Portable air cleaners such as HEPAs and Corsi-Rosenthal Boxes are a simple, cost-effective tool:

- Reduce COVID transmission without modifying the existing building ventilation.
- Reducing COVID transmission will reduce employee and student absenteeism.

This document seeks to show you why **you should bring in portable air cleaners into your building** - and address any concerns you might have. Below are links that will take you directly to each section.

Reasons why you should allow portable air cleaners in your building.

The top 3 richest counties in America have deployed portable air cleaners in every single classroom.

Would you prefer this information in video format?

Many school organizations around the world have rolled out portable air cleaners.

Every relevant public health authority recommends portable air cleaners to reduce transmission of COVID.

Elite University Indoor Air Quality Groups recommend them.

Portable air cleaners have been studied and found to remove aerosols from the air.

Children are impacted by COVID, and transmit to each other, teachers, and loved ones.

COVID is airborne via aerosols.

Masks are essential, but not enough.

The Solution

HEPA Air Cleaners sound very expensive, but are not.

The Corsi-Rosenthal Box is a more cost-effective solution.

Schools that are known to have rolled out Corsi-Rosenthal Boxes.

Examples of outbreak prevention.

Authorities who specifically have recommended the Corsi-Rosenthal Box.

What are the upsides besides the COVID free air?

Downsides of the Corsi-Rosenthal Box.

Concerns about the Corsi-Rosenthal Box - and portable air cleaners.

Electricity – are these fans a danger with the filters attached? Will they catch on fire?

Electricity - will these overload our circuits?

HVAC - Will these interfere with our current HVAC architecture?

HVAC - We just upgraded our HVAC to MERV 13. We don't need these.

Will the Corsi-Rosenthal box just blow infectious air on people?

Equity Considerations - the school board does not have enough funds to provide them to every classroom.

Reasons why you should allow portable air cleaners in your building.

The top 3 richest counties in America have deployed portable air cleaners in every single classroom.

This is relevant because their money gives them access to the world's best experts in any field - and portable air cleaners are part of their solution.

- Marin County, California, third richest county in America,has HEPA Air Cleaners in every single classroom.
- New York County, New York, second richest county in America, has portable air cleaners.
- Teton County, Wyoming, the richest county in America, has HEPA Air Cleaners in every single classroom.

Work for you? Click here to skip to a cost effective solution.
Work for you, but you have concerns about electrical, safety, etc? Click here.

Would you prefer this information in video format?

In this 8 minute video, Dr. Richard Corsi, who is very published in the Indoor Air Quality field, discusses school ventilation as it applies to COVID and portable air cleaners.

Work for you? Click here to skip to a cost effective solution.
Work for you, but you have concerns about electrical, safety, etc? Click here.

Many school organizations around the world have rolled out portable air cleaners.

This is just a sampling.

- **USA:**
  - **Harvard** has deployed them in every dormitory bedroom and bathroom and multiple-occupant bathroom.
  - 20,000 in Chicago, Illinois, USA.
  - 5,000 in Boston, Massachusetts, USA.

    - 600 in Warwick, Rhode Island, USA
    - Boulder Valley School District, ranked #528 of 10,772 school districts.

- **Other countries:**
    - 114,000 in every single classroom in Korea.
    - 50,000 in Victoria, Australia.
    - 20,000 in Ontario, Canada.
    - 8,000 in the UK after deploying monitors to find trouble areas.
    - Toronto school district.
    - 175 in the Canadian province, Prince Edward Island.

Work for you? Click here to skip to a cost effective solution.
Work for you, but you have concerns about electrical, safety, etc? Click here.

Every relevant public health authority recommends portable air cleaners to reduce transmission of COVID.

- The **CDC** recommends them:
    - "Use portable high-efficiency particulate air (HEPA) fan/filtration systems to enhance air cleaning (especially in higher risk areas such as a nurse's office or areas frequently inhabited by people with a higher likelihood of having COVID-19 and/or an increased risk of getting COVID-19)."

