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EdWorkingPaper No. 26-1384

U.S. Schools' Proximity to Environmental Hazard Sites: A National Analysis

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We conduct a nationwide assessment of U.S. PreK-12 public and private schools' proximity to known environmental hazard sites tracked by the U.S. Environmental Protection Agency: Superfund sites, Brownfields, and Toxics Release Inventory facilities. Prior research documents a range of negative health and academic consequences for youth exposed to pollution and legacy contaminants released by these sites. Nearly 10,000 schools (8%), enrolling 3.36 million students and employing 480,000 teachers and staff, are located within a quarter mile (~400 meters) of a hazardous site where exposure risk is most acute. Approximately 44% of schools are located within one mile – a distance where negative exposure effects are well documented. Risks are borne disproportionately by Native, Black, Hispanic, and low-income students who are 124%, 86%, 43%, and 40% more likely to attend schools within a quarter mile of a hazardous site. Differential proximity to multiple hazards and higher-risk sites is also highly inequitable.

VERSION: January 2026

Suggested citation: Malik, Sohil, Matthew A. Kraft, and Grace Falken. (2026). U.S. Schools' Proximity to Environmental Hazard Sites: A National Analysis. (EdWorkingPaper: 26-1384). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/e04x-8655

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Abstract

We conduct a nationwide assessment of U.S. PreK-12 public and private schools' proximity to known environmental hazard sites tracked by the U.S. Environmental Protection Agency: Superfund sites, Brownfields, and Toxics Release Inventory facilities. Prior research documents a range of negative health and academic consequences for youth exposed to pollution and legacy contaminants released by these sites. Nearly 10,000 schools (8%), enrolling 3.36 million students and employing 480,000 teachers and staff, are located within a quarter mile (~400 meters) of a hazardous site where exposure risk is most acute. Approximately 44% of schools are located within one mile – a distance where negative exposure effects are well documented. Risks are borne disproportionately by Native, Black, Hispanic, and low-income students who are 124%, 86%, 43%, and 40% more likely to attend schools within a quarter mile of a hazardous site. Differential proximity to multiple hazards and higher-risk sites is also highly inequitable.

Correspondence regarding the article can be sent to Matthew Kraft at mkraft@brown.edu. We are grateful for the excellent research assistance provided by Eugenia Bamfo, Malcolm Certain, Madeleine Connery, Tiffany Kuo, Sylvia Larkin, Hayden McAllister, Sruti Peddi, Claire Piron, Maxwell Robinson, Audrey Sanger, Nathan Tavares, and Olivia Tingley-Kelley as well as guidance from Frank Donnelly. We thank Alex Bolves, Alvin Christian, Hunter Gehlbach, Kristen Hengtgen, Claudia Persico, William Rodick, Laura Schifter and participants at the SREE annual conference and the Annenberg Half-Baked seminar series for feedback on early drafts. The Annenberg Institute and the Taubman Center for American Politics and Policy at Brown University provided support for this research.

Introduction

K-12 students in the United States spend an average of 1,230 hours in school each year (Kraft & Novicoff, 2024), and often hundreds more in afterschool programs and extracurricular activities. This amounts to between 20 to 25% of children's waking hours, making school grounds a critical yet often overlooked source of environmental exposure. In addition, many students live near their schools, meaning that potential exposure from nearby hazardous sites can affect both their school environments as well as their home environments.

While high-profile cases such as Louisiana's "Cancer Alley" have raised public concern, we know far less about the full extent of potential exposure that students experience while at school. Beyond classrooms, playgrounds, and athletic fields, many students walk or commute to school daily, potentially encountering pollutants from nearby industrial or contaminated sites in surrounding neighborhoods. The location of schools relative to these hazards has direct implications for children's development and learning. It also has important consequences for the health of educators and staff who work in these environments.

Prior research documents how youth exposed to pollution at school experience negative health and academic effects (Currie et al., 2011; Heissel et al., 2022; Persico & Venator, 2021). However, most studies focus on a single emission type, hazard site category, or geographic region, limiting our understanding of the scale and scope of students' potential exposure to industrial pollution and legacy contaminants nationwide. We aim to advance our understanding of the risks posed on a national scale by studying three research questions:

1. How many U.S. PreK-12 schools are located near known environmental hazard sites?
2. To what extent does school proximity to hazard sites vary across students' backgrounds?
3. To what extent does school proximity to hazard sites vary by geographic context and urbanicity?

We conduct a comprehensive, nationwide assessment of schools' proximity to known environmental hazards to estimate students', teachers', and staffs' potential exposure to pollutants and carcinogens at school. Using geographic information systems (GIS), we integrate federal education data on the universe of PreK-12 schools in the United States with national inventories of Superfund sites, brownfields, and Toxics Release Inventory (TRI) facilities maintained by the U.S. Environmental Protection Agency (EPA). These three site types capture historical and ongoing contamination, both of which pose significant health risks (Amin et al., 2018; Chen et al., 2015; Lodge et al., 2020).

We also examine how schools' demographic composition, geographic location, and type (public or private) relate to their proximity to hazardous sites. Previous studies demonstrate that environmental hazards are disproportionately concentrated in marginalized communities due to longstanding structural inequities, such as historic housing policies, redlining, and local zoning

decisions, which have often facilitated the placement of industrial facilities in low-income communities and communities of color (Mohai & Saha, 2015; Oliva & Som, 2022). These patterns likely extend to schools and may further contribute to educational inequities.

Our aim is to clarify the scope and scale of potential pollutant and carcinogen exposure in U.S. schools and to identify inequities in proximity to environmental hazards. Because pollutants disperse through multiple pathways, we map potential exposure as a radial distance rather than precisely modeling specific exposure mechanisms (e.g., being downstream of pollutants). This approach complements detailed pathway studies (Dominici & Zigler, 2017) and can inform education policy, environmental regulations, remediation efforts, and initiatives to address inequitable learning environments in schools.

Literature Review

Superfund sites, brownfields, and TRI facilities represent three major sources of environmental contamination. Superfund sites contain legacy contamination, often in soil and groundwater, resulting from past industrial activities, waste disposal, or chemical spills. Brownfields represent former industrial or commercial properties with variable contamination risks depending on site history and remediation efforts. TRI facilities actively handle and release hazardous chemicals. We present characteristics along with examples of each site category in Appendix Table A1.

Exposure to Superfunds, brownfields, and TRI facilities can affect human health, with children facing heightened risk due to their early stages of physical and neurological development (Currie, 2013). Potential exposure pathways include contact with contaminated soil or dust; ingestion of polluted groundwater; and inhalation of airborne pollutants from direct facility emissions or vapor intrusion from contaminated soil or groundwater.

<u>Superfund Sites</u>

Superfund sites are frequently contaminated with heavy metals such as lead, arsenic, and mercury, as well as dioxins, volatile organic compounds, and, in some cases, radioactive materials (Sustainability Directory, n.d.; US EPA, 2015). Ecological studies document that counties with greater Superfund site density tend to have higher cancer risk and larger shares of residents of color (Amin et al., 2018). Studies that exploit variation in the timing of Superfund cleanup efforts document how remediation improves infant health, reducing adverse birth outcomes within 2 km (~1.25 miles) of sites (Currie et al., 2011) and lowering blood lead levels among infants in affected zip codes (Ye et al., 2022). A national study leveraging a matching estimation approach found that living within 0.2 miles (322 meters) of Superfund sites decreases life expectancy, particularly in areas with high sociodemographic disadvantage (Kiaghadi et al., 2021). Finally, Persico et al. (2020) compare siblings in households born before and after a Superfund cleanup and find that exposure to Superfunds prior to remediation substantially increases the likelihood of grade repetition, raises the incidence of behavioral problems, and

leads to measurable declines in standardized test scores. Notably, effects are evident even for families living up to 2 miles (3.2 km) away from affected sites.

