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How School Facilities Impact Student Health and Performance: Advancing Equity With Green Infrastructure

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This brief informs California's LEA leaders about approaches to sustainably modernizing school facilities to advance educational and health equity for students and briefly explores associated funding strategies.

Introduction

In recent years, California's PK–12 educational leaders have embraced whole-child approaches, recognizing their importance for achieving educational equity (Breaking Barriers et al., 2022; California Department of Education, n.d.). However, the role of school facilities in promoting students' learning and overall well-being has remained largely on the periphery of this conversation. The built environment, as highlighted by challenges in ventilation and filtration during the COVID-19 pandemic, is a crucial factor in students' success and wellness (Lancet COVID-19 Commission, Task Force on Safe Work, Safe School, and Safe Travel, 2021, as cited in Patel et al., 2023).

Despite their importance, California's public PK–12 school facilities remain chronically outdated and underfunded. A 2022 University of California, Berkeley study found that nearly 75 percent of districts are not meeting annual facility capital renewal or maintenance and operations investment spending standards (Vincent et al., 2022). Another analysis by the Public Policy Institute of California in 2020 reported that nearly 40 percent of California's students attend schools that do not meet minimum facility standards (Gao & Lafortune, 2020). The issue of inadequate school infrastructure and substantial gaps in facility investments is not confined to California alone; rather, it is a nationwide phenomenon (Filardo, 2021). Furthermore, on both nationwide and statewide scales, racial, ethnic, socioeconomic, and geographic disparities characterize school facility conditions and spending patterns (Filardo, 2021; Lafortune & Gao, 2022).

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The widespread need for school infrastructure improvement presents an opportunity to invest in facilities that are also responsive to our new climate reality. California's school communities are already experiencing climate impacts, such as historic wildfires, floods, droughts, and heat waves that are only projected to increase in severity and frequency. Climate change also increases the risk of future pandemics by fueling the transmission of new viruses across species and enabling more hospitable pathogenic conditions (Carlson et al., 2022; Mora et al., 2022).

These intensifying climate impacts augment the importance of providing campus communities with resilient, sustainable, and healthy built environments. Because schools frequently become hazard response spaces, resilient facilities can serve as safe destinations during and after disasters (Filardo, 2021).

Investing in the construction of sustainable school facilities through modernization and new developments is also about equity. Because students from families with low income, Black and Indigenous students, and students of color are disproportionately impacted by both outdated public school facilities and environmental hazards more broadly, investment in sustainable facilities' modernization has the potential to mitigate negative impacts on health, well-being, and academic performance for many of California's most marginalized youth (Bullard et al., 2011; Eitland et al., 2017).

Some California local education agencies (LEAs) have already begun making pledges and taking actions that acknowledge the interplay between sustainably designed school facilities and student well-being and academic performance. This map from the New Buildings Institute shows 23 California LEAs, including 6 small school districts, that have formally adopted facilities goals to address carbon emissions and related challenges, such as climate resiliency and campus health. One recent example is the Sacramento Unified School District's commitment to carbon neutrality districtwide by at least 2045, which is accompanied by the district's facilities equity index to guide investments.

Student Wellness and Performance

While everyone is affected by their environment's conditions, students' developing bodies are particularly sensitive and thus particularly susceptible to them (Sadrizadeh et al., 2022). Research evidences that school facilities' indoor air quality, thermal comfort, lighting, and toxic pollutant concentration are linked to student performance and health through what some researchers refer to as "causal chains" (Bernstein & Baker, 2012; Mendell & Heath, 2005; National Research Council, 2007; Sadrizadeh et al., 2022).[1]

1 Evidencing direct causal relationships between building features and impacts on people is a challenge for researchers due to the intricacies of how people interact with their environments, though techniques are being developed. Environmental health researchers responded to this challenge in part by establishing causal chains. Bernstein and Baker (2012) offer an illustrative example of a causal chain: Instead of establishing that a maintenance practice causes fewer asthma attacks, researchers can test and evidence that the practice inhibits the growth of mold. Mold, causal studies can show, impacts asthma rates.