- The **Department of Education,** in a guidance document titled "Improving Ventilation in Schools, Colleges, and Universities to Prevent COVID-19" recommends:
    - "**Portable air cleaners can go in any room of a school building to serve as an additional safety and mitigation layer**, including in areas where airflow may be limited, and/or in areas where sick individuals may be present such as a nurse's office or sick/isolation room."

- The **World Health Organization** recommends them for homes, schools (non-residential buildings), and hospitals.

- The **EPA** recommends them.
    - The EPA has found that improving ventilation, improves tests scores.

- **ASHRAE** recommends them.

Work for you? Click here to skip to a cost effective solution.
Work for you, but you have concerns about electrical, safety, etc? Click here.

Elite University Indoor Air Quality Groups recommend them.

- John Hopkins Center for Health Security.
- Healthy Buildings Program at the Harvard T.H. Chan School of Public Health

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Portable air cleaners have been studied and found to remove aerosols efficiently from the air.

(Not sure what aerosols are? Click here)

Hospitals have done most of the research on respiratory aerosols removal. Portable air cleaning is **additive**, and enhances the air cleaning even in hospitals.

Hospitals typically have the best ventilation/ filtration systems at **6-12 Air Changes per Hour (ACH)**, with the exception of cleanroom labs at **20-500 ACH**.

School classrooms often have **.4 ACH** as seen in this study of 61 California classrooms. Even before the pandemic, tens of thousands of classrooms had insufficient ventilation rates.

- Real life CDC Study.
    - 48% reduction of cases in schools using HEPA filtration, masks, and ventilation improvements.
    - 39% reduction of cases without HEPA filtration, but with masks and ventilation improvements.
    - 37% reduction of cases with just masks.

- 4 HEPA air filters were tested in a normal high school classroom during class. They reduced aerosols by 90% in 30 minutes. Source.

- The #CorsiRosenthalBoxes reduced PM2.5 and PM10 by 43% & 30% in 53 Arizona and Connecticut classrooms.

Source.

- Two #CorsiRosenthalBoxes in a classroom increased ventilation to 12-15 ACH in this study by NIOSH and the CDC.
  Source.

- "Combined interventions (i.e., natural ventilation, masks, and HEPA filtration) were the most effective (≥ 30-fold decrease)." Source.

- "A single bed hospital room equipped with an excellent ventilation rate (~ 14 air changes per hour) can clear the aerosols in 20 minutes. However, with the addition of two air cleaners, the clearance time became 3 times faster (in 6 minutes and 30 seconds)." Source.

- "With 2 small domestic air cleaners in a single patient room of a hospital ward, 99% of aerosols could be cleared within 5.5 minutes." Source.

- A systematic review found: "Portable HEPA filter systems have been shown to be another effective tool in reducing viral load." Source.

- **CDC**: "Portable HEPA air cleaners offer a simple means to increase the filtration of aerosol particles from a room without modifying the existing building ventilation system…" Source.

- **CDC**: "A simulated infected meeting participant who was exhaling aerosols was placed in a room with two simulated uninfected participants and a simulated uninfected speaker. Using two HEPA air cleaners close to the aerosol source reduced the aerosol exposure of the uninfected participants and speaker by up to 65%. A combination of HEPA air cleaners and universal masking reduced exposure by up to 90%." Source.

Work for you? Click here to skip to a cost effective solution.
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Children are impacted by COVID, and transmit to each other, teachers, and loved ones.

- Children don't get acute sickness as much as adults - but they do get hospitalized. And there has been a surge in their hospitalizations.

- 10% do get LongCOVID - where the child may be extremely fatigued amongst a host of other symptoms for months or even with no end in sight.

- Children also get Multisystem Inflammatory Syndrome in Children (MIS-C), albeit more rarely. Essentially, inflammation throughout the body, usually painful.

- Children transmit diseases to their teachers and the administrative staff.

