



The Science of COVID-19 Safety for Coffee Businesses

An SCA White Paper



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Summary

While we were measuring the impact COVID-19 has on the Specialty Coffee industry during our recent survey project, one clear fact came through: understanding COVID-19 science and safety is key in order for coffee businesses to survive.

We are proud to present The Science of COVID-19 Safety for Coffee Businesses: Frequently Asked Questions and Scientific Advice, a white paper accompanying the second video in our Community Impact of COVID-19 series. In this paper, Professor William D. Ristenpart of the UC Davis Coffee Center answers frequently asked questions about the science of COVID-19 transmission in coffee spaces.

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Introduction

Who are you?

I'm an engineer with expertise in "transport phenomena," which is the study of how molecules, droplets, and particles move around. One of my research thrusts over the past decade has been the transport of pathogen-laden droplets through the air. If you are interested, the end of this document has a bibliography of my peer-reviewed articles on infectious disease transmission.

And why should we read this?

The main goal of this document is to provide a plain English overview on the science of airborne COVID-19 transmission and how to maximize safety. The focus is on the coffee industry and coffee businesses, but the underlying scientific advice is applicable to all small retail establishments.

Should I really read this?

Yes! It was written with you in mind, whether you are a barista, a CEO, or anyone in between. There are specific action items that leaders can take action on, and employees can bring attention to, that will help protect workers and customers alike.

COVID-19 Transmission

What causes COVID-19?

You've probably heard the phrase "SARS-CoV-2," which is the official name of the virus that causes the disease COVID-19. The virus is really, really small—it is about 100 nanometers in size. That means you could fit about 10 billion viruses into something the size of the period at the end of this sentence. If you inhale the virus or it somehow else enters your body, like any other virus it starts hijacking your cells and forcing them to produce more virus. Eventually your body is overwhelmed, and you get sick with all the symptoms of COVID-19 (including dry coughing and shortness of breath).

The title of this document focuses on airborne transmission of COVID-19. Doesn't it mostly spread through handshakes and touching?

No. Very early in the pandemic, scientists thought that COVID-19 primarily spread through direct touch, and so the emphasis was on avoiding touching and using hand sanitizer. Now, however, we have much more data – and there is overwhelming evidence that COVID-19 is primarily transmitted through the air. Early on there was a strong scientific consensus about airborne transmission in the academic community, and after some delays both the [Centers for Disease Control and Prevention \(CDC\)](#) and the [World Health Organization \(WHO\)](#) now state explicitly that the main route of transmission is through the air.

Should I still avoid handshakes?

Yes, there is still the remote possibility of getting infected via a handshake, or other contaminated surfaces (like a doorknob). But probably the bigger concern is that during a handshake, you are face-to-face with the other person, meaning you might inhale their exhaled air—and thus inhale the virus.

But as long as they don't cough or sneeze, I should be safe, right?

No, this is a huge misconception. Almost all media representations of "airborne disease transmission" show pictures of people sneezing, but these representations are highly misleading: sneezing isn't even a symptom of COVID-19! But the pictures give the idea that you need big blobs of saliva and respiratory fluid to fly out and hit somebody else in the face. That isn't true: just breathing or speaking cause virus to get into the air. And much transmission occurs from people who don't have any symptoms at all.

Really? People without symptoms can transmit COVID-19?

Yes—and in fact, most epidemiological estimates indicate that the vast majority of transmissions are from individuals who don't have symptoms. That means you can get infected by someone who looks fine and feels fine—but in reality they're infected, and infecting others.

You mentioned that speaking can transmit the virus. Do you mean in the little droplets that occasionally fly out when somebody is speaking?

The technical word for that is "spittle," and spittle droplets could indeed carry virus. But the much bigger concern for speaking and breathing is aerosols.

Wait, what is an aerosol? Isn't that for hairspray?

An "aerosol" is a bunch of microscopically small particles or droplets that are small and lightweight enough to remain suspended in the air for a long time. A classic example is cigarette smoke, which you can see easily lingers in the air. An "expiratory aerosol" is an aerosol that a human emitted via expiration, such as by breathing out or speaking aloud, and is much more dilute so you can't see it like you can see a bunch of smoke. (A can of hairspray emits an aerosol spray that is designed to let droplets uniformly coat your hair to make it look good.)

***I don't see or feel any aerosols when I breathe out...
how do I know they are there?***

The aerosols are typically about 1 micrometer in diameter (that's a millionth of a meter). That's way too small to see with the naked eye (humans can't resolve anything less than about 30 micrometers). But scientists know that expiratory aerosols are emitted because we have sophisticated equipment (using lasers and optics) to detect them.

If these aerosols are so small, why do I have to worry about them?

Because even though they're too small to see, they are still huge compared to the virus... and expiratory aerosols are known to carry viral pathogens, like influenza or SARS-CoV-2.

How do these aerosols form when I breathe or speak?

If you put your fingers on your throat when you speak, you will feel the vibrations of your vocal cords. Those vibrations represent the opening and closing of the vocal cords, typically somewhere between 100 to 200 times per second as you talk. Each time the vocal cords open and close, the liquid lining them is pulled apart and can form tiny microscopic droplets. As you exhale, these droplets are emitted into the surrounding air, where ultimately they can be inhaled by nearby individuals—and if you're infected, these aerosol droplets could be carrying virus.



Face Masks

OK, if COVID is spread by aerosols I emit when I talk, does that mean I shouldn't talk? How do I prevent spreading it?

