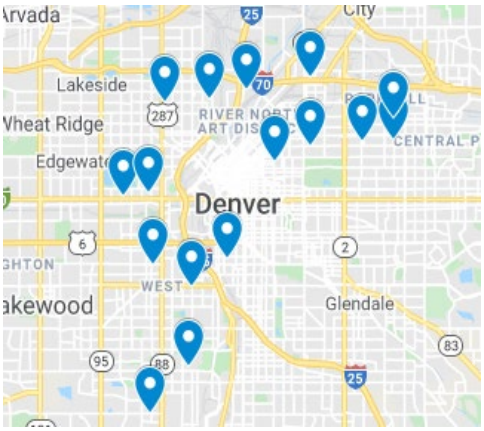
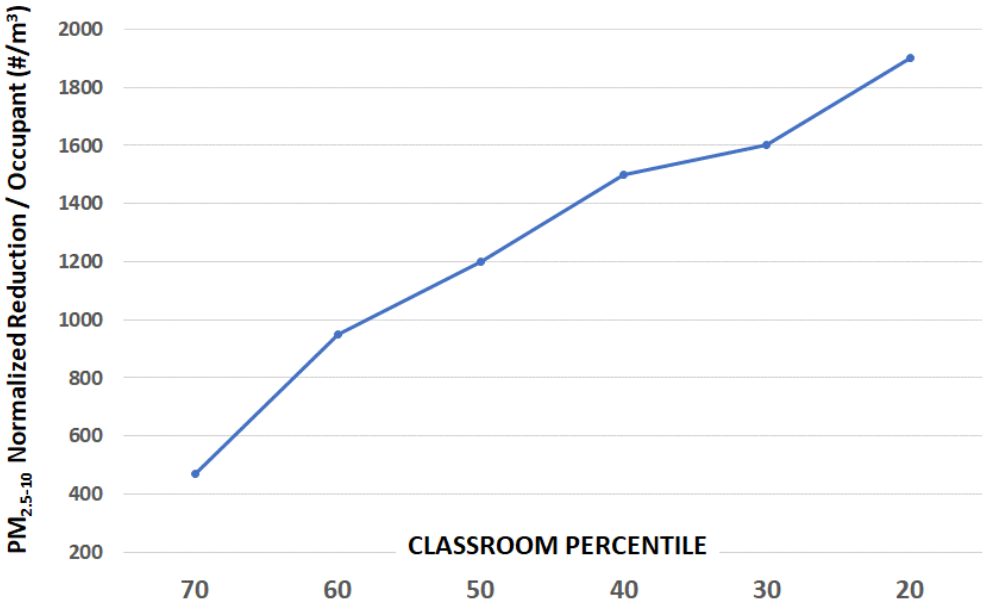
Reduction of PM exposures in aged and modern elementary school Classrooms leveraging supplementary in-room HEPA filtration

Motivation and problem statement. A recent study by the University of Colorado Boulder, successfully demonstrated that Carrier air purifiers are able to sustain significantly reduced levels of respirable airborne particles in student-filled classrooms by an average of 50% as compared to classrooms without air purifiers. Along with improved cleaning practices and systemic HVAC improvements, in-room air purifiers equipped with HEPA filters, offer an immediate, pragmatic alternative to supplement poorer performing ventilation systems in occupied classrooms. We report the effect of deploying Carrier RMAP air purifiers on airborne PM level in occupied classrooms with broad range of architectural configurations in both new and aged (historical) buildings.

