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School environmental conditions and links to academic performance and absenteeism in urban, mid-Atlantic public schools

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Abstract

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School facility conditions, environment, and perceptions of safety and learning have been investigated for their impact on child development. However, it is important to consider how the environment separately influences academic performance and attendance after controlling for school and community factors. Using results from the Maryland School Assessment, we considered outcomes of school-level proficiency in reading and math plus attendance and chronic absences, defined as missing 20 or more days, for grades 3-5 and 6-8 at 158 urban schools. Characteristics of the environment included school facility conditions, density of nearby roads, and an index industrial air pollution. Perceptions of school safety, learning, and institutional environment were acquired from a School Climate Survey. Also considered were neighborhood factors at the community statistical area, including demographics, crime, and poverty based on school location. Poisson regression adjusted for over-dispersion was used to model academic achievement and multiple linear models were used for attendance. Each 10-unit change in facility condition index, denoting worse quality buildings, was associated with a decrease in reading (1.0% (95% CI: 0.1-1.9%)) and math scores (0.21% (95% CI: 0.20-0.40)), while chronic absences increased by 0.75% (95% CI: 0.30-1.39). Each log increase the EPA's Risk Screening Environmental Indicator (RSEI) value for industrial hazards, resulted in a marginally significant trend of increasing absenteeism ($p < 0.06$), but no association was observed with academic achievement. All results were robust to school-level measures of racial composition, free and reduced meals eligibility, and community poverty and crime. These findings provide empirical evidence for the importance of the community and school environment, including building conditions and neighborhood toxic substance risk, on academic achievement and attendance.

Keywords

absenteeism; academic achievement; air pollution; chronic absence; facility condition; schools

Introduction

An estimated 35.4 million prekindergarten through 8th grade students will spend the majority of their day attending U.S. public schools (NCES 2016). While near home environmental conditions (Diette et al. 2007) and neighborhood characteristics (Viner et al. 2012) may impact childhood health, the conditions at schools have been shown to affect both health and learning potential, causing long-term impacts on future opportunities (Durán-Narucki 2008). Ambient air pollution (Gilliland et al. 2001; Mohai et al. 2011; Park et al. 2002; Sheehan et al. 2017), building conditions (Evans et al. 2010; Mendell and Heath 2005; Simons et al. 2010), perceptions of school safety and environment (Durham et al. 2014; Wang et al. 2014; Bosworth et al. 2011; Milam et al. 2010), and community factors (Bowen and Bowen 1999; Eamon 2005; Milam et al. 2010) have all been associated with declines in academic performance and increases in absenteeism among children.

Consideration of school-level exposures is critical in evaluating adolescent health and the downstream effects that health may have on school performance. As a subpopulation, children are of particular concern; their smaller size, combined with still developing respiratory and neurological systems makes them physiologically vulnerable to chemical exposures (Gauderman et al. 2007; Legot et al. 2012). Near-school industrial hazards and

traffic pollutants pose substantial risk and have been connected with developmental, reproductive, neurological, immunologic, respiratory, and hematological morbidities (Freire et al. 2010; US EPA 2013). Many chemicals may be causally linked to multiple outcomes making it possible for a single toxin to drive several health effects (Legot et al. 2012). However, despite these risks, regulations regarding the siting of schools are limited. Twenty states lack legislation for siting schools and only 10 states prohibit new schools from being located near hazardous activities (Gaffron and Niemeier 2015).

Research investigating the effects of industrial pollutants on school children has been a topic of growing interest. Studies in the United States and Asia have found that exposure to industrial air pollution and Toxic Release Inventory (TRI) sites are associated with declines in academic performance and increased absenteeism among school children (Grineski et al. 2016; Lucier et al. 2011; Makino 2000; Pastor et al. 2004; Rosofsky et al. 2014). Although published results show consistent trends, most investigations focus on single student populations and outcomes. It has not been effectively demonstrated how school and community characteristics may influence academic performance and absenteeism within a single city, and how this might vary by age groups. These factors should be important considerations for improving academic success and planning the locations of new schools.

The objective of this research was to investigate how ambient environmental conditions and the school physical environment simultaneously impact academic performance and absenteeism among students. Primary factors included school building proximity to roadways, air pollution toxicity from industrial sites, condition of school buildings, surveyed perceptions of schools safety, teaching, and leadership, and community measures of poverty, crime, and socio-demographic variables. This study adds to existing ecologic assessments of school-based exposures, but by incorporating a comprehensive school inspection, multiple community-level factors, and stratifying outcomes by age, it addresses a literature gap concerning multi-factor relationships with both academic performance and absenteeism.

