to others".

Assessment of evidence

- "Discontinue Contact Precautions after signs and symptoms of the infection have resolved or according to pathogen-specific recommendations in Appendix A". [NC]
- "Discontinue Droplet Precautions after signs and symptoms of the infection have resolved or according to pathogen-specific recommendations in Appendix A". [NC]
- "Discontinue Airborne Precautions according to pathogen-specific recommendations in Appendix A." [NC]

Appendix A features a large table with a list of infections/conditions, type of precaution, duration of precaution and a section for other 'precautions/comments'.

Some contradictions, for example, major draining abscess indicates duration of precautions for duration of illness but then states, "until drainage stops or can be contained by dressing". Examples of duration guidance include: until one year of age, if nasopharyngeal and urine cultures repeatedly negative after three months of age (do you need both types of culture, how many repeats?), duration of illness, until off antimicrobial treatment and culture negative, until 24 hours after initiation of effective therapy, until 48 hours after resolution of symptoms or to control outbreak, until lesions dry and crusted, until five days after the onset of swelling, until four days after onset of rash unless immunocompromised then for duration of illness, for duration of hospitalisation if immunocompromised, and so on.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Richards V, Tremblay E. Assessment of current methicillin-resistant Staphylococcus aureus screening protocols and	Retrospective observational study	**Level 3**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
outcomes at an academic medical center American Journal of Infection Control. 2019; 47:906-910.					

Assessment of evidence

This retrospective study assessed the current policy for removal of contact precautions for patients with MRSA in a 972-bed academic medical centre in Florida, US. This study included patients screened for MRSA between 1 January 2010 and 31 December 2017. Swab collection was also assessed for "correctness" by assigning swabbing a pass or fail. To fail, one of three events would have occurred; 1) >1 nasal swab was collected on the same day, 2) a nasal swab was collected on the same day as an extra-nasal clinical culture (for the purpose of diagnosing or treating active MRSA collection), or 3) a nasal swab was taken within the active infection period (<30 days).

Indication for removal of contact precautions was a patient being free from MRSA infection and the collection of 2 negative MRSA swab tests (collected from anterior nares) on separate days.

Within the study period, 8,310 patients were screened for MRSA, accounting for 11,601 nasal swabs. When following the current indication for removal of contact precautions, 559 patients were removed from contact precautions. However, assessment of the "correctness" of swabbing found that 81 patients were incorrectly removed from contact precautions, for instance, these patients had at least one "failing" swab sample. This finding indicates that the current indications for removal of contact precautions are inadequate at correctly predicting when contact precautions should be removed for MRSA patients. The authors of this study suggest increasing the number of negative tests required for removal of contact precautions.

Limitations:

- Single swabbing site (anterior nares).
- US setting.

Assessment of evidence
• Retrospective design.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Killingley B, Greatorex J, Cauchemes S, et al. Virus shedding and environmental deposition of novel A (H1N1) pandemic influenza virus: interim findings. Health Technology Assessment. 2010; 14(46):237-354.	Observational study with air sampling	**Level 3**	Shedding of virus from subject into environment and association with symptom duration/symptom severity. Air sampling and viability for influenza virus.	Symptom score and viral shedding. Mean shedding duration for those on antivirals vs those not. Comparing particle counts at distances 3ft vs 7ft.	Virus shedding (nose swab) and environmental deposition (fomites and air) as measured by PCR and virus culture techniques. Particle size distribution (µm). Daily symptom scores. Medication logs.

Assessment of evidence
This limited observational study carried out in the UK involved 43 participants (23 adults, 20 children). The study suggests viral shedding of H1N1 influenza virus (determined through air and environmental sampling) to occur for a median time of 6.2 days ranging three to 10 days when determined by PCR, and a median of 4.7 days ranging three to eight days when determined by culture, with no significant difference between adults and children. Limitations: • Inclusion of subjects from community, may not generalize to health and care settings. Hospitalized subjects only initial environmental samples from hospital, later ones from community.

Assessment of evidence
• No specific cleaning protocol for households, will introduce variation. • Subjects were not stationary during air sampling “though they were asked to remain in the same position if they could”, distance from the subject to the sampler may have varied. • Proportion of subjects had antiviral medication (54%). • Lower bound for culture of live virus shedding range calculated through assumptions (median duration 2.9 days, range 0-8). • More than one infected persons in room at time of air sampling on occasion. • No baseline measurements or settle time allowed for air sampling.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Shrestha SK, Sunkesula VCK, Kundrapu S, et al. Acquisition of Clostridium difficile on hands of healthcare personnel caring for patients with resolved C. difficile infection. Infection Control & Hospital	Observational study	**Level 3**	N/A	N/A	N/A

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Epidemiology. 2016; 37(4):475-477.					

