Health Protection Scotland

NHS National Services Scotland

Cystic Fibrosis Literature Review:

Infection Prevention and Control for patients with Cystic Fibrosis

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Purpose:	To inform the National Infection Prevention and Control Manual in order to facilitate the prevention and control of healthcare associated infections associated with Cystic Fibrosis patients.
Target audience:	All NHSScotland staff involved in the prevention and control of infection in Scotland.
Circulation list:	Infection Control Managers, Infection Prevention and Control Teams, Public Health Teams
Description:	This literature review examines the available professional literature on infection prevention and control for cystic fibrosis patients.
Update/review schedule:	Updated in real time with changes made to recommendations as required.
Cross reference:	National Infection Prevention and Control Manual
Update level:	Practice – ***No significant change to practice*** Research – ***No significant change to research***

Contents

1. Topic

Infection prevention and control for cystic fibrosis.

2. Background

Cystic fibrosis (CF) is an inherited condition that affects over 900 people in Scotland.[1] People with CF are susceptible to respiratory infections, which are a leading cause of morbidity and mortality in this population.[2] In addition to recognised pathogens, such as *Pseudomonas aeruginosa*, *Burkholderia cepacia* complex and *Staphylococcus aureus*, novel Gram-negative non-fermenter bacteria and non-tuberculous mycobacteria (NTM) have gained clinical significance.[2] While the majority of pathogens in people with CF are acquired from the environment, there is strong evidence of person-to-person transmission within and outside of healthcare settings.[2] The NTM *Mycobacterium abscessus* complex has become a pathogen of increasing concern in people with CF, with recent evidence for person-to-person transmission and outbreaks in CF treatment centres.[3-5]

Updated infection prevention and control guidance for CF commissioned by the Cystic Fibrosis Foundation (USA), and *Mycobacterium abscessus* infection prevention and control guidance published by the Cystic Fibrosis Trust (UK) were published in 2018.[6;7] However, there is currently no comprehensive Scottish guidance. In response to increasing concerns around transmission of respiratory pathogens between people with CF, a need for Scottish cystic fibrosis infection prevention and control guidance was identified.

3. Aim

To carry out a literature review to inform the development of cystic fibrosis infection prevention and control guidance.

4. Objectives

- To identify and review relevant published cystic fibrosis infection prevention and control guidance documents, and assess whether they are suitable for adoption in Scotland.

- To identify and review relevant published scientific literature on infection prevention and control for cystic fibrosis, and produce graded evidence statements.

5. Research questions

The following research questions were addressed:

Neonatal

- What additional standard infection prevention and control (SICPs) measures should be applied for CF neonatal patients in the healthcare setting (inpatient and outpatient)?
    - Should CF inpatients always be cared for in a single room?
    - Is negative pressure isolation required for CF inpatients?
    - Is there a minimum recommended number of air changes in rooms where CF in/outpatients are placed/managed?
    - Should CF in/outpatients be routinely segregated from others with or without CF?
    - Is routine (SICPs) PPE adequate when assessing/caring for CF in/outpatients?
    - Is there a PPE requirement for patients when in an outbreak situation?
    - Is routine (SICPs) equipment and environmental decontamination adequate for CF in/outpatients?
    - What prevention measures can be taken at home?

Paediatric

- What additional standard infection prevention and control (SICPs) measures should be applied for CF paediatric patients in the healthcare setting (inpatient and outpatient)?
    - Should CF inpatients always be cared for in a single room?
    - Is negative pressure isolation required for CF inpatients?
    - Is there a minimum recommended number of air changes in rooms where CF in/outpatients are placed/managed?
    - Should CF in/outpatients be routinely segregated from others with or without CF?
    - Is routine (SICPs) PPE adequate when assessing/caring for CF in/outpatients?
    - Is there a PPE requirement for patients when in an outbreak situation?
    - Is routine (SICPs) equipment and environmental decontamination adequate for CF in/outpatients?

  - What prevention measures can be taken at home?
- What infection control measures should be applied for CF paediatric patients out with the healthcare setting e.g. schools, travel/holidays?

Adult

- What additional standard infection prevention and control (SICPs) measures should be applied for CF adult patients in the healthcare setting (inpatient and outpatient)?
  - Should CF inpatients always be cared for in a single room?
  - Is negative pressure isolation required for CF inpatients?
  - Is there a minimum recommended number of air changes in rooms where CF in/outpatients are placed/managed?
  - Should CF in/outpatients be routinely segregated from others with or without CF?
  - Is routine (SICPs) PPE adequate when assessing/caring for CF in/outpatients?
  - Is there a PPE requirement for patients when in an outbreak situation?
  - Is routine (SICPs) equipment and environmental decontamination adequate for CF in/outpatients?
  - What prevention measures can be taken at home?
- What infection control measures should be applied for CF adult patients out with the healthcare setting?
- Is there any guidance for adults with CF employed as healthcare, school or nursery workers?

6. Definitions

Segregation: Throughout this document the term segregation is used as organising/scheduling CF patients according to clinic i.e. segregation in **time** rather than a place.

