Aspergillus fumigatus – a ubiquitous foe

Aspergillus, a fungus whose spores are ubiquitous in the environment, and are normally found in air, can be a significant issue in healthcare premises, and especially in hospital ventilation systems. Here Andrew Poplett, an engineer with over 28 years' healthcare building services engineering experience, and an Authorised Engineer for both specialist ventilation and water quality, explains its occurrence, spread, and prevalence. He discusses how estates and facilities personnel, in conjunction with their clinical and infection control counterparts, can act to control and manage *Aspergillus*, and thus help safeguard patients, staff, and visitors, in hospitals and other healthcare facilities, against its negative impact on health.

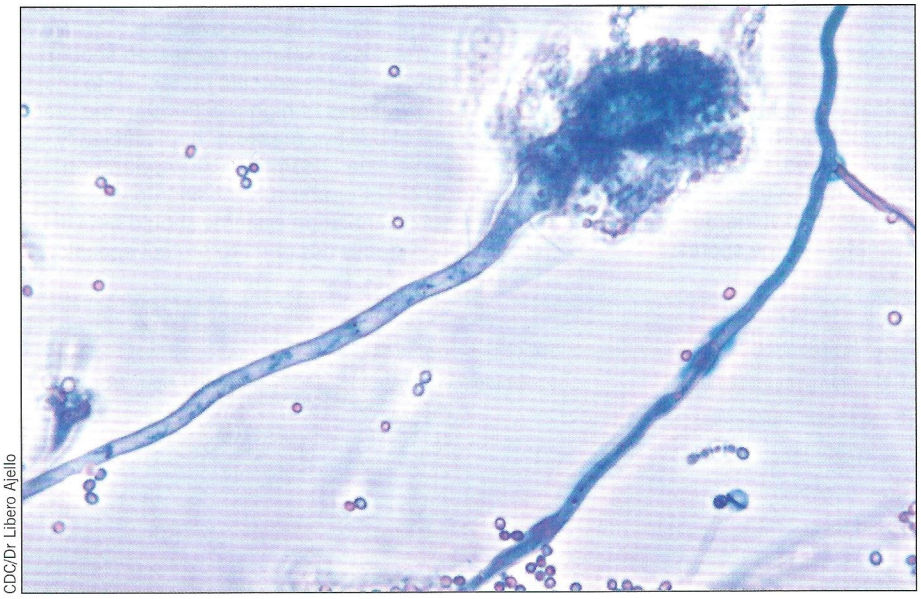
Healthcare has advanced significantly in recent years, and the pace of development is apparently endless. As newer medical technologies and treatments repair the human body in ways never imagined a few years ago, infectious diseases are emerging as a leading cause of morbidity and mortality among these newly susceptible patients. Invasive and chronic fungal infections have become a formidable clinical opponent, and foremost among them is *Aspergillus fumigatus*.

In 1939, Henrici argued 'in man... *Aspergillus* infections are so rare as to be of little practical importance'.[1] Since then, more extensive treatment options and medical advances have radically reversed this position, and, as a result, the number and complexity of patients treated within modern hospitals make *Aspergillus* a real risk, and a potentially costly threat.

Spores are ubiquitous

Aspergillus is a fungus – whose spores are ubiquitous in the environment – normally found in air (including hospital ventilation systems), water, soil, decaying plant matter, food, dust, and human habitats. This makes it extremely difficult, if not impossible, to control at the point of source. Among the fungus's key characteristics are:

- The fungal spores have an effective diameter of 2-3 μ (21,000 times smaller than a golf ball).
- Infection is mainly via inhalation, although direct wound contamination is also possible.
- Multiplication and growth are strongest in warm/damp environments (e.g. the human body).



CDC/Dr Libero Ajello

A single Aspergillus *spore typically found in moist air streams and environments.*

Risk to the immunocompromised

While *Aspergillus* rarely poses a threat to normal healthy people, it is recognised as a potential cause of severe illness and mortality in highly immunocompromised patients. The primary route of infection is through inhalation of fungal spores, which colonise the lungs, and can spread via the bloodstream to other major organs. Infection is also believed to occur directly into deep wounds during surgery. However, due to the hygiene standards in theatres, and the relatively short exposure times involved, this is not believed to pose a significant risk.

