

BREATHING IN

Covid Closed the Nation's Schools. Cleaner Air Can Keep Them Open.

Scientists and educators are searching for ways to improve air quality in the nation's often dilapidated school buildings.



By Apoorva Mandavilli

Apoorva Mandavilli visited schools in Denver, Boulder, Colo., and State College, Pa., and interviewed dozens of scientists, officials, educators and students about the air in school buildings.

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On a sunny afternoon in a cluttered music room at East High in Denver, two sophomores practiced violin while their music teacher, Keith Oxman, labored over a desk in an adjoining office.

The ceiling fans were off to prevent the sheet music from scattering. The windows were sealed shut. East High is Denver's largest high school and among the oldest, and there is no modern ventilation system.

As the pandemic broke out, Mr. Oxman, 65 and a cancer survivor, feared getting sick or carrying the virus to his 101-year-old father. So he left the school when it first closed, in March 2020, and did not return for more than a year, staying home during later virus surges.

"We were supposed to have the windows open," he said. "But the windows don't open."

Poorly ventilated spaces offer ideal transmission conditions for the coronavirus, and at the height of the pandemic, schools like East High were a searing point of controversy. An outbreak that began in November 2021 sickened more than 500 students — about one in five — and 65 staff members, one of whom died.

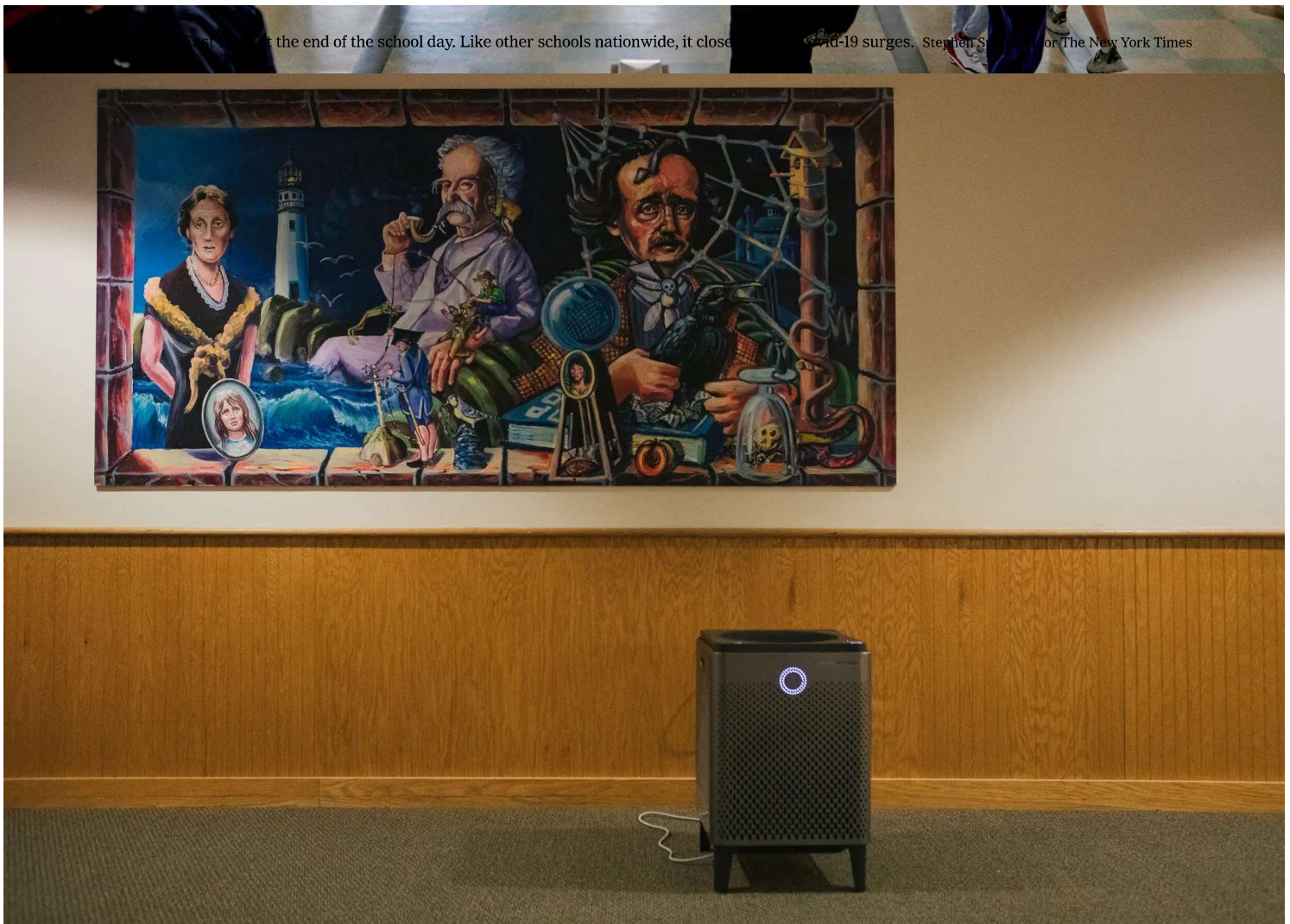
The pandemic led to repeated closures at tens of thousands of schools across the nation. The shutdowns sent educational achievement tumbling, disrupted the lives of millions of American families, and set off a wave of anger, particularly among conservatives, that has not subsided.

