Prevention and management of healthcare ventilation system-associated infection incidents/outbreaks

HPS are aware of the limitations of current guidance in this area and are currently working towards delivery of comprehensive evidence-based guidance which will form Chapter 4 of the National Infection Prevention and Control Manual (NIPCM). In the interim, this **aide memoire** provides best practice recommendations to ensure clinical staff, estates and facilities staff, and Infection Prevention and Control Teams (IPCT) have an understanding of the preventative measures required and the appropriate actions that should be implemented in the event of a healthcare ventilation system-associated infection incident/outbreak. Evidence is derived from outbreak reports, (Scottish and International) and the HPS rapid review of HAI Infection Risks and Outbreaks Associated with Healthcare Ventilation Systems.

1. Infectious agents associated with ventilation systems

The below list includes the infectious agents which have been **identified in the literature**. **NB this list is not exhaustive, and is not intended for use as an alert organism list**. The alert organisms list (Appendix 13 of the NIPCM) should be used in conjunction with local Board surveillance data i.e. a greater than expected rate of infection/colonisation compared with the usual background rate for that healthcare location, and local teams should consider if further investigation is required.

Acinetobacter baumannii

Acremonium kiliense

Alternaria spp.

Aspergillus spp.

Bacillus cereus

Cryptococcus spp.

Mucorales (*Rhizomucor, Cunninghamella bertholletiae, Lichtheimia corymbifera*)

Paecilomyces variotti

Penicillium spp.

Phialemonium spp.

Propionibacterium acnes

Pseudomonas aeruginosa

Serratia marcescens

Staphylococcus aureus

Stenotrophomonas maltophilia

2. Potential sources of ventilation system-associated infections

- **Influx of external fomites (dust and other particulate):** from any activity that creates an airflow disturbance with associated release of particulate matter, for example nearby construction work, earthmoving, landscaping, helicopter movement from hospital helipads, bird activity. Improper access for maintenance and improper closing of filter/inspection access doors may also allow ingress of fomites.

- **Contaminated ventilation system**: any component that supports the growth/survival of an infectious agent, e.g. insulation material, filters, noise-dampening materials, humidifiers, condensation drip pans, condensate traps, cooling coils, heating batteries, air-conditioning units, grilles, vents, ducts.

3. Causes of ventilation system-associated infections

- **Failure of design:** owing to inadequate assessment of risk, for example placement of air intake/exhaust in high risk areas (i.e. intake/exhaust louvres on the building external envelope adjacent to helipads, vegetation or vehicle movement, and internally mounted air supply/extract terminals placed above clinical wash hand sinks or adjacent to sluices), installation of systems/components that do not meet the requirements of the facility/climate/usage, poor access to components that require audit/maintenance/cleaning, inadequate quality checks and sign-off during design and commissioning phases of any new build/remodel.

- **Noncompliance with optimal operation:** any activity that disrupts pre-established air flows or pressure differentials (doors or vents to pressurised rooms being left open, high person traffic in operating theatres, inactivation of the system during quiet times/overnight); any inappropriate activity that results in non-compliance with optimal operation.

- **Inadequate cleaning and/or maintenance:** overdue filter replacements, accumulation of debris/dust in grilles/vents, deteriorated insulation material.

4. Transmission routes

Transmission routes identified in the literature include:

- **Direct:** inhalation of infectious agents
- **Indirect**: contact with contaminated environment, equipment, healthcare workers hands
- **Aerosolisation**: when the ventilation system facilitates dispersal of an infectious agent not usually transmitted via the air

5. Infections associated with ventilation systems

These include: bloodstream, respiratory, skin and soft tissue infection (SSTI), surgical site infection including orthopaedic and cardiac, and eye infections (endophthalmitis). Direct infection via inhalation, contamination of open skin/wounds, or contamination of medical surfaces/devices was reported in all cases.

6. High risk patient groups/settings

High risk patients are those who are defined in the literature as immunocompromised (having an impaired immune system) as a result of their disease or treatment and may include the following (please note this list is not exhaustive):

- those patients whose immune mechanisms are deficient because of immunologic disorders (e.g. human immunodeficiency virus [HIV] infection or congenital immune deficiency syndrome);
- patients with chronic diseases (e.g. diabetes, cancer, emphysema, or cardiac failure);
- patients undergoing immuno-suppressive therapy (e.g. radiation, cytoxic chemotherapy, anti-rejection medication, or steroids);
- patients who are severely neutropenic for prolonged periods of time (i.e an absolute neutrophil count [ANC] of ≤ 500 cells/mL);
- allogeneic Haemopoietic Stem Cell Transplantation patients;
- renal dialysis patients.

High risk settings i.e. those inpatient settings identified in ventilation system-associated incidents/outbreaks, include neonatal, paediatric and adult ICUs, renal, haematology, oncology and bone marrow transplant units, respiratory units, operating departments, burns units and other care areas where patients have extensive breaches in their dermal integrity.