The diagnosis of aspergillosis is often difficult, involving invasive procedures. Treatment is lengthy and costly, and mortality still high, despite new therapies, thus making prevention a high priority in the management of all at-risk patients.

Epidemiology

There are two principle types of *Aspergillus* infection: non-invasive chronic aspergillosis (pulmonary), and invasive aspergillosis. In basic, non-clinical terms, non-invasive chronic pulmonary aspergillosis is typically a non-life-threatening pulmonary disorder similar to asthma or pneumonia. While it can be very serious, most people with no pre-existing pulmonary conditions and healthy immune systems experience an 'allergic-style' reaction, and treatment can be ongoing but effective.

A dose-response relationship exists between exposure to airborne spores, and

the risk of pulmonary infection. Epidemics of invasive aspergillosis have been traced to heavy contamination of hospital air, and a well-recognised association exists between outbreaks of nosocomial invasive aspergillosis, and hospital demolition/construction work (NDSC, 2001; CCDR, 2001).[2,3]

Serious 'historical' outbreaks

Invasive aspergillosis occurs where patients typically with weakened immune systems, or recovering from significant clinical treatments, are infected, and the infection is transmitted through the bloodstream to infect and colonise critical parts of the body. Well-publicised and serious historic invasive aspergillosis (IA) infections/outbreaks have included:

- **1974:** 19 deaths in a four-year period in the UK, with eight deaths in seven months.
- **1983:** 18 deaths in Lyon in France, with 22 infected over two-year period.
- **1985:** 11 deaths in a US military hospital.
- **1990:** Five deaths in Nebraska in the US.
- **1999:** Three deaths in Newcastle General Hospital in the UK.

Accurate information on cases of infection and outbreaks is hampered due to the disease not being a notifiable disease under RIDDOR (the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013), and is solely dependent upon clinical assessments and research reviews. Aspergillosis typically causes infection in the lungs, brain, blood vessels, heart, and kidneys. It can result in death, and treatment is potentially both toxic and expensive.

Incidence and mortality rates for invasive aspergillosis in the US, in terms of the related medical procedure or condition, by percentage for 1998, are shown in Table 1.

Key risk groups and areas

Key 'risks groups and risk areas', meanwhile, include:

- Organ transplants.
- Oncology/cancer treatment.
- Patients on high dose steroids.
- Haematology
- ICU/PICU.
- SCID (Severe combined immunodeficiency treatment, and bone marrow transplantation (BMT).
- HIV-positive patients.
- Laboratory facilities.

Little peer-reviewed evidence

Although little peer-reviewed evidence exists to clearly demonstrate the impact of *Aspergillus* on healthcare, in the United States, in 1996, there were an estimated 10,190 aspergillosis-related hospital admissions, which resulted in 1,970 deaths, 176,300 hospital days, and a cost of $633 million – the average period of hospital care was 17.3 days, at a cost of $62,000.[4]

Currently it is believed that 10-15% of patients with organ or stem cell transplants are exposed to some degree of infection. The overall mortality rates for these groups when developing aspergillosis infections ranges from 40-90% (Lin *et al*, 2001).[5]

Courtesy of Quartec

Removal of mould from a hospital roof undertaken under fully controlled conditions with air management systems in place. Repeated ozone air sterilisation and continuous HEPA air filtration were used throughout the project.

Managing the risk

As with most infection control issues, the impact and control of *Aspergillus* cannot be achieved in isolation by any one stakeholder; effective joint working is at the core of any precautions, and management of the risk. The clinical and medical staff, infection prevention team, hotel services team, and estates team, all have responsibility for the treatment and protection of patients; the infection control team endeavours to identify the source of the infection, and the estates and facilities team is tasked with installing systems and equipment within, as well as maintaining and cleaning, the patient areas. Due to the nature of the *Aspergillus* fungus, and the risk of release during construction or refurbishment work, estates personnel may well adopt a 'defensive' stance, and look to protect or manage dust release from a given area. Although such a vigilant approach is to be welcomed, and reduces overall risk, it should not be used in place of protecting the identified vulnerable patients given the nature of the spores.