As the next presidential election gathers steam, extended school closures and remote learning have become a centerpiece of the Republican argument that the pandemic was mishandled, the subject of repeated hearings in the House of Representatives and a barrage of academic papers on learning loss and mental health disorders among children.

But scientists who study viral transmission see another lesson in the pandemic school closures: Had the indoor air been cleaner and safer, they may have been avoidable. The coronavirus is an airborne threat, and the incidence of Covid was about 40 percent lower in schools that improved air quality, one study found.

The average American school building is about 50 years old. According to a 2020 analysis by the Government Accountability Office, about 41 percent of school districts needed to update or replace the heating, ventilation and air-conditioning systems in at least half of their schools, about 36,000 buildings in all.





An air purifier in a hallway at East High. Many scientists believe that had the air in the nation's schools been cleaner, closures could have been avoided. Michelle Gustafson for The New York Times

There have never been more resources available for the task: nearly \$200 billion, from an array of pandemic-related measures, including the American Rescue Plan Act. Another \$350 billion was allotted to state and local governments, some of which could be used to improve ventilation in schools.

"It's a once-in-a-generation opportunity to fix decades of neglect of our school building infrastructure," said Joseph Allen, director of the Healthy Buildings program at the Harvard T.H. Chan School of Public Health.

Schoolchildren are heading back to classrooms by the tens of millions now, yet much of the funding for such improvements is sitting untouched in most states.

Among the reasons: a lack of clear federal guidance on cleaning indoor air, no senior administration official designated to oversee such a campaign, few experts to help the schools spend the funds wisely, supply chain delays for new equipment, and insufficient staff to maintain improvements that are made.

Some school officials simply may not know that the funds are available. "I cannot believe the amount of money that is still unspent," Dr. Allen said. "It's really frustrating."

The pandemic prompted the federal funding, but the problem is bigger than the coronavirus. Indoor air may be contaminated not just by pathogens, but also by a range of pollutants like carbon monoxide, radon and lead particles. Concentrations can be five times higher or more indoors than they are outdoors, according to the Environmental Protection Agency.

And smoke is an increasing threat. A plume from Canadian wildfires closed schools across the Northeast in early June. Smoke closed 120 schools in California last September.

The air in Denver was so fouled by wildfire smoke in May that the city briefly ranked as the second most polluted worldwide. Schools remained open, though many outdoor events were postponed.

Nearly one in 13 American schoolchildren has asthma, which can be exacerbated by exposure to smoke; already it is the leading cause of absenteeism due to chronic illness. Asthma rates at several Denver public schools are higher than 20 percent, more than twice the national average.