    - For example, in Alabama, "The staffing shortages left classrooms without teachers. Schools were without essential staff such as child nutrition workers to serve meals and custodians to clean buildings, according to the Birmingham American Federation of Teachers."

    - In New Mexico, "Teachers who have classrooms of over 20 children have also reported having as few as five students show up in the last two weeks because of COVID."

- For the continuity of children's education, there clearly is a need to do something.

COVID is airborne via aerosols.

COVID was thought to be transmitted by droplets like from sneezes, but is now known to be airborne via aerosols.

It is transmitted **primarily** by respiratory aerosols, followed by droplets, with contaminated surfaces (fomites) a distant third.

Aerosols are fine particles suspended in the air.

Smoke is made up of aerosols. The vegetables you burned last week in the kitchen? The cigarette smoke coming from the school bathroom? Both are aerosols.

And just like smoke, **unless you do something to get rid of them, they just get thicker in concentration.** The thicker they are, the greater the chance of catching COVID.

When we breathe, talk, sing, laugh, shout, cough, or sneeze, we generate respiratory aerosols. This paragraph has the technical details of how they are formed (source):

Sites of aerosol formation

Respiratory aerosols can be classified into alveolar, bronchiolar, bronchial, laryngeal, and oral aerosols, according to the sites where they are produced (*3*, *84*, *85*). Bronchiolar aerosols are formed during normal breathing (*3*). During exhalation, the liquid film lining the lumenal surfaces of the bronchioles ruptures to produce small aerosols. Such aerosols are generated by shear forces that destabilize the air-liquid or air-mucous interface. Respiratory airflows are often turbulent under high airflow velocities, particularly in the large lumens of the upper airways, which transition to laminar flow in the bronchi and bronchioles (*76*, *86*–*88*). Laryngeal aerosols are generated through vocal fold vibrations during vocalization (*3*). The apposition of vocal folds forms liquid bridges, which burst into aerosols during exhalation. By contrast, droplets (>100 μm) are primarily produced from saliva in the oral cavity (*3*). Aerosol emission rates increase with airflow velocity and speech volume during activities such as singing and shouting (*9*, *89*, *90*).

All relevant Public Health organizations agree that COVID is airborne via aerosols.

The World Health Organization:

- "Another person can then contract the virus when infectious particles that pass through the air are inhaled at short range (this is often called **short-range aerosol or short-range airborne transmission**)"

- "The virus can also spread in poorly ventilated and/or crowded indoor settings, where people tend to spend longer periods of time. This is because aerosols can remain suspended in the air or travel farther than conversational distance (this is often called l**ong-range aerosol or long-range airborne transmission**)."

The CDC:

- "Inhalation of air carrying very small fine droplets and **aerosol particles** that contain infectious virus. Risk of transmission is greatest within three to six feet of an infectious source where the concentration of these very fine droplets and particles is greatest."

Aerosols float for a very long time.

COVID is generally found in tiny aerosols - 0 to 5 micron in size. In a typical classroom, the half-life of an aerosol floating around depends on the size.

The **half-life** of how long they float:

- .5 micron aerosol is 41 hours.
- 1 micron aerosol is 12 hours.
- 3 micron is 1.5 hours.
- CDC NIOSH Source.

Think of the particles that float in your living room in a beam of sunshine. Those are 50 micron aerosols. (Those aerosols are mostly lint from clothes, carpets, furniture, etc.)

Aerosols will be dispersed by fresh air if you have really good ventilation. When you burn the bacon in the kitchen, unless you open a window or turn on the range fan, the smoke just stays there. Same thing happens in classrooms with respiratory aerosols.

Our buildings tend to be designed for energy conservation, not for energy conservation AND ventilation.

Ventilation is bringing in fresh air from outside. Filtration is cleaning the air inside. When it's cold outside, filtration is often the better solution.

Filtration can be improved by using portable air cleaners.

Click here to go back to the studies section.

Masks are essential, but not enough.

Masks are very effective if everyone is in KF94, N95, FFP2 or better at all times indoors - including lunches and breaks.