Brownfields

Brownfields often contain contaminants including, but not limited to, lead, asbestos, volatile organic compounds, petroleum, and arsenic (US EPA, 2025). Residential proximity to brownfields is associated with immune system disruption (Lodge et al., 2020), lower birth weights (J. Wang, 2011), as well as a range of other adverse health outcomes (W. Wang et al., 2023). Slawsky et al. (2022) report that children born within 2 km (~1.25 miles) of brownfields have increased odds of having a birth defect, with greater risk associated with exposure to more sites. Lodge et al. (2022) find that higher residential brownfield density within up to 800 meters (0.5 miles) of children's homes is associated with higher blood-lead levels. School districts containing brownfields with higher toxicity scores have higher rates of students receiving special education services (Shrestha et al., 2023). While associational, these studies all suggest an exposure-response relationship between brownfields and children's health.

Toxics Release Inventory Facilities

TRI facilities report releases of numerous hazardous chemicals including lead, mercury, dioxins, ethylene oxide (a flammable gas and known carcinogen), and per- and polyfluoroalkyl substances (PFAS), a class of persistent synthetic chemicals that accumulate in body tissue. These chemicals represent only a subset of the hundreds of toxic substances tracked under the TRI program, which currently includes 799 individually listed chemicals and 33 chemical categories (US EPA, 2018).

TRI emissions are associated with higher infant mortality, chronic illnesses, and rates of cardiovascular conditions in nearby communities (Agarwal et al., 2010; Chen et al., 2015; Sansom et al., 2023). Health risks appear elevated within a mile of TRI facilities, with studies reporting increased rates of childhood brain cancer (Choi et al., 2006) and pulmonary diseases (Kaushal et al., 2024). Three studies exploit how the timing and location of TRI facility openings and closures affect residential or school exposure, finding direct negative impacts on health and learning. Currie et al. (2015) find exposure to a TRI facility while in utero reduces infant birthweight for children in households living within 0.5 miles of a facility. Persico and Venator (2021) report that TRI plant openings within one mile of a school decrease test scores and increase suspension rates. Similarly, Jacqz (2022) shows that higher aggregate TRI emissions within a school district reduce academic proficiency rates.

Exposure Disparities

Industrial operations often locate their facilities in marginalized communities that have more limited political and economic power to oppose them (Mohai & Saha, 2015). As a result, students of color and low-income students face disproportionate exposure to environmental hazards while in school, such as neurological air toxins (Grineski & Collins, 2018). For example,

schools located near lead-emitting facilities serve higher proportions of Black and Hispanic students and lower proportions of White students (Oliva & Som, 2022). Similarly, students of color and those from low-income backgrounds experience higher exposure to airborne particulate matter (Cheeseman et al., 2022) and nitrogen dioxide, with disparities apparent in urban areas robust to adjusting for income (Bechle et al., 2023). Schools that serve a majority of Black students and students from low-income backgrounds are 18% more likely to be within 250 meters of a major roadway that are sources of significant traffic pollution (Kingsley et al., 2014). These patterns underscore the uneven distribution of environmental hazards across racial and economic groups and highlight persistent inequities in school and neighborhood exposure.

Data

Our analytic dataset combines data on the universe of formal, brick-and-mortar public and private PreK-12 schools in the United States from the National Center for Education Statistics (NCES) with environmental hazard data from the EPA, reflecting a cross-sectional snapshot of school-based potential exposure to environmental hazards.

We use public school data for the 2023-2024 school year maintained by the NCES Common Core of Data (CCD). The CCD provides school locations, urbanicity, enrollment, student demographics (including race and Free or Reduced-Price Lunch [FRPL] eligibility), and counts of full-time equivalent (FTE) teachers. Data on English Learner (EL) students and students with disabilities covered by the Individuals with Disabilities Education Act come from the 2021-2022 Civil Rights Data Collection (CRDC).

We use private school data for the 2019-2020 school year from the NCES Private School Universe Survey (PSS), which includes enrollment, racial composition of students, and counts of FTE teachers.[1] We augment this data with information on private school locations and urbanicity from the 2023-2024 NCES Education Demographic and Geographic Estimates (EDGE) program. Our analytic sample (n = 118,070) includes all formal PreK-12 schools except those that operate fully virtually.

We collect environmental hazard data from three EPA programs: Superfund sites; brownfields in the Assessment, Cleanup, and Redevelopment Exchange System (ACRES); and TRI facilities reporting for 2024. The ACRES dataset includes only a subset of brownfields that have received federal funding for remediation efforts; although there are an estimated 450,000 brownfields nationwide, ACRES covers roughly 40,000 such sites. Together, these datasets capture both legacy contamination and ongoing toxic releases, offering broad and consistently maintained national coverage.

[1] We include both public and private schools in spatial analyses and racial demographic comparisons. Analyses involving enrollment of FRPL, EL, and students with disabilities are limited to public schools due to data availability.

Table 1 shows brownfields as the most common category (n = 40,990), followed by TRI facilities (n = 21,223) and Superfund sites (n = 13,195). Across the three groups, our complete sample includes more than 75,000 pollution sites nationwide.[2] For more information on our data sources and sample selection, see Appendix B1.

Methods

Prior studies have found negative effects of known environmental hazard sites across a range of distance thresholds. Given the variable range of established effects, we replicate our analysis across four distance radii from hazard sites (≤ 0.125 miles, ≤ 0.25 miles, ≤ 0.50 miles, and ≤ 1.00 miles). We prioritize results within 0.25 miles – about 400 meters, or one lap around a high school track – where potential exposure intensity is likely most acute (Currie et al., 2015).

To identify school proximity, we convert schools and pollution sites to spatial point geometries using reported latitude and longitude coordinates. We then generate radial buffers at each of the four specified distances around each pollution site, delineating areas of potential exposure. We identify schools located within each buffer and calculate summary statistics at both the school and site levels.

We also assess potential exposure intensity by identifying specific sites that may pose higher risks within each site type. We classify Superfund sites as higher-risk if they currently appear on the National Priorities List (NPL) – the EPA's list of the most serious hazardous sites – or are part of an NPL site, which accounts for 13% of Superfund sites in our sample. We classify brownfields as higher-risk if they are flagged for cleanup and contain contaminants at actionable levels (26% of brownfields in our sample).[3] We designate TRI facilities as higher-risk if they release more than 1,000 pounds of toxic chemicals annually on- or off-site (42% of TRI sites in our sample). Table 1 reports the counts of higher-risk sites by type.

Finally, we conduct a site-centered analysis to assess the proportion of environmental hazard sites located near schools and to highlight where remediation or monitoring efforts could have the greatest impact.

Our goal is to provide a comprehensive national assessment of school proximity to hazardous sites, though this approach involves important trade-offs. We measure distance from pollution sites using radial buffers, which do not fully capture the complex and varied dynamics of direct exposure to specific pollutants or contaminants. We also do not consider how extreme weather events – such as flooding, severe rainfall, or wildfires – might accelerate or concentrate the release of pollutants from hazardous sites, which could further influence student exposure. We cannot precisely quantify exposure intensity, as it varies across sites according to pollutant type,

[2] We retain only records with unique identifiers and valid geographic coordinates, removing entries with missing or duplicated locations. We include each site only once in the combined "All Pollution Sites" category, even if it is listed across multiple EPA datasets, to avoid double-counting.

[3] The EPA assigns brownfield cleanup designations according to the planned future use of the property (such as residential or industrial).

quantity, and site history. Finally, we do not account for the duration of exposure over the years that students attend schools, which can produce compounding cumulative effects. Despite these limitations, our analysis offers a broad, nationwide perspective on the scale and distribution of potential student exposure to environmental hazards.

Results

National Overview

Across the United States, thousands of schools are located within a few minutes' walk of environmental hazard sites. Nearly 10,000 schools, about 8%, are located within a quarter mile of at least one such site (Table 2). Considering only higher-risk sites, we still find meaningful exposure, with 3% of all schools located within a quarter mile. Broadening to a mile radius of hazardous sites – distances at which negative effects are well documented – 44% of schools are exposed to any hazardous site, and 22% are exposed to higher-risk sites.

As seen in Figure 1, we observe similar proximity rates for both public and private schools across both the full set of pollution sites and the subset classified as higher-risk. This suggests that potential exposure risk is not exclusive to the public school system nor reduced in the private K-12 sector, despite the more affluent student population (Murnane & Reardon, 2018) and potential increased flexibility in both siting selection for schools and school choices for parents.

