



# PRESSURE DIFFERENTIAL IN HEALTH CARE FACILITY AIRBORNE ISOLATION ROOMS

## EXECUTIVE SUMMARY

JUNE 2018





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## **CSA GROUP RESEARCH**

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# EXECUTIVE SUMMARY

Indoor air quality, temperature, and humidity are important health and wellness considerations that are especially critical to the health of patients, staff, and visitors in health care facilities (HCFs). Patients with infections can be contagious and susceptible to further infection. Inadequate indoor air quality can complicate patient care and recovery and negatively affect the health and wellness of other occupants. The proper design, installation, commissioning, operation, maintenance, and testing of heating, ventilation, and air-conditioning (HVAC) systems can reduce the risk of infection transmission and support positive clinical outcomes for patients. In addition, a well-designed HVAC system can help facilities meet their energy conservation objectives and promote the judicious use of renewable and non-renewable resources.

The CSA Z257.6 Technical Subcommittee is currently working to develop a new edition of CSA Standard Z317.2, *Special requirements for heating, ventilation and air-conditioning (HVAC) systems in health care facilities*. A requirement exists in the most recent edition (2015) of the standard for a minimum 7.5 Pa air pressure differential to be maintained between the inside of a negative pressure airborne isolation room (AIR) and the adjacent corridor and rooms (other than an anteroom). This pressure differential is an environmental control created by maintaining a differential airflow between supply and exhaust airflows, and is designed to protect the general population from an occupant in isolation by ensuring air movement from adjacent spaces into the AIR. This is considered essential to maintaining a safe care environment.

The objective of the research project was to perform a systematic review of published academic and grey literature in an effort to see if there was support for the 7.5 Pa air pressure differential requirement in CSA Standard Z317.2 for the design of AIRs for the next edition. In addition, stakeholders were consulted to better understand the pressure differential requirement in CSA Standard Z317.2 of 7.5 Pa between the AIR and the adjacent corridor and rooms with the end goal of confirming that this requirement was supported by evidence.

A rigorous assessment of the literature was conducted and revealed limited studies regarding specific evidence to support that the 7.5 Pa air pressure differential requirement was an optimal value that was safer for patients. Nationally and internationally, minimum recommended air pressure differentials for AIRs vary from 2.5 Pa to 30 Pa. None of these guidelines provided definitive background data to substantiate their requirements. However, the performance of AIRs to substantiate the 2.5 Pa US guidelines has been tested in many studies. These studies also tested ventilation rates in the form of air changes per hour (ACH) in isolation rooms. ACH have been identified as contributing to the prevention of contaminated room air from leaking into adjacent areas. The most critical requirement for the proper functioning of the ventilation system is that it should minimize the escape of contaminated air from the AIR; airflow movement should always be from clean area towards the patient. This can be accomplished by removing or diluting infectious agents in the air and maintaining adequate negative pressure between the AIR and adjacent spaces to ensure inward air movement. From the literature, there is insufficient scientific evidence to recommend an optimum differential pressure that is proven to prevent the escape of infectious air from the AIR. Technically, a small pressure differential is more difficult to maintain constantly in variable conditions such as wind and stack effect, air supply and exhaust variations, health care provider traffic, etc., especially if the AIR is not well sealed. Even if the pressure differential between the corridor and AIR is adequate, some air always escapes during the movement of staff between a corridor and AIR.

Many studies have investigated different ventilation characteristics including mechanical supply and exhaust flow rates, air velocities and directions, and differential pressures. In addition, blower door and smoke tube tests have been conducted to investigate AIR leakage.

Tracer gas measurements have been done to determine effective air exchange rates and to study exfiltration of air into the anteroom and hallway. The dispersion of infectious particles has been simulated with tracer gases and aerosols. Sulphur hexafluoride has been widely used to test isolation rooms. Tracer gas studies done in a test chamber simulating a negative pressure AIR indicated that the best protection for the health care workers was achieved with the highest pressure differential of 15 Pa and ventilation rate of 24 ACH. However, the pressure differential was found to be more important so that 15 Pa/12 ACH was a more effective ventilation efficiency than 8 Pa/24 ACH. This was attributed to larger air flow through door gaps in the first scenario. Door-slot and other types of leakage are important considerations for the performance of AIRs. Insufficient tightness in joints and penetrations in the room envelope make it difficult to control air flow rates and pressure differentials. Often, unintended leakage sources, such as electrical and other outlets, ceiling, and plumbing are common.

Anterooms provide additional protection, especially when the isolation room door is opened. Some countries (e.g., Sweden, Japan, and Australia) require that AIRs have an anteroom, whereas other countries do not, but recognize that anterooms may increase ventilation system efficiency. Anterooms can also provide a controlled environment to put on and remove personal protective equipment, prepare clinical equipment, perform hand washing, and store immediately necessary supplies like respirators. However, few studies on the effect of the anteroom on pressure differentials in AIRs have been conducted.

There are even fewer studies about the effect of door-opening motion on air exchange between the isolation room and anteroom/corridor. The studies showed that door swing outside the room towards a positively pressurized zone was more disadvantageous, allowing more contaminated particles to enter the AIR when compared to cases when the door was opened into the contaminated room (with negative pressure). The reason for such a phenomenon is the effect created by drawing contaminated air out of the AIR on the back side of the door opening outwards from the AIR, and further pushing of the contamination into the room when the door was closed. Smoke visualizations demonstrate that the opening motion of the sliding-door creates less airflow through the doorway. The effect of passage is significant with both door types yet more distinct with sliding-doors. Half-open door decreases the amount of air migrating across the doorway substantially. The longer the total cycle and hold-open times, the greater the airflow through the doorway. The faster the door motion, the smaller the amount of air migrating across the doorway. The detected effect of the door speed is against the results of previous studies and needs to be further studied. Passage increases the airflow between the rooms significantly (especially with the sliding-door) whereas the effect of passage speed is unclear. Overall, substantially less air is seen and measured to flow out of the isolation room with the sliding-door setup. Contaminant migration is also influenced by its transfer on the feet of the person passing through the door. With an increase in pressure and velocity on the door left ajar, the influence of door swing decreases while the effect on contamination transfer on the feet increases. There is insufficient data to recommend an optimal pressurization level between the corridor, anteroom, and AIR. Pressure differential is a tool for contamination control; however it is not a 'magic shield.'

This research has provided valuable information for consideration by the Technical Subcommittee in their development of the next edition of CSA Standard Z317.2. This evidence building research project will also be beneficial to help provide an increased acceptance and uptake of the Standard by those involved in the planning, design, construction, commissioning, operation, and maintenance of HVAC systems in health care facilities.

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