

FINAL PROJECT REPORT

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The evaluation of green school building attributes and their effect on the health and performance of students and teachers in New York State

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EXECUTIVE SUMMARY

Background

The green building movement has in the past focused primarily on the economic benefits or general environmental impacts of buildings rather than the effects on occupants. However, students, teachers and other staff spend a substantial proportion of their time in schools. The question of potential health and performance gains in relation to green buildings still needs to be addressed. Prior studies have focused on adults working in office buildings, adverse health effects, and general building conditions or single school factors (e.g. indoor air quality (IAQ)), few studies have evaluated the impact of the school environment as a whole on occupant performance. Specifically, few examined school cleanliness, various IAQ factors, acoustics, and lighting and their joint effects. To fill some of these gaps, the objective of the current project was to assess if green school building factors individually and jointly affect student performance and health as well as teacher teaching ability and health in New York State (NYS).

Methods

This study consisted of three components: statewide data linkage analyses, a statewide telephone teacher survey, and a sub-sample of school walkthroughs (objective measurements and occupant surveys). Statewide analyses examining the relationship between school building conditions and student performance and health were conducted by linking NYS Building Condition Survey (BCS) data with student attendance and test performance data, and school district level asthma hospitalization data in NYS public schools (excluding New York City). Sixty-six building-related variables were analyzed separately and also grouped into attributes measuring IAQ, dryness, cleanliness, acoustics and lighting. Additional building attributes reflecting well-maintained building systems were identified including site utilities, envelope, interior, plumbing and HVAC system. A summary measure of greenness, the green school index (GSI) was developed, cumulating the variables described above. The second study component consisted of a statewide telephone survey of teachers asking about teacher demographics, teaching experience and hours, health symptoms, perceptions of the school environment, whether certain classroom conditions affected teaching ability, and home environmental conditions. The third study component consisted of school walkthroughs and objective measurements conducted in ten schools to evaluate classroom conditions and IAQ as well as measuring temperature, relative humidity, carbon dioxide (CO₂), sound, and lighting. Surveys of school nurses and teachers were also conducted in these schools.

Results

This study found that the most commonly reported healthy green school building conditions included absence of visible mold problems (> 96%) and vermin infestations (>96%). On the other hand, the most unhealthy school building problems were visible water damage/leaks (18%-29%) and unsatisfactory rating of components of the building envelope, including, the roof, windows and skylights (17%-20%).

Specific indicators affecting IAQ, such as fresh air intakes away from sources of diesel exhaust (Odds Ratios [ORs]) ranging from 1.9-2.8), air intake free of blockages (OR: 2.03), and properly functioning dampers (OR: 1.61), as well as a summary measure of IAQ (OR: 1.36), were the most important factors contributing to good student attendance in NYS. The GSI, representing

good IAQ, absence of moisture/mold, good lighting, good acoustics, cleanliness and well-maintained building systems was also found to be significantly associated with good attendance in NYS (OR: 1.22). In addition, good lighting fixtures ratings (OR: 1.55) and no active infestations of cockroaches (OR:10.2) were significantly related to good attendance. We also found significantly interactive effects of the geographic region of the school (upstate vs. downstate schools) between the association of some school factors and student outcomes. In other words, we found that many healthy green building conditions were significantly associated with favorable outcomes for the occupants in upstate NY schools, including fresh air intakes away from sources of diesel exhaust (ORs ranged from 2.35-3.07), air intakes free of blockages (OR: 2.33) or ductwork free of dirt (OR: 2.33), good condition of air filters (OR: 1.40), functioning dampers (OR: 2.08), good overall IAQ/ ventilation (OR: 1.39) and good acoustics (OR: 1.47). However, some of these positive relationships were not found in downstate schools except for fresh air intakes away from sources of diesel exhaust (ORs ranging from 2.87 to 3.03) and air intakes free of blockages (OR: 1.81).

In terms of school performance, good condition of air filters was associated with good 4th grade academic performance (OR: 1.42) in statewide analyses. In upstate schools, good condition of air filters (OR: 2.27), good humidity/ moisture rating (OR: 1.62), and excellent/ satisfactory lighting fixtures (OR: 2.97) as well as a good overall IAQ attribute score (OR: 1.68) were found to be significantly associated with good student test scores, but these associations did not hold for downstate schools.

