PREVENTING INFECTION BY MONITORING AIR QUALITY WITH TELEMETRY – “LET’S NOT BE BEHIND THE 8 BALL”

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INTRODUCTION

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health, comfort and performance of building occupants. There are hundreds of pollutants that affect IAQ and thousands of sources. Worldwide research shows that more than 900 different contaminants are present in the indoor environment, a problem which is exacerbated by the interaction of a complex set of factors that are constantly changing.

Indoor air is typically discussed in reference to the health impact of the air to building occupants and is defined by the National Health and Medical Research Centre (NHMRC) as air within a building occupied for at least one hour by people of various states of health.

Understanding and controlling pollutants indoors can help reduce the risk of indoor health concerns.

Health effects from poor air quality may be caused from short or long duration exposures to pollutants, and may manifest early or much later after the exposure. Health effects can include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable, sometimes the treatment is simply eliminating the person’s exposure to the source of the pollution, if it can be identified. Soon after exposure to some indoor air pollutants, symptoms of some diseases such as asthma may show up, be aggravated or worsened.

The likelihood of immediate reactions to indoor air pollutants depends on several factors including age and preexisting medical conditions. In some cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies from person to person.

Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease and cancer, can be severely debilitating or fatal. It is prudent to try to improve the indoor air quality exposure even if symptoms are not noticeable.

Clean air is especially important to at-risk population groups within healthcare facilities, in particular those with chronic respiratory conditions.

With the increasing knowledge and guidelines applicable to indoor air quality, pro-active healthcare facility managers are developing strategies to assess sources of poor air quality and robust management procedures to minimise healthcare occupant exposure.

In conjunction with Australian and New Zealand standards, legislative, and regulatory requirements and State healthcare engineering guidelines the following guidelines should also be considered in the provision of indoor air by building owners and facility management teams:

- Particulates - Workplace Exposure Standards for Airborne Contaminants (2011), World Health Organisation Air Quality Guidelines (Global Update 2005), National Environmental Protection Measure (NEPM) for ambient airborne PM10 particulates

- Carbon Monoxide - Workplace Exposure Standards for Airborne Contaminants (2011) of 30 ppm, the World Health Organisation Air Quality Guidelines (Global Update 2005).

- Ozone - World Health Organisation Air Quality Guidelines (Global Update 2005)

- Formaldehyde - Workplace Exposure Standards for Airborne Contaminants (2011), World Health Organisation Air Quality Guidelines (Global Update 2005)

- Humidity - (Managing Indoor Environment Quality, Property Council of Australia 2009), ASHRAE 55-2013 guidelines, ISO 7730 (2005)

- Temperature - (Managing Indoor Environment Quality, Property Council of Australia 2009). PCA, ASHRAE and ISO standards for recommended values of thermal comfort parameters.

- Carbon Dioxide – Workplace Exposure Standards for Airborne Contaminants (2011), AS1668 (2012), industry accepted limit for comfort (Brown (CSIRO) 1997, Health & Welfare Canada 1989).

The management and monitoring of indoor air quality is one important component of an effective Infection Control Management Plan during construction, renovation, repair, excavation and demolition activities in hospitals and healthcare facilities.

As described in the Australian Guidelines for the Prevention and Control of Infection in Healthcare 2010 (NHMRC) effective control and prevention measures are necessary during construction and renovation within a healthcare facility, because such activities have been frequently implicated in outbreaks of airborne infection.

The key to eliminating infections is to minimise the dust generated during the construction activity and to prevent dust infiltration into patient-care areas near the construction. Suggested approaches to reducing airborne transmission within the Australian guidelines include:

- installation of effective air filtration

- specifying appropriate ventilation systems and air change rates (eg negative airflow pressure)

- employing monitoring and control measures during construction or renovation

- using single-bed instead of multi-bed rooms.

It is recognised that early risk identification and implementation of controls will minimise the risk of infection but may not completely eradicate the risk of infection for vulnerable patient groups.

As an integral component of the Infection Control Management Plan during construction, renovation, repair, excavation and demolition projects at a number of major hospitals, QED Environmental Services has successfully implemented telemetry air quality monitoring. This led to evaluation of engineering controls, greater contractor accountability, coordinated response by and communication among stakeholders, and ultimately lower risk of patient infection.

MAIN BODY

Effective infection prevention and control is central to providing high quality health care for patients and a safe working environment for those that work in healthcare settings. There are around 200,000 healthcare-associated infections (HAIs) in Australian acute healthcare facilities each year (Cruickshank M & Ferguson J (eds) (2008)).

