

Evaluating Impacts of Green Building Attributes in Schools on Students/Teachers



Shao Lin, Christine Kielb, Anne Orsini, Neil Muscatiello, Syni-An Hwang
Bureau of Environmental & Occupational Epidemiology,
New York State Department of Health (NYSDOH)

Project Partners

Bureau of Toxic Substances Assessment, NYSDOH

Bureau of Occupational Health, NYSDOH

Office of Facilities Planning, New York State Education Department

Board of Cooperative Educational Services (BOCES)

U.S. Congressman Paul Tonko

New York State United Teachers (NYSUT)

Funded by the United States Green Building Council (USGBC)

Research Gaps & Study Goals

Research Gaps

- Previous studies primarily focused on their economic or environmental impacts rather than occupant outcomes.
- Many studies looked at the impact of individual green attributes, but few studied the collective effects.
- Research was lacking for quantifying and evaluating green attributes and their potential positive impact on occupants.

Goal: Identify and measure “green” building attributes and assess if they, individually and collectively, may positively affect occupant health, attendance and performance in NYS schools.

Study Components

School Conditions and Student performance/health:

Linked 2005 NYS Building Condition Survey (BCS) to 2004-2005 student attendance/test performance (N=2750) and health

Statewide Teacher Survey:

- Telephone Survey through NYS United Teacher's Union of a random sample of FT classroom teachers (N=501) from non-NYC Schools to assess teacher health, performance and classroom environments

Sub-study of 10 Schools:

- Building/Classroom Walk-throughs (5-10 classrooms per school)
- Teacher (N=299) and Nurse Surveys (N=9)
- Continuous measurements of carbon dioxide, temperature, relative humidity, light intensity; point measurements of noise in 87 classrooms

Statewide BCS Analysis

(N=2750 non-NYC public schools)

Design: Cross-sectional study using logistic regression

Exposures:

- “Green” Building Attributes: individual variables including indoor air quality, thermal comfort, dryness, cleanliness, well-maintained systems, acoustics, and lighting
- Green School Index (GSI): a composite of all variables

Outcomes:

- Attendance rate (annual average) by school
- Standardized test performance by school (% of school scoring at highest level (between 85-100) on Math, Science, English)
- Asthma hospital admission rates by school district

Confounders controlled in the model:

- School percent eligible for free lunch, district race/ethnicity %, district expenditure per pupil, pupil per teacher ratio, outdoor environment (school proximity to highway, airport and industrial facilities), urbanicity, presence of high school students, building age, student density, and geographic location (upstate or downstate)

Building Condition Survey (BCS)

- Mandated for all public schools by the 1999 Commissioner of Education regulations (part 155, sections 3 and 4)
- One component of the Comprehensive Public School Safety Program
- Physical inspection by team that includes architect or engineer
- Schools required to complete every five years since 2000
- 2005 BCS contains more specific information on IAQ
- BCS includes 500 building condition variables and about 70 variables were examined in this project
- NYSED posts results on website (available to public), providing a sustainable data source for school indicators

BCS Survey Contents

- **Program spaces, building age and square footage**
- **Overall building rating** - Ratings (excellent, satisfactory, unsatisfactory, failing)
- **Individual systems** (ratings, remaining useful life)
 - Building Site
 - Exterior elements
 - Structural elements
 - Interior elements
 - Fire protection and security
 - Electrical systems
 - Roofing
 - Plumbing
 - HVAC systems
 - Special construction
- **Environmental/comfort/health parameters** (ratings and comments)
 - General appearance
 - Cleanliness
 - Acoustics
 - Lighting
 - Vermin
- **Indoor Air Quality (IAQ)**
 - Visible Mold
 - Humidity/Moisture
 - Ventilation
 - District IAQ program

School attendance (90th percentile and above) and individual green building attributes in NYS public schools, 2005

Building Condition	All Schools OR adj* (90% CI) N=2713	Upstate Schools OR adj** (90% CI) N=1813	Downstate Schools OR adj** (90% CI) N=900
Indoor Air Quality			
Air intakes not near bus loading	1.94 (1.36-2.76)†	2.35 (1.42-3.90)†	1.48 (0.89-2.46)
Air intakes not near truck delivery areas	2.32 (1.53-3.53)†	1.92 (1.11-3.33)	2.87 (1.50-5.48)†
Air intakes not near garbage disposal areas	2.84 (1.46-5.54)†	3.07 (1.11-8.45)	3.03 (1.24-7.44)†
Ductwork free of dirt/dust/debris	1.29 (0.91-1.82)	2.51 (1.28-4.92)†	0.96 (0.63-1.46)
Intakes free of blockages	2.03 (1.35-3.04)†	2.33 (1.18-4.58)†	1.81 (1.08-3.02)
Air filter condition good	1.22 (0.98-1.50)	1.40 (1.03-1.91)	1.07 (0.79-1.46)
Dampers functioning	1.61 (1.10-2.35)†	2.08 (1.13-3.81)†	1.42 (0.86-2.35)
Overall IAQ/Ventilation Rating Good	1.17 (0.94-1.46)	1.39 (1.05-1.84)	0.95 (0.66-1.36)
Good Acoustics	0.94 (0.75-1.17)	1.47 (1.09-1.98)†	0.54 (0.39-0.76)†
Good Lighting			
Lighting quality rated good	0.81 (0.65-1.00)	1.07 (0.79-1.44)	0.61 (0.44-0.83)†
Excellent/Satisfactory Fixtures	1.55 (1.06-2.27)	1.64 (0.92-2.94)	1.53 (0.91-2.56)
Good Cleanliness			
Good general appearance	0.80 (0.61-1.04)	1.03 (0.72-1.47)	0.66 (0.43-0.996)
No active infestations of cockroaches	10.2 (1.88-54.7)†	0.74 (0.12-4.41)	-----