Enrollment and Staff

Approximately 3.36 million students (6.5%) attend schools within a quarter mile of an environmental hazard site (see Figure 2). We estimate that public and private schools within a quarter mile of these sites employ more than 480,000 FTE staff, including both teachers and non-instructional personnel (Appendix Table A2).[4] Across all students and staff, approximately 3.85 million people (1% of the U.S. population) are within a quarter mile of an environmental hazard site every day of the school year. This number balloons to 24.65 million people (7% of the U.S. population) within 1 mile.

Student Demographics

Figure 3 displays the percentage of students within each demographic group who attend schools within 0.25 miles of at least one pollution site. The risks associated with attending a school near a known environmental hazard site are disproportionately borne by students of color, particularly Native, Black, and Hispanic students, and students from low-income backgrounds. We find that compared to White peers, Native, Black, and Hispanic students are 124%, 86%, and 43% more likely to attend a school within a quarter mile of a hazard site.[5] These disparities are more acute within the public school system than the private school system (see Appendix Table A5). Cutting

[4] Estimates of FTE non-instructional staff are approximate and intended for comparative purposes. For more information on the calculation, please refer to Appendix B2.
[5] See Appendix B3 for how disparity ratios were calculated.

across these systems, Native, Black, and Hispanic public-school students are 135%, 92%, and 49% more likely than White students to attend a school within a quarter mile, relative to 21%, 48%, and 22% in private schools. These racial disparities in proximity to known environmental hazards are most acute within short distances, where intensity of exposure likely increases.

We also find disparities in proximity by socioeconomic status and specialized program participation. Public school students eligible for FRPL are 40% more likely than non-eligible students to attend schools within a quarter mile of environmental hazard sites (see Appendix Table A6). Similarly, EL students are 21% more likely than non-EL students to attend public schools within a quarter mile of these sites. We find no sizable differences for students with disabilities. These racial, socioeconomic, and EL disparities are consistent when we focus on higher-risk sites (see Appendix Tables A7 and A8).

Proximity to multiple sites is also unequally distributed (see Figure 4). Across all schools, 4.8% of Native students, 3.4% of Black students, 2.3% of Hispanic students, and 1.3% of White students attend schools within a quarter mile of two or more sites. These differences translate into substantial disparities: Native, Black, and Hispanic students are roughly 3.7, 2.6, and 1.8 times more likely, respectively, than White students to attend a school near multiple sites. Among public schools, 2.3% of FRPL students and 2.5% of EL students attend schools within a quarter mile of two or more hazard sites, compared with 1.2% of non-FRPL students and 1.7% of non-EL students, making students from low-income backgrounds and EL status 1.9 and 1.5 times more likely to attend a school near multiple sites.

These results indicate that students of color and low-income students are not only more likely to attend schools near a single hazard site, but are also disproportionately likely to attend schools near higher-risk sites and multiple environmental hazards, highlighting the compounded environmental risk for these populations.

Geographic Variation

We find that the likelihood of a school being located near a known environmental hazard site varies by both urbanicity and across states. Schools in cities face the greatest potential exposure, with 12.7% within a quarter mile of an environmental hazard site, followed by towns (10.3%), suburban areas (6.0%), and rural areas (5.1%) (see Figure 5).

Figure 6 maps the proportion of schools located within a quarter mile of an environmental hazard site for each state. By U.S. census region, schools in the Northeast (11.6%) and Midwest (10.2%) are most likely to be located within a quarter mile of an environmental hazard site. In comparison, schools in the West (8.0%) and South (5.1%) are less likely to be near these sites. State-level variation is substantial, ranging from about 3.1% (Texas) to nearly 26.3% (Rhode Island) of schools within a quarter mile of a site (see Appendix Table A9). Figure 7 explores how total pollution site density and population density relate to the number of sites near schools. High rates of school proximity to hazardous sites in Vermont and Montana are likely driven by their

rankings as the first and second highest states in environmental hazard site density per 100,000 residents (see Appendix Table A10). In contrast, Rhode Island and D.C.'s high rates of school proximity to hazardous sites are likely driven by their small size and high population densities. However, even among states with similar site and population densities, the share of sites located near schools varies, suggesting the influence of local policy and land-use decisions.

Site-Centered Analysis

Overall, 17% of all sites are located within a quarter mile of at least one school (see Appendix Table A11). Examining site types individually, approximately 25% of brownfields, 14% of Superfund sites, and 6% of TRI sites fall within this distance. This site-centered perspective complements the school-centered analysis by identifying where remediation, monitoring, and regulatory action could have the greatest impact. Together, these findings underscore the extensive spatial overlap between environmental hazards and educational spaces.

Conclusion

This paper provides a nationwide assessment of the potential exposure of U.S. students, educators, and school staff to industrial pollutants and toxins. Millions of students attend schools in close proximity to hazardous sites that research shows can adversely affect both health and academic outcomes. These risks are unevenly distributed: students of color and those from low-income backgrounds disproportionately attend schools located near such hazards and a subset of higher-risk sites. These students also face compounded risks from proximity to multiple sites.

Importantly, our estimates are conservative. Our analysis includes only the roughly 40,000 brownfields in the ACRES dataset, even though an estimated 450,000 brownfields exist nationwide. We also exclude other major pollution sources – such as vehicle emissions along the Interstate Highway System (Kingsley et al., 2014), the nearly half a million diesel-powered school buses that transport millions of students daily (Moon et al., 2024), lead from plumbing materials in school buildings (Sorensen et al., 2019), indoor environmental contaminants documented in school facilities (Sadrizadeh et al., 2022), wildfires (Wen & Burke, 2022), and facilities not captured in the EPA datasets we analyze.

Identifying schools near known pollution sites can support targeted monitoring of air, soil, and water quality; expanded remediation efforts; modernization of school facilities to mitigate exposure; and more accurate communication of health risks to students, families, and staff. These findings can also inform decisions on future school siting, environmental regulations, and policies aimed at promoting both educational and environmental equity.

Although these hazards originate outdoors, they also have direct consequences for inside the classroom: pollutants can enter classrooms through ventilation systems, windows, and aging building infrastructure, making clean air an essential component of school infrastructure. Outdoor air quality quickly translates into the air students breathe indoors, underscoring the importance of mitigating exposure both outside and inside school environments.

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Tables

Table 1. Counts of Environmental Hazard Sites

Site Type	All	Higher-Risk
Superfund	13,195	1,730
Brownfield	40,990	10,592
Toxics Release Inventory	21,223	8,882
All Pollution Sites	75,393	21,202

Sources: U.S. Environmental Protection Agency.

Note: This table reports the counts of environmental hazard sites in our sample by type and the number we classify as higher-risk based on our calculations. We designate Superfund sites as higher-risk if they currently appear on the National Priorities List (NPL) or are part of an NPL site, brownfields if they are flagged for cleanup and contain actionable contaminants, and TRI facilities if they release more than 1,000 pounds of toxic chemicals annually on- or off-site.