1. Methods

1.1. Study Population and Overall Design

The study population included Baltimore City public school children in 3rd through 8th grade. A total of 158 schools were examined using school performance data from the 2013-14 school year provided by the Maryland State Department of Education (MSDE) as part of their accountability program. Nine of the 158 schools represent alternative programs and settings to serve special needs students who do not participate in traditional testing and were excluded from analysis. School environmental data, school climate surveys, and community characteristics were also obtained as part of the analysis.

1.2. Performance Outcome Measures

Academic achievement was evaluated using the Maryland School Assessment (MSA), an annually administered accountability assessment taken by Maryland 3rd to 8th grade school children, during the 2013-2014 school year. The number of students taking the exam was provided for each school, along with the count of students who scored proficient or

advanced in reading or math as determined by standards set by MSDE as part of *No Child Left Behind*. It should be noted that 2013-2014 was the last year of the MSA. Transitions were being made to the Partnership for Assessment of Readiness for College and Careers assessment with some educators already teaching to those standards. The attendance rate is an average of daily attendance across the academic year. The chronic absence rate identifies students who miss more than 20 days of school if enrolled for at least 90 days. Four separate performance measures were considered: 1) the percentage of students achieving a proficient or advanced status in reading, 2) the percentage of students achieving a proficient or advanced status in math, 3) the attendance rate, and 4) the chronic absence rate.

1.3. School Environmental Data

The U.S. EPA Risk-Screening Environmental Indicator (RSEI) for industrial hazards is a model of toxic substance risk from TRI sites that considers factors of distance to industrial point source, quantity of chemicals released, chemical toxicity, and environmental fate and transport. Increasing numeric scores represent greater general risk (EPA 2017). Data for the 2014 year RESI were downloaded as 810×810m grids and spatially overlaid with school locations. Each school location was assigned the value of its underlying toxicity concentration grid cell, which represents the TRI chemical concentration multiplied by a toxicity weight. The toxicity weight is based on human health effects from long-term chemical exposures to the most sensitive oral or inhalation exposure pathway (EPA 2016). The RSEI serves as an indicator for potential chronic human health impacts due to toxic releases at nearby industrial facilities.

Physical features and school building characteristics, such as size, condition, utilization, and educational adequacy, were assessed for all Baltimore City Public Schools in 2012 (Baltimore Board of School Commissioners 2013). Reported values included a facility condition index (FCI) and an educational adequacy score. The FCI is an industry standard used to evaluate building conditions, comparing the cost of repairs against building replacement: 10% is good condition; 11-30% is average; 31-50% is poor; 51-74% is very poor; 75% is candidate for replacement. The educational adequacy score is a metric that captures how well the school's physical structure, technology, and space serves academic goals. On a 1-100 scale, it is asserted that 80 should be the target of a modern building (Baltimore Board of School Commissioners 2013).

To assess the roadways around school buildings, TIGER/Line Maryland primary and secondary roads shapefiles from 2013 were downloaded (U. S. Census Bureau 2013). We considered roads classified in two broad categories: 1) all roads (including highways, major roads, and city streets), and 2) highways and major roads only. Classifications for pedestrian paths and 'other' roads (minor alleys, private roads, parking lot roads) were not considered. The total length of 'all roads' and 'major roads and highways' were separately calculated at 100, 200, and 300 meter buffers around each school.

1.4. School Characteristics

A comprehensive list of available school-level variables were acquired through the MSDE for the 2013-2014 school year (<http://reportcard.msde.maryland.gov>). These included the

percentage of white students, the percentage of black students, the percentage of students eligible for free and reduced meals (FARMS; used by the district as a proxy for poverty), and the percent of students enrolled in a special education program at each school (an indicator of additional academic needs and services which must be supplied by the school).