Indoor Air Quality

Poor indoor air quality (IAQ) directly harms student health, which can consequently hinder academic success either directly or indirectly (Sadrizadeh et al., 2022; Wargocki, 2022). The negative impacts of poorly ventilated and poorly filtered learning environments include the following:

- **increased viral transmission**: Viruses spread more easily in schools with inadequate air filtration systems and poor ventilation due to higher viral particulate concentrations (Eitland et al., 2017).
- **increased risk of respiratory illness and allergen impacts**: Classroom air pollutant exposure has been linked to degraded lung function, respiratory infection, increased allergen sensitivity, airway inflammation, exacerbated asthma, and lung cancer (Matthaios et al., 2022; Sadrizadeh et al., 2022). Humidity caused by poor heating, ventilation, and air conditioning (HVAC) systems promotes mold growth and the spread of bacteria, which are linked to respiratory illness and asthma (Eitland et al., 2017).
- **increased risk of neurological harm**: Indoor classroom air pollutant exposure can harm students' developing neurological systems, cognitive performance, and focus and thus negatively impact their learning (Matthaios et al., 2022; Mendell & Heath, 2005; Sadrizadeh et al., 2022). Additionally, research on ambient outdoor pollution links pollutants found in classrooms to alterations in child brain development and neurological disorders (Cotter et al., 2023; Fu et al., 2022).

Beyond these direct health impacts, the relationship between chronic absenteeism and asthma is an example of a "causal chain" connecting school facilities to performance. Asthma is a leading cause of chronic absenteeism, increasing a student's likelihood of experiencing absenteeism's negative educational impacts (Centers for Disease Control and Prevention, n.d.; Eitland et al., 2017; Meng et al., 2012), such as lower academic achievement and a higher likelihood of dropping out of school (Balfanz et al., 2007; Gottfried, 2014; Liu et al., 2021). Asthma attacks are more likely to be triggered when the IAQ is poor, leading to lost school time. A family's perceptions of a school's ability to insulate their student from suboptimal outdoor environments can also result in lost school time, such as on days of dense wildfire smoke.[2]

Chronic absenteeism has extensive consequences, as emphasized by the significant uptick in the aftermath of the COVID-19 pandemic. They include, but are not limited to, the acquisition of fewer literacy skills in the early grades, lower standardized reading and math test scores, lower high school graduation rates, and decreased social engagement (Balfanz & Byrnes, 2012; Chang et al., 2023, Gottfried, 2014; Liu et al., 2021; Santibañez & Guarino, 2021).

2 Smoke from California wildfires, which are increasing in intensity and frequency, is up to 10 times more toxic to young people than are other types of air pollution (Aguilera et al., 2021).

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Improving IAQ through improved ventilation and air filtration systems is a key part of addressing asthma-related absenteeism, as well as the other risks of poor IAQ. Importantly, improved ventilation and air filtration also advance equity for students. Students from families with low income and students attending schools with high proportions of students from families (or households) with low income are more likely to miss school as a result of asthma (Meng et al., 2012). Asthma is significantly more prevalent among youth of color nationwide, regardless of income level (Basch, 2011; Zanobetti et al., 2022). **Accordingly, students from households with low income and students of color stand to benefit most from mitigating asthma-related absenteeism through improving facilities for IAQ.** Because California school districts are funded based on average daily attendance, investments in improved air quality can help to reduce funding loss due to related absences (Attendance Works, 2017).

Because IAQ is an equity issue, Oakland Unified will collaborate with the California Department of Public Health to monitor its classroom and campus air quality as part of a recently awarded federal grant to promote environmental equity (McBride, 2023).

Thermal Health: Heat

Classroom thermal health (temperature and humidity) is another key condition of the built environment that can impact youth health and academic performance. Hot temperatures are most often the concern, as **youth are more susceptible to the effects of heat stress**, prefer cooler conditions, and seem to experience more discomfort in warmer temperatures than do adults (Eitland et al., 2017; Zomorodian et al., 2016).

The extensive heat-related health consequences for students include heat-related illness, coughing and asthma, renal disease from dehydration, nervous system diseases, and ear and bacterial intestinal infections (Patel et al., 2023). The extreme temperatures and lengthening heat waves resulting from global climate change highlight the importance of addressing the impact of heat on student learning. Consequences can include disrupted learning when facilities are ill-equipped to cope with extreme temperatures and schools are forced to close.