Clinical judgement is required to assess individual patient risk for any patient not being managed in these high risk settings.

7. Definitions of ventilation system-associated incidents/outbreaks (refer to Chapter 3 of the NIPCM)

- A **single** case of infection or two or more cases of colonisation with an alert organism (as per Appendix 13 of the NIPCM) in a **high risk setting/patient** of which there is evidence of acquisition within that healthcare setting (i.e. occurring ≥48 hours after admission), will require investigation to exclude the possibility of linked cases (including historic), which could indicate an **outbreak,** or an ongoing contamination issue.
- In addition to this, the following scenarios may require further investigation depending on the clinical presentation and the infectious agent;
    - a single case of colonisation or infection **at any time** from point of stay in the **neonatal ICU**;
    - a single case **in any setting** where the infection episode and/or causative infectious agent is very rare/novel or highly antibiotic-resistant.
- In all other situations, the trigger for further investigation would be two or more linked cases with the same infectious agent associated with the same healthcare setting over a specified time period.
- If further linked cases have been identified, a more extensive investigation will be required to exclude all potential sources. If there is an indication of an association with healthcare ventilation, consideration should be given to conducting environmental sampling. For environmental sampling guidance, see the Irish Health Protection Surveillance Centre's National Guidelines for the Prevention of Nosocomial Aspergillus.
- All teams should be notified of any construction, renovation, repair, or demolition activities within the healthcare setting and in the nearby vicinity (e.g nearby earthmoving) which could increase both the risk of environmental contamination and ventilation system-associated infection.

8. Preventing an incident/outbreak

Ventilation system maintenance

- For all settings, ventilation systems will require maintenance and cleaning; cleaning schedules should incorporate regular visual inspection of ventilation grilles for lint and dust accumulation.
- High risk settings should be included in a Planned Preventive Maintenance (PPM) programme that includes pressure/air flow monitoring equipment of all ventilation systems.
- As a minimum, ventilation systems supplying high-risk settings should be inspected quarterly and their performance measured and verified annually.

- If a system serving a high-risk area is consistently identified as poor regarding compliance with minimum standards and/or maintenance quality at the quarterly inspections, consideration should be given to adjusting the maintenance plan or to repairing/refurbishing/replacing all or part of the system.

Care activities

- Depending on local guidance/policy, antifungal prophylaxis may be recommended for patients at high risk of developing infection (for example invasive aspergillosis), e.g. hematopoietic stem cell transplant (HSCT) recipients with graft-versus host disease (GVHD) and neutropenic patients with acute myelogenous leukaemia (AML) or myelodysplastic syndrome (MDS).

The care environment

- Highly immunocompromised patients should be managed in a positively-pressured high efficiency particulate air (HEPA)-filtered environment.
- Windows should be sealed in all high-risk settings and window designs should avoid the use of internal window ledges to prevent build up of dust.
- Specific additional guidance for high-risk settings includes daily wet-dusting of all horizontal surfaces using cloths moistened with a healthcare approved detergent, avoidance of flowers (fresh or dried) or potted plants within the setting and use of vacuum cleaners equipped with HEPA filters.

9. Specific considerations for planned construction/renovation activity

The following actions are required to reduce patients' exposures to dust and environmental contamination:

- Multiple disciplines and stakeholders must be involved in pre-emptive planning; the Healthcare Associated Infection System for Controlling Risk in the Built Environment (HAI-SCRIBE) tool should be used to assess and manage the risk of infection.
- IPCTs should be notified prior to any construction/renovation activities in the healthcare facility; and should take note of any construction/earthmoving activities in the vicinity of the healthcare facility (such activities should ideally be reported to the NHS site by the contractor however the mechanisms to enable this have yet to be determined).
- High-risk patients should avoid all hospital construction/renovation areas and any outside areas where landscaping/earthmoving is occurring. Where this is not possible, these patients should wear surgical fluid-resistant face masks when outside of inpatient rooms, in order to reduce potential exposure to infectious agents.

- Placement of adhesive floor strips outside the door(s) to the construction area to trap dust.
- Sealing of any windows, doors and roof-space to control dust.
- Installation of temporary sealed partitions where appropriate.
- Daily vacuuming of affected areas with HEPA-filtered vacuum cleaners.
- Damp-mopping of the area just outside the door(s) to the construction area to trap dust.
- Removal of construction material/debris in containers with tightly fitting lids, or covering debris with wet sheets to reduce dust dispersal.
- Targeted environmental sampling in and around high-risk areas can be employed as a measure of enhanced surveillance during any healthcare building works; the frequency of this should be determined by the IPCT, microbiology department, and estates and facilities. Although there are no nationally agreed standards relating to fungal air sampling; an exposure level of < 5 CFU/m^3 of *Aspergillus* spp. in high-risk areas and < 0.1 CFU/m in HEPA-filtered environments, with limits of 15 CFU/m^3 for total colony counts of all fungal organisms, has previously been recommended.[1, 2] (*N.B.* A number of outbreaks reported that air-monitoring resulted in no detectable fungal counts; negative results should therefore be interpreted with caution due to the possible sporadic release of spores).
- Records should be maintained to evidence when the above measures are implemented, at all stages of the project i.e. design, planning, construction, commissioning, handover, and ongoing planned maintenance.