1.5. School Climate Survey

The Baltimore Education Research Consortium (BERC) used 2012-2013 survey questionnaire data to align with the five broad areas of school climate as determined by the National School Climate Center (www.schoolclimate.org): 1) safety - including how well students and staff understand what is physical and verbal abuse, consistent rule enforcement, how safe people feel from physical harm, plus safety from verbal abuse, teasing, and exclusion; 2) teaching and learning - including support of teaching practices, opportunities to demonstrate skills, academic rigor, support for independent thinking, and atmosphere for dialogue; 3) interpersonal relationships - including respect for diversity and tolerance, supportive adult relationships with students (expectations for student success, willingness to listen, personal attention), and social support among students (peer relationships, student academic help, new student acclimatization); 4) environment - including positive identification with school participation in school life, the cleanliness, order, and appeal of facilities; and 5) leadership/staff relations – including a clear administrative vision, accessible school staff, and positive attitudes among staff to support work and learning. While surveys were administered to faculty and staff, students, and parents, the faculty and staff response data were used in the model. Parent surveys were not considered due to low response rates (~25%); student surveys were not used because the district reduced the number of survey items to compensate for a separate classroom survey leaving the collected information much less predictive. In contrast faculty and staff responses were correlated with independent reviews of school performance (Durham et al. 2014). For each of the five topics, results were presented in terms of the percentage of faculty and staff within each individual school that ‘Strongly Disagreed,’ ‘Disagreed,’ ‘Agreed,’ or ‘Strongly Agreed,’ with the ‘Agree’ and ‘Strongly Agree’ and ‘Disagree’ and ‘Strongly Disagree’ percentages aggregated into two variables for analysis. Additional description of survey questions can be found in Table S1 and the data are publicly available (<http://www.baltimorecityschools.org/Page/31013>).

1.6. Community Characteristics Data

Community-level characteristics were downloaded from the Baltimore Neighborhood Indicators Alliance Vital Signs website (Baltimore Neighborhood Indicators Alliance 2014). Vital Signs represents a long running project led by the University of Baltimore of compiled Baltimore City data on Census Demographics, Housing and Community Development, Children and Family Health, Crime and Safety, Workforce and Economic Development, and Education for Baltimore City. We investigated 27 variables of potential importance. Data were aggregated to the community statistical area (CSA), which represent neighborhoods based on combining 2010 Census tract boundaries. Baltimore City contains 55 CSAs and values typically represent conditions occurring within neighborhoods (Baltimore Neighborhood Indicators Alliance 2014). Individual schools were assigned the community-level characteristic of the CSA in which they reside.

A comprehensive list of all variables considered in this analysis can be found in Table S2 for school-level measures and Table S3 for community-level measures.

1.7. Statistical Analysis

The four performance outcomes of 1) percent of students achieving proficient or advanced performance in reading, 2) percent of students achieving proficient or advanced performance in math, 3) attendance rate, and 4) chronic absence rate were assessed. Models were evaluated separately for each outcome over grades 3 to 5 and for grades 6 to 8. For academic proficiency of reading and math performance, a negative binomial generalized linear Poisson regression model (to accommodate statistical over-dispersion) was utilized with an offset equivalent to the number of students tested at each school. Linear regression was used for attendance and chronic absence rates.

We initially explored the unadjusted association between the four outcomes and each independent variable. Covariates achieving statistical significance ($p < 0.05$) in these univariate models were included in the multivariate assessments for those outcomes. To achieve parsimony, we used variance inflation factors and a forward and backward selecting stepwise Akaike Information Criteria (AIC) to eliminate collinear variables or those with limited statistical contribution. We tested for normality of data and outliers using Q-Q plots and Cook's distance metrics. One overly influential school from the grades 6 to 8 attendance and chronic absence rates model was removed. Variables failing to achieve a p-value of 0.1 were removed from the model, followed by a final selection of variables achieving $p < 0.05$.

We adjusted for the confounding effect of older students by classifying schools as elementary grades only (K-5), elementary and middle school grades (K-8), middle school grades only (6-8), and middle school plus high school grades (6-12). The RSEI distribution displayed a strong positive skew and was addressed through a log-transformation. Statistical computations were performed using the R Statistical software (v. 3.0) with Geographic Information Systems (GIS) and mapping functions from 'sp' and 'gstat' packages (R Core Team 2016).

2. Results

A summary of the school-level characteristics representing elementary and middle school grades is presented in Table 1. A total of 126 schools were included in the elementary grades cohort and 91 schools were included in the middle grades cohort. The majority of Baltimore City public schools contain elementary grades only (K-5) or elementary and middle grades (K-8). Only 23 schools serve only middle school grades or middle and high school grades. Figure 1 shows a map of school locations by school type and proximity to major roads and toxic release inventory (TRI) sites.

Reading proficiency averaged 63.0% (13.3% SD) in elementary school grades and 60.7% (15.4% SD) in middle school grades, while math proficiency was 45.2% (17.4% SD) and 38.6% (18.4% SD) in those same cohorts, respectively. Mean attendance rates were similar (around 93%) for both grade groups; however, chronic absence rates were 1.4% (4.6% SD) higher in middle school grades, although not statistically significant. School characteristics

showed a high percentage of students in elementary grades (88.1%) and middle schools grades (88.4%) eligible for FARMS, while schools served an average of 83% black student populations. Middle school grades had a significantly higher percentage (21.8%; 13.1% SD) of students enrolled in special education compared to elementary grades (13.9%; 8.1% SD) based on a t-test comparison ($p < 0.05$).