A strong body of research shows that the built environment in particular influences the incidence of infection in hospitals and that, by careful consideration of environmental transmission routes of air, surface and water in the design and operation of healthcare facilities, incidence of hospital-acquired infections can be dramatically reduced.

Infection Control is of major concern on all hospital projects because of the potential contaminate exposure to high numbers of immune compromised patients. The level of risk associated with each project is dependent on the project complexity, location of the works, the type of work being undertaken, and the proximity to patients with varying degrees of infection risk.

Infection Control during Construction

In order to minimise the risk of hospital-acquired infections, management plans for construction projects within and adjacent to hospitals should incorporate infection prevention and control strategies.

The 2015 Australiasian Health Facilities Guidelines "Part D - Infection Prevention and Control" identifies minimum control measures to be implemented when undertaking construction activities on occupied healthcare sites. Based on these recommendations and international best practice, control measures for a specific activity can be identified that will reduce the risk of infection to designated patient groups or zones. There are four key steps in managing the associated risks:

- Identify the type of construction activity,
- Determine the population or geographical risk group,
- Identify the control measures,
- Implement and monitor prescribed control measures.

The Green Star Healthcare Rating Tool (V1 design and as-built) also recommends management of air quality during construction via the requirement of a Construction Indoor Air Quality Management Plan.

Construction, renovation, repair, excavation and demolition activities in hospitals and healthcare facilities present a variety of situations which may release contaminants and pollutants that can impact the indoor air quality (IAQ) of a building. These contaminants may be transported to other areas via the heating, ventilation and air conditioning systems and subsequently affect populations beyond the immediate project area.

Advanced planning and coordination by project and facility managers is required to minimise the risk of infection to at-risk patients. Implementation of effective engineering control strategies, establishing effective communication lines amongst project stakeholders along with the implementation of environmental monitoring for any building or maintenance project are to be considered to successfully control pollutant levels, allay concerns, and maintain occupant comfort during and after construction activities.

The population most at risk from infection is usually immunocompromised either by underlying disease or by contemporaneous treatments e.g., chemotherapy. Although construction activities at any location may pose a risk to this population group, undertaking these activities within healthcare facilities poses unique risks due to proximity and the numbers of at-risk people in the one location.

Environmental Monitoring

Common environmental contaminates during construction, renovation, repair, excavation and demolition activities:

- Particulates (Dusts and Fibres)
  - Nuisance / hazardous
- Volatile Organic Compounds (VOCs)
  - From coatings, sealants, adhesives, carpeting, composite wood products, etc.
- Combustion products
  - Carbon monoxide,
  - Carbon dioxide,
  - Nitrogen oxides,
  - Sulfur dioxide, and
  - Ozone.
- Biological materials
  - Bacteria, yeast, mould,
  - Dust mites,
  - Insect parts, and
  - Microorganisms

Monitoring these contaminants is the key to reducing risk of infection. Infection Control Risk Assessments are essential to identifying the type of monitoring required, parameters monitored and period of monitoring. Dependent on the environment and scenario being monitored, the implementation can vary from spot measurements to continuous telemetry monitoring. There are many applications and solutions for air quality monitoring ranging from static standalone instrumentation to solutions embedded within Building Management Systems.

Benefits of continuous telemetry monitoring in healthcare facilities;

- Continuous monitoring of occupant exposure (At-risk patient populations),
- Real-time alerts allowing for rapid response,
- Evaluation of engineering control effectiveness (such as dust barriers or temporary hoarding, exhaust ventilation and management of pollutant paths),
- Improved contractor accountability and commitment to infection control,
- Improved client / tenant relationships between project groups, facility management, healthcare staff and patients, and
- Robust project documentation through recording of results, incidents and outcomes of control investigations.

It may be unrealistic to attempt to completely eliminate airborne contaminants during a construction project, but it is possible to minimise occupant exposure to those contaminants by careful scheduling of the work, implementing effective engineering controls, active monitoring during the project and effective real-time communication using telemetry.

Telemetry, or wireless communication, is a highly successful monitoring tool for real-time environmental monitoring. The real time monitoring allows an instant response to an event, before complaints are received by the project team from patients, healthcare staff and infection control departments. Conventional data logging of environmental parameters is the reactionary approach, telemetry air quality monitoring provides awareness of the incidents as they occur and provides the opportunity to act upon the notifications to minimise impacts on at-risk populations.