Routes of transmission: There are three main routes of transmission for respiratory infections namely, airborne, droplet and contact (indirect or direct). The NIPCM[8] defines each of them as follows:

Airborne (aerosol) transmission: "The spread of infection from one person to another by airborne particles (aerosols) containing infectious agents".[8] Aerosols are small particles of <5µm diameter. A recent literature review published by HPS highlighted that "certain healthcare

activities and procedures termed 'aerosol generating procedures' (AGPs) can generate aerosols, and create the potential for airborne transmission of infections that may otherwise only be transmissible by the droplet route".[9]

Droplet transmission: "The spread of infection from one person to another by droplets containing infectious agents".[8] Droplets are larger than aerosols with a >5μm diameter.

Contact transmission: "The spread of infectious agents from one person to another by contact. When spread occurs through skin-to-skin contact, this is called direct contact transmission. When spread occurs via a contaminated object, this is called indirect contact transmission".[8]

7. Methodology

Search Strategy

Google searches were carried out to identify relevant guidance documents.

NHS Evidence was searched to identify relevant guidance documents.

The following databases were searched to identify relevant academic literature:

- MEDLINE
- EMBASE
- CINAHL

Search terms were developed and adapted to suit each database.

In addition to this, reference lists of the identified academic articles were screened for relevant documents.

Exclusion criteria

Academic literature and guidance were excluded from the review on the basis of the following exclusion criteria:

- Item was not in English
- Item did not concern infection prevention and control for cystic fibrosis (off-topic)

Screening

There was a two-stage process for screening the items returned from the literature searches. In the first stage, the title/abstract was screened against the exclusion criteria by the reviewer. Items that were not excluded at the screening stage were progressed to the second screening stage. In the second stage of the screening process, the full texts of remaining items were screened against the exclusion criteria by the reviewer. Items that were not excluded at the second screening stage were included in the review.

Critical appraisal

Guidance documents were appraised using the AGREE tool. Included academic literature was critically appraised using SIGN 50 methodology.

8. Recommendations

Should CF inpatients be cared for in a single room?

Patients with CF should be cared for in en-suite single rooms regardless of their respiratory culture.

(AGREE rating: Recommend)

There are no specific recommendations for adult, paediatric or neonatal patients.

Is negative pressure isolation required for CF inpatients?

Negative pressure isolation rooms may be considered, when these are available, for patients whose sputum is positive for *Mycobacterium abscessus* complex.

(Grade D Recommendation)

Inclusion of negative pressure isolation rooms should be considered when designing new healthcare facilities.

(Good practice point)

In outbreak situations patients whose sputum is positive for *Mycobacterium abscessus* complex should be placed in negative pressure rooms.

(Grade D Recommendation)

Pulmonary Function Tests (PFTs)/spirometry should ideally be performed in a negative pressure room where these are available. Alternatively, PFTs should be performed in a single inpatient or outpatient room or in a respiratory function laboratory. Room doors should be closed during and after the procedure to allow sufficient time for air contamination to decrease (see Appendix 5). The use of microbiological filters in PFT equipment may limit aerosol dispersion in the room.

(AGREE rating: Recommend)

(Grade D Recommendation)

Is there a minimum recommended number of air changes in rooms where CF in/outpatients are placed/managed?

All patients with CF should be assessed/managed in rooms with a minimum of 6 ACH.

(Mandatory)

(Grade D Recommendation)

There is no specific recommendation for adult, paediatric or neonatal patients.

Should CF in/outpatients be routinely segregated from others with or without CF?

Regardless of patient's respiratory culture result, patients' time in waiting rooms and other shared areas should be minimal. Patients should be transferred to a consulting/examination room as soon as possible after arrival to reduce sharing common areas with other people with CF. Strategies should be implemented to reduce patients' time in shared areas (e.g. use of fast-track appointment systems).

(AGREE rating: Recommend)

(Grade D Recommendation)

Patients should avoid self-check in stations as these can become contaminated and CF patients may congregate there.

(Good practice point)

Patients with suspected or confirmed infection/colonisation with *M. abscessus* should be segregated from **all other** patients with CF, regardless of their respiratory culture result. Separate all CF patients individually during the clinic, organising:

- the use of communal areas (e.g. play facilities, cinemas); and
- attendance at diagnostic, treatment and pharmacy facilities.

(Grade D Recommendation)

Patients with suspected or confirmed infection/colonisation with *Burkholderia cepacia* complex or *P. aeruginosa* should be segregated from **all other** patients with CF, regardless of their respiratory culture result.

(Grade D recommendation)

CF patients with suspected or confirmed infection/colonisation with *M. abscessus* complex, *Burkholderia cepacia* complex, *P. aeruginosa* or any other multi-drug resistant organisms (MDROs) should be segregated from non-CF patients who are immune compromised (e.g. haemato-oncology patients).

(Good practice point)

Newly diagnosed individuals with CF should be separated from other people with CF until their parents/guardians have received appropriate training/education regarding IP&C for CF.

(AGREE rating: Recommend)

Is routine (SICPs) PPE adequate when assessing/caring for CF in/outpatients?

Contact precautions should be implemented when caring for inpatients and outpatient patients with CF, regardless of their respiratory culture. Healthcare workers should wear disposable gloves and aprons when caring for CF patients.

(AGREE rating: Recommend)

(Grade D Recommendation)

Healthcare workers should consider disposable gowns when aprons provide inadequate cover to uniform/clothing to the task or procedure to be performed (e.g. chest physiotherapy).

(Good Practice Point)

Patients may wish to use surgical masks at all times when in a healthcare facility, excluding examination rooms, their hospital room and during PFTs.