The school environment is represented separately through the facility condition index, educational adequacy score, and RSEI (Figure 2). Three schools met the FCI standard of 'good condition,' while 22 were considered 'average condition.' The other 122 schools were rated in 'poor or worse' condition with 40 schools scoring as candidates for replacement. The mean educational adequacy score was around 56, ranging from 17.2 to 68.7. No schools achieved the 80 educational adequacy score target for a modern building. The mapped RSEI showed a strong trend of increasing risk toward southeast Baltimore, where TRI sites are clustered around the Port of Baltimore (Figure 1). RSEI values were heavily right-skewed with the Curtis Bay and Bay Brook area schools; these are located at the southern end of the city and have scores 5-times higher than the average of all other schools.

Figure 3 shows the spatial variation of four significant community level variables, including teen births and measures of crime and poverty. Spatial trends are apparent. The north central portion of the city shows lower community levels of poverty and crime, while the CSAs with the greatest poverty appear clustered around the downtown central area of the city. West Baltimore shows higher number of homicides, while arrests are greatest in the central part of the city.

Out of 52 initial variables examined (Tables S3–S6), we found 42 to be statistically significant in unadjusted models. The distance of school buildings to 'all roads' and 'major roads and highways' were not significant and excluded from further consideration in the multivariate assessment. Results from the multivariate models are reported in Tables 2 and 3 and represent only those covariates showing statistically significant associations.

School environment and neighborhood characteristics were associated with academic performance. Worsening school environment (facility condition index), increased perception of unsafe schools, increased special education population, and higher teen birth rates at the community level were associated with decreased academic performance, based on reading and math performance at the elementary grade level (Table 2A). When schools contained both elementary and middle school grades, as opposed to elementary grades only, math performance decreased by 10.64% (estimated effect change -10.64% , 95% CI: -19.24 , -1.14) and reading performance decreased by 5.44% (estimated effect change -5.44% , 95% CI: -9.95 , -0.70) among the elementary grade level students. For middle school students, higher attendance rates and better school facilities (educational adequacy scores) increased academic performance (Table 2B). However, greater student eligibility for FARMS, higher perception of poor teaching/learning, and greater numbers of community teen births decreased academic performance. Similar to younger students, middle school grades in schools with older students showed decreases in reading and math performance. In schools that contained both middle and high school grades, we found middle school math scores to

decrease by 38.44% (estimated effect change -38.44% 95% CI: $-48.37, -26.44$) and reading scores to decrease by 12.05% (estimated effect change -12.05% , 95% CI: $-18.38, -5.26$).

School environment and safety were associated with attendance rates and chronic absences, which may be a surrogate for health (Table 3A and 3B). For each 10% increase in the surveyed perception of unsafe schools, attendance rates decreased by -0.75% (95% CI: $-1.01, -0.48$) and -1.69% (95% CI: $-2.69, -0.69$) for elementary and middle school grades respectively, while chronic absences increased by 3.61% (95% CI: $2.33, 4.90$) and 8.09% (95% CI: $4.95, 11.24$). Associations with the EPA RSEI value found chronic absences to increase by 3.40% (95% CI: $-0.08, 6.76$) in elementary grades for each log increase in RSEI and 8.09% (95% CI: $4.95, 11.24$) in middle school grades. These results represent strong trends and approached statistical significance ($p < 0.06$). Poor attendance and higher chronic absences were associated with additional factors including worse facilities, increasing poverty, and higher crime, notably among the elementary grade cohort. Our final model was able to explain 46% and 29% of variability in attendance rate and 45% and 38% of variability in chronic absence rates among elementary and middle school grades respectively.

3. Discussion

Our study found that school building conditions, physical environment, and community factors were associated with academic performance among elementary and middle school children in the mid-Atlantic region. We observed building conditions, industrial pollutant levels, school safety, and neighborhood crime to significantly impact student absenteeism. We did not observe proximity to roadway types of any kind to be associated with performance or absences. These results suggest that industrial toxins may play a more critical role in absenteeism compared to academic achievement, while school facilities, student safety, community crime, and poverty are important predictors of both outcomes. By incorporating a variety of school- and community-level characteristics, this study applies a multi-factor assessment to extend inference about how children's environmental exposures impact academic achievement and health.