For this method to be effective an Alert and Action Protocol is established as part of the project planning. This would include an alarm system that is set at an agreed contaminate concentration, a time-frame for investigation, rectification and notification to project lead and key stakeholders. This alarming system enforces contractor accountability and aids effective management by the building or facility manager.

A comprehensive environmental sampling regime includes comparative evaluation of the indoor environment with baseline measurements taken prior to any works, throughout the project period and following the completion of any project.

Case Study

QED Environmental Services has successfully implemented real time telemetry air quality monitoring solutions for varied projects within healthcare facilities. One in particular is a large scale HVAC refurbishment project where the internal linings of the air conditioning unit was refurbished whilst the system remained live. It was integral to the project that the HVAC systems maintained high quality conditioned air to the at-risk patient groups throughout the refurbishment programme. Patient-care areas included the Respiratory High Dependency Unit (HDU), Intensive Care Units (ICU), Coronary Care Unit (CCU) and general patient ward areas.

With a design supply air rate of 36,600 l/s the refurbished system mechanically induced up to 284 trillion litres of air into immuno-compromised patient areas during the project period. Considering the high potential of generating pollutants, maintenance and monitoring of engineering controls was essential to the successful completion of the refurbishment project.

The live pollutant monitoring programmes measured airborne particles at the supply air discharge to the Intensive Care Unit (ICU) and Respiratory High Dependency Unit (HDU) as an indicator for contamination caused by the refurbishment activities. When elevated levels were measured instant SMS and email notifications were issued to QED and the project team ensuring the appropriate engineering controls were reviewed and corrective actions were implemented to mitigate any risk to the at-risk patient groups and zones.

"Particulate Matter (PM)" is a term used for a mixture of solid particles and liquid droplets found in the air. Some particulates are large or dark enough to be seen, while other particulates are so small they can be detected only with analytical instruments.

The size of particles is directly linked to their potential for causing health problems. The smaller sized particles are inhaled more deeply into the lungs, and if ultrafine in size, the particulates may pass directly into the bloodstream. Exposure to particles can affect the lungs and heart, and in particular for individuals with pre-existing conditions, the young and the elderly. As such PM10 particulates were measured throughout the project to capture the respirable proportion of particles in the air.

The monitoring programme measured low levels of airborne PM10 particulates throughout the refurbishment programme with an average project concentration of 0.004 mg/m3.

Following an Infection Control Risk Assessment the alarm system protocols for airborne PM10 particulates was established with the "Alert" and "Alarm" criteria set at 0.03mg/m3 and 0.05mg/m3, respectively. With exceedances of the "Alert" level the head contractor investigated possible sources of airborne particulate matter and reviewed the dust suppression controls. The receipt of an "Alarm" level exceedance by the project team triggered the cessation of site works and the application of additional abatement controls, where necessary, to prevent further occupant exposure. Throughout the HVAC refurbishment project a number of events activated SMS and email notifications to the project team.