A swath of **large studies link heat to diminished student performance** (Haverinen-Shaughnessy & Shaughnessy, 2015; Park, 2017; Roach & Whitney, 2022). They indicate how heat impacts reasoning, time to complete tasks, sustained concentration, and exam scores. A 2019 National Bureau of Economic Research causal study found that *cumulative* heat exposure from the year prior (and even multiple years prior) reduces students' rate of learning as measured by standardized test scores (Goodman et al., 2018). Goodman et al. (2018) also found that air conditioning could effectively mitigate these negative impacts.

However, exposure to heat and the **ability to alleviate heat stress through school infrastructure like air conditioning, is inequitable.** Goodman et al. (2018) found thermal conditions to be a **meaningful factor in racial and geographic achievement disparities.** According to their findings, heat exposure from the previous year has about a 3 times greater impact on Black and Hispanic/Latine students' learning than it does on White students' learning. The disparities appeared tied to (a) school investment in facilities, specifically HVAC systems, and (b) the geographic distribution of racially marginalized students in hotter locations.

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Light

Research from the fields of environmental health and psychology indicates that indoor natural lighting and circadian-stimulating artificial lighting has benefits for mood, concentration, and alertness (Eitland et al., 2017)**.** While the research on daylight's impacts in school settings is limited, robust research on office workers supports that it has meaningful health and performance benefits.

One noteworthy **benefit of exposure to natural light during the day is improved sleep quality**, which is associated with reductions in depressive symptoms and improved cognition (Eitland et al., 2017). Furthermore, students in facilities with window views of green space have exhibited better test performance and **faster recuperation from stress and mental exertion** relative to their peers without such visual access (Li & Sullivan, 2016). The mental and physical health benefits of green space are well documented, as are broader inequities in the distribution of community access to natural environments (Klompmaker et al., 2023).

Fiscally, increasing access to natural light, or "daylighting," can **minimize district energy consumption and costs**. Improving natural lighting in school facilities can positively impact (a) students' mental and emotional well-being, (b) students' ability to focus and stay engaged, and (c) LEAs' budgets.

Sustainable School Design Approaches

The multidisciplinary environmental health research described in this brief illustrates how sustainable school design, or "green schools," in particular, have the potential to improve learning, ensure student well-being, and meet the challenges of a changing climate (Patel et al., 2023; Vakalis et al., 2021).[3] Investment in sustainable school facilities can also promote resilience to otherwise disruptive events, such as power outages and heat waves. Here are a few examples of building approaches to advance educational equity, student health, and environmental and fiscal sustainability:

- **Electrify school energy systems over time.**
  - Replace gas-powered boilers with heat pumps.
  - Invest in electric HVAC systems and ensure their maintenance.
  - Replace gas-powered kitchen appliances with electric appliances to minimize ambient pollutants.
  - Electrify bus fleets.
    - While not a direct element of school buildings, idling buses expose students to significant pollution.
    - Beginning in 2035, California's AB 579 requires that districts can only purchase zero-emission buses.

3 Sustainable school design and modernization refers to school facilities adaptation and construction that focus on "building practices that protect both building occupants and the environment" and that recognize that health and well-being and "learning and academic performance [are] closely tied to the built environment."

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- **Establish research-based limits for indoor pollution concentrations.** Monitor for key pollutant levels such as carbon dioxide, ozone, and nitrous oxide.
- **Improve school building envelopes.**[4] Passive building design techniques can maintain thermal comfort and conserve energy. This upgrade must be combined with measures to maintain a quality ventilation system.
- **Utilize healthy and sustainable building materials and practices in construction.** Identify and limit harmful sources of indoor pollutants, such as volatile organic compounds, PCBs, and PFAS, which can be found in building materials, as well as toxic chemical pollutants produced during construction.
- **Design education spaces with access to daylight in mind.** For example, increase the number or size of windows in classrooms, particularly those with views of green spaces.
- **Develop green schoolyards with shading and native plants.** Despite costing more up front than asphalt-based yards, green schoolyards mitigate the heating effect of blacktop, thereby reducing energy needs. They also support students' mental and physical health, attendance, and performance.