Cloth and surgical masks do reduce the rate of transmission by providing source control, but are insufficient because they are not designed to trap all viral particles.

Air cleaning is necessary for those wearing cloth or surgical masks or not wearing KF94, N95, FFP2 correctly. So, air cleaning is necessary for everyone.

For example - everyone laughs and talks in school. When they do, the mask can come off for a second - and their respiratory aerosols float into the air.

Air cleaning is an added layer of protection to remove those stray aerosols.

Work for you, but you have concerns about electrical, safety, etc? Click here.

Click here to go back up to the Table of Contents.

The Solution

Before we go any farther, we need to be **crystal clear.**

Portable air cleaners will not stop all transmission.

Why? Because children and teachers are all wearing masks - and not respirators like N95's.

For the same reason that healthcare workers in hospitals still catch COVID wearing just surgical masks. Hospitals are considered to have the best ventilation ranging from 6 to 12 Air Changes per Hour. Classrooms

We emit respiratory aerosols when we breathe, talk, etc., they are most concentrated near us like odorless cigarette smoke near a smoker. It does take a bit of time for air cleaners to clean the air. During that time is when transmission from those near aerosols can happen.

But portable air cleaners do significantly reduce the amount of transmission. If the air is NOT cleaned, then the aerosols become more concentrated and risk of transmission goes up significantly.

On a related note - portable air cleaners that generate ions, plasma, or any other additive technology are not recommended by IAQ (Indoor Air Quality) or aerosol scientists. Here is a one-sheet developed by the US Green Building Council.

HEPA Air Cleaners can be very expensive, but can be reasonably priced. Selection tool here.

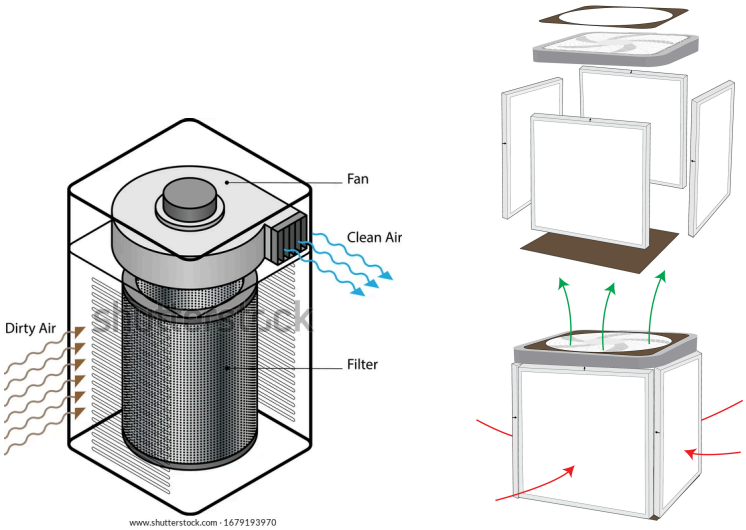
Simple portable HEPA air cleaners sufficient for a normal classroom are modestly priced. As seen here for $550 to $900.

Here is an excellent tool if you wanted to price out HEPA air cleaners.

The Corsi-Rosenthal Box is a more cost-effective solution.

The Corsi-Rosenthal Box is a DIY Air Cleaner that costs under $100 USD, matches a $900 HEPA air cleaner for performance, and can be built as a science project by a class of ten-year-olds.