The principal of Garden Place Academy, Andrea Renteria, in the school gym. Until a cooling system was installed, temperatures sometimes reached the low 100s in classrooms. Stephen Speranza for The New York Times



The view through windows in East High's library. Denver, like many U.S. cities, regularly contends with wildfire smoke. Stephen Speranza for The New York Times

Modern air-filtration systems can remove even the fine particulates that make smoke so unhealthy. And decades of research have suggested that improving air quality also can raise academic performance, increase test scores, bolster attention and memory, and decrease absences due to illness or other factors.

"We would not accept drinking water that is full of pathogens and looks dirty," said Linsey Marr, an expert in airborne transmission of viruses at Virginia Tech. "But we've been living with air that is full of pathogens and dirty."

Until recently, it wasn't even clear to school officials how clean the air in school buildings should be. In May, however, the Centers for Disease Control and Prevention recommended that there should be five so-called air changes — the equivalent of replacing all the air in a room — per hour.

In June, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, an influential standards-setting organization, published its first-ever requirements for "pathogen-free air flow" in buildings, including combinations of filtration and ventilation technologies that building managers can ratchet up during outbreaks.

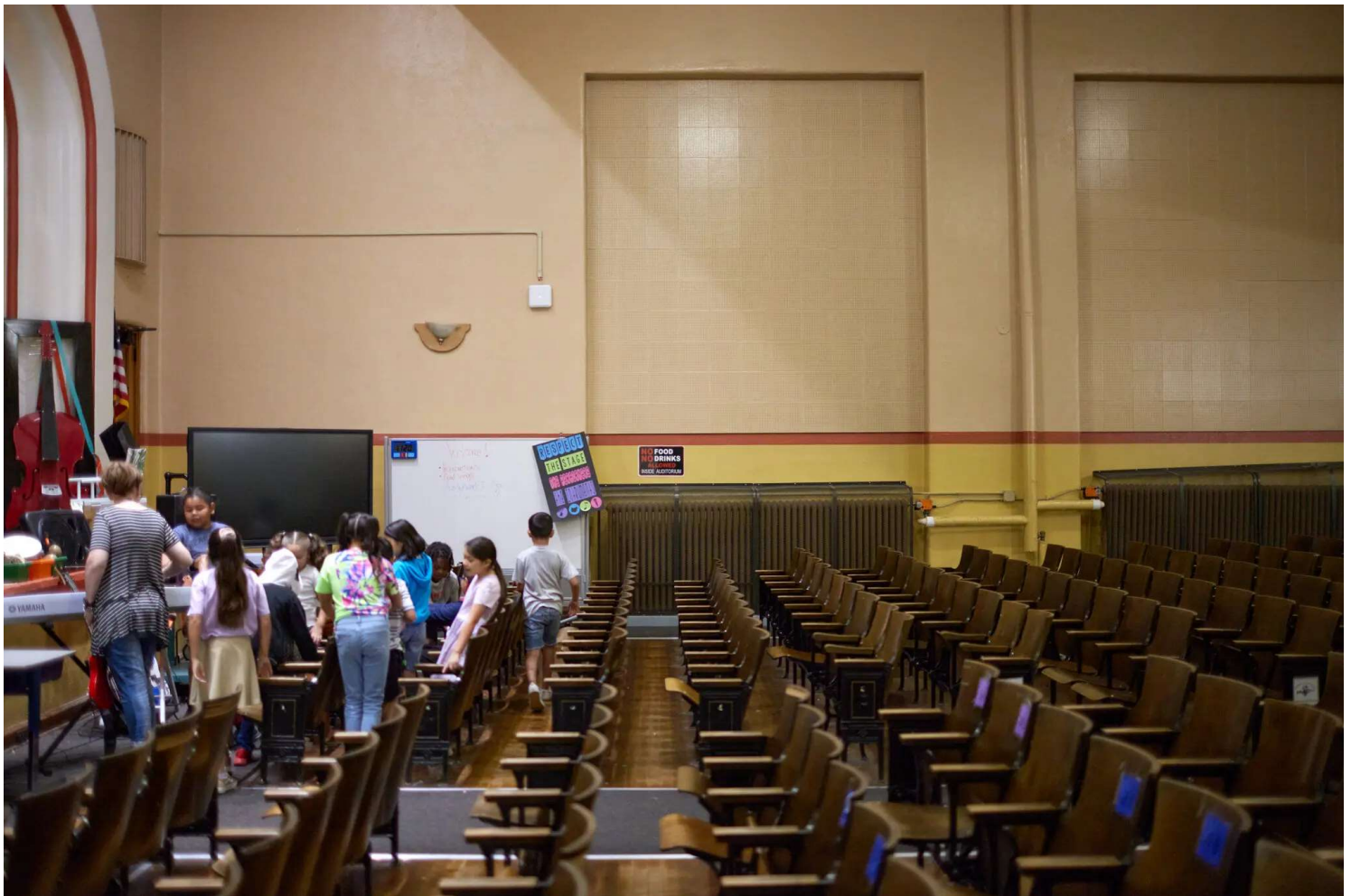
"If I had to pick one place for pilot programs to invest money in layers for ventilation and filtration, school is the place to start," said David Michaels, an epidemiologist at George Washington University who led the Occupational Safety and Health Administration during the Obama administration.