Funding for Facility Adaptation

Sustainable Facilities Can Reduce Cost Pressures

In a 2023 report, the Legislative Analyst's Office stated that California's education system will "face higher and more volatile cost pressures" due to climate change and that school facility adaptations are necessary to withstand the adverse impacts of climate change (Li & Jimenez, 2022). In other words, one challenge created by climate change for K–12 is increased and less predictable costs. One strategy for addressing that challenge is to design school facilities with resilience and sustainability in mind.

Sustainable Facility Design Can Reduce Operating and Construction Costs

In most districts, only salaries outrank energy costs (The White House, 2022). By reducing energy consumption, green facility investments can provide significant savings while providing student health and performance benefits. Furthermore, studies conducted by the U.S. Department of Energy refute the popular belief that zero energy (ZE) schools cost more (Torcellini et al., 2021). They find that ZE schools can not only reduce operating costs but also be constructed at similar or lower costs than conventional schools.

In some instances, as in the case of green schoolyards, sustainable design approaches can have higher up-front costs even if those are outweighed by mid-to-longer term benefits. However, LEAs can leverage a combination of state and federal funding programs to offset costs in those instances, as well as when seeking to construct or adapt facilities more generally. See Figure 1 for potential state and federal funding sources.

4 The building envelope includes "the walls, windows, roof, and foundation" and "forms the primary thermal barrier between the interior and exterior environments." Envelope technologies account for about "30% of the primary energy consumed in residential and commercial buildings" and "plays a key role in determining levels of comfort, natural lighting, ventilation, and how much energy is required to heat and cool a building" (Better Buildings, n.d.).

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Figure 1. State and Federal Funding Sources

<table>
<tr><th>Federal funding sources</th><th>California-specific funding sources</th></tr>
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Bipartisan Infrastructure Law

- $500 million for the Renew America's Schools program—funds for school energy efficiency and clean energy improvements
- $5 billion for the Clean School Bus program—funds to adopt zero- and low-emission school buses

Inflation Reduction Act

- Grants and tax incentives for electric HVAC systems, heat pumps, solar installation, battery storage, electric school bus fleets, and green retrofits; key provisions include the following:
  - $50 million for the Funding to Address Air Pollution at Schools program
  - $1 billion for the Clean Heavy-Duty Vehicle program
  - $60 million for the Diesel Emission Reduction Act
  - tax deductions through Energy Efficient Commercial Buildings Deduction
  - tax credits for clean energy investments and production
- For more, see The Aspen Institute and World Resources Institute's guide, *K12 Education and Climate Provisions in the Inflation Reduction Act*.

Remaining ESSER Funds

- School facilities repairs and improvements are allowable uses of ESSER III so long as they help reduce viral transmissibility or environmental health hazard exposure.
- As of September 30, 2023, California had spent 49% of its $15.08 billion ESSER III allocation, leaving a remainder of about $7.68 billion to draw down.

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California Schools Healthy Air, Plumbing, and Efficiency Program (CalSHAPE)

- $20 million to upgrade and repair HVAC systems and replace noncompliant plumbing

Zero Emission School Bus and Infrastructure Program (ZESBI)

- $135 million to transition to zero-emission bus fleets and develop charging infrastructure

Green Schoolyard Grant Program

- $100 million to increase nature and canopy coverage on public K–12 and nonprofit childcare facilities

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Leveraging federal and state funding sources designed for climate resiliency and public infrastructure improvements, like those in Figure 1, can support California's LEAs to address outdated facilities that have uneven health and performance impacts. Such resources can also bolster the financial feasibility of high performance green school infrastructure to advance learning environments that are more sustainable, healthy, and equitable. The resources featured in Figure 2 can offer additional guidance to learn about and fund sustainable school facilities.