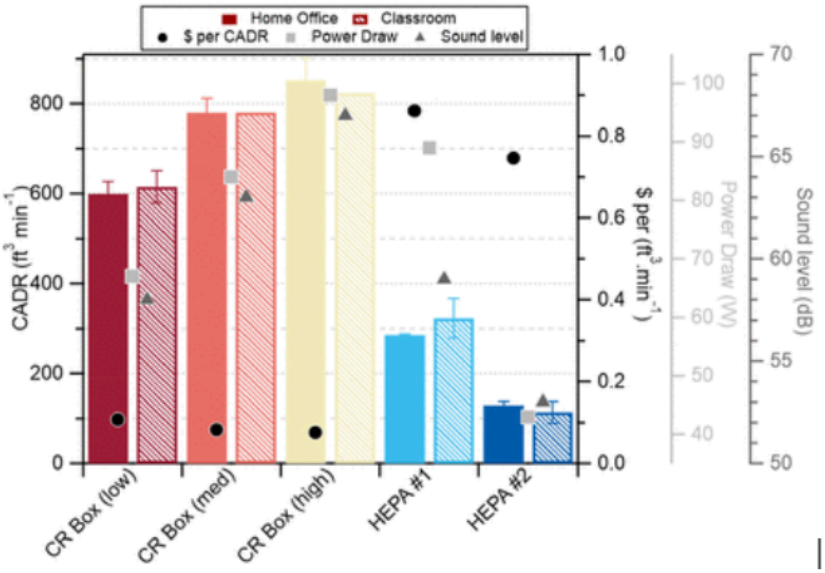
The Corsi-Rosenthal Box is basically 4 or 5 filters that surround a fan - which pulls air through the filters. A commercial HEPA purifier has the same basic set-up. Here is a HEPA air purifier on the left, and a Corsi-Rosenthal Box on the right.



The fan used in the Corsi-Rosenthal Boxes are typically 3 speed fans, and the 5 filter Corsi-Rosenthal Box delivers a Clean Air Deliver Rate (CADR) of 615 ft^3/min on low up to 823 ft^3/min.

“The CADR values for the Corsi-Rosenthal Box substantially exceed those of the particular commercial HEPA filters used here (Figure 2a). **For further comparison, no U.S. Energy Star certified air cleaners have CADR values (for either tobacco smoke, dust, or pollen) matching the CADR value for the CR Box even on low speed**… “ **Source**.

Here we can see the CR Box on the left, compared to 2 commercial HEPAs in blue on the right.



The Corsi-Rosenthal Box is far more effective than any commercial offering at the same price point.

- In this peer reviewed study, examining classrooms: "…our study shows that box fan air cleaners can serve as an effective low-cost alternative for mitigating airborne transmission risks in poorly ventilated spaces."

- UC Davis Western Cooling Efficiency Center found it **delivers an equivalent performance to commercial air cleaners that cost 3x as much**.
    - Their final report.

- The Built Environment Research Group at the Illinois Institute of Technology found these excellent results for the 4 Filter version of the Corsi/Rosenthal Box.

- Dr. Marwa Zaatari, Mechanical Engineer, IAQ Consultant, USGBC Board Member, ASHRAE Epidemic Task Force, PHD with focus on IAQ/Energy/filtration.
    - "It is the most cost effective purifier on the chart."

- 4 HEPA air filters were tested in a normal high school classroom during class. They reduced aerosols by 90% in 30 minutes. Source.
    - It should be noted they had 333 m^3/h CADR. This is equivalent to 196 ft^3/min. Or 784 ft^3/min for all 4.

    - 2 CorsiRosenthal Boxes **on low** will be 1,230 ft^3/min, significantly outperforming the commercial HEPA filters. Philips Model 2887/10 - this is a $500 to 600 unit conservatively, and was on turbo mode - so very loud.
    - **$2000 outperformed by $200.**

- Two #CorsiRosenthalBoxes in a classroom increased ventilation to 12-15 ACH in this study by NIOSH and the CDC.
    - Source**.**

Schools that are known to have rolled out Corsi-Rosenthal Boxes.