(Good practice point)

(Grade D Recommendation)

Healthcare workers should consider wearing fluid repellent surgical masks (FRSMs) when caring for CF patients under droplet precautions (e.g. adenovirus), known or suspected to be infected with *Mycobacterium abscessus* complex, or if spraying or splashing of body fluids is anticipated.

(AGREE rating: Strongly recommend)

(Good Practice Point)

Healthcare workers should wear FFP3 respirators when caring for CF patients under airborne precautions (e.g. performing AGPs).

(AGREE rating: Recommend)

Healthcare workers and other members of staff should perform hand hygiene following the NIPCM:

1. before touching a patient;
2. before clean/aseptic procedures. If ABHR cannot be used then antimicrobial liquid soap should be used;
3. after body fluid exposure risk;
4. after touching a patient; and
5. after touching a patient's immediate surroundings.

Wash hands with non-antimicrobial liquid soap and water if:

- hands are visibly soiled or dirty;
- caring for patients with vomiting or diarrhoeal illnesses; or
- caring for a patient with a suspected or known gastro-intestinal infection e.g. norovirus or a spore forming organism such as Clostridium difficile.

In all other circumstances use ABHRs for routine hand hygiene during care.

(Mandatory)

There are no specific recommendations for adult, paediatric or neonatal patients.

What PPE for patients is recommended in an outbreak situation?

During an outbreak situation (as defined in section 3.1 of the NIPCM) patients should be recommended to use surgical masks at all times when in a healthcare facility, excluding examination rooms, their hospital room and during PFTs.

(AGREE rating: Recommend)

Is routine (SICPs) equipment and environmental decontamination adequate for CF in/outpatients?

Room surfaces and equipment should be decontaminated between CF patients. This should be carried out following equipment decontamination recommendations in the NIPCM.

(AGREE rating: Recommend)

(Grade D Recommendation)

Rooms should be decontaminated after an inpatient with positive respiratory culture for *M. abscessus* is discharged and after any aerosol generating procedures (AGPs, see appendix 4). The room decontamination should be carried out by staff trained in room decontamination procedures.

(AGREE rating: Recommend)

(Grade D Recommendation)

If a patient with CF has *M. abscessus* or any other MDRO, consideration may be given to the use of Hydrogen peroxide vapour (HPV) as an adjunct to terminal room cleaning.

(Good Practice Point)

Sinks and showers should be decontaminated at least daily to avoid contamination from the environment.

(Grade D Recommendation)

Sterile water should be used for the final rinse after disinfection of respiratory equipment. Tap water should be used before disinfection and for steam disinfection.

(AGREE rating: Recommend)

(Grade D Recommendation)

Single-use disposable care equipment should be used for patients known or suspected to be infected with a microorganism spread by airborne (aerosol), droplet, or contact routes.

(Good Practice Point)

Nebulisers are for single-patient use only. **Disposable nebulisers** should be discarded every 24 hours. In addition to this, mouthpieces should be disinfected between uses with a 70% alcohol wipe. Between treatments, **reusable nebulisers** should be decontaminated (sterilised) after each use using either cold or heat methods, following manufacturer's recommendations. Nebulisers should be returned decontaminated to the patient before they leave the hospital. Decontaminated nebulisers should be allowed to air-dry.

(Mandatory)

(AGREE rating: Recommend)

(Grade D Recommendation)

Respiratory function equipment should be decontaminated following manufacturer's recommendations. Material's susceptibility to the different decontamination methods should be taken into account.[1]

(Good Practice Point)

Ergometers should be decontaminated with disposable cloth/paper towel after each patient use with a neutral purpose detergent solution.

(Good Practice Point)

Abdominal bands used as sleep study equipment should be washed after each use with a neutral purpose detergent solution. Alternatively, disposable bands should be used.

(Good Practice Point)

Valved-holding chambers from nebulisers should be made of antistatic material and cleaned in a neutral purpose detergent solution, rinsed and allowed to air-dry after use.

(Grade D Recommendation)

[1] The decontamination of respiratory equipment used by CF patients is under review.

Stethoscopes should be kept in the room, and be disinfected with 60- 70% isopropyl alcohol after and before each use.

(AGREE rating: Recommend)

(Grade D Recommendation)

(Mandatory)

Physiotherapists involved in the management of CF patients should have access to individual microbiological status that will facilitate assessment of risk of cross-transmission.

(Grade D recommendation)

Objects, such as toys or electronic devices should be brought from home by the patient and should not be shared amongst CF patients. Alternatively, healthcare decontamination schedules should clearly state who is responsible for and frequency of cleaning. Objects that are difficult to clean (e.g. soft toys) are discouraged.

(AGREE rating: Recommend)

There are no specific recommendations for adult, children or neonates.

What prevention measures can be taken at home?

Nebulisers should be cleaned and disinfected after each use. Cleaning should be carried out using water and detergent. Heat (e.g. boiling for 5 minutes, microwaving, placing in the dishwasher or baby bottle sterilizers) or cold methods (i.e. soaking in 70% isopropyl for 5 minutes or in 3% hydrogen peroxide for 30 minutes) should be used for disinfection. Whether to use heat or cold methods will be defined by the manufacturer's recommendations.

(AGREE rating: Recommend)

(Grade D Recommendation)

Patients should have their own respiratory devices, which should not be shared with other people with CF; this recommendation also applies to people living in the same household.

