Title:

The importance of integrated system design for the effectiveness of Portable Air Cleaners in Airborne Infection Control

Background: The results of the recent study into the effectiveness of portable air cleaners (PACs), as an infection control measure against TB, delivered unexpectedly low results. That finding initiated a further study to understand the contribution of system design to the effectiveness of PACs in airborne infection control.

Design/Methods: The objective of this further study was to quantitatively evaluate the contributions of combined ventilation and PAC systems and identify factors with the potential to reduce the functional effectiveness of such systems.

In this study, the performance of both the mechanical ventilation system and PAC unit was validated (7 and 12 air changes per hour (ACH) respectively).

The validation of the ventilation system included volumetric airflow measurements and quantitative air change efficiency assessments.

The compliance with design criteria of the PAC was assessed by volumetric airflow measurements, filtration efficiency tests and the derivation of effective clean air delivery rates (CADR).

A computational fluid dynamics (CFD) simulation of the wards was developed to model the system contamination removal effectiveness (CRE) at designed and measured capacities with the PAC running and idle. Streamlines were simulated to visualise airflow interactions between the PAC and HVAC systems.

Results: Even with high total filter leakage (15% vs. 0.05% specified), an acceptable effective CADR of 11.9 ACH was measured from the PAC.

The ventilation system's air change rate measured higher than specified at 10.8 ACH with near fully-mixed flow.

The simulation using the system's design capacities showed a significant contribution by the PAC to the CRE. The simulation using the higher airflow rates, measured during validation, showed little contribution by the PAC.

The simulated airstreams indicated that the PAC operation could reduce the performance of the HVAC system by stimulating airflow short-circuiting.

Conclusion: The study indicates that the contribution of PACs in airborne infection control may be limited to spaces with inadequate pre-existing ventilation systems or low ventilation rates. Where spaces are fitted with effective mechanical ventilation, the addition of PACs may offer no real improvement to infection control.

The CFD results demonstrated the potential of PACs to disrupt and reduce the contamination control effectiveness of well-designed and functioning ventilation systems if their location within the room is not well considered.