- 250 boxes for University of California of San Diego
- 140 boxes for 6th grade classrooms.
- 125 boxes for K–12 classrooms throughout metro Phoenix.
- 100 boxes at UConn.
- 100 boxes at Portage Area School District.
- 66 boxes for elementary schools in WS/FCS
- 50 boxes at Brown University.
- All of River Heights Elementary School - made by 5th graders.
- 30 boxes for 8th grade at Sacramento Rio Tierra Junior High School
- Researchers from the UC Davis Energy and Efficiency Institute (EEI) partnered with science teachers at Rio Tierra Junior High School in Sacramento to teach a two-day lesson on air quality and build 30 portable air cleaners with approximately 150 8th grade students. The portable air cleaners will be distributed to every classroom on campus.26 boxes at Pierre Elliott Trudeau Elementary School in the Hull sector of Gatineau, Quebec
- 23 boxes for Ascension Catholic School in Louisville, Kentucky:
- 22 boxes for Essex Westford School District.
- 18 for a small East Rochester school **.**
- 12 boxes for an Albertan, Canada school.
- 7 boxes for a Children's Dance School.
- 6 boxes for a private school
- Small school - one for every classroom.
    - Round 2 of building boxes.
- 3 boxes in the Cayman Islands.

Examples of outbreak prevention.

Before sharing those examples, it has to be pointed out that it is difficult to prove something has been prevented. For example, are there examples of outbreaks prevented by surface cleaning/ sanitation?

No, but we clean surfaces, because we know approximately how long the virus lives and know that cleaning removes it from the environment. Which helps stop transmission.

Similarly, we know the **virus is infectious in the air and that the aerosol route is the primary path of transmission**. So, we must clean the air to remove the virus. Which helps stop transmission.

Actual examples:

- 18 CR Boxes for a small East Rochester school - ***had no outbreaks from October to Christmas break.***
- HEPA's in this school - no outbreaks.
- Childcare class - no outbreak.
- A series of homes where someone brought in COVID - but no one else caught it.

Authorities who specifically have recommended the Corsi-Rosenthal Box.

- State of California in the Safe Schools for All Hub. Specifically, here.
    - "You can add portable air cleaning devices to classrooms to supplement mechanical and natural ventilation. Purchase PACs that are sized appropriately and circulate air through High Efficiency Particulate Air or "HEPA" filters. Most PACs will list the intended room size. Avoid devices that advertise "ionizer" or "ozone" technology. Alternatively, a low-cost DIY PAC such as the **Corsi-Rosenthal Box** can be built and added to classrooms. "

What are the upsides besides COVID free air?

- What is in the outside air, such as wildfire smoke and miccroplastic pollution from roads, will be soon be in the air you are breathing inside. 37-42% within one hour . 100% by the fifth hour. This process is called infiltration.

- CRBoxes efficiently remove PM2.5 and Pm10 air pollution.
- The EPA found that CRBoxes efficiently removed smoke pollution.
- CRBoxes efficiently clean the air of PFAs and phthalates.
- Reduction of employee and student absenteeism.
- These can be built by the children as a class project. This can give students a sense of agency - letting them wrestle control back from the virus, and making their classroom safe again. Bringing a sense of togetherness back to the classroom.
- They can be deployed as part of a science lesson.
- They can be as fancy as you want them to be. Here are some examples.

Downsides of the Corsi-Rosenthal Box.

- The filters have to be replaced every 6 months or so. 3 months during forest fire season.
- The top speed can be loud - that's why we recommend two per classroom on low speed.
- To build one typically takes 30 to 45 minutes.

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Concerns about the Corsi-Rosenthal Box - and portable air cleaners.

There are understandable concerns often raised about the Corsi-Rosenthal Box. These are addressed here.

Electricity – are these fans a danger with the filters attached? Will they catch on fire?

No. This is a report by Chemical Insights, an Institution of the Underwriter's Limited, the most famous safety testing organization in the world. They found no risk of fire from even filters as dirty as on the right, below:

Fan with clean filter | Fan with smoke filter | Fan with dust laden filter

FIGURE 2. PICTURES OF TESTED BOX FANS WITH FILTERS AND THERMOCOUPLES ATTACHED.

Additionally, the fans recommended (the Utilitech and Lasko brands) have fuses in the plugs. If there are any issues with load, the fuses will break, and the fans will shut off automatically.

Electricity - will these overload our circuits?

No more so than other small appliances used in classrooms by teachers. For example, essential oil diffusers use 15 Watts.