(AGREE rating: Recommend)

(Grade D Recommendation)

There are no specific recommendations for adult, paediatric or neonatal patients.

What infection control measures should be applied for CF adult and paediatric patients outwith the healthcare setting?

Individuals with CF should not have close physical contact (e.g. intimate contact, hand-shaking, kissing) with other people with CF. Individuals with CF should not share respiratory equipment and personal items. This recommendation includes those living in the same household.

(AGREE rating: Recommend)

(Grade D Recommendation)

CF specific social gatherings are discouraged. If more than one person with CF attends the same social gathering, they should adhere to good respiratory and cough hygiene measures as per section 1.3 of the NIPCM.

(AGREE rating: Recommend)

(Grade D Recommendation)

People with CF should not swim in stagnant water sources or poorly maintained swimming pools. However, people with CF can use swimming pools and water parks where water is disinfected (e.g. by chlorination).

(AGREE rating: Recommend)

(Grade D Recommendation)

Is there any guidance for adults with CF employed as healthcare, school or nursery workers?

Healthcare workers with CF should seek advice from Occupational Health.

(AGREE rating: Recommend)

(Grade D Recommendation)

Professionals with CF working at nurseries or at schools should adhere to good hygiene practices and cough etiquette. In addition, all professionals working in such setting must comply with the "Infection Prevention and Control in Childcare Settings" guidance.

(Good Practice Point)

9. Discussion

9.1. Implications for practice

Should CF inpatients always be cared for in a single room?

People with CF can be colonised/infected with pathogens that are transmissible to other CF patients via different transmission routes (i.e. direct or indirect contact, droplet and airborne transmission). It is therefore essential to limit this transmissibility by implementing effective infection prevention and control measures.

The NIPCM[10] recommends that only suspected/known infectious patients should be placed in single rooms. However, guidelines for CF suggest that all patients with CF should be cared for in en-suite single rooms.[6;11]

A recent study failed to find significant difference in *P. aeruginosa* acquisition between centres that included single room care for patients as part of a multitier measure and between those that did not.[12] However, results from this study should be interpreted with caution, since they did not analyse the effectiveness of each of the IPC measures separately.

(AGREE rating: Recommend)

(Grade D Recommendation)

Is negative pressure isolation required for CF inpatients?

Two different outbreak reports suggested that negative pressure isolation was effective to stop cross-infection of *M. abscessus subsp. massiliense.*[13;14] Nevertheless, evidence is scarce on whether this measure is required for other microorganisms, such as *P. aeruginosa*.

In a non-outbreak situation negative pressure may be considered for patients whose sputum is positive for *M. abscessus* complex.[15] Patient placement in negative pressure rooms may be influenced by the capability of the healthcare facility. In this regard, inclusion of negative pressure rooms should be considered when designing new healthcare facilities.

(Grade D Recommendation)

(Good practice point)

Air contamination can happen during PFTs due to aerosols generated during examination. An American guideline suggests that PFTs should ideally be performed in a negative pressure room.[6] Alternatively, PFTs should be performed in a single outpatient or inpatient room, or in a respiratory function laboratory.[15] Room doors should be closed during and after the procedure. Sufficient time should be allowed to elapse between patients to allow for air contamination to decrease.[6;16;17] The use of microbiological filters in PFT equipment may limit aerosol dispersion in the room.

(AGREE rating: Recommend)

(Grade D Recommendation)

Is there a minimum recommended number of air changes in rooms where CF in/outpatients are placed/managed?

The CF Trust recommends that CF patients should be cared for in well ventilated rooms.[15] In this regard, Scottish and English Health Technical Memorandums (HTMs) recommend that single rooms should have 6 ACH (see appendix 5).[18;19] Results from Knibbs et al. suggest that *"at 2 ACH, 90% of viable airborne Pseudomonas aeruginosa are removed in approximately 49min (95%CI 41 to 61 min), decreasing as ventilation rate increases to approximately 24min (95%CI 22 to 26min) at 5 ACH and to 13min (95%CI 12 to 13) at 10 ACH."*

(Mandatory)

(AGREE rating: Recommend)

(Grade D recommendation)

Should CF in/outpatients be routinely segregated from others with or without CF?

There was consensus in the literature that **all** CF patients' time in shared areas, such as waiting rooms, should be minimised;.[6;14;20;21] NICE[22] recommends the use of fast-track appointment systems for the management of patients with tuberculosis. The same or similar approach could be applied in healthcare facilities caring for/assessing individuals with cystic fibrosis.