There are tentative signs of progress. A C.D.C. survey last year found that 70 percent of 420 schools nationwide had evaluated their ventilation systems, although many implemented only low-cost improvements, like opening doors or windows.

An agency survey published in April found that one in three school districts had completed or planned improvements in air quality, and that more than one-quarter had installed air cleaners or planned to do so. Several states are pursuing legislation intended to improve air quality in schools.

Researchers at the C.D.C. and the Georgia Department of Public Health surveyed 169 elementary schools in Georgia at the end of 2020, after in-person learning had resumed in the state.

Schools that improved ventilation had 39 percent fewer Covid cases, compared with schools that had not. Schools that combined better ventilation with filtration had 48 percent fewer cases.



A music class taking place in an auditorium without windows at Garden Place Academy. Stephen Speranza for The New York Times



Terita Walker, the principal of East High, must juggle a number of priorities, including students' safety and academic achievement. Stephen Speranza for The New York Times

A large study of schools in Italy estimated that students in classrooms equipped with ventilation systems or devices that deliver clean air had an at least 74 percent lower risk of infection than students in classrooms with open windows.

C.D.C. researchers have estimated that air purifiers may decrease the exposure to aerosols — tiny floating droplets that might contain virus — by up to 65 percent.

But with few trees, asphalt-covered yards and overcrowded buildings, many urban schools are struggling to cope with pathogens, pollution and climate change.

Rising temperatures alone are straining their resources. Already this summer, students in Philadelphia and Baltimore were sent home because a lack of air-conditioning made school buildings unbearable, even dangerous.

In the Denver district, 37 schools have no air-conditioning. Officials have installed new cooling systems in 11 schools over the past few years and plan to complete 13 more by the end of 2024.

"Before we had the air cooling system, it was getting to the high 90s, low 100s in our classrooms," said Andrea Renteria, principal of Garden Place Elementary School, on Denver's north side. The school was established in 1904, and 92 percent of the student body are children of color.

It still gets too hot in the school's gym. With the floor-to-ceiling windows painted shut, the coach props open doors to let in air. But the school is barely a block away from the nexus of two major highways, so the outside air isn't much healthier.

Students of color more often attend schools close to highways and factories that spew air pollution, and heat waves are becoming more intense across the country.

Several studies have found that hot classrooms result in a drop in test scores, which particularly affects students of color. That link alone accounts for roughly 5 percent of the racial achievement gap, according to a 2018 estimate by the National Bureau of Economic Research.

Still, urban schools must juggle a host of competing priorities, including the safety, mental health and achievement of students. Air quality can seem less urgent.

“Even in the times of Covid, there were things that were higher on the list for people than that,” Terita Walker, the principal of East High, said.

Patchwork Solutions

In an effort to find solutions to the indoor-air problem, researchers at the University of Colorado, Boulder, installed air quality monitors in dozens of Denver schools, including East High, before and after introducing classroom air purifiers.