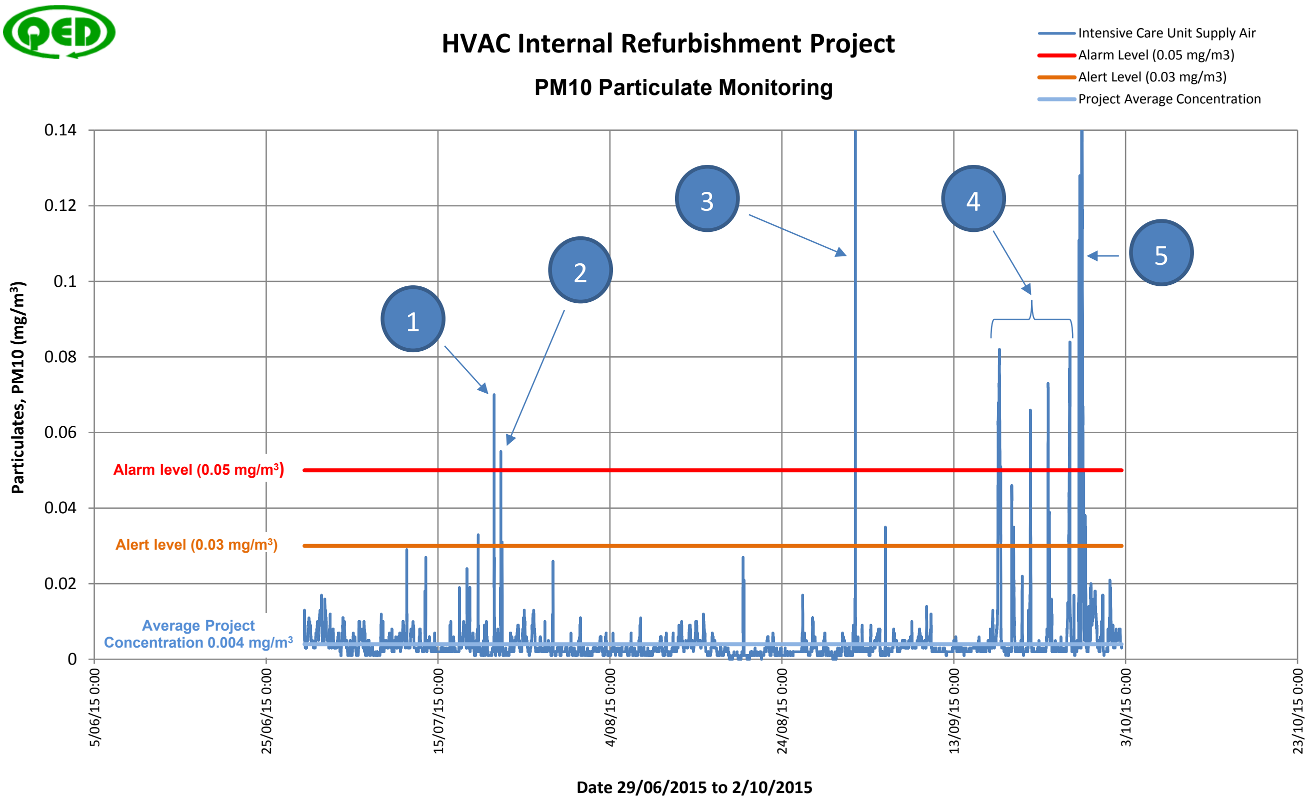

Figure 1: PM_{10} Particulate Monitoring

As illustrated in the monitoring results in Figure 1 the "Alarm" events experienced during the refurbishment project initiated an immediate response.

1. The primary filtration system was compromised during demolition works.
    - Works ceased immediately, the AC unit was shutdown and the dust suppression controls were reinstated.
2. Unauthorized use of a plasma cutter by a sub-contractor within the AC unit outside a scheduled shutdown period.
    - Works ceased immediately, investigation into the use of hot work equipment and permits was conducted resulting in the reinforcement/education of appropriate work practices/procedures with the workforce.
3. Inappropriate removal of dust and debris from within the cold deck plenum prior to the reinstatement of the AC following a shutdown.
    - Works ceased immediately, the AC unit was shutdown and the appropriate level of surface cleaning was conducted before reinstatement.
4. Welding fumes bypassed the installed engineering controls and were induced into the supply air ducting whilst the air distribution system was under negative pressure.
    - Works ceased immediately, additional exhaust and ventilation strategies were implemented and where possible welding activities were relocated.
5. Particulates were induced into the outside air intake during a period of prescribed burning by the Department of Environment of Western Australia.
    - Although these contaminates were not sourced from the refurbishment works, the telemetry system alerted stakeholders of the externally induced particulate matter and in turn enabled the site engineers to manage the air quality by manually overriding the operation of the outside air dampers. Simultaneously, additional environmental parameters such as carbon dioxide and temperature were monitored allowing informed decision making by facility management to provide adequate ventilation and air quality to the hospital occupants during this period.

Following each event mandatory reporting was completed by the head contractor who was responsible for providing a body of evidence to support the contributing factors resulting in the elevation of particulates, this was recorded and documented on an "Environmental Monitoring Incident Form". This process enforced contractor accountability, transparency and responsiveness to events, review of control effectiveness, and provided evidence for future project evaluation and infection control investigations.

CONCLUSION

Effective infection prevention and control is central to providing high quality health care for patients and a safe working environment for those that work in healthcare settings. Infection Control is of major concern on all hospital building projects because of the potential contaminate exposure to high numbers of immune compromised patients.

Construction, renovation, repair, excavation and demolition activities in hospitals and healthcare facilities present a variety of situations which may compromise the health of the building occupants. Effective control and prevention measures are necessary during such activities within a healthcare facility because they have been frequently implicated in outbreaks of airborne infection. The key to eliminating infections is to minimise the dust generated during the construction activity and to prevent dust infiltration into patient-care areas.

Implementation of effective monitoring programmes such as telemetry air quality monitoring are a key component to evaluate contaminate distribution to at-risk patient populations and zones within health care facilities. This proactive approach informs all relevant stakeholders at the time of incident to allow corrective actions to be implemented and minimise impacts on at-risk populations.

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