(AGREE rating: Recommend)

(Grade D recommendation)

(Good practice point)

Although the guideline published in 2013 by the CF Foundation[6] and one single-cohort study found insufficient evidence to support CF patient segregation, the more recent guidelines published by the CF Trust recommended that CF patients with *M.abscessus* complex infection or colonisation should be segregated from **all** other CF patients.[15;23] In this regard, NICE guidelines recommend that *"each specialist cystic fibrosis clinic should be organised to prevent cross-infection"*.[24] Therefore, all individuals with CF should be separated individually by organising the use of communal areas and attendance at diagnostic, treatment and pharmacy facilities.[24]

The CF Trust also recommends that patients colonised/infected with *B. cepacia* complex should be segregated from **all other** patients with CF, regardless of their respiratory culture result.[7] In this regard, experts suggest that individuals with *B. cepacia* complex should be segregated according to the strain they have. [7]

Pseudomonas aeruginosa is commonly acquired by CF patients from the environment. Nevertheless, there is evidence that some strains of *P. aeruginosa* can also be transmitted from patient-to-patient (e.g. the Liverpool epidemic strain – LES).[7;25;26] In this regard, there is some evidence in the literature on the effectiveness of segregation of patients with CF that are colonised/infected with *P. aeruginosa.* Several studies found that segregation measures effectively reduced *P.aeruginosa* cross-infection between CF patients infected/colonised with *P. aeruginosa* and those without infection/colonisation.[26-28] Furthermore, some *P. aeruginosa* strains are linked to more complications than others, and are associated with higher mortality rates; it could therefore be argued that segregation by strain should be encouraged.[7;25;26] In this regard, an Australian study also found that segregation by cohorts significantly reduced the prevalence of the Australian epidemic strain-1 (AES-1), however it should be highlighted that this study did not study the impact of other changes in practice on the prevalence.[26]

In contrast, a Dutch study that analysed *P. aeruginosa* infection data before and after segregation was implemented outwith healthcare settings failed to obtain statistically significant results.[29]

(Grade D recommendation)

CF patients with suspected or confirmed infection/colonisation with *M. abscessus* complex, *Burkholderia cepacia* complex, *P. aeruginosa* or any other multiresistant organisms should be segregated from non-CF patients that are immunocompromised (e.g. haematology-oncology patients).

(Good practice point)

The CF Foundation recommends that newly diagnosed people with CF should be separated from other individuals with CF until their parents/guardians have received appropriate training/education regarding IP&C for CF.[6]

(AGREE rating: Recommend)

Is routine (SICPs) PPE adequate when assessing/caring for CF in/outpatients?

Different guidelines agreed that contact precautions should be implemented when caring/assessing CF patients.In this regard, staff should wear gloves and aprons/gowns when caring for or assessing CF patients.[6;15;20;30] In addition to this, the CF Trust[15] highlighted the importance of hand-washing after having contact with or the immediate environment of a patient with CF colonised or infected with *M. abscessus* complex.

(AGREE rating: Recommend)

(Grade D recommendation)

With regard to the use of masks by healthcare workers, the NIPCM[10] states that a FRSM must be *used "if splashing or spraying of blood, body fluids, secretions or excretions onto respiratory mucosa (nose and mouth) is anticipated/likely"* or *"to protect patients from the operator as a source of infection"*. The CF Foundation recommended that staff should wear surgical masks (FRSMs) or FFP3 respirators when caring for CF patients under droplet precautions or airborne precautions, respectively.[6]

(Mandatory)

(AGREE rating: Recommend)

(Grade D Recommendation)

There is still controversy on whether patients should wear masks in healthcare settings. Several guidelines suggested that CF patients should wear masks a when in a healthcare setting based on evidence regarding environmental contamination in hospitals.[6;20;31] However, a recent guideline by the CF Trust found insufficient evidence to support use of masks by patients.[30]

(Good practice point)

Different guidelines recommend that healthcare workers and other members of the staff should wash/rub their hands using water and soap or ABHR before and after having contact with or the immediate environment of a patient with CF colonised or infected with *M. abscessus* complex.[6;15] However, according to the NIPCM[10], hand hygiene should not be limited to specific pathogens and hand hygiene should be carried out in the following situations:

1. before touching a patient;
2. before clean/aseptic procedures. If ABHR cannot be used then antimicrobial liquid soap should be used;
3. after body fluid exposure risk;
4. after touching a patient; and
5. after touching a patient's immediate surroundings.

Wash your hands with non-antimicrobial soap and water if:

- hands are visibly soiled or dirty;
- caring for patients with vomiting or diarrhoeal illness; or
- caring for a patient with a suspected or known gastro-intestinal infection e.g. norovirus or a spore forming organisms such as *Clostridium difficile*.

In all other circumstances use ABHRs for touring hand hygiene during care.

(Mandatory)

What PPE for patients is recommended in an outbreak situation?

In spite of the controversy on whether patients should wear masks in healthcare settings, surgical masks should be worn by patients in outbreak situations to avoid cross-transmission of pathogens.[6;15;20] The NIPCM[10] defines a healthcare associated infection outbreak situation as:

- Two or more linked cases with the same infectious agent associated with the same healthcare setting over a specified time period; or
- A higher than expected number of cases of HAI in a given healthcare area over a specified time period.

(AGREE rating: Recommend)

Is routine (SICPs) equipment and environmental decontamination adequate for CF in/outpatients?