Mark Hernandez, an air quality expert at the university who leads the project, and his colleagues have found that in an average classroom with poor ventilation — about 1,000 square feet, a ceiling height of about eight feet and occupied by 25 students — two air purifiers can remove particulate matter that might trigger allergies and asthma, and double the air exchange rate.

The data have prompted state officials to offer air purifiers to schools that most need them. The researchers now have a grant to install 2,400 air quality monitors in schools throughout the state, and will assess whether the improvements make a meaningful difference in absenteeism.



An air purifier in a dining hall at Boulder High School, which began making investments in air quality long before the pandemic. Stephen Speranza for The New York Times



An air quality sensor at Barnum Elementary in Denver. The device can give an approximate assessment of the air circulating in a room. Stephen Speranza for The New York Times

Without guidance from experts like Dr. Hernandez, however, finding the right air filters — let alone overhauling an entire ventilation system — is daunting for school officials.

“You’re asking school districts and facilities that really don’t understand the sort of fundamentals and mechanical systems to make decisions,” said Richard Corsi, dean of the College of Engineering at University of California, Davis. “It’s difficult for them.”

In the absence of consistent federal guidance, school districts are cobbling together a patchwork of measures.

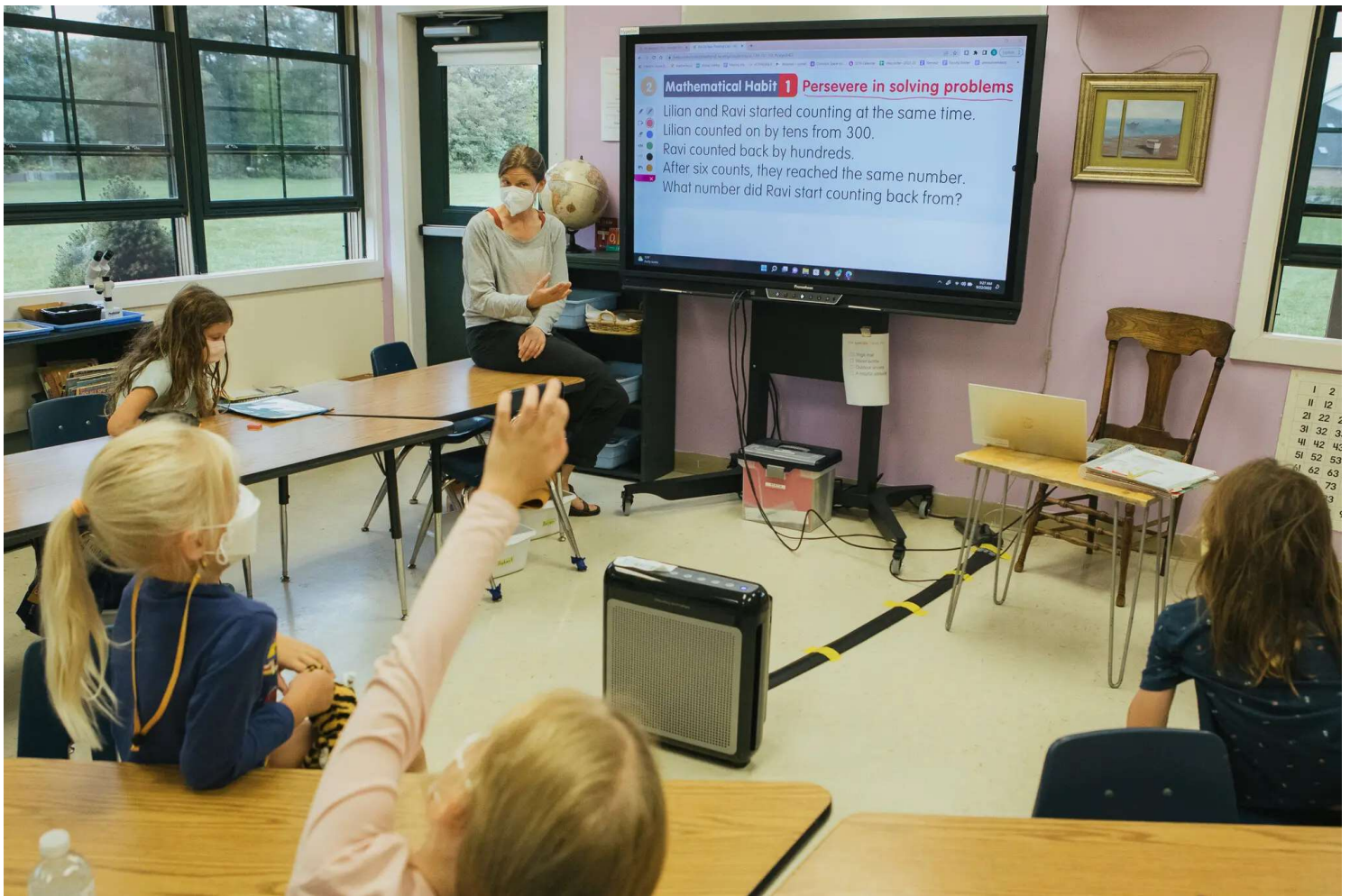
Los Angeles schools invested in 55,000 commercial-grade air cleaners, while Seattle schools opted for less costly hand-held sensors. In Westchester County, N.Y., officials distributed more than 5,600 air purifiers to district schools. Boston Public Schools set up a district-wide system to monitor air quality.