Table 2. Schools Near Environmental Hazard Sites

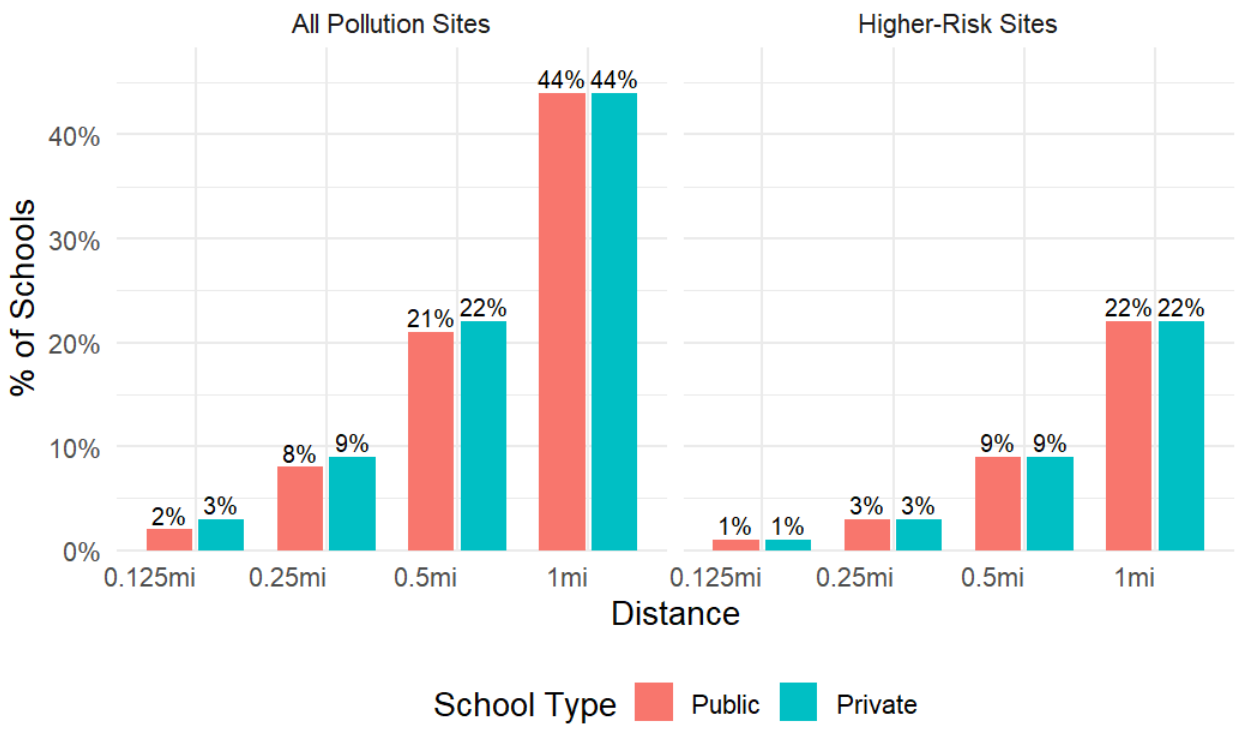
Distance	Schools Near All Sites	Proportion of Schools (Near All Sites)	Schools Near Higher-Risk Sites	Proportion of Schools (Near Higher-Risk Sites)
		Panel A. All Schools		
0 – 0.125 mi	3,042	0.03	952	0.01
0 – 0.250 mi	9,662	0.08	3,339	0.03
0 – 0.500 mi	25,310	0.21	10,362	0.09
0 – 1.000 mi	51,608	0.44	26,009	0.22
		Panel B. Public Schools		
0 – 0.125 mi	2,373	0.02	738	0.01
0 – 0.250 mi	7,683	0.08	2,673	0.03
0 – 0.500 mi	20,445	0.21	8,442	0.09
0 – 1.000 mi	41,736	0.44	21,154	0.22
		Panel C. Private Schools		
0 – 0.125 mi	669	0.03	214	0.01
0 – 0.250 mi	1,979	0.09	666	0.03
0 – 0.500 mi	4,865	0.22	1,920	0.09
0 – 1.000 mi	9,872	0.44	4,855	0.22

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: The table shows counts and proportions of schools located near all hazard sites and, separately, near higher-risk sites, for each of the four distances considered in the analysis. Our total sample of schools includes 95,560 public schools and 22,510 private schools.

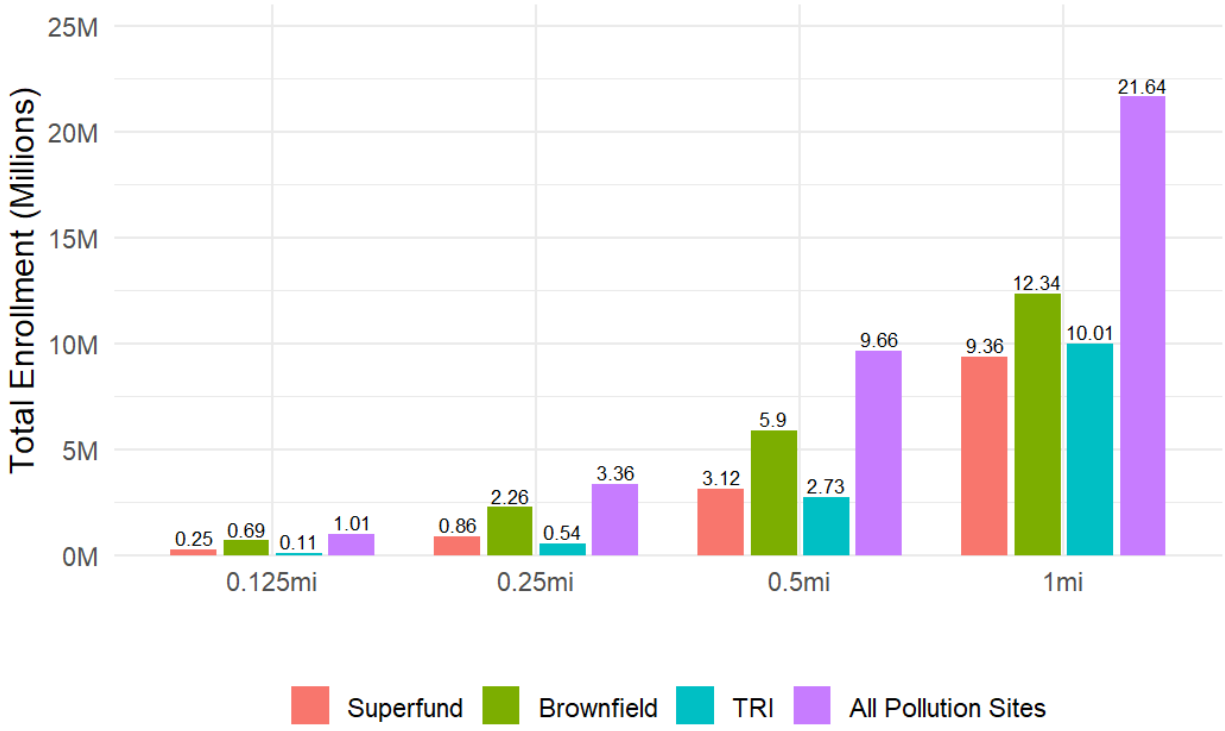
Figures

Figure 1. Proportion of Schools Near Environmental Hazards by School Type



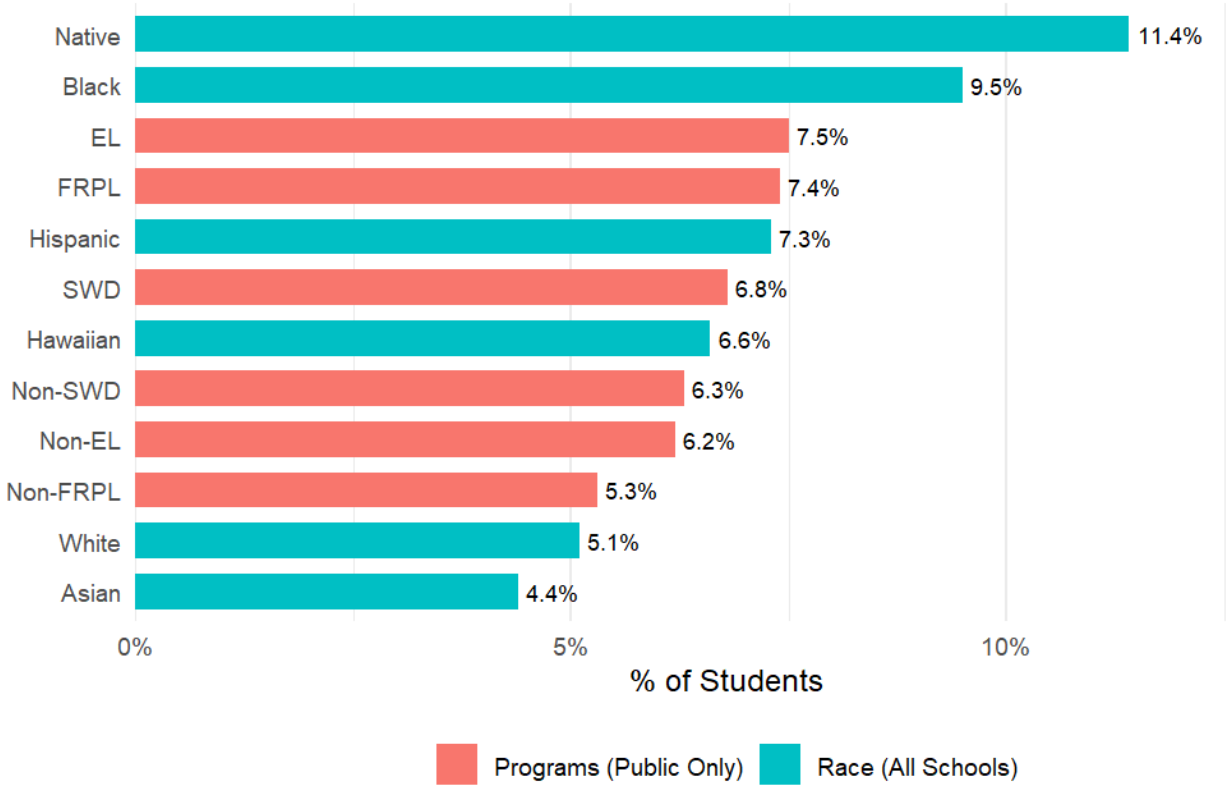
Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This graph compares the proportion of schools near environmental hazard sites, including the subset classified as higher-risk, at four specified distances (0.125, 0.25, 0.5, and 1 mile), categorized by school type (public vs. private).