Several pathogens, such as, *P.aeruginosa*, *M. abscessus* complex or *B. cepacia* complex can be transmitted from patient-to-patient via direct or indirect contact, droplets and aerosol generation. [2;3;5;32] It is therefore essential to adhere to SICPs and TBPs guidance as per national infection prevention and control guidelines.[3;33]

A recent study demonstrated that cough aerosols of viable *Pseudomonas aeruginosa* survive at least 45 minutes in the environment and it is therefore essential that appropriate infection prevention measures are implemented.[17] In this regard, several American studies suggest that rooms, including examination rooms, should be cleaned between patients using a one-step cleaning and EPA registered hospital-grade disinfectant.[6;15;34;35] In Scotland, cleaning should be carried out following the NIPCM[10] which states 1,000ppm av. cl. should be used for disinfection of the care environment after patient discharge and routinely on sanitary fittings. Available literature regarding effectiveness of disinfectants against NTM is scarce; a recent experimental study concluded that some of the most commonly used biocides were not effective against NTM.[37] However, a recent study found that chlorine based disinfectant at high concentration (at least 1,000 ppm) were effective for decontamination. [36] Higher concentrations (e.g. 10,000ppm chlorine) should be used for considerable *P.aeruginosa* positive CF sputum spillages.[36]

After an inpatient with positive respiratory culture for *M. abscessus* complex is discharged or after aerosol generating procedures, room doors should be kept closed for at least an hour before cleaning the room, although this will depend on the airflow in the room.[3;14;15] Staff should be aware of their responsibilities and the frequency of cleaning required.[10]

(AGREE rating: Recommend)

(Grade D Recommendation)

In order to avoid cross-transmission all isolation rooms should be disinfected/terminally cleaned as per NIPCM between patients with *M. abscessus* complex positive respiratory cultures.[10] Room surfaces and equipment should be routinely decontaminated after AGPs.[3;14]

(Grade D Recommendation)

Rooms should be terminally cleaned after a CF patient with positive respiratory culture for *M. abscessus* complex is discharged to limit the potential for cross-infection. This should be done following the NIPCM.[10] In addition, *"bed screens, curtains and bedding should be removed prior to the room being decontaminated"*.[38] Although the CF Trust guideline[15] included an example protocol where hydrogen peroxide vapour (HPV) was used for terminal cleaning after discharge of patients with *M. abscessus* complex, we did not find evidence for or against this practice. However, *"hydrogen peroxide vapour may be considered as an additional measure following disinfection of vacated isolation rooms for patients colonised or infected"* with *M. abscessus* complex.[38] HPS does not recommend the routine use of HPV.[38]

(Good Practice Point)

In their study, Festini *et al.*[39] found that the prevalence of *P. aeruginosa* in sinks of an outpatient CF clinic was particularly high (44.3% of sampled sinks). In addition to this, they pointed out *P. aeruginosa* was also present inside sink drains within patient's WCs. This highlights the importance of cleaning and disinfecting to avoid cross-transmission of pathogens from inanimate surfaces. In this regard, chapter 2 of the NIPCM states that decontamination should be carried out at least daily.[10]

(Grade D Recommendation)

Water can be a source of different microorganisms.[40] Although tap water can be used before equipment disinfection, it is essential that only **sterile** water is used in the final rinsing of respiratory equipment (e.g. nebulisers). [6]

(AGREE rating: Recommend)

(Grade D Recommendation)

A previous literature review carried out by HPS concluded that *"single-use disposable care equipment should be used for patients known or suspected to be infected with microorganisms spread by airborne (aerosol), droplet, or contact routes"*.[38]

(Good Practice Point)

Nebulisers are single-patient use devices which can be reused by the same patient.[6;10] Two types of nebulisers are used in hospital settings. Disposable nebulisers; reused by the same patient for up to 24 hours, and reusable nebulisers. Several guidelines and academic articles suggest that nebulisers should be rinsed with sterile water after each use and be discarded after 24 hours.[4142] Nevertheless, a recent study concluded that it is safe to use these devices for up to 72h.[43]

Reusable nebulisers can be used for longer than 24 hours by the same patient (e.g. home nebulisers). These should be decontaminated after each use using either cold or heat methods, following manufacturer's recommendations. These, if taken into hospital should be returned to the patient before they leave the healthcare facility.[6] Decontaminated nebulisers should be allowed to air-dry.[6;42;44]

(Mandatory)

(AGREE rating: Recommend)

(Grade D Recommendation)

Respiratory function equipment should be decontaminated following manufacturer's recommendations.[45] Material's susceptibility to the different decontamination methods should be taken into account.[45]

One small experimental study concluded that non-invasive ventilation devices (NIV) did not get contaminated after use and suggested that cleaning the outside of the device is sufficient.[46] The same study found that use of ethylene oxide was not always effective for decontaminating NIV devices.[46] However, results of this study should be interpreted with caution due to its small sample size, other possible sources of contamination and lack of further studies to support this statement.

(Good Point Practice)[2]

[2] Section to be revised. Ongoing discussions with experts.

All non-invasive equipment should be decontaminated following appendix 7 of the NIPCM.[10] Ergometers should be wiped down after each patient use.[45] In addition, abdominal bands should be washed after each use. [45] Alternatively, disposable bands should be used.

(Good Point Practice)

Valved-holding chambers can be added to nebulisers and they serve as a spacer, allowing more space between the medicament and the mouth of the patient, which gives the patients more time for inhalation. These should be rinsed with water after cleaning with detergent and water. O'Malley[42] advised that rinsing the soap off could affect the electrostatic charge of the chamber, leaving the detergent to dry could cause contact dermatitis in patients. It is therefore preferable to use valved-holding chambers made of antistatic material.[42]

(Grade D Recommendation)

An American guideline, a single cohort study and the NIPCM agree that stethoscopes should be disinfected after and before each use, following manufacturer's recommendations.[6;10;47] Appendix 7 of the NIPCM[10] also states that stethoscopes, as reusable non-invasive care equipment, should be wiped using 60-70% isopropyl alcohol (not chlorine based products).