In many schools, however, spending on ventilation trails other priorities, like hiring staff, purchasing laptops and other equipment, or extra help for students who have fallen behind. Across the country, spending per school on air quality ranges widely, from just \$67 to \$2,675,000, according to a report in November.

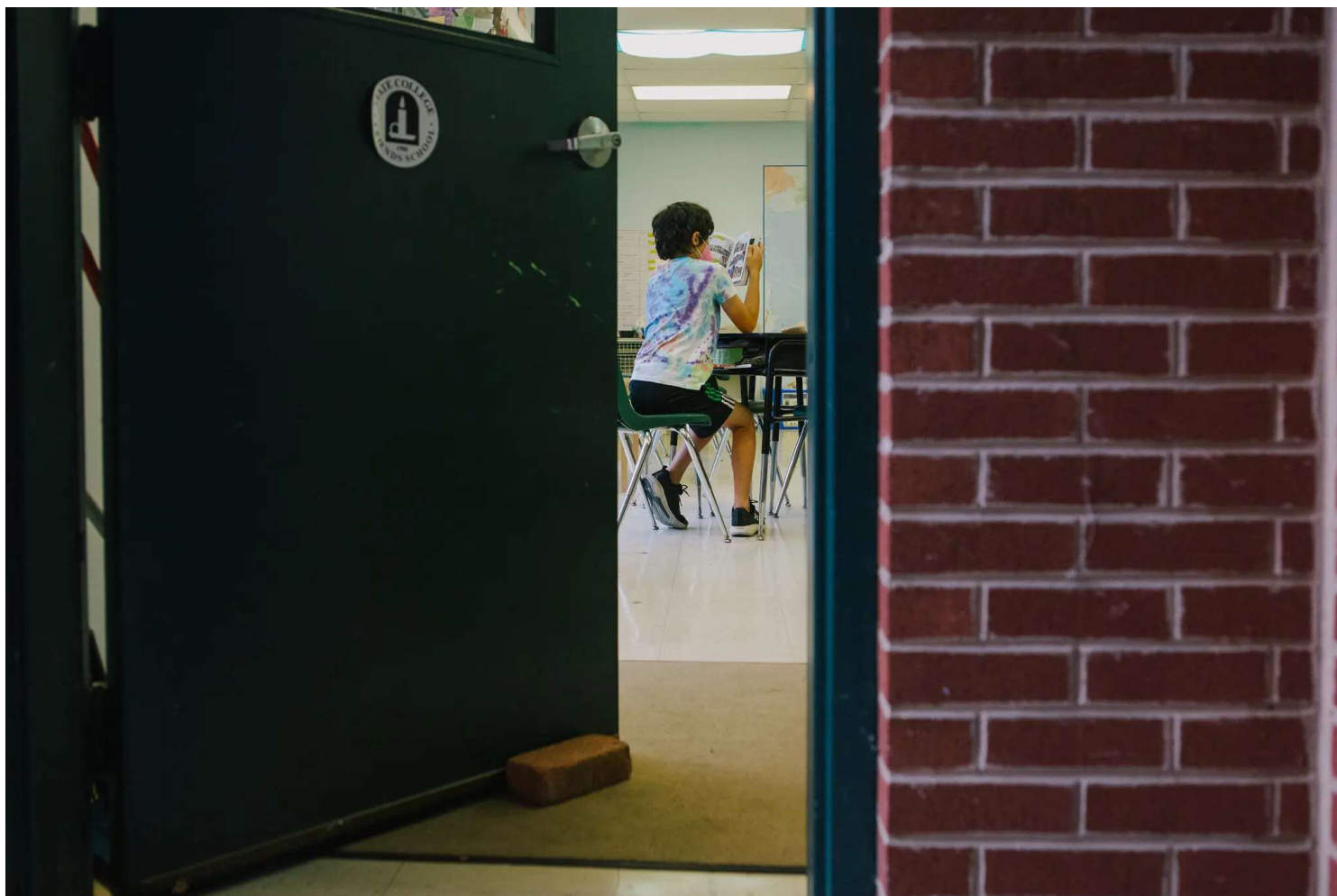
For districts that make it a priority, cleaner air can yield big payoffs. Less than 30 miles from East High, Boulder High School has air purifiers and sensors in nearly every classroom that can alert technicians when the air quality drops below acceptable levels.