Implementing a strategy

When hospital construction and renovation activities are in the planning stage, it is important to implement a strategy to protect patients at high risk from aspergillosis, and exposure to high ambient air spore levels. This will necessitate creating and maintaining an environment as safe as practically achievable and free of contaminants, including *Aspergillus* spores.

In basic terms, protection of vulnerable patients can be divided into two classifications – permanent and temporary.

Permanent protection measures

Due to the extent and prevalence of *Aspergillus* in the environment, a two-stage protection protocol is required. Some classification of patients will require permanent protection due to the nature of their illness or treatment. These patients are identified by the clinicians and infection control team responsible for agreeing the degree of protection required, with professional advice from the estates department on the practical solutions available.

The design solution harnessed should seek to provide specific protection to known areas of high risk through the use of positive pressure, high-efficiency, particulate absorption (HEPA) filtration (E12/H14 or above) ventilation plant. Such ventilation systems should be individually designed to protect specific

Table 1: Key medical procedures or conditions, by percentage, resulting in incidence of, and mortality from, invasive aspergillosis (IA) in the US, in 1998.

Condition	Incidence of IA (%)	Mortality from IA (%)
BMT (acute leukaemia)	4-9	90
Heart and lung transplant	3-19	93
Liver transplant	1.5-15	77
Renal transplant	0.5-10	70
Heart transplant	0-24	50

Source: www.aspergillus.man.ac.uk

Control of *Aspergillus* cannot be achieved in isolation by any one stakeholder; effective joint working is at the core of any precautions and management of risk

areas. The performance specifications for such plant stipulate a minimum 10 air changes/hour, maintaining a positive pressure of between 10 and 20 Pascals, in accordance with the recommendations of BS EN ISO 14644.

The estates team will also need to identify the maintenance implications of the design, and develop the appropriate systems (usually in the form of planned preventative maintenance contracts). In addition, the energy implications of such installations should be considered. All filters should comply with the requirements of EN 779:2012 and EN 1822:2009, as well as HTM 03-01 Part A.

Balancing cost and timescales

Having established those areas of the hospital which require permanent protection, there are a number of options available which balance cost and timescales against degree of protection. These include:

- Closing and sealing all windows to reduce infiltration into ward areas (including trickle vents).
- Installing individual window-mounted filters to allow fresh air to be induced into occupied areas as a result of differential pressure within and outside the building. These, do not, however, provide a sustainable air pressure profile, and, as such, are not suitable as a long-term protection solution.
- Installing fan filter units to either recirculate air within the occupied spaces, or connect to outside air to pressurise the occupied areas. Again, there is little evidence research to support this solution, and further studies are needed to establish a clear clinical benefit to support this approach.
- Installing patient-specific portable laminar flow cubicles, providing HEPA quality filtered air. This approach has been used within clinical areas housing immunosuppressed patients (including those housed in 'bubble beds'), and there are well-established clinical results.
- Installing central ventilation plant to supply ducted HEPA (E 12/H14-filtered) quality tempered fresh air to pressurise occupied areas on a floor-by-floor basis.
- Providing and supplying HEPA quality air to individual cubicles, and isolation-style cubicles, serving dedicated rooms.

Further guidance on design solutions for, for instance, 'isolation-style cubicles', can be found in HBN 4 Supplement 1 relating to recommendations for isolation rooms in healthcare environments.

Non HEPA-filtered surgical suites

Non HEPA-filtered surgical suites are another potential source of contamination; however, due to the limited exposure times, and the nature of the majority of surgical patients treated in such facilities, the current NHS Estates guidance does not require HEPA-filtered air quality in operating theatres.

Alongside these engineering solutions, personnel including estates and facilities, infection control, and clinical teams, should review other typical hospital activities to ensure that a full assessment of risk is completed and maintained.

'Soft FM' issues

One area of *Aspergillus* growth and contamination is the use of non-HEPA-filtered vacuum cleaners, and the cross-infection risks of non-dedicated devices for critical areas. While most critical clinical

areas use hard (vinyl) floor finishes, some support areas – such as rest rooms and relatives' rooms – still have carpeted areas, and these can become contaminated with spores.