(Mandatory)

(AGREE rating: Recommend)

(Grade D Recommendation)

In the guidance document addressed to physiotherapists, the CF trust[30] recommended that physiotherapists should have access to individual microbiological status that will facilitate the assessment of cross-transmission risk.

(Grade D recommendation)

Toys and other objects used by patients while they are in healthcare facilities should be brought from home by patients.[6;20] Alternatively, healthcare facilities should have cleaning schedules that clearly state who is responsible for and the frequency of cleaning of these objects. In addition to this, the use of objects that are difficult to clean (e.g. soft toys) should be discouraged.[20]

(AGREE rating: Recommend)

What prevention measures can be taken at home?

Nebulisers get contaminated after use.[48] Therefore, it is essential that nebulisers are cleaned and disinfected after each use using appropriate methods, following manufacturer's recommendations.[6;42;48] Several methods can be used for nebuliser disinfection at home. Two consequent experimental studies demonstrated that baby bottle sterilisers can effectively disinfect nebulisers, whose parts should be taken apart, against different bacteria (i.e. *P. aeruginosa, S. aureus, B. cepacea, H. influenzae* and NTM).[49;50] Furthermore, patients should have their own respiratory devices.

(AGREE rating: Recommend)

(Grade D Recommendation)

Clearance devices, such as those used on positive expiratory pressure (PEP), can become contaminated after use by patients; therefore patients should have their own.[6;30;46;51] In spite of the evidence on clearance device contamination, there are no specific guidelines for airway clearance devices and there is insufficient evidence on the applicability of nebuliser disinfection guidelines for cleaning these devices.[51]

What infection control measures should be applied for CF adult/paediatric patients out with the healthcare setting?

The CF Foundation and the CF Trust discourage physical contact, including intimate contact or hand-shaking between individuals with CF.[6;7] Furthermore, the CF Trust also recommends that individuals with CF do not share cars unless they live in the same household. Since cross-transmission can occur from inanimate objects, personal items and respiratory equipment should not be shared between people with CF.[6;53] In this regard, a Danish study reported a cross-transmission of *Achromobacter rhulandii* between two friends.[53] The authors suggested that the cross-transmission happened despite the two girls were never in the same room although they played in the same house. [53]

(AGREE rating: Recommend)

(Grade D Recommendation)

Several studies and guidelines agreed that CF specific social gatherings should be discouraged based on a number of cross-infection cases reported in the literature.[3;6;53] Although Saiman *et al*.[6] discouraged attending CF educational programmes, which would congregate several people with CF in the same place, Riderberg *et al*.[54] did not find sufficient evidence to support this statement.

(AGREE rating: Recommend)

(Grade D Recommendation)

Water is a known source of different pathogens.[56] Use of stagnant water sources, Jacuzzis or poorly maintained swimming pools is not recommended for people with CF.[6;56] However, people with CF can use/swim in pools and water parks where water is disinfected (e.g. by chlorination).[6;56]

(AGREE rating: Strongly recommend)

(Grade D Recommendation)

There is no evidence to suggest that people with CF should not swim in natural water sources with flowing water (e.g. the ocean, lochs).

At school[3], children with CF should not be in the same classroom as other children with CF, unless they live in the same household.[6;55] The CF Foundation[6] also agrees on the importance of teachers receiving training and complying with local infection control principles to reduce contact between individuals with CF.

In order to limit/avoid the transmission of pathogens between children with CF, the CF Trust[55] recommend that children with CF should adhere to cough etiquette and should be encouraged to regularly wash hands with soap and water or with alcohol gels. This is particularly important after coughing, sneezing and playing with possibly contaminated sources (e.g. water or mud).

The CF Trust[55] also recommends that classrooms are appropriately ventilated, which can be achieved by regularly opening the windows.

Stagnant water, and moist sand or soil can grow bacteria and fungi that can be harmful for CF children. Therefore, at school, pre-school children with CF should be provided with fresh water and dry sand to play. Toys that can store stagnant water in the inside must be avoided.[55]

[3] Advice for school children will be provided on a patient leaflet.

Is there any guidance for adults with CF employed as healthcare, school or nursery workers?

A cross-sectional study suggested that CF individuals that work as healthcare workers are at a greater risk of acquiring MRSA compared to people with CF that work in other areas.[57] Accordingly, the CF Foundation[6] recommends that strategies should be implemented in order to reduce risk of transmission of different pathogens between patient and healthcare worker with CF. In this regard, the CF Foundation recommended that CF healthcare workers should not work with CF patients and that it should be assessed case-by-case whether they should take care of non-CF patients.

(AGREE rating: Recommend)

(Grade D Recommendation)

There is no evidence for specific recommendations regarding adults with jobs other than healthcare workers. In this regard, more research is required. However, it could be argued that people with CF working at schools should follow recommendations written for school children (i.e. complying with good hygiene practices, cough etiquette and avoiding being in the same room as other individuals with CF). In addition, all professionals working in such settings must comply with the “Infection Prevention and Control in Childcare Settings”[58] guidance.

9.2. Implications for research

This literature review identified several gaps in the extant literature.

Firstly, this literature review did not find any evidence on the effectiveness of existing methods for terminal decontamination of a hospital room after a patient with *M. abscessus* complex is discharged.