Poor air quality has been associated with increased incidence of acute illnesses that drive higher absenteeism among children (Grineski et al. 2016; Mohai et al. 2011; Pastor et al. 2004; Rosofsky et al. 2014). Consistent with these studies, our investigation found similar associations between industrial pollutant exposure and absenteeism, even after controlling for school and community-level factors. Industrial air pollution poses a particular health risk, as it may contain particles, heavy metals, and volatile organic compounds (Kampa and Castanas 2008). It is hypothesized that student populations will have worse health when located in communities with higher RSEI values. However our study relied on aggregated school data and so it could not be determined if individual absences were due to respiratory-related morbidity or other causes. High industrial air pollution may also drive parental avoidance behavior, even without acute health events, causing further school absences among asthmatics and children with chronic respiratory illnesses (Currie et al. 2009; Lucier et al. 2011).

While we observed industrial pollutants to increase absenteeism, we did not find an association with academic performance. This is in contrast to prior research (Mohai et al. 2011; Rosofsky et al. 2014). In communities with high volume industrial pollution, the presence of neurotoxins, developmental toxins, and heavy metals were found to lower academic potential by limiting cognitive development (Legot et al. 2012). In El Paso, Texas each IQR increase in hazardous air pollution resulted in a 0.40 (95% CI: 0.64, 0.17) decrease in grade point average, with associations between TRI sites and reduced academic performance observed in Louisiana and Texas (Lucier et al. 2011; Pastor et al. 2004). It is possible that the schools in our study are not proximally located to industrial sites that produce toxins specific to developmental disorders. Instead academic performance may be driven by perceptions of school-safety, building conditions, or community crime, which are control variables unique to our study. Another consideration is that the industrial pollution effects are already accounted for in a model that includes absenteeism, which is strongly correlated with student performance.

Multiple studies have identified the importance of not only industrial pollutants, but also ambient air pollution on academic performance and absences (Chen et al. 2000; Gilliland et al. 2001; Park et al. 2002). A constraint on our assessment was a lack of measurable pollution data. We did not sample ambient air pollution at school sites for these years. While two central site air pollution monitors exist in Baltimore City, these do not provide sufficient information to evaluate variability between schools. As a surrogate we used the proximity of roads and road density to account for traffic-related air pollution exposure (Brauer et al. 2003; Gauderman et al. 2007). It has been demonstrated that distance to roadways shows greater risk for mortality, respiratory morbidity, and cognitive development compared to background air pollution concentrations (Sunyer et al. 2015; Freire et al. 2010; Kim et al. 2004; Hoek et al. 2002). However, our investigation did not find roadway density to be associated with either school absences or academic achievement. Baltimore schools averaged a total road length of nearly 5.9km (IQR: 4.3, 7.1) within 300m of buildings. This high near-school road density, combined with multiple industry sources, may make roadways an inadequate measure of air pollution exposure for this region.

Another finding is that facility conditions and potentially indoor air quality (Mendell and Heath 2005) are having a larger impact on student performance and absenteeism. We found 77% of Baltimore school facilities to be characterized as 'poor or worse' conditions and no buildings were considered adequate for educational activities. The presence of poor ventilation, mouse or cockroach allergens, and deficient classrooms were all found to reduce attendance and impede educational performance, especially in schools from lower SES districts and among younger students (Sheehan et al. 2017; Simons et al. 2010). Penetration of outdoor air pollutants into the indoor school environment has been demonstrated in other settings (Rivas et al. 2014) and is highly likely in Baltimore, where open windows often compensate for variable heating and inadequate cooling.

Beyond environmental associations, several broad relationships were observed between academic and absenteeism outcomes and community and school-level factors. Our study area is an urban region with neighborhoods characterized by high crime and poverty. Prior research has shown that both community violence and perceptions of safety can decrease

academic achievement (Bowen and Bowen 1999; Milam et al. 2010; Durham et al. 2014). Our study found worse perceptions of school safety and community crime to be major contributors to increased absences for all grades. Milam et al. (2010) argued that students who fear for their safety at or while walking to school will have a compromised ability to focus on academics and are more likely to stay at home. We further found school safety related to decreased academic performance in elementary grades. Similar findings were identified in a cohort of 5th grade students, where each point in declining school-level climate and self-reported peer victimization, was related to a 1-point decrease in GPA (Wang et al. 2014). An additional confounder for academic performance was our finding of decreasing academic achievement in schools containing older students. This is consistent with findings that older students are more likely to perpetuate risky behavior, including smoking, drinking, and drug use, which lead to negative academic and developmental outcomes (Brand et al. 2003).