Figure 2. Guidance for Funding Sustainable School Facilities

- Department of Energy: Efficient and Healthy Schools Financing Resources
- Rewiring America: *Electrify Everything in Your School Handbook: From Campaign to Implementation*
- New Buildings Institute: *The Building Electrification Technology Roadmap for Schools*
- National Renewable Energy Laboratory: *Affordable Zero Energy K–12 Schools: The Cost Barrier Illusion*

Additional Resources

- National Renewable Energy Laboratory: *A Guide to Zero Energy and Zero Energy Ready K–12 Schools*
- New Buildings Institute: *Decarbonization Roadmap Guide for School Building Decision Makers*
- Climate Ready Schools Coalition: Climate-Resilient California Schools: A Call to Action
- U.S. Environmental Protection Agency: Climate Resilient Schools Program: low to no cost technical assistance for school districts to plan school upgrades to make their buildings more resilient to climate change
- California Energy Commission: Bright Schools Program—no cost technical assistance to identify cost-effective energy saving opportunities for California public and charter schools

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References

Aguilera, R., Corringham, T., Gershunov, A., Leibel, S., & Benmarhnia, T. (2021). Fine particles in wildfire smoke and pediatric respiratory health in California. *Pediatrics*, *147*(4), e2020027128. https://doi.org/10.1542/peds.2020-027128

The Aspen Institute & World Resources Institute. (2022). *K12 education and climate provisions in the Inflation Reduction Act*. https://www.thisisplaneted.org/img/K12-InflationReductionAct-Final-Screen.pdf

Attendance Works. (2017). *How the rubber meets the road: Funding efforts to reduce chronic absence in California school districts*. https://attendanceworks.org/wp-content/uploads/2017/08/Funding-CA-in-CA-3-20-2017-1.pdf

Balfanz, R., & Byrnes, V. (2012). The importance of being there: A report on absenteeism in the nation's public schools. *Education Digest: Essential Readings Condensed for Quick Review*, *78*.

Balfanz, R., Herzog, L., & Mac Iver, D. J. (2007). Preventing student disengagement and keeping students on the graduation path in urban middle-grades schools: Early identification and effective interventions. *Educational Psychologist*, *42*(4), 223–235. https://doi.org/10.1080/00461520701621079

Basch, C. E. (2011). Asthma and the achievement gap among urban minority youth. *Journal of School Health*, *81*(10), 606–613. https://doi.org/10.1111/j.1746-1561.2011.00634.x

Bernstein, H., & Baker, L. (2012). *The impact of school buildings on student health and performance*. University of California, Berkeley with the Center for Green Schools at the U.S. Green Building Council in Partnership with McGraw-Hill Research Foundation.

Better Buildings. (n.d.). *Building envelope*. U.S. Department of Energy. https://betterbuildingssolutioncenter.energy.gov/building-envelope

Breaking Barriers, California Alliance of Child and Family Services, Santa Clara County Office of Education, & WestEd. (2022). *Supporting California's children through a whole child approach: A field guide for creating integrated, school-based systems of care*.

Bullard, R. D., Johnson, G. S., & Torres, A. O. (2011). Environmental health and racial equity in the United States: *Building environmentally just, sustainable, and livable communities*. American Public Health Association. https://ajph.aphapublications.org/doi/book/10.2105/9780875530079

California Department of Education. (n.d.). *LCFF priorities/whole child resource map*. https://www.cde.ca.gov/eo/in/lcff1sys-resources.asp

Carlson, C. J., Albery, G. F., Merow, C., Trisos, C. H., Zipfel, C. M., Eskew, E. A., Olival, K. J., Ross, N., & Bansal, S. (2022). Climate change increases cross-species viral transmission risk. *Nature*, *607*, 555–562. https://doi.org/10.1038/s41586-022-04788-w

WestEd
Western Educational Equity Assistance Center

Centers for Disease Control and Prevention. (n.d.). *CDC healthy schools: Asthma*. https://www.cdc.gov/healthyschools/asthma/index.htm

Chang, H., Leong, C., Ariza, G., Casey, M., & Duffy, H. (2023). *Quick start guide for districts to improve attendance*. Western Educational Equity Assistance Center at WestEd. https://weeac.wested.org/resource/quick-start-guide-for-districts-to-improve-attendance

Cotter, D. L., Campbell, C. E., Sukumaran, K., McConnell, R., Berhane, K., Schwartz, J., Hackman, D. A., Ahmadi, H., Chen, J.-C., & Herting, M. M. (2023). Effects of ambient fine particulates, nitrogen dioxide, and ozone on maturation of functional brain networks across early adolescence. *Environment International*, *177*, 108001. https://doi.org/10.1016/j.envint.2023.108001

Eitland, E., Klingensmith, L., MacNaughton, P., Cedeno Laurent, J., Spengler, J., Bernstein, A., & Allen, J. G. (2017). *Schools for health: Foundations for success*. Harvard T.H. Chan School of Public Health. https://forhealth.org/Harvard.Schools_For_Health.Foundations_for_Student_Success.pdf

Filardo, M. (2021). *State of our schools: America's PK–12 public school facilities 2021*. 21st Century School Fund.