†=p value of 0.05 or less

*Adjusted for percent eligible for free lunch, district white enrollment, district expenditure per pupil, pupil per teacher ratio, outdoor environment, urbanicity, presence of non-high school students, building age, student density, and geographically located in downstate counties.

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School attendance (90th percentile and above) and composite healthy green building index in NYS public schools, 2005

Healthy Green Attribute Scores (Above Median)	All Schools OR adj* (90% CI) N=2523	Upstate Schools OR adj** (90% CI) N=1703	Downstate Schools OR adj** (90% CI) N=820
Indoor Air Quality Score	1.36 (1.11-1.67)†	1.67 (1.27-2.22)†	1.08 (0.78-1.49)
Dryness 1 Score (no moisture)	1.02 (0.83-1.25)	0.91 (0.69-1.19)	1.15 (0.85-1.57)
Dryness 2 Score (no mold)	1.06 (0.70-1.58)	1.11 (0.64-1.91)	0.96 (0.51-1.79)
Acoustics Score	0.94 (0.75-1.17)	1.38 (1.02-1.87)	0.55 (0.39-0.78)†
Lighting Score	0.89 (0.72-1.10)	1.16 (0.86-1.56)	0.68 (0.49-0.94)†
Cleanliness Score	1.06 (0.82-1.38)	1.22 (0.85-1.75)	0.86 (0.59-1.27)
Building Site Utilities Score	1.09 (0.90-1.34)	1.10 (0.85-1.42)	1.07 (0.78-1.47)
Building Site Other Utilities Score	1.09 (0.88-1.35)	1.24 (0.94-1.64)	1.00 (0.71-1.41)
Building Envelope Score	0.95 (0.78-1.16)	1.20 (0.92-1.57)	0.76 (0.56-1.04)
Building Interior Score	1.17 (0.95-1.43)	1.18 (0.91-1.55)	1.19 (0.86-1.64)
Building Plumbing Score	0.96 (0.77-1.21)	1.07 (0.79-1.46)	0.87 (0.61-1.25)
Building HVAC Score	0.96 (0.79-1.17)	1.00 (0.77-1.30)	0.94 (0.69-1.29)
Total Healthy School Greenness Score	1.22 (0.996-1.48)	1.51 (1.16-1.97)†	0.92 (0.67-1.26)

†=p value of 0.05 or less

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School performance on 4th grade Math, Science, and English standardized tests (75th percentile and above) and healthy green building conditions in NYS public schools, 2005

Building Condition	All Schools OR adj* (90% CI) N=1435	Upstate Schools OR adj** (90% CI) N=946	Downstate Schools OR adj** (90% CI) N=489
Indoor Air Quality			
Air filter condition good	1.42 (1.06-1.89)†	2.27 (1.38-3.75)†	1.18 (0.80-1.74)
Dryness-No Moisture Problems			
Good humidity/moisture rating	1.08 (0.83-1.40)	1.62 (1.06-2.47)	0.92 (0.64-1.34)
Good Lighting			
Excellent/Satisfactory Fixtures	1.40 (0.90-2.20)	2.97 (1.07-8.25)	1.14 (0.65-2.02)

†=p value of 0.05 or less

*Adjusted for percent eligible for free lunch, district white enrollment, district expenditure per pupil, pupil per teacher ratio, outdoor environment, urbanicity, presence of non-high school students, building age, student density, geographically located in downstate counties, attendance, and 4th grade enrollment.

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BCS and Student Outcomes Summary

- The most common favorable building conditions in NYS: absence of visible mold and vermin infestations
- Most IAQ variables, high IAQ total scores, and good ventilation were associated with good attendance
- Good condition of air filters, lighting and dryness, and high IAQ scores were related to good test scores
- School cleanliness and good maintenance of school plumbing systems may lower asthma admissions

Strengths and Limitations

- Large N; available, sustainable data source
- Data general, somewhat subjective, snapshot

Teacher Survey and Classroom Measurement Summary



- Many health symptoms reported by teachers appear to be work-related and affected their performance.
- Most favorable classroom conditions, particularly relating to dust and dryness, glare control and absence of excessive noise in hallways, inversely associated with teachers' symptoms.
- Indoor temperature and humidity in 10 NYS schools were generally within acceptable ranges.
- High classroom CO₂ levels were significantly associated with any allergic symptoms and ≥ 3 health symptoms reported by teachers.