Figure 2. Enrollment Totals for Both Public and Private Schools



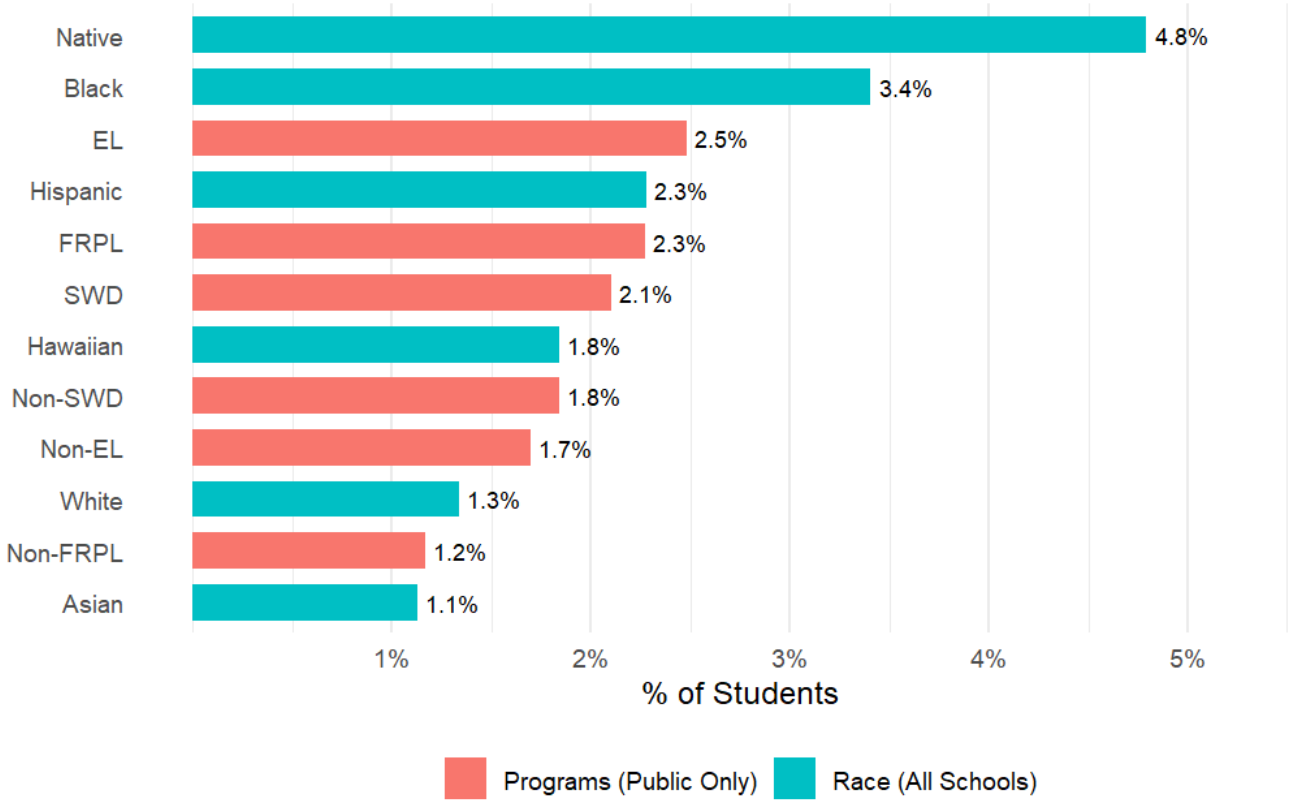
Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This graph compares the total student enrollment of schools near environmental hazard sites at four specified distances (0.125, 0.25, 0.5, and 1 mile), categorized by site type. We include each site only once in the combined "All Pollution Sites" category, even if it is listed across multiple EPA datasets, to avoid double-counting. TRI = Toxics Release Inventory.

Figure 3. Student Composition of Schools Within 0.25 Miles of Pollution Sites



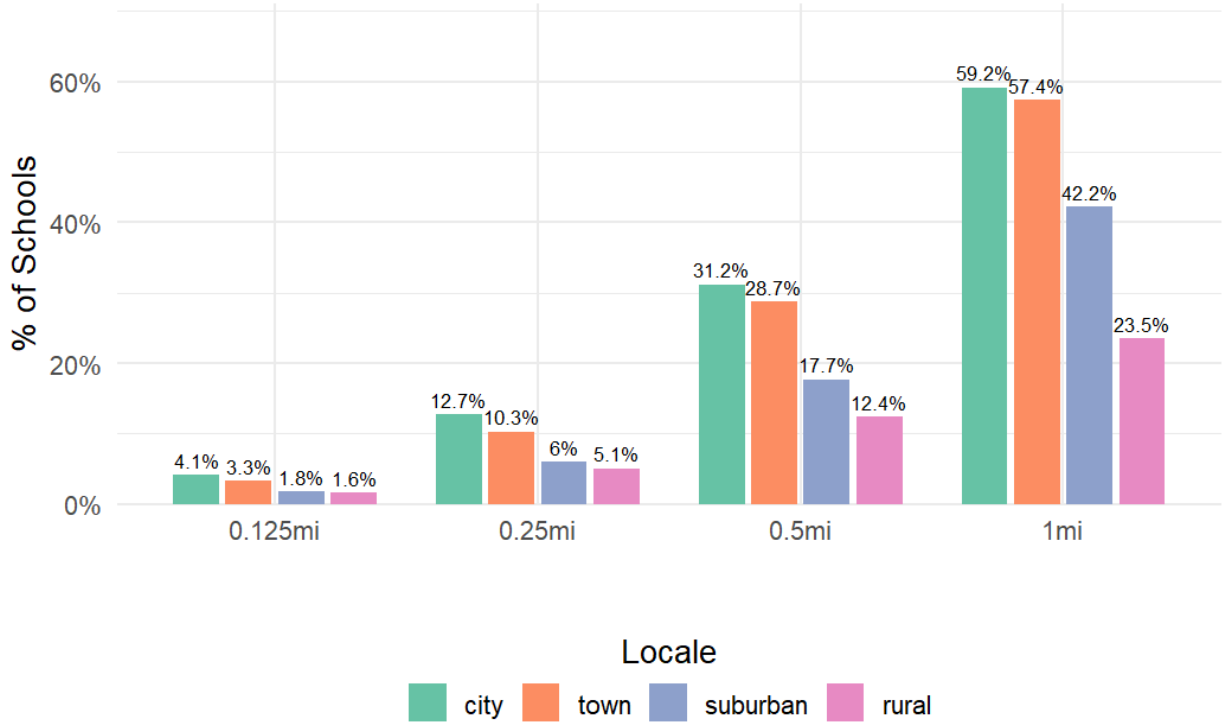
Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This graph shows the percentage of students within each demographic group who attend schools located within 0.25 miles of at least one pollution site. Race-based estimates reflect students in all schools (public and private), while estimates for FRPL, EL, and students with disabilities reflect students in public schools only due to data availability. Bars are ordered from highest to lowest proportion. FRPL = Free or Reduced-Price Lunch; EL = English Learner; SWD = students with disabilities covered by the Individuals with Disabilities Education Act.