There are several limitations to our study. Our analysis did not account for the potential impacts of school turnover, which have been associated with lowered academic performance (Alexander and Entwisle 1996). Schools with high pupil turnover will experience worse academic scores and higher absenteeism due to these disruptive events. Alternatively, misclassification of school and community-level confounders may occur if students take proficiency exams in one school, but attended a different school for most of the year. However, only 3.5% of students were not tested at their school. Of that group we have information on the other school only for students who remained in the district, which is less than half on average. Without information on the old and new schools attended, we are limited in our ability to assess whether school exposures were different. A second concern is that as an ecologic study, we cannot investigate the influence of individual-level factors on academic performance and absenteeism, such as family education and home environment on academic performance and absenteeism. Our assessment relies on aggregated data, at the school or community level, which potentially misclassifies exposure. This may be pronounced for schools located on the edge of CSA boundaries. However, the use of aggregated data is common due to the ease of data acquisition and the importance of maintaining personal privacy. Furthermore, Baltimore school children typically attend schools close to their homes with this relationship being pronounced in younger students. School-level community factors will have a likelihood of representing conditions typical at individual homes, while our inclusion of a reduced school lunch variable can be used as a proxy for low-income (Morrissey et al. 2014).

A third limitation is that environmental data is incomplete. Baltimore City has limited air monitoring stations and measures such as the EPA's RSEI have fairly large spatial resolution, so exposure assessments may fail to capture small-scale differences at nearby schools. Our investigation may also overlook environmental exposures important to childhood health. Heavy metals, particularly lead, have been associated with deficiencies in intellectual and academic performance (Bellinger et al. 1992; Mielke et al. 2005). However, in the absence of biomarker data, their impact on the Baltimore City cohort could not be assessed.

Conclusions

Numerous factors influence the academic performance and absenteeism of school children, including the environment, building conditions, safety, teaching, and the surrounding community. Our findings suggest that the condition of school buildings and perceptions of safety strongly influenced both academic performance and absenteeism. Industrial toxins were associated with an increase in absences, but were not linked with reduced academic performance. Healthy school environments more supportive for learning and development can be promoted through investment in building infrastructure and safety measures. Siting new schools in areas less impacted by industrial sources of pollution and by modifying existing schools to better meet academic needs will foster improved environmental health with long-term developmental benefits for adolescents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BERC	Baltimore Education Research Consortium
CSA	Community Statistical Area
EPA	Environmental Protection Agency
FARMS	Free and reduced meals
FCI	Facility Condition Index
MSA	Maryland School Assessment
MSDE	Maryland State Department of Education
RSEI	Risk-Screening Environmental Indicators
TRI	Toxic Release Inventory

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Highlights

- The impact of environment and community on school performance was assessed
- Exposure to industrial hazards increases absenteeism among school-aged children
- Building facilities and perceptions of safety impact performance and absenteeism
- Consideration of school and community factors is important for adolescent success

Figure 1. Distribution of Baltimore City schools (N=158) representing grades 3 through 8. Mapped background includes community statistical area (CSA) boundaries, major roads and highways, toxic release inventory (TRI) sites.

Figure 2.

Mapped Baltimore City Schools (N=158) stratified by facility condition index[†] (FCI), educational adequacy scores,[‡] and the Risk Screening Environmental Indicator[#] (RSEI) value.

[†] The FCI is an industry standard percentage of building conditions: 10% is good condition; 11-30% is average; 31-50% is poor; 51-74% is very poor; 75% is candidate for replacement.

[‡] The educational adequacy score measures how well a school's physical structure, technology, and space serves academic goals. On a 1 to 100 scale, lower scores indicate inadequate buildings and 80 is a modern building target. No schools achieved a score higher than 69.

[#]The EPA Risk Screening Environmental Indicator models risk from industrial toxic release inventory sites. It considers factors including distance to point source, quantity of chemicals released, toxicity, and fate and transport. Increasing scores represent greater general risk. Numeric categories are roughly equivalent to distribution quantiles.

Teen Births per 1,000 Teens **% Poverty Households** **Homicides per 1,000 People** **Adult Arrests per 1,000 people** **Figure 3.**

Mapped community statistical area (CSA) characteristics in Baltimore City for: number of teen births per 1,000 female teens; percent of households at or below the poverty line; the number of homicides per 1,000 people; number of adult arrests per 1,000 people.

Table 1.