10. Managing an incident/outbreak

In conjunction with Chapter 3 of the NIPCM, the following actions should be considered. Please note that responsibilities may differ according to local policy.

Clinical staff
☐ Clinical cases have been isolated or cohorted if appropriate.
☐ Patients identified as high-risk for infection that are not currently being cared for within a protective environment have been moved to a positively-pressured, HEPA-filtered environment following a risk assessment.
☐ Single use care equipment is in use wherever possible; other care equipment (such as commodes, lifting equipment) is dedicated to a single patient.
☐ All reusable care equipment is decontaminated between each use using a cleaning agent with 1000 parts per million (ppm) available chlorine (av cl.) as per Appendix 7 of the NIPCM.
Estates and facilities staff
☐ A visual inspection of the ventilation system supplying the suspected area/environment has been conducted to identify any physical deterioration, accumulation of lint/dust/debris, areas indicative of colonisation with fungal microbes or presence of vermin, and any other non-compliances; filters should be properly installed and of the appropriate grade for the clinical area being served.
☐ A visual inspection of surrounding areas/spaces adjacent to system components (i.e. intake vents) has been conducted to identify any high risk activities/design flaws/indicators of vermin or contamination (this should include external intake vents/air conditioning units located outdoors).
☐ An inspection of the air-flow/pressure differentials within the setting to identify any non-compliances; this should also include a review of past air-flow/pressure audits.
☐ A review of all ventilation system cleaning, maintenance and filter change activities in the preceding months has been conducted.
☐ Environmental cleaning protocols for the clinical area(s) affected have been reviewed with input from IPCT and domestic services.
IPCT
☐ A clinical risk assessment has been conducted for all patients
☐ A retrospective review of clinical cases/isolates has been conducted to identify any linked cases – this may require assessment of multiple units/areas.
☐ Environmental sampling of all suspected components/areas/environments has been considered; if possible, molecular sub-typing of infectious agents isolated from patients and environmental samples should be performed to establish strain identities. For environmental sampling guidance, see the Irish Health Protection Surveillance Centre's National Guidelines for the Prevention of Nosocomial Aspergillus.
☐ Historical environmental test results have been reviewed (if available).
☐ The severity of the incident has been assessed using the HIIAT and reported to HPS as per Chapter 3 of the NIPCM.
☐ The situation has been communicated to all staff including clinical, domestic, estates and facilities, IPCT members, and the microbiology department.
Domestic services team
☐ Staff to commence **enhanced cleaning** of affected areas preferably at least twice daily *(*use combined detergent/disinfectant containing 1,000 ppm av cl; include all hard surfaces, equipment, and frequently touched surfaces e.g. door handles, light switches, bed rails)

11. Remedial actions

The incident management team (IMT) would make the decision to undertake the following **remedial actions** appropriate to the level of contamination:

- Disinfection of part of, or the whole ventilation supply system, using a healthcare approved disinfectant/fumigant.
- Repair, replacement or redesign of part of, or the whole ventilation supply system.
- Replacement of ventilation filters, or installation of HEPA filters into areas not previously HEPA-supplied. If HEPA filtration is added to an existing system, Estates and Facilities teams should ensure air flow is not reduced or impeded, as this could impact on exiting air flow pathways and pressure differentials.
- If air-supply systems to high-risk settings are not optimal, portable industrial-grade HEPA filters should be used on a temporary basis until rooms with optimal air-handling systems become available. The portable unit should be capable of recirculating all of the room air and should provide the equivalent of ≥12 air changes per hour. Filter units should be capable of operating in combination with the existing air handling system and should not interfere with the existing pressure differential of the room. Filter units should be placed to avoid air flow drawing past the breathing zone of patients, visitors and healthcare workers.

References

1. Sehulster L, Chinn, R. Y. W., Arduino, M. J., Carpenter, J., Donlan, R., Ashford, D., Besser, R., Fields, B., McNeil, M. M., Whitney, C., Wong, S., Juranek, D., Cleveland, J. . *Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC).* 2004. American Society for Healthcare Engineering/American Hospital Association.

2. Chang CC, Ananda-Rajah M, Belcastro A, et al. Consensus guidelines for implementation of quality processes to prevent invasive fungal disease and enhanced surveillance measures during hospital building works, 2014. *Intern Med J* 2014; 44: 1389-1397. 2014/12/09. DOI: 10.1111/imj.12601.