Organic vegetation is also a known source of *Aspergillus* growth, and consequently siting of flowers and potted plants in 'at risk' ward areas should be restricted. External grounds maintenance must also be carefully monitored to reduce any build-up of decaying vegetation.

Temporary precautions

The second essential form of protection is good housekeeping – to minimise the release of spores – and the maximisation of prevention methods such as good hygiene and increased cleaning protocols. These are more likely to be influenced by the nature and extent of a given project or period of clinical treatment.

All competent persons are responsible for assessing the risks from *Aspergillus* on any works which are planned to be undertaken. The project team, in collaboration with the control of infection and clinical teams, should assess the works, and detail any risk areas and the precautions to be adopted prior to any works commencing, and these should be recorded in project files. The degree of precautions will be dependent on the area involved, nature of works, and the risk of dust release and spread.

Laboratories

It is not just within high risk patient areas where careful consideration is needed. Any work near laboratories, and especially those undertaking microbiology, must be notified to the manager in control of the facilities, as contamination of culture plates will make the diagnosis of a fungal infection difficult, as it may not always be possible to distinguish contaminants from true clinical conditions.

Refuse skips

All skips used for the temporary storage and disposal of waste materials should ideally be fully covered and lockable to prevent dust release and unauthorised disturbance. Where this is not practicable, skips must be covered by means of a secure intact tarpaulin at all times when not being filled. When filling a skip using mechanical plant, or using heavily dust-laden materials, consideration should be given to prevailing wind direction and dust suppression techniques, such as damping down or enclosure.

Dust suppression

Due to the ubiquitous nature of *Aspergillus* spores, many estates works carry the risk of *Aspergillus* disturbance, through drilling, digging, decorating, and demolition. While it is frequently not possible to eliminate dust creation during such activities, certain good practices should be followed to help limit the effect, as required by HTM 03-01.

In addition to the use of dust suppression on skips, other control measures may need to be considered for certain works. These could include the use of dust collection mats (sticky mats) on points of access and egress to work areas. If installed, however, these must be maintained, and are not recommended in clinical areas such as theatres; they are suitable only for limiting the spread of dust from work areas.

Courtesy of Quartec

A hospital intensive care unit, with sampling pumps clearly visible, following a thorough mould removal and remediation process.

Major demolition

If disposing of entire buildings, the ratio of dust release versus duration should be considered when deciding on a preferred demolition technique, along with prevailing wind direction and damping down, which could be factors to consider. All elements and considerations must be recorded in project files, and agreed with all relevant stakeholders.

Minor demolition/refurbishment

If undertaking limited demolition or renovation works within the confines of an existing building (e.g. ward upgrades), the area must be effectively sealed off from other occupied areas of the hospital and thoroughfares. Dedicated access routes need to be established to minimise the spread of dust, and contact with patients, visitors, and staff. The use of dedicated staircases or lifts, clearly signposted for trade staff, should be considered, with sticky mats or changing/transition areas used for personnel entering or leaving a works/construction area.

If such precautions are deemed necessary, then they must be subject to regular audit and maintenance to ensure effectiveness. Other means of isolation, including screening off and temporary partitions, are also effective, provided that such measures do not compromise fire escape or equipment transport routes. In the most extreme cases, the use of negative pressure, HEPA-filtered enclosures – similar to those used by asbestos removal companies – could be considered. However the structures may cause more risk during assembly and dismantling than protection during works.

Minor repairs

Numerous maintenance activities can give rise to the creation of dust (drilling, sanding down, plastering etc.). If such works are limited to a small area, or are required to be done in a high risk patient area, then the use of local exhaust ventilation (LEV) systems are recommended. These can take the form of either a HEPA-filtered vacuum cleaner or mobile extract fan system. The extent and nature of the works will determine the type of system required. The use of non HEPA-filtered vacuum cleaners will help to limit dust emissions; however these devices do not eliminate *Aspergillus* particles, and can therefore not be used in high-risk areas.