Figure 4. Student Composition of Schools Within Quarter Mile of 2+ of Pollution Sites



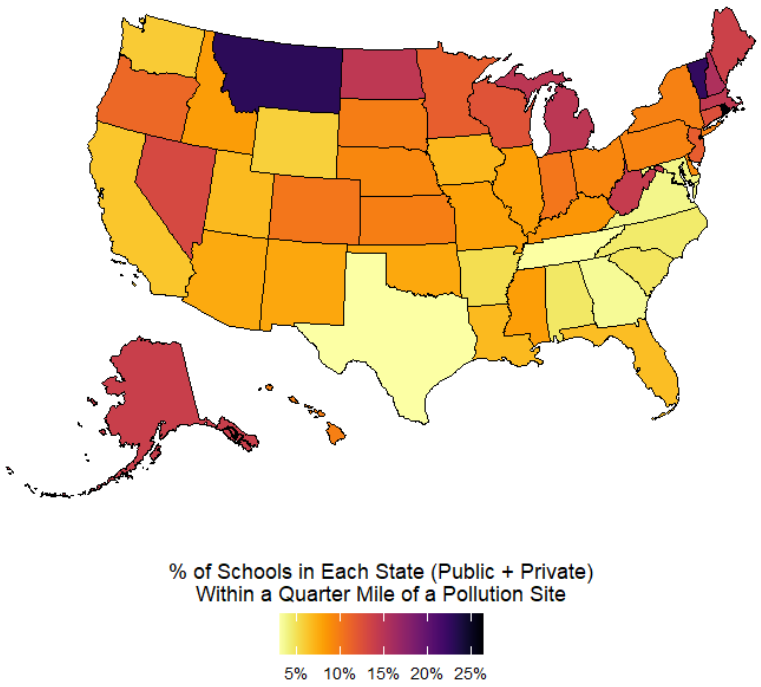
Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This graph shows the percentage of students within each demographic group who attend schools located within a quarter mile of two or more environmental hazard sites. Race-based estimates reflect students in all schools (public and private), while estimates for FRPL, EL, and students with disabilities reflect students in public schools only due to data availability. Bars are ordered from highest to lowest proportion. FRPL = Free or Reduced-Price Lunch; EL = English Learner; SWD = students with disabilities covered by the Individuals with Disabilities Education Act.

Figure 5. Proportion of Schools Near All Environmental Hazard Sites, by Urbanicity



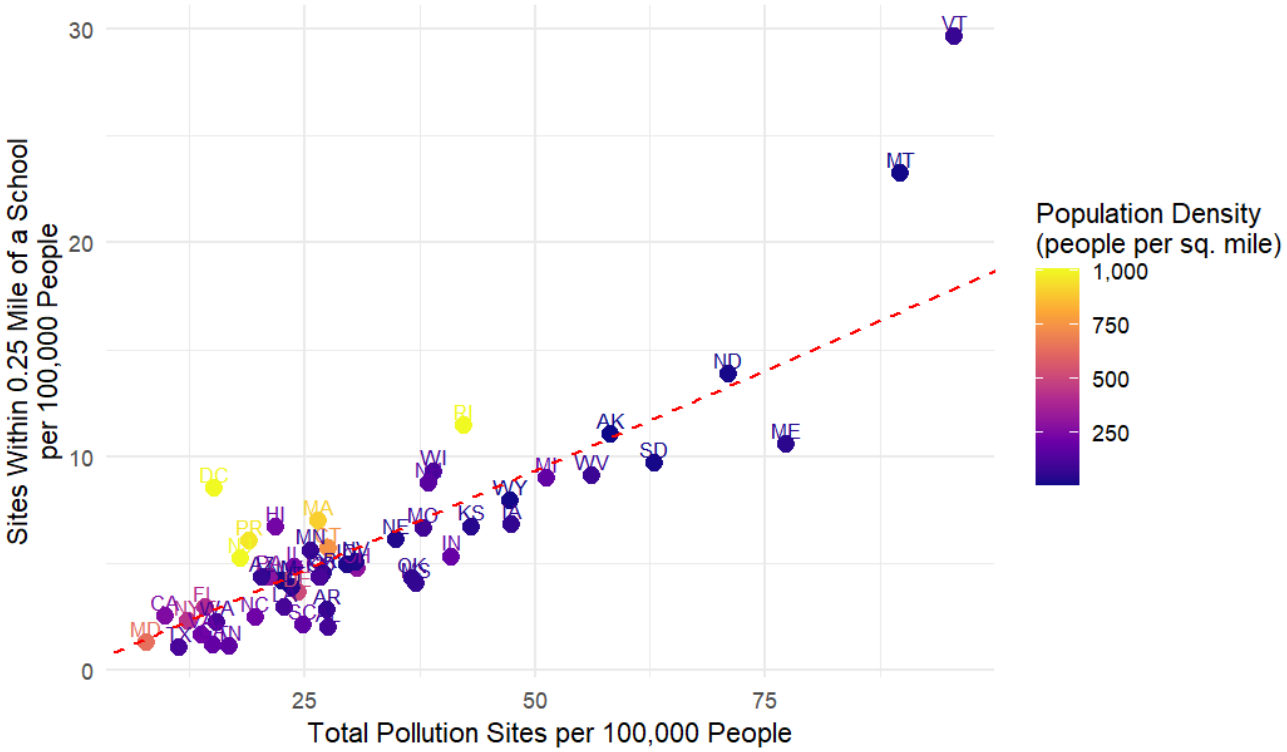
Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This graph compares the proportion of schools near environmental hazard sites at four specified distances (0.125, 0.25, 0.5, and 1 mile), by locale type (urbanicity).

Figure 6. Percentage of Schools Within a Quarter Mile of Environmental Hazard Sites by State



Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This choropleth map presents the percentage of all schools (public and private) within a quarter mile of environmental hazard sites, by state.

Figure 7. Pollution Site Density and Proximity to Schools by State



Sources: U.S. Census Bureau; National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: This figure plots pollution sites versus sites within 0.25 mile of a school per 100,000 people, by state. Colors indicate population density (capped at the 95th percentile to limit the influence of extreme values). The dashed red line denotes the national average share of pollution sites located within 0.25 mile of a school; states above the line have more sites near schools than expected, and states below the line have fewer than expected. Population estimates are based on the U.S. Census Bureau 2022 state population estimates and are provided via the statepop dataset in R. Population density estimates are based on the 2020 Census.

Appendix A

Appendix Table A1. Characteristics of Industrial Pollution Sites in the Study

Site Type	Description	Exposure Mechanisms	Common Pollutants	Examples
Superfund	EPA-designated sites with significant legacy contamination under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	Contact with contaminated soil or groundwater; inhalation of vapor intrusion; consumption of locally contaminated resources	Heavy metals such as lead, arsenic, and mercury, as well as dioxins, volatile organic compounds, and, in some cases, radioactive materials	Former manufacturing facilities, petroleum refineries, landfills, mining sites
Brownfield	Former industrial or commercial properties where real or suspected contamination complicates redevelopment or reuse	Disturbance of residual contaminants in soil, dust, or groundwater during redevelopment or construction	Lead, asbestos, volatile organic compounds, petroleum, and arsenic	Potentially contaminated former gas stations, dry cleaners, auto repair shops, factories
Toxics Release Inventory	Active facilities that manufacture, process, or use listed toxic chemicals and must report releases to the EPA	Air emissions, water discharges, surface runoff, or spills of toxic chemicals	Lead, mercury, dioxins, ethylene oxide, and per- and polyfluoroalkyl substances (PFAS)	Manufacturing facilities, hazardous waste treatment facilities, mining or extraction operations, power plants

Appendix Table A2. Student Enrollment and FTE Staff Counts

Distance	Total Student Enrollment	FTE Teachers	Estimate of FTE Non-Instructional Personnel	Estimated Total Students and Staff
		Panel A. All Schools		
0 – 0.125 mi	1,005,016	69,695	72,901	1,147,612
0 – 0.250 mi	3,362,635	236,481	247,359	3,846,475
0 – 0.500 mi	9,655,700	669,620	700,423	11,025,743
0 – 1.000 mi	21,635,929	1,473,629	1,541,416	24,650,974
		Panel B. Public Schools		
0 – 0.125 mi	933,035	63,302	66,214	1,062,551
0 – 0.250 mi	3,113,489	214,840	224,723	3,553,052
0 – 0.500 mi	9,000,294	613,867	642,105	10,256,266
0 – 1.000 mi	20,256,452	1,355,935	1,418,308	23,030,695
		Panel C. Private Schools		
0 – 0.125 mi	71,981	6,393	6,687	85,061
0 – 0.250 mi	249,146	21,641	22,636	293,423
0 – 0.500 mi	655,406	55,753	58,318	769,477
0 – 1.000 mi	1,379,477	117,694	123,108	1,620,279

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This table reports counts of student enrollment, FTE teachers, and estimated FTE non-instructional personnel, by school type and distance for all hazard sites. FTE = Full-Time Equivalent.