School-level summary statistics of Baltimore City schools academic performance, school-environment, characteristics, surveyed performance, and community characteristics (2013-2014 academic year)

School Statistics	School Variable	Grades 3-5	Grades 6-8
		Mean (SD)	Mean (SD)
Performance Measures	Reading Proficiency (%) [†]	63.0% (13.3)	60.7% (15.4)
	Math Proficiency (%) [†]	45.2% (17.4)	38.6% (18.4)
	Attendance Rate	93.0% (1.7)	92.6% (3.4)
	Chronic Absence Rate ^{††}	16.6% (8.1)	18.0% (12.7)
School Environment	Facility Condition Index (FCI) [‡]	61.5 (26.1)	55.5 (25.8)
	Educational Adequacy Score [‡]	56.0 (7.8)	55.4% (9.0)
	Risk Screening Environmental Indicator (RSEI) [#]	3,547 (2,099)	3,716 (2,363)
	Length of All Roads (m) within 100m of School	671.5 (243.0)	620.8 (227.2)
	Length of Highways or Major Roads (m) within 100m of School	82.2 (214.0)	50.9 (171.2)
School Characteristics	Free/Reduced Meals Eligible	88.1% (14.5)	88.4% (10.9)
	% of Students Enrolled in Special Education	13.9% (8.1)	21.8% (13.1)
	% Black Students	84.3% (23.1)	82.8% (23.7)
School Climate Survey ^{†††}	School Safety - Disagree	21.2% (9.8)	22.3% (10.0)
	Teaching and Learning - Disagree	14.8% (7.0)	15.5% (7.1)
	Leadership and Staff Relations - Disagree	18.1% (9.4)	19.4% (9.7)
School Type (Count, % total)	Elementary Grades Only	52 (41.3%)	-
	Elementary + Middle Grades	74 (58.7%)	68 (74.7%)
	Middle Grades Only	-	8 (8.8%)
	Middle Grades + High School	-	15 (16.5%)
Community Characteristics [§]	CSA Teen Birth Rate (per 1,000 female teens)	38.8 (21.7)	37.7 (21.8)
	CSA % Adults on Probation/Parole	6.3% (3.2)	5.8% (3.1)
	CSA % Family Households below the Poverty Line	21.6% (11.2)	20.9% (12.1)
	CSA Gun Homicides Rate (per 1,000 residents)	0.3 (0.2)	0.3 (0.2)
	CSA Adult Arrests Rate (per 1,000 adults)	58.6 (43.0)	51.8 (38.2)
	CSA Juvenile Drug Arrest Rate (per 1,000 juveniles)	34.2 (32.1)	28.3 (28.5)
	CSA Racial Diversity Index ^{§§}	33.9 (22.8)	37.5 (23.1)
	CSA % Female Headed Households	56.0% (15.6)	54.2% (17.0)
	CSA % Vacant/Abandoned Houses	9.9% (11.1)	7.6% (9.5)

[†]Denotes the percentage of students performing at a proficient or advanced level based on standardized reading and mathematics testing

[‡]FCI is a percentage representing building conditions with lower scores representing better conditions and higher scores representing greater need for building replacement. Educational adequacy scores represent how well a facility meets academic needs with lower scores representing inadequate buildings.

[#]The RSEI is an EPA modeled value of chemical risk from industrial toxic release inventory (TRI) sites. Higher scores indicate greater risks.

^{††}The percent of students missing 20 or more days during a school year

^{††}Surveyed data from the Baltimore Education Research Consortium showing the percent of faculty that disagree with school safety, teaching and learning, or leadership and staff relations.

[§]Represents Neighborhood Indicators Alliance Vital Signs data for community statistical area characteristics at each schools location.

^{§§}Racial diversity index ranges from 0 to 100, where 0 represents no diversity and 100 represents total diversity.

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Table 2A.

Estimated percent change among students in elementary grades (3-5) achieving proficiency or advanced mathematics or reading scores for each 1-unit change in school and community level variables.

	Mathematics		Reading	
School and Community Variables	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Facility Condition Index	−0.21% (−0.40, −0.02)	<0.05	−0.10% (−0.19, −0.01)	<0.05
% of students in special education	−1.89% (−2.98, −0.91)	<0.001	−0.95% (−1.54, −0.38)	<0.001
% Eligible for free/reduced meals	-	NS	−0.27% (−0.44, −0.09)	<0.05
% perception of unsafe schools	−2.27% (−2.76, −1.77)	<0.001	−1.09% (−1.33, −0.84)	<0.001
School-Type				
Elementary Grades only [†]	Ref	-	Ref	-
Elementary and Middle Grades	−10.64% (−19.24, −1.14)	<0.05	−5.44% (−9.95, −0.70)	<0.05
CSA Teen Birth Rate	−0.33% (−0.55, −0.12)	<0.05	−0.23% (−0.33, −0.12)	<0.001
CSA Gun related homicide rate [‡]	−3.02% (−4.28, −1.47)	<0.001	-	NS
CSA Racial Diversity Index	-	NS	0.17% (0.08, 0.27)	<0.001

NS denotes non-significance and exclusion from the final model for that outcome

[†] Represents the reference group (Ref) for school-type categories (elementary and junior high grades)

[‡] Based on a 0.1 change in the number of gun related homicides per 1,000 people at the CSA level

Table 2B.