Cleaning protocols

In addition to minimising the spread of dust through estates precautions, consideration should be given to increasing existing cleaning regimes during the course of any prolonged or major redevelopment works. In particular, it is advisable to increase cleaning of surfaces to prevent dust accumulation on surfaces, ceilings, and air duct grilles. Damp dusting, rather than dry cleaning, is recommended. Any air filtration system should be regularly checked and maintained, including any adjoining theatres and 'at risk' areas.

Pedestrian traffic

Pedestrian traffic from construction sites should be directed away from patient areas, with workmen having a separate entrance to the construction site, as

outlined above. Where possible, patients and visitors should avoid entering the hospital adjacent to major construction/demolition sites, where debris or dust is being removed. The precautions required should be identified during the initial risk assessment, and should be included at tender stage to ensure that all necessary precautionary measures are taken.

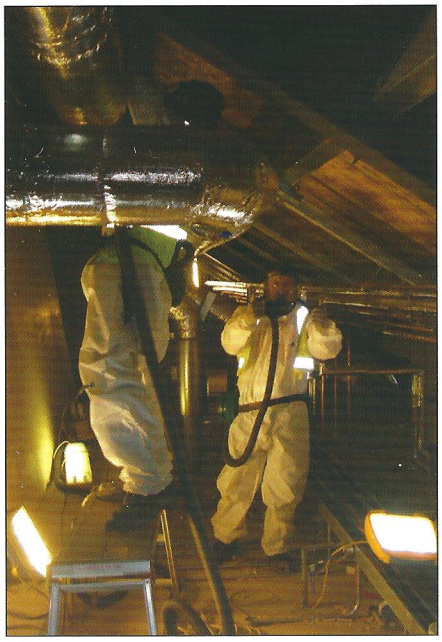
Increased awareness

The single most important element in reducing the risk from *Aspergillus* is effective communication between all relevant parties, including estates and infection control personnel, sub-contractors, architects, and medical staff – all of whom have a major role to play. The primary role of the estates team is to co-ordinate the briefing of all parties on the extent of works being undertaken, and to ensure that best practice is followed in preventing/limiting potential *Aspergillus* release.

Liaison and communication responsibilities

Communication and awareness of the pervasiveness of, and risks associated with, *Aspergillus* are the primary key to reducing the risk to patients. To this end the estates team has an absolute responsibility to ensure that details of all works and maintenance activities are effectively communicated to the infection control team, who, in turn, can advise clinicians and minimise risk to patients.

To ensure that this communication actually occurs, infection control representatives should be invited to all estates pre-start and project planning meetings to ensure that adequate thought has been given to *Aspergillus*. Prior to any works being tendered, infection control staff must be given the opportunity to comment on the extent of precautionary measures deemed necessary through the written risk assessment. Estates Department representatives should also attend the regular Trust infection control meetings, and communicate major planned redevelopment works at this forum.



Courtesy of Quartec

These personnel undertaking mould removal are wearing type 5 disposable overalls and full FFP3-rated face respiratory protection.

Monitoring protocols

Due to the prevalence of *Aspergillus* spores, it is generally an accepted practice not to regularly screen or monitor for their presence. However, in certain high risk areas, or in relation to major development or demolition, monitoring growth counts before, during, and after works can help in establishing 'normal background' and 'action' levels.

Outbreak/control team

Aspergillus is not a notifiable disease; however, in the case of acute *Aspergillus*-related illness, there may be RIDDOR-related implications. The infection control team should monitor any occurrences, and advise, via established protocols, as to any concerns or actions required.

Conclusions

In summary, *Aspergillus* is easy to find, but challenging to control, and its impact on highly vulnerable patients severe. Anecdotal evidence and reports suggest that infections are on the rise, while the overall cost – in terms of patient risk and clinical episodes – makes an awareness of the potential risks essential for all healthcare estates professionals. Effective communication, early assessment of risk, and joint working with clinical colleagues, are all key to ensuring that healthcare environments remain as safe as possible for those in our care.

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Following direct involvement in the resolution of an *Aspergillus* outbreak in 1999, he has worked to raise awareness of the fungus, and says he feels strongly that protocols for the management of *Aspergillus* infection, and the associated precautions, should be standardised throughout the UK, as they are in Ireland.