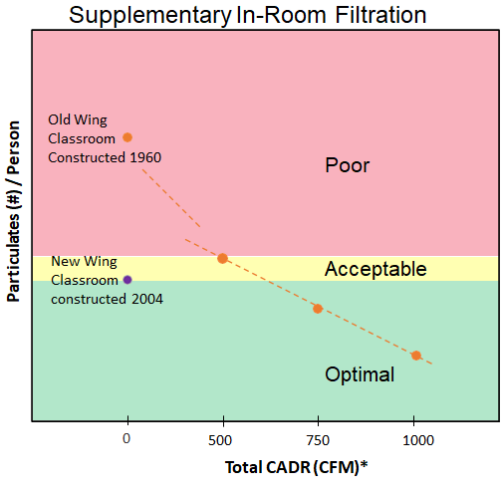
A case study comparing Particulate exposures in aged and modern elementary school classrooms in response to supplementary in-room filtration

Motivation and problem statement. The need to reduce airborne (biological) particle exposures in our built environment is evident. Many school buildings are in immediate need of HVAC system upgrades, yet the resources for rehabilitating ventilation systems are not available at this scale. Along with improved cleaning practices, in-room high efficiency filter enhancements offer an immediate, pragmatic alternative to supplement poorer performing ventilation systems in this context. In response we report the effect of deploying Carrier RMAP-XL air purifier on airborne PM and acoustic loads in school classrooms before and during their occupation under CoVID restrictions.

Setting. In cooperation with the Denver Public School District, the setting for this demonstration study is the historic Cheltenham Elementary School. This school presented ideal, collocated infrastructure for PM exposure comparisons, where an aged classroom building (1960) with "unit ventilators" is joined to a newer building fitted with modern air handlers (2004, upgraded 2019). University of Colorado engineering teams measured real-time air exchange rates and placed high efficiency filters in multiple classrooms. The CO_2 levels, PM loads and acoustic envelopes where then measured and compared between classrooms in the new and old wings.

Results. Regardless of air exchange rate, classrooms in the "old wing" had markedly higher PM loads than their counterparts in the new wing—most notably in the fine PM fraction. Occupant-normalized PM in "old wing" classrooms could be controlled in the range of "new wing" rooms, with the addition of 3 Carrier RMAP-XL air purifiers deployed an equivalent of 1000 CFM equivalent CADR. This deployment reduced airborne PM by 67%, with room doors open (CoVID protocol).



Condition (all unoccupied)	Noise Level at Teacher's Desk (dBA)
Background Noise	47.5 +/- 0.6
Increase Above Background with 2 HEPAs	1.9
Increase Above Background with 3 HEPAs	2.6
Increase Above Background with 4 HEPAs	3.3

The acoustic projection of the units *as deployed*, were juxtaposed to the cumulative background sound pressure in these classrooms. In unoccupied classrooms, the sound pressure at the teachers' desks averaged 47.5 ± 0.6 dBA. There was a disproportional increase in sound pressure at the teachers' desk in response to the number of Carrier RMAP-XL air purifiers operating at their maximum speed. There was no more than an 8% dBA increase above background noise.

Summary. As judged by real-time (bio)aerosol cytometry of occupied classroom air, Carrier RMAP-XL air purifiers were able to sustain significantly reduced (67%) airborne $PM_{2.5}$ loads in occupied K-12 classroom with compromised air quality. Common models using only CADR and floor area, could overestimate this performance. As judged by *in-situ* sound pressure emissions, the acoustic envelope projected by these air purifiers was less than 10% of the background and fell within a range that does not interfere with classroom communications under WHO guidelines.

Denver Public Schools Demonstration

Carrier Air Purifier Classroom Effectiveness

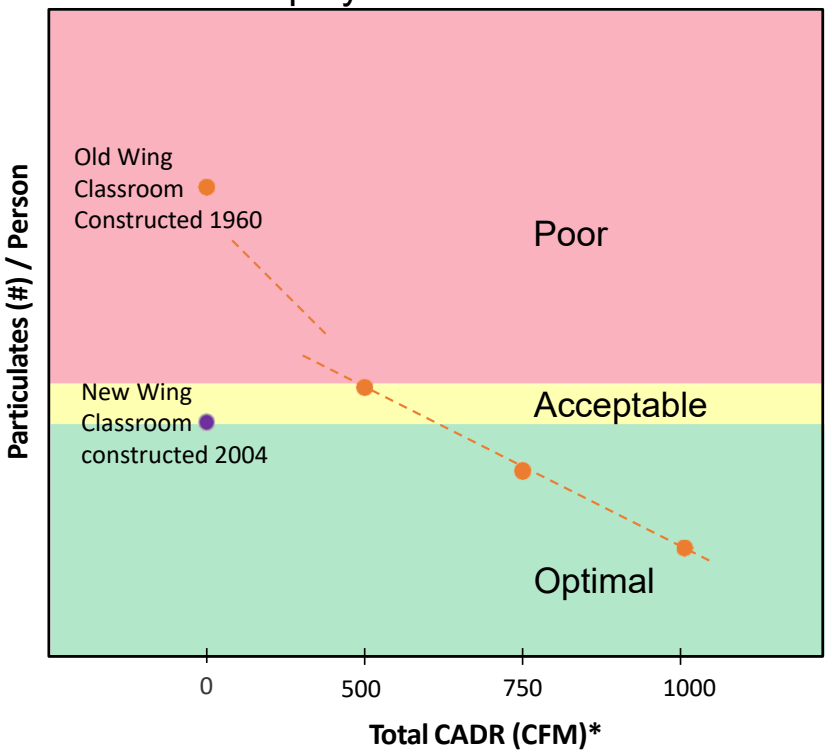
Deploying 500 CFM of in room air filtration using RMAP-XL air purifiers in “old construction” classrooms creates equity with new construction classrooms

Create a better environment by increasing air filtration to 1000 CFM of CADR

In room air purifiers achieve up to 67% airborne particle exposure reduction

University of Colorado Boulder

Classroom Deployment of Carrier Air Purifiers



*CADR, a metric for selecting air cleaners based on the volume of clean air delivered in a fixed period of time.

Carrier