Although, the CF Trust suggested that HPV can be used for this purpose based on a hospital cleaning protocol, further research is required on the effectiveness of this method against *M. abscessus* complex. A literature review carried out by HPS in 2016 did not identify any study that assessed the effectiveness of this method for *M. abscessus* complex.[15;59]

Secondly, although squalamine is not an approved disinfectant in the UK an experimental study obtained promising results about its effectiveness as a disinfectant for nebulisers contaminated with *S. Aureus, P. aeruginosa* and *Candida Albicans,* but not for *Asperigillus Niger*.[60]

Thirdly, Manor *et al.*[51] reported that guidelines for cleaning nebulisers are not effective for cleaning airway clearance devices. Future studies should focus on what methods can be used for this purpose. These studies should include the frequency of cleaning required and the methods that should be used.

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Appendix 1: Medline Search

Ovid MEDLINE(R) 1946 to present with daily update

AND

1 (all "OR")	2 (all "OR")
Cystic fibrosis/ Cystic fibrosis.mp.	Infection control/ Infection control.mp. Hygiene/ Decontamination/ Disinfection/ Cross infection/ Patients isolation/ Communicable Diseases/

Limits

English language
Publication Year 2012-current

Results: 153

Appendix 2: EMBASE Search

Ovid EMBASE 1946 to present with daily update

AND

1 (all "OR")	2 (all "OR")
Cystic fibrosis/ Cystic fibrosis.mp.	Infection control/ Infection control.mp. Hygiene/ Decontamination/ Disinfection/ Cross infection/ Patients isolation/ Communicable Diseases/

Limits

English language
Publication Year 2012-current

Results: 501

Appendix 3: CINAHL Search

AND

1 (all "OR")	2 (all "OR")
MH Cystic Fibrosis AB cystic fibrosis	MH Infection Control TX infection control MH Hygiene MH Sterilisation and Disinfection MH Cross Infection MH Patient Isolation MH Communicable Diseases MH Equipment Contamination TX cleaning

Limits

English language
Publication Year 2012-current

Results: 81

Appendix 4: AGP List from HPS, 2017 (pag. 19)[61]

- Intubation and extubation
- Manual ventilation
- Open suctioning
- Cardiopulmonary resuscitation
- Bronchoscopy
- Surgery and post-mortem procedures involving high-speed devices
- Some dental procedures (e.g. drilling)
- Non-invasive ventilation (NIV) e.g. Bi-level Positive Airway Pressure (BiPAP) and Continuous Positive Airway Pressure ventilation (CPAP)
- High-Frequency Oscillating Ventilation (HFOV)
- Induction of sputum

Appendix 5: Recommended air-change rates, appendix 1 from HFS (2014)[18]

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
General ward	S / N	6	-	G4	30	18-28	
Communal ward toilet	E	10	-ve	-	40	-	
Single room	S / E / N	6	0 or –ve	G4	30	18-28	
Single room WC	E	3	-ve	-	40	-	
Clean utility	S	6	+ve	G4	40	18-28	
Dirty utility	E	6	-ve	-	40	-	
Ward Isolation room	-	-	-	-	-	-	See SHPN 4; Supplement 1
Infectious disease Iso room	E	10	-5	G4	30	18-28	Extract filtration may be required
Neutropenic patient ward	S	10	+10	H12	30	18-28	
Critical Care Areas	S	10	+10	F7	30	*18-25*	Isolation room may be –ve press
Birthing Room	S & E	15	-ve	G4	40	*18-25*	Provide clean air-flow path
SCBU	S	6	+ve	F7	30	*18-25*	Isolation room may be –ve press
Preparation room (Lay-up)	S	>25	35	F7*	40	*18-25*	*H12 if a lay-up for a UCV Theatre
Preparation room / bay sterile pack store	S	10	25	F7	40	*18-25*	*50NR if a bay in a UCV Theatre
Operating theatre	S	25	25	F7	40	*18-25*	
UCV Operating theatre	S	25*	25	H12	40	*18-25*	Fresh air rate; excludes re-circulation
Anaesthetic room	S & E	15	>10	F7	40	*18-25*	Provide clean air-flow path
Theatre Sluice/dirty utility	E	>20	-5	-	40	-	
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path
Cardiac catheterisation lab	S	15	+ve	F7	40	*18-22*	
Endoscopy room	S	15	+ve	F7	40	*18-25*	
Endoscopy cleaning	E	>10	-ve	-	40	-	
Day case theatre	S	15	+ve	F7	40	*18-25*	
Treatment room	S	10	+ve	F7	35	*18-25*	
Pharmacy aseptic suite	S	20	#	H14	-	*18-22*	# See EGGMP (Orange guide) a
Cat 3 or 4 containment room	#	>20	#	H14*	-	*18-22*	# See ACDP guide; *Filter in extract
Post mortem room	S & E	S = 10 E = 12	-ve	G4	35	*18–22*	Provide clean air-flow path
Specimen store	E	-	-ve	-	-	-	Fan accessible from outside of store

Table A1 continued

Notes: 18°C-22°C indicates the range over which the temperature may float

18°C-22°C indicates the range over which the temperature should be capable of being controlled

S = supply N = natural ventilation

E = extract [a] – European guidelines on good manufacturing practice published by the Medicines and Healthcare products Regulatory Authority (MHRA)