Fu, C., Kuang, D., Zhang, H., Ren, J., & Chen, J. (2022). Different components of air pollutants and neurological disorders. *Frontiers in Public Health*, *10*, 959921. https://doi.org/10.3389/fpubh.2022.959921

Gao, N., & Lafortune, J. (2020). *Improving K–12 school facilities in California*. Public Policy Institute of California.

Goodman, J., Hurwitz, M., Park, J., & Smith, J. (2018). *Heat and learning* (NBER Working Paper Series 24639). National Bureau of Economic Research. https://doi.org/10.3386/w24639

Gottfried, M. A. (2014). Chronic absenteeism and its effects on students' academic and socioemotional outcomes. *Journal of Education for Students Placed at Risk (JESPAR)*, *19*(2), 53–75. https://doi.org/10.1080/10824669.2014.962696

Haverinen-Shaughnessy, U., & Shaughnessy, R. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PLOS ONE*, *10*(8), e0136165. https://doi.org/10.1371/journal.pone.0136165

Klompmaker, J. O., Hart, J. E., Bailey, C. R., Browning, M. H. E. M., Casey, J. A., Hanley, J. R., Minson, C. T., Ogletree, S. S., Rigolon, A., Laden, F., & James, P. (2023). Racial, ethnic, and socioeconomic disparities in multiple measures of blue and green spaces in the United States. *Environmental Health Perspectives*, *131*(1), 017007. https://doi.org/10.1289/EHP11164

Lafortune, J., & Gao, N. (2022). *Equitable state funding for school facilities*. Public Policy Institute of California.

Li, A., & Jimenez, F. (2022). *Climate change impacts across California K–12 education*. Legislative Analyst's Office. https://lao.ca.gov/reports/2022/4586/Climate-Change-Impacts-K-12-Education-040522.pdf

Li, D., & Sullivan, W. C. (2016). Impact of views to school landscapes on recovery from stress and mental fatigue. *Landscape and Urban Planning*, *148*, 149–158. https://doi.org/10.1016/j.landurbplan.2015.12.015

WestEd

Western Educational Equity Assistance Center

Liu, J., Lee, M., & Gershenson, S. (2021). The short- and long-run impacts of secondary school absences. *Journal of Public Economics*, *199*, 104441. https://doi.org/10.1016/j.jpubeco.2021.104441

Matthaios, V. N., Kang, C.-M., Wolfson, J. M., Greco, K. F., Gaffin, J. M., Hauptman, M., Cunningham, A., Petty, C. R., Lawrence, J., Phipatanakul, W., Gold, D. R., & Koutrakis, P. (2022). Factors influencing classroom exposures to fine particles, black carbon, and nitrogen dioxide in inner-city schools and their implications for indoor air quality. *Environmental Health Perspectives*, *130*(4), 047005. https://doi.org/10.1289/EHP10007

McBride, A. (2023, November 17). Oakland schools will monitor air quality in classrooms and on campus. *The Oaklandside*. https://oaklandside.org/2023/11/17/oakland-air-quality-california-health-environment-pollution/#:~:text=In%20an%20effort%20to%20better,in%20placing%20air%20sensors%20on

Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. *Indoor Air*, *15*(1), 27–52. https://doi.org/10.1111/j.1600-0668.2004.00320.x

Meng, Y., Babey, S. H., & Wolstein, J. (2012). Asthma-related school absenteeism and school concentration of low-income students in California. *Preventing Chronic Disease*, *9*, 110312. https://doi.org/10.5888/pcd9.110312