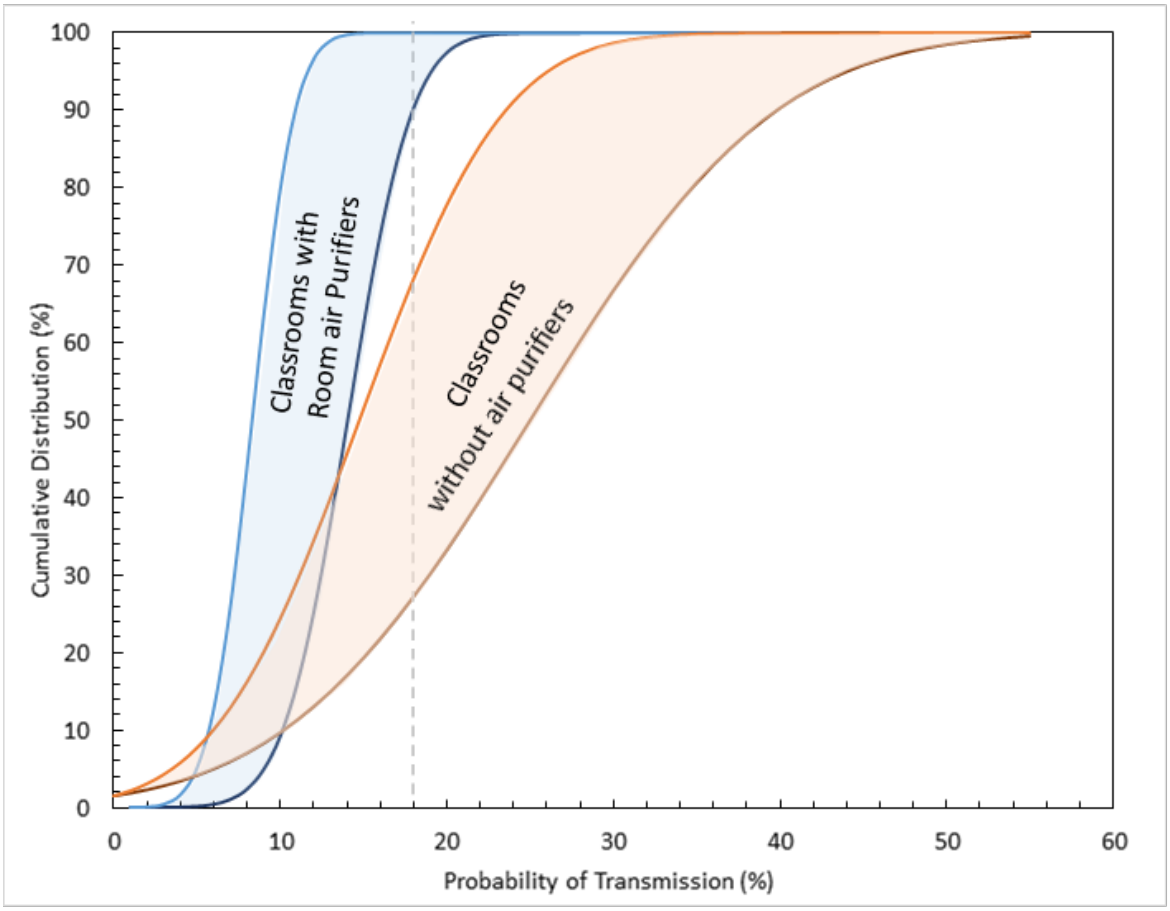
Setting. In cooperation with the Denver Public School District, the setting for this demonstration study is 20 metropolitan Elementary Schools over the spring academic semester, 2021. During this time, these schools were operating under CoVID protocols, with open doors and social distancing practices enforced. This presented statistically significant numbers of collocated classrooms for PM exposure comparisons, where 60 classrooms outfitted with RMAP air purifiers were juxtaposed to 30 otherwise identical classrooms with similar occupancy. Using aerosol cytometers, University of Colorado teams compared PM loads in classrooms with and without RMAP air purifiers.



Results. Regardless of air exchange rate, a significant fraction of classrooms operating with RMAP air purifiers had markedly lower PM loads than their counterpart classrooms without air purifiers installed. On average, RMAP operation (500 cfm effective CADR) provided each student with significant respirable particle reduction ($PM_{2.5\text{-}10}$) in their local classroom air. The PM particle exposure reductions realized by the average student in the average classroom (50^{th} percentile) was at least 1200 #/m^3 on a typical school day. In the rooms that were equipped with the least-effective ventilation systems, the placement of air purifiers was able to produce an approximate 50% reduction in transmission risk, putting them on par with the better-ventilated classrooms. Classrooms with the air purifiers engaged saw a reduction in the number of respirable airborne particles ranging between 200 and 2000 particles per cubic meter per student, as compared to comparable classrooms without air purifiers installed which ranged from 800 – 4000 particles per cubic meter per student. Particulate reductions were most prominent in classrooms with poorer-performing ventilation systems. Respirable particle reductions in occupied classroom ranges from at least 500 #/ m^3 (70^{th} %ile) and 2000 #/ m^3 (20^{th} %ile).



Complementary modeling of airborne disease transmission using an academic cooperative shareware (www.safeairspaces.com) projected significant reductions in exposure risks. The model considered architectural factors, student occupancy and the ventilation performance measured. The operations of two in-room air purifiers reduced maximum probability of airborne disease transmission for the average classroom monitored from 26% to 13% (c.a. ½).



Summary. As judged by real-time (bio)aerosol cytometry of occupied classroom air, Carrier RMAP air purifiers were able to sustain significant reductions in airborne PM loads in occupied elementary school classrooms with less-than-optimal ventilation status. The same was true for estimates of the maximum probability of airborne infection risks. Common models using only $CADR_{max}$ and floor area would likely overestimate this performance. As judged by *in-situ* sound pressure emissions, the acoustic envelope projected by these air purifiers under actual operating conditions fell within a range that does not interfere with classroom communications under WHO guidelines.