Clearly humans need to communicate, but the easiest and best way to prevent spreading COVID is by wearing a mask.

I work in a coffee business, not a hospital. Do I really need to wear a mask?

Yes! Absolutely yes. Wearing a mask protects you, and it protects others. There are multiple examples of outbreaks where those wearing masks did not become infected, while those without masks got sick. Even cheap cloth masks filter out a large fraction of aerosol particles, both on the way in or the way out.

But I feel fine, and I'm not coughing. Do I still need a mask?

Yes. Remember, much (or even most) of the transmission is from individuals who don't have any symptoms. That means they feel totally fine, but when they breathe or speak, they're emitting aerosols that carry the virus and infect others. Wearing a mask helps prevent that.

We have a customer who regularly refuses to wear a mask. They claim that they have a medical exemption because wearing a mask lowers their oxygen levels. Should we let them in without a mask?

There is no evidence that wearing a cloth fabric mask or a surgical mask has any impact at all on dissolved oxygen levels in your blood. If they are healthy enough to walk into your establishment, and has enough lung power to tell you that they don't need to wear a mask, then they are healthy enough to put a piece of cloth over their face.

What about plastic face shields? Can we wear those instead of a cloth mask?

Plastic face shields block "large" respiratory droplets, the ones you can see with the naked eye. But they don't block the small aerosols emitted by breathing and talking. So a face shield is better than nothing, but you really need to wear a mask as well to block the aerosols. Note that health care workers in high risk environments typically wear both a mask and a face shield—they never wear just a face shield without a mask.

I work the cash register, and there's a big plastic screen between me and the customers. Why do I need to wear a mask if the screen is protecting me?

Because it's only protecting you from the large respiratory droplets, not the aerosols. Imagine if the customer on the other side of the screen lit a cigarette. The screen would only slow down the smoke slightly—in typical indoor spaces you would smell the smoke pretty quickly. You can't smell aerosols emitted by people during talking, but they get carried around in the air just like smoke. You need to wear a mask even if there's a large screen.

Assessing Your Ventilation

If these aerosols emitted by people are floating around in the air, what else can we do besides wearing a mask?

You need to check, and likely improve, your ventilation.

What do you mean by “ventilation”?

Most people never think about it, but every indoor space needs to get fresh air from outside. Some spaces, like garden sheds, only get fresh air through the gaps near the doors or windows—this is called “natural ventilation.” The vast majority of retail establishments have large air handling units that push air around—this is called “mechanical” ventilation. A common abbreviation in the industry is “HVAC,” which stands for “heating, ventilation, and air conditioning.”

What does the ventilation have to do with COVID-19 transmission?

Remember, COVID-19 is transmitted in invisible, lightweight aerosol particles that can float around in the air for hours. If you have a low ventilation rate, then the aerosols stay in your room for a longer time period, and you are more likely to inhale them. Instead, if you have a high ventilation rate, then the aerosol particles are flushed out of the room more quickly, and you are less likely to inhale them. Imagine a room with somebody smoking a cigarette: with low ventilation, the room will get very smoky and you’ll inhale a lot of smoke, but with high ventilation, the room won’t get as smoky.

How is the ventilation rate characterized?

The most important metric is called the “Air Changes per Hour,” or ACH. This is the number that says on average how many times per hour ALL of the air in the room is replaced. For example, if you have a room with 4 ACH, then all of the air is flushed in and out 4 times every 60 minutes (or equivalently, 1 time every 15 minutes). Note this is an average (some of the air stays shorter and some longer) but the ACH is an important metric for gauging how likely you are to inhale a pathogen-laden aerosol.

What is a “good” ACH value?

In general, the higher the better. Many of the outbreaks of COVID-19 have been associated with indoor spaces that have ACH values near 1, which is clearly way too low. There are different guidelines for different types of rooms. The CDC, for example, publishes minimum ACH values for surgical rooms, patient rooms, hallways, kitchens, etc.—their list is available [here](#) and a few key room types are tabulated below:

Room Type	ACH
Bathroom	10
Food Preparation	10
Dining Room	4
Food Storage	2

Note these are minimum values, and that even a pantry with only transient occupancy (the food storage) should have at least 2 ACH. Several of the most infamous outbreaks of COVID have involved crowded spaces with less than 1 ACH, which is clearly inadequate. Note also that other organizations publish other guidelines: the National Comfort Institute recommends 8 to 10 ACH for restaurant dining rooms, and building codes in most jurisdictions use much more complicated formulas to assess minimum ventilation rates. In general, you want the ACH to be as high as possible, especially in the middle of a pandemic driven by airborne transmission.

How do I measure the ACH in my establishment?

You need to find out two numbers and divide them: the ACH is the ratio of the total ventilation airflow rate, and the room volume. The equation is $ACH = F / V$, where F is the flowrate and V is the volume.

I don't know either of those. How do I calculate the room volume?

The volume is just the area of the room (say in square feet) multiplied by the ceiling height. For example, if your café is 900 square feet, and you have 10 foot ceilings, then your volume is $900 \text{ ft}^2 \times 10 \text{ ft} = 9,000 \text{ ft}^3$. (You would read that aloud as "nine thousand cubic feet.")

OK, what about the ventilation rate?

This is trickier. The mechanical ventilation rate is typically measured in "cubic feet per minute" (CFM). If you are a do-it-yourself type person, then you can procure some "wind-vane anemometers" to measure the airflow rate delivered by your HVAC system into your room. These anemometers have