Assessment of evidence

This observational study used contamination of healthcare worker hands as an indicator for carriage of *C. difficile* infection (CDI) after contact precautions have been removed. The study was undertaken in a medical centre in the US over a 4-month period, where the local policy was to remove contact precautions two days after the completion of CDI treatment as long as diarrhoea was resolved with treatment.

A convenience sample of healthcare worker (HCW) hands was sampled for toxigenic *C. difficile* before and after providing care for patients with current, recent, or remote CDI. A comparison group of HCWs providing care for patients with no history of CDI on wards with no CDI patients within the previous four weeks was also sampled. Cultures were obtained using premoistened sterile gauze pads, wiping the entire surface of both hands, before culturing by broth enrichment.

Cultures were obtained during 93 encounters with 53 patients. 4-5% of HCWs had CDI contaminated hands before patient care. Hand contamination occurred as frequently during care of patients with recently resolved CDI as during care of patients with current CDI infection (12% and 21%, respectively, $p=0.20$). Hand contamination was significantly less common following care of patients with no or remote CDI (5% and 3%, respectively, $p<0.05$).

Glove use during patient interactions was also noted during the study with gloves worn during all interactions with patients with current CDI, but only 17% of interactions with recent CDI. It was reported that gloves were not worn in any of the interactions with patients with remote or no CDI. A positive corelation between duration of the interaction and contamination of hands was also identified ($p<0.0001$).

The findings of this study suggest that the current local policy of removing contact precautions two days after end of CDI treatment may not be sufficient to prevent onward transmission, and so extension of the period between end of treatment and removal of contact precautions.

Limitations:

- US setting.

Assessment of evidence
• Small sample size. • Single centre study. • Molecular typing not undertaken to confirm CDI links. • Cannot confirm source of hand contamination (patients or environment). • Activities undertaken during patient interactions not reported.

Study	Study Type	Evidence Level	Intervention	Comparison	Outcome measure
Vikram HR, Dumigan DG, Kohan C, et al. Discontinuation of contact precautions for patients no longer colonized with methicillin-resistant Staphylococcus aureus. Infect Control Hosp Epidemiol. 2010; 31(5):541-543. Date last updated: July 2010.	Prospective study	**Level 3**	N/A	N/A	N/A

Assessment of evidence

Setting: US.

This prospective study assessed the use of surveillance cultures to identify previous MRSA carriers without current colonisation for the discontinuation of contact precautions The study was undertaken in a community teaching hospital in the US between 15 March and 5 September 2004.

In patients that were under contact precautions were identified and patients without positive MRSA culture in the previous six months were included in the analysis of this study. Swabs were used to collect samples from both anterior nares, any wound that is present, and both axillae and perineum (when no wound present). Samples were inoculated onto blood agar and incubated at 37˚C for 48 hours. *S. aureus* colonies were tested for coagulase production, those that were coagulase-positive were screened for methicillin resistance. Medical records were retrospectively reviewed to assess if any antibiotics were prescribed to included patients during the 72-hour period before culture swabs were obtained.

Current indication used for discontinuation of contact precautions was three consecutive negative MRSA cultures. If no cultures yielded MRSA, patients were considered no longer colonised and contact precautions were removed.

Surveillance samples were collected immediately following a negative result from the previous set (usually >48 hours after collection of the previous set). If previous surveillance sampling or clinical specimens were MRSA-positive, collection of subsequent samples was abandoned.

The correct specimens were available for 98 patients who were readmitted with no MRSA-positive culture results from the previous six months, 57 of these patients remained colonised with MRSA after three sets of surveillance cultures. Twenty one of the 98 included patients had three sets of negative surveillance cultures and were removed from contact precautions. Of the 57 patients that remained colonised, 12 would have been missed if only one set of cultures was obtained and five would have been missed if only two sets of surveillance culture had been obtained.

These findings support the use of three consecutive MRSA-negative cultures to identify patients that can have contact precautions removed.

Limitations:

- Single centre study.

Assessment of evidence
• Small sample size. • US setting • Sampling times for MRSA positive patients unclear.