A standard consumer HEPA air cleaner uses 20 to 90 Watts.

A CR Box uses 50 to 90 Watts.

HVAC - Will these interfere with our current HVAC architecture?

No - Air cleaning is additive, not subtractive.

For example – hospitals have excellent air cleaning from very engineered environments. In this study – "A single bed hospital room equipped with an excellent ventilation rate (~ 14 air changes per hour) can clear the aerosols in 20 minutes. However, with the addition of two air cleaners, the clearance time became 3 times faster (in 6 minutes and 30 seconds)."

All relevant public health organizations recommend them.

- The **CDC** recommends them:
    - "Use portable high-efficiency particulate air (HEPA) fan/filtration systems to enhance air cleaning (especially in higher risk areas such as a nurse's office or areas frequently inhabited by people with a higher likelihood of having COVID-19 and/or an increased risk of getting COVID-19)."

- The **Department of Education,** in a guidance document titled "Improving Ventilation in Schools, Colleges, and Universities to Prevent COVID-19" recommends:
    - "**Portable air cleaners can go in any room of a school building to serve as an additional safety and mitigation layer**, including in areas where airflow may be limited, and/or in areas where sick individuals may be present such as a nurse's office or sick/isolation room."

- **ASHRAE** recommends them.

Usually, concerns from an HVAC consideration, come from thinking about Airborne Infectious Isolation Rooms.

Per David Elfstrom, "An AIIR is designed to not have mixing of the air, to prevent infection from a known source and to keep air moving from clean to dirty on its way out of the room. **In a classroom we don't know who is infected, so it's best to mix & filter & replace & dilute the air.** "

This conversation was on twitter, here.

HVAC - We just upgraded our HVAC to MERV 13. We don't need these.

If you upgraded your HVAC to MERV 13 - that's fantastic! Most likely, you are at 4 to 5 ACH, once you include the ongoing respiratory aerosols emissions from the students in their cloth masks. Here's a Harvard Health Buildings procedure that can walk you through how to determine what ACH you have.

But unless you have 16 ACH or greater? Portable air cleaners can help reduce transmission.

In this study, “A single bed hospital room equipped with an excellent ventilation rate (~ **14 air changes per hour**) can clear the aerosols in 20 minutes. However, with the addition of two air cleaners, the clearance time became 3 times faster (in 6 minutes and 30 seconds).”

Will the Corsi-Rosenthal box just blow infectious air on people?

No - the fan is pointed straight up, and is pulling the air in **through** the filters. So, it is actually **cleaner air** being blown out.

There are smaller versions which don’t point straight up - but we recommend not to point the fans at anyone. Not out of concern, as the air coming out of them will be cleaner than the surrounding air or from an infected individual, but out of an abundance of caution and to avoid someone being annoyed with a fan blowing on them.

Here’s a real-world example of cleaner air coming out using a Dylos particle counter. The picture on the left is the The picture on the right is the particle counter in front of the fan measuring the amount of particles going out.

Particle counter to the side of the CR Box, measuring particles going in, prior to cleaning.	Particle counter in front of the fan measuring the amount of particles going out, after being cleaned.
255 particles >= .5 microns. 28 particles >= 2.5 microns.	70 particles >= .5 microns. 7 particles >= 2.5 microns.

Equity Considerations - the school board does not have enough funds to provide them to every classroom.

Having filters in some classrooms but not in others **is an equity concern**, but this is where the community spirit of the CR Box comes into play.

Community fund-raising drives can be run to raise funds. Teachers, parents, parent councils can all jump in.

There's a program in Arizona that is a partnership between Arizona State University and local school partners. This program has resulted in 125 boxes for K–12 classrooms throughout metro Phoenix.

It is an ongoing effort - here is their link-tree.

If you are interested in getting more information on how to set up such a partnership, they have kindly agreed to be contacted here: asupublichealth @ gmail.com.

Here is a picture of some of their volunteers with Corsi-Rosenthal Boxes.