Appendix Table A3. Proportion of Students by Race Attending Schools Near Hazard Sites

Distance	Proportion Black	Proportion Hispanic	Proportion Native	Proportion Hawaiian	Proportion Asian	Proportion White
			Panel A. All Schools			
0 – 0.125 mi	0.029	0.022	0.045	0.015	0.013	0.015
0 – 0.250 mi	0.095	0.073	0.114	0.066	0.044	0.051
0 – 0.500 mi	0.248	0.209	0.258	0.205	0.143	0.155
0 – 1.000 mi	0.499	0.460	0.458	0.449	0.361	0.368
			Panel B. Public Schools			
0 – 0.125 mi	0.028	0.022	0.045	0.015	0.012	0.014
0 – 0.250 mi	0.094	0.073	0.115	0.067	0.042	0.049
0 – 0.500 mi	0.247	0.208	0.260	0.209	0.139	0.151
0 – 1.000 mi	0.498	0.459	0.458	0.457	0.356	0.362
			Panel C. Private Schools			
0 – 0.125 mi	0.041	0.025	0.047	0.017	0.025	0.021
0 – 0.250 mi	0.114	0.094	0.093	0.059	0.075	0.077
0 – 0.500 mi	0.279	0.255	0.199	0.163	0.198	0.206
0 – 1.000 mi	0.545	0.510	0.452	0.361	0.440	0.438

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: This table reports the proportion of students, by race, attending schools within the four specified distances, by school type, for all hazard sites.

Appendix Table A4. Proportion of Public-School Students by Program Attending Schools Near Hazard Sites

Distance	Proportion FRPL	Proportion Non-FRPL	Proportion EL	Proportion Non-EL	Proportion SWD	Proportion Non-SWD
0 – 0.125 mi	0.022	0.016	0.023	0.019	0.020	0.019
0 – 0.250 mi	0.074	0.053	0.075	0.062	0.068	0.063
0 – 0.500 mi	0.210	0.157	0.216	0.180	0.192	0.183
0 – 1.000 mi	0.457	0.370	0.476	0.406	0.425	0.412

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: This table reports the proportion of public-school students, by program, attending schools within the four specified distances for all hazard sites. FRPL = Free or Reduced-Price Lunch; EL = English Learner; SWD = students with disabilities covered by the Individuals with Disabilities Education Act.

Appendix Table A5. Disparity Ratios by Race (Proximity to All Hazard Sites)

Distance	Black vs. White	Hispanic vs. White	Native vs. White	Hawaiian vs. White	Asian vs. White
			Panel A. All Schools		
0 – 0.125 mi	1.93	1.47	3.00	1.00	0.87
0 – 0.250 mi	1.86	1.43	2.24	1.29	0.86
0 – 0.500 mi	1.60	1.35	1.66	1.32	0.92
0 – 1.000 mi	1.36	1.25	1.24	1.22	0.98
			Panel B. Public Schools		
0 – 0.125 mi	2.00	1.57	3.21	1.07	0.86
0 – 0.250 mi	1.92	1.49	2.35	1.37	0.86
0 – 0.500 mi	1.64	1.38	1.72	1.38	0.92
0 – 1.000 mi	1.38	1.27	1.27	1.26	0.98
			Panel C. Private Schools		
0 – 0.125 mi	1.95	1.19	2.24	0.81	1.19
0 – 0.250 mi	1.48	1.22	1.21	0.77	0.97
0 – 0.500 mi	1.35	1.24	0.97	0.79	0.96
0 – 1.000 mi	1.24	1.16	1.03	0.82	1.00

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: This table reports disparity ratios for Black vs. White, Hispanic vs. White, Native vs. White, Hawaiian vs. White, and Asian vs. White students, by school type and distance, for all hazard sites. Ratios reflect the relative proximity of schools to industrial pollution sites and do not measure actual exposure to pollutants.

Appendix Table A6. Public School Disparity Ratios by Program (Proximity to All Hazard Sites)

Distance	FRPL vs. Non-FRPL	EL vs. Non-EL	SWD vs. Non-SWD
0 – 0.125 mi	1.38	1.21	1.05
0 – 0.250 mi	1.40	1.21	1.08
0 – 0.500 mi	1.34	1.20	1.05
0 – 1.000 mi	1.24	1.17	1.03

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This table reports disparity ratios for FRPL vs. Non-FRPL, EL vs. Non-EL, SWD vs. Non-SWD by distance, for all hazard sites. Ratios reflect the relative proximity of schools to industrial pollution sites and do not measure actual exposure to pollutants. FRPL, EL, and SWD ratios reflect public schools only due to data availability. FRPL = Free or Reduced-Price Lunch; EL = English Learner; SWD = students with disabilities covered by the Individuals with Disabilities Education Act.

Appendix Table A7. Disparity Ratios by Race (Proximity to Higher-Risk Sites)

Distance	Black vs. White	Hispanic vs. White	Native vs. White	Hawaiian vs. White	Asian vs. White
			Panel A. All Schools		
0 – 0.125 mi	2.00	1.50	4.50	0.75	0.50
0 – 0.250 mi	1.88	1.38	3.50	1.19	0.75
0 – 0.500 mi	1.77	1.39	2.33	1.26	0.84
0 – 1.000 mi	1.53	1.33	1.49	1.24	0.93
			Panel B. Public Schools		
0 – 0.125 mi	2.00	1.50	4.50	0.75	0.50
0 – 0.250 mi	1.88	1.38	3.50	1.19	0.69
0 – 0.500 mi	1.79	1.39	2.39	1.29	0.82
0 – 1.000 mi	1.55	1.35	1.52	1.28	0.93
			Panel C. Private Schools		
0 – 0.125 mi	2.33	1.33	5.33	0.50	0.83
0 – 0.250 mi	1.71	1.08	1.88	0.88	1.00
0 – 0.500 mi	1.68	1.36	1.39	0.87	1.00
0 – 1.000 mi	1.44	1.25	1.20	0.83	1.00

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.

Note: This table reports disparity ratios for Black vs. White, Hispanic vs. White, Native vs. White, Hawaiian vs. White, and Asian vs. White students, by school type and distance, for higher-risk sites. Ratios reflect the relative proximity of schools to industrial pollution sites and do not measure actual exposure to pollutants.

Appendix Table A8. Public School Disparity Ratios by Program (Proximity to Higher-Risk Sites)

Distance	FRPL vs. Non-FRPL	EL vs. Non-EL	SWD vs. Non-SWD
0 – 0.125 mi	1.50	1.20	1.00
0 – 0.250 mi	1.35	1.20	1.10
0 – 0.500 mi	1.36	1.24	1.09
0 – 1.000 mi	1.31	1.23	1.05

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This table reports disparity ratios for FRPL vs. Non-FRPL, EL vs. Non-EL, SWD vs. Non-SWD by distance, for higher-risk sites. Ratios reflect the relative proximity of schools to industrial pollution sites and do not measure actual exposure to pollutants. FRPL, EL, and SWD ratios reflect public schools only due to data availability. FRPL = Free or Reduced-Price Lunch; EL = English Learner; SWD = students with disabilities covered by the Individuals with Disabilities Education Act.