The Boulder schools made the improvements with a \$576.5 million bond issued in 2014, long before the pandemic, and partnered with scientists to collect data before and after the installations.

The research wrapped up early last year, and the results so far indicate that the network produced a 44 percent drop in carbon dioxide levels, often used as a proxy for air quality. The school had a coronavirus outbreak during the Omicron wave — seven staff members and 237 students — but arguably fared better than the county as a whole.



A second-grade math class at State College Friends School in State College, Pa. The school has air purifiers in classrooms and keeps windows open; even in poor weather, students are regularly outside. Michelle Gustafson for The New York Times



Ethan Long, a student, reading in a classroom at State College Friends School. Michelle Gustafson for The New York Times

In State College, Pa., many schools shut down for days or weeks during Covid-19 surges because too many students or teachers were sick with the virus.

But State College Friends School, a small Quaker institution, has remained open since the fall of 2020. The school identified just four cases of in-school transmission in the 2021-22 school year.

The school was built in the 1960s, and every classroom opens to the outside. Large classroom windows remain open on all but the most frigid days, and each room is outfitted with air filters and fans.

When the weather cooperates, students play outside on the lush grounds; when it doesn't, they snack on camp chairs in covered patios outside their classrooms.

Friends is an unusual school by most measures. It's tiny, with just 120 students. The staff members and students wore high-quality masks until the number of local Covid cases dropped below 50 per 100,000 people this spring. And the school has gotten assistance from air quality experts at Penn State University, practically in its backyard.

Not every school can look like Friends — nor is that necessary.

Dr. Hernandez estimates that spending \$65 per student per classroom per year on air purifiers could significantly reduce pathogens and pollution in classrooms.

At East High in Denver, as in the rest of America, Covid is fast receding as a priority. Mr. Oxman, the music teacher, is back full time, but the pandemic doesn't seem to have brought many lasting changes. East High is mostly the same.

"Things are kind of going back to the way they were," he said.

Apoorva Mandavilli is a reporter focused on science and global health. She was a part of the team that won the 2021 Pulitzer Prize for Public Service for coverage of the pandemic. More about Apoorva Mandavilli

A version of this article appears in print on , Section A, Page 1 of the New York edition with the headline: Bad Ventilation Remains Threat To U.S. Students