Estimated percent change in middle school grades (6-8) achieving proficiency or advanced mathematics or reading scores for each 1-unit change in school and community level variables.

	Mathematics		Reading	
School and Community Variables	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Attendance Rate	4.53% (1.56, 7.66)	<0.05	2.16% (0.96, 3.40)	<0.001
Facility Condition Index	-	NS	-0.10% (-0.20, 0.01)	0.07 *
Educational adequacy score	0.85% (0.07, 1.61)	<0.05	0.40% (0.10, 0.70)	<0.05
% Eligible for free/reduced meals	-0.86% (-1.67, -0.07)	<0.05	-0.47% (-0.77, -0.17)	<0.05
% Black Students	-	NS	-0.12% (-0.22, -0.01)	<0.05
% perception of poor teaching and learning	-2.60% (-3.53, -1.64)	<0.001	-1.22% (-1.62, -0.81)	<0.001
School-Type				
Elementary and Middle Grades [†]	Ref	-	Ref	-
Middle Grades Only	-24.08% (-39.72, -3.53)	<0.05	-11.85% (-20.19, -2.69)	<0.05
Middle Grades and HS	-38.44% (-48.37, -26.44)	<0.001	-12.05% (-18.38, -5.26)	<0.001
CSA Teen Birth Rate	-0.32% (-0.67, 0.03)	<0.10 *	-0.22% (-0.36, -0.09)	<0.001
CSA Number of Gun Homicides [‡]	-3.70 (-5.34, -1.47)	<0.05	-	NS
CSA Number of Juvenile Drug Arrests	-	NS	0.28% (0.11, 0.45)	<0.001
CSA % Vacant Housing	-	NS	-1.16% (-1.67, 0.64)	<0.001

NS denotes non-significance and exclusion from the final model for that outcome

* Marginal statistical significance

[†] Represents the reference group (Ref) for school-type categories

[‡] Based on a 0.1 change in the number of gun related homicides per 1,000 people at the CSA level

Table 3A.

The estimated change in attendance rate and chronic absence rate (e.g. missing 20 or more days per year) among elementary school students for each 10-unit increase in school and community level variables.

School and Community Variables	Attendance Rate		Chronic Absence Rate	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
Facility Condition Index	−0.16% (−0.25, −0.07)	<0.001	0.75% (0.30, 1.19)	<0.001
RSEI Value [‡]	-	NS	3.40% (−0.08, 6.76) [*]	<0.06
% perception of unsafe schools	−0.75% (−1.01, −0.48)	<0.001	3.61% (2.33, 4.90)	<0.001
CSA % Households Below the Poverty Line	−0.37% (−0.59, −0.14)	<0.001	1.95% (0.47, 3.43)	<0.05
CSA Arrest Rate	-	NS	−0.57% (−1.01, −0.13)	<0.05
CSA Number Gun Related Homicides [‡]	-	NS	0.83% (0.22, 1.43)	<0.05

NS denotes non-significance and exclusion from the final model for that outcome

^{*} Marginal statistical significance

[‡] Based on a log increase in RSEI value at school locations

[‡] Based on a 0.1 change in the number of gun related homicides per 1,000 people at the CSA level

Table 3B.

The estimated change in attendance rate and chronic absence rate (e.g. missing 20 or more days per year) among middle school students for each 10-unit increase in school and community level variables.

School and Community Variables	Attendance Rate		Chronic Absence Rate	
	Estimate (95% CI)	p-value	Estimate (95% CI)	p-value
RSEI Value [†]	-1.15% (-1.98, -0.31)	<0.05	3.57% (-0.21, 7.27) [*]	<0.06
% perception of unsafe schools	-1.69% (-2.69, -0.69)	<0.001	8.09% (4.95, 11.24)	<0.001
% perception of negative school environment	1.11% (-0.06, 2.28) [*]	<0.07	-	NS
% perception of poor leadership and staff relations	-	NS	-3.90% (-7.16, -0.64)	<0.05

NS denotes non-significance and exclusion from the final model for that outcome

^{*} Marginal statistical significance

[†] Based on a log increase in RSEI value at school locations