Appendix Table A9. Percentage of Schools Within 0.25mi of Hazard Sites, by State

State	Proportion of Schools Within 0.25mi of Environmental Hazard Sites
AK	0.1383
AL	0.0457
AR	0.0507
AZ	0.0748
BIE	0.1437
CA	0.0623
CO	0.1012
CT	0.1249
DC	0.2517
DE	0.0900
FL	0.0656
GA	0.0347
HI	0.0962
IA	0.0687
ID	0.0811
IL	0.0799
IN	0.1013
KS	0.0966
KY	0.0848
LA	0.0676
MA	0.1444
MD	0.0380
ME	0.1366
MI	0.1469
MN	0.1151
MO	0.0792
MS	0.0805
MT	0.2279
NC	0.0444
ND	0.1453
NE	0.0918
NH	0.1546
NJ	0.1154
NM	0.0760
NV	0.1295

NY	0.0953
OH	0.0923
OK	0.0758
OR	0.1090
PA	0.0945
PR	0.1625
RI	0.2628
SC	0.0474
SD	0.0976
TN	0.0314
TX	0.0312
UT	0.0673
VA	0.0375
VI	0.2500
VT	0.2245
WA	0.0593
WI	0.1224
WV	0.1408
WY	0.0572

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This table reports the percentage of schools (public and private) located within 0.25 miles of any environmental hazard site, for all 50 states, Washington, D.C., Bureau of Indian Education (BIE) schools, Puerto Rico (PR), and the U.S. Virgin Islands (VI).

Appendix Table A10. Sites per 100,000 Residents by State

State	Site Count	Population	Sites per 100k
AK	427	733,583	58.2
AL	1,396	5,074,296	27.5
AR	834	3,045,637	27.4
AZ	1,494	7,359,197	20.3
CA	3,867	39,029,342	9.9
CO	1,562	5,839,926	26.7
CT	1,000	3,626,205	27.6
DC	102	671,803	15.2
DE	248	1,018,396	24.4
FL	3,177	22,244,823	14.3
GA	1,647	10,912,876	15.1
HI	314	1,440,196	21.8
IA	1,520	3,200,517	47.5
ID	575	1,939,033	29.7
IL	3,011	12,582,032	23.9
IN	2,796	6,833,037	40.9
KS	1,266	2,937,150	43.1
KY	1,199	4,512,310	26.6
LA	1,044	4,590,241	22.7
MA	1,851	6,981,974	26.5
MD	480	6,164,660	7.8
ME	1,071	1,385,340	77.3
MI	5,141	10,034,113	51.2
MN	1,467	5,717,184	25.7
MO	2,341	6,177,957	37.9
MS	1,092	2,940,057	37.1
MT	1,008	1,122,867	89.8
NC	2,102	10,698,973	19.6
ND	554	779,261	71.1
NE	688	1,967,923	35.0
NH	536	1,395,231	38.4
NJ	1,673	9,261,699	18.1
NM	477	2,113,344	22.6
NV	971	3,177,772	30.6
NY	2,418	19,677,151	12.3
OH	3,603	11,756,058	30.6

OK	1,478	4,019,800	36.8
OR	1,144	4,240,137	27.0
PA	2,747	12,972,008	21.2
PR	611	3,221,789	19.0
RI	463	1,093,734	42.3
SC	1,315	5,282,634	24.9
SD	573	909,824	63.0
TN	1,183	7,051,339	16.8
TX	3,407	30,029,572	11.3
UT	797	3,380,800	23.6
VA	1,195	8,683,619	13.8
VT	618	647,064	95.5
WA	1,198	7,785,786	15.4
WI	2,298	5,892,539	39.0
WV	997	1,775,156	56.2
WY	275	581,381	47.3

Sources: U.S. Census Bureau; U.S. Environmental Protection Agency.

Note: This table reports the count of environmental hazard sites within each state, Washington, D.C., and Puerto Rico, as well as the number of sites per 100,000 residents. Population estimates are based on the U.S. Census Bureau 2022 state population estimates and are provided via the statepop dataset in R.

Appendix Table A11. Sites within Proximal Distance of Schools

Distance	Sites within indicated distance of at least one school	
	Number	**Proportion**
Panel A. Superfunds		
0 – 0.125 mi	557	0.04
0 – 0.250 mi	1,800	0.14
0 – 0.500 mi	4,730	0.36
0 – 1.000 mi	8,229	0.62
Panel B. Brownfields		
0 – 0.125 mi	2,917	0.07
0 – 0.250 mi	10,081	0.25
0 – 0.500 mi	24,539	0.60
0 – 1.000 mi	34,685	0.85
Panel C. Toxic Release Inventory		
0 – 0.125 mi	257	0.01
0 – 0.250 mi	1,234	0.06
0 – 0.500 mi	4,983	0.23
0 – 1.000 mi	12,135	0.57
Panel D. All Pollution Sites		
0 – 0.125 mi	3,730	0.05
0 – 0.250 mi	13,114	0.17
0 – 0.500 mi	34,247	0.45
0 – 1.000 mi	55,040	0.73

Sources: National Center for Education Statistics; U.S. Environmental Protection Agency.
Note: This table reports the count and proportion of environmental hazard sites that have a school located within each of the four specified distances.

Appendix B

Appendix B1. Data Sources and Sample Selection

We acquire school data from multiple NCES sources. For public schools, we use the ELSI Table Generator to download data for the 2023-2024 school year from the CCD. The CCD provides school locations, urbanicity, enrollment, student demographics, and counts of FTE teachers. We obtain enrollment data on English Learner (EL) students and students with disabilities (SWD) covered by the Individuals with Disabilities Education Act from the 2021-2022 CRDC.

For private schools, we also use the ELSI Table Generator to download data for the 2019-2020 school year from the PSS, which includes enrollment, racial composition of students, and FTE teacher counts. We supplement private school location and urbanicity information using the 2023-2024 NCES EDGE program.

We exclude all schools enrolling one or fewer students from our sample, as well as public schools that operate fully virtually. Virtual status is not available for private schools. After these restrictions, our final sample includes 95,560 public schools and 22,510 private schools.

Environmental hazard data come from three EPA programs:

- Superfund: Active site inventory from the EPA.
- Brownfield: Data from EPA's Cleanups in My Community (CIMC) service, covering approximately 40,000 properties that have received EPA brownfields funding.
- Toxic Release Inventory: Data from the EPA TRI Basic Data Files for 2024.

These datasets provide the locations and characteristics of environmental hazards analyzed in this study.

Appendix B2. Calculation of Total FTE Staff Estimates

To estimate total school staffing, we start with available teacher FTE counts and derive estimates for non-teaching staff. Using data from the NCES *Digest of Education Statistics* (Table 213.10), we note that public schools in Fall 2022 employed 3,228,895 FTE teachers and 3,377,237 FTE school-based non-teaching staff (including principals and assistant principals, instructional aides, guidance counselors, librarians, and other support staff).

This corresponds to a ratio of FTE non-instructional staff to FTE teachers of about 1.046.

We apply this ratio to both public and private schools to estimate total staffing. All figures are reported in FTE units.

Appendix B3. Calculation of Disparity Ratios

To examine whether students from different demographics are more likely to attend schools near environmental hazard sites, we calculate disparity ratios comparing demographics such as Black vs. White, Hispanic vs. White, FRPL vs. non-FRPL, EL vs. non-EL, and SWD vs. non-SWD. These ratios indicate relative proximity to sites, not measured exposure to pollutants.

- Step 1 - Compute Probability for Each Demographic Group
  For a given distance x from all pollution sites, we first compute the probability that a student from a particular demographic attends a school near a site:

$$P_{Group\ A}(x) = \frac{Students\ in\ Group\ A\ near\ pollution\ sites\ (at\ distance\ x)}{Students\ in\ Group\ A\ across\ all\ schools}$$

$$P_{Group\ B}(x) = \frac{Students\ in\ Group\ B\ near\ pollution\ sites\ (at\ distance\ x)}{Students\ in\ Group\ B\ across\ all\ schools}$$

- Step 2 - Compute Disparity Ratio

We then compute the ratio of these probabilities between the two demographic groups:

$$Ratio_{Group\ A\ vs\ Group\ B}(x) = \frac{P_{Group\ A}(x)}{P_{Group\ B}(x)}$$

A ratio greater than 1 indicates that students in Group A are more likely than students in Group B to attend schools near pollution sites at distance x.