Mora, C., McKenzie, T., Gaw, I. M., Dean, J. M., von Hammerstein, H., Knudson, T. A., Setter, R. O., Smith, C. Z., Webster, K. M., Patz, J. A., & Franklin, E. C. (2022). Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change*, *12*, 869–875. https://doi.org/10.1038/s41558-022-01426-1

National Research Council. (2007). *Green schools: Attributes for health and learning*. The National Academies Press. https://doi.org/10.17226/11756

Park, J. (2017). *Hot temperature, high stakes exams, and avoidance behavior: Evidence from New York City public schools*. https://api.semanticscholar.org/CorpusID:34559343

Patel, L., Vincent, J. M., Klein, J., Doane, K., Lew, Z., Yeghoian, A., & Hansen, J. (2023). *A call to action: Climate-resilient California schools. Safeguarding children's health and opportunity to learn in TK-12*. Stanford University.

Roach, T., & Whitney, J. (2022). Heat and learning in elementary and middle school. *Education Economics*, *30*(1), 29–46. https://doi.org/10.1080/09645292.2021.1931815

Sadrizadeh, S., Yao, R., Yuan, F., Awbi, H., Bahnfleth, W., Bi, Y., Cao, G., Croitoru, C., de Dear, R., Haghighat, F., Kumar, P., Malayeri, M., Nasiri, F., Ruud, M., Sadeghian, P., Wargocki, P., Xiong, J., Yu, W., & Li, B. (2022). Indoor air quality and health in schools: A critical review for developing the roadmap for the future school environment. *Journal of Building Engineering*, *57*, 104908. https://doi.org/10.1016/j.jobe.2022.104908

Santibañez, L., & Guarino, C. M. (2021). The effects of absenteeism on academic and social-emotional outcomes: Lessons for COVID-19. *Educational Researcher*, *50*(6), 392–400. https://doi.org/10.3102/0013189X21994488

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Torcellini, P., Zaleski, S., & McIntyre, M. (2021). *Affordable zero energy K-12 schools: The cost barrier illusion* (NREL/TP-5500-80766). National Renewable Energy Laboratory. https://doi.org/10.2172/1837979

United States Department of Education. (n.d.). *Education Stabilization Fund: California*. https://covid-relief-data.ed.gov/profile/state/CA

Vakalis, D., Lepine, C., MacLean, H. L., & Siegel, J. A. (2021). Can green schools influence academic performance? *Critical Reviews in Environmental Science and Technology*, *51*(13), 1354–1396. https://doi.org/10.1080/10643389.2020.1753631

Vincent, J. M., Semhar, G., & Neinstedt, L. (2022). *Gauging good stewardship: Is California adequately and equitably investing in its public school facilities?* Center for Cities + Schools, University of California, Berkeley.

Wargocki, P. (2022). Effects of classroom air quality on learning in schools. In Y. Zhang, P. K. Hopke, & C. Mandin (Eds.), *Handbook of indoor air quality* (pp. 1447–1459). Springer, Singapore. https://doi.org/10.1007/978-981-16-7680-2_65

The White House. (2022, April 4). *FACT SHEET: The Biden-Harris action plan for building better school infrastructure* [Press release]. https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/04/fact-sheet-the-biden-harris-action-plan-for-building-better-school-infrastructure

Zanobetti, A., Ryan, P. H., Coull, B., Brokamp, C., Datta, S., Blossom, J., Lothrop, N., Miller, R. L., Beamer, P. I., Visness, C. M., Andrews, H., Bacharier, L. B., Hartert, T., Johnson, C. C., Ownby, D., Khurana Hershey, G. K., Joseph, C., Yiqiang, S., Mendonça, E. A., ... Children's Respiratory and Environmental Workgroup (CREW) Consortium. (2022). Childhood asthma incidence, early and persistent wheeze, and neighborhood socioeconomic factors in the ECHO/CREW Consortium. *JAMA Pediatrics*, *176*(8), 759–767. https://doi.org/10.1001/jamapediatrics.2022.1446

Zomorodian, Z. S., Tahsildoost, M., & Hafezi, M. (2016). Thermal comfort in educational buildings: A review article. *Renewable and Sustainable Energy Reviews*, *59*, 895–906. https://doi.org/10.1016/j.rser.2016.01.033

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