The median asthma hospitalization rate from 2003-2006 among school-age children by NYS school district (excluding NYC) was 18.13 per 10,000. A statewide analysis of school district conditions and asthma hospitalization rates found that high cleanliness scores (OR: 1.46) and good building plumbing scores (OR: 1.90) were significantly associated with lower asthma hospitalization rates, after controlling for potential confounders.

A statewide teacher survey (N=501) found the most commonly reported of 14 health symptoms to be sinus problems (22.2%) and allergies/congestion (21.4%). For the most common symptoms, large proportions of teachers reported worsening during the school day or week, ranging from 38.3% for sneezing to 82.9% for throat irritation. Similar proportions reported improvement of these symptoms when away from work (62.6% for allergies/congestion to 92.1% for throat irritation). Substantial proportions of teachers (16.7% to 42.3%) also reported that a given symptom affects their work or attendance. Almost half (48.9%) of teachers surveyed reported having one or more symptom, and over 40% reported having at least one allergic-type symptom. Symptoms potentially associated with poor lighting parameters were reported by 29.3% and acoustics-related symptoms such as headaches and throat irritation were reported by 30.9% of teachers. The most favorable school conditions associated with reduced teacher health symptoms included absence of mold or odors from mold, moisture damage, dust/dust reservoirs, vermin, art supplies, scented products, paint, cleaners and noise; adequate storage, classroom climate comfort and ability to control temperature with a thermostat, glare, and hear students in a normal tone of voice (ORs ranging from 0.15 to 0.60).

A sub-study consisting of school walkthroughs and measurements found that approximately 64% of classrooms had CO₂ concentrations above the maximum recommended level of 1,000 parts

per million (ppm) at some point during the monitoring period, and in nearly 25% of classrooms CO₂ levels were above 1,000 ppm around 40% of the time. Classroom temperature and humidity were generally within acceptable ranges. This study found that high CO₂ levels measured in classrooms were significantly associated with teachers reporting any and multiple health symptoms. Teachers who felt their symptoms affected teaching ability were more likely to teach in a classroom with higher measured levels of CO₂ although it was not statistically significant.

Summary of key findings and conclusions:

- The most common unfavorable building conditions in NYS public schools were water damage/leaks and unsatisfactory rating of components of the building envelope.
- The most common favorable building conditions reported in NYS schools were absence of visible mold and vermin infestations.
- Schools with good IAQ, especially having fresh air intakes away from sources of diesel exhaust and having good ventilation, were 94%-184% more likely to have a good attendance rate than other schools.
- Good lighting fixtures and no active infestations of cockroaches were related to good attendance.
- Schools with high IAQ total scores and a high Healthy Greenness School Index (GSI) were more likely to have high student attendance rates (36% and 22 % respectively).
- Schools with good condition of air filters were also 42% more likely to have good 4th grade academic performance.
- The favorable effects of healthy school building conditions on student attendance and performance mainly appeared in upstate schools and less in downstate schools.
- School cleanliness and good maintenance of school plumbing systems may contribute to lower school district asthma hospitalization rates.
- Many health symptoms reported by teachers were potentially work-related, and many of these symptoms were perceived to affect their attendance and/or teaching ability.
- Most favorable school conditions were associated with reduced teacher's report of health symptoms.
- Classroom measurements in ten NYS schools of temperature and humidity were generally within acceptable ranges.
- High classroom CO₂ levels were significantly associated with teacher reports of three or more health symptoms as well as the reporting of any allergic symptoms.

In summary, this study emphasized the potential importance of healthy school building characteristics, especially IAQ and ventilation as well as cleanliness, thermal comfort, lighting and acoustics, on school occupant health and performance, which affects the functioning of the educational system for teachers and students. These results add to the growing body of literature addressing the positive impact of healthy and green school characteristics on occupants, and can be used to guide stakeholders in advocating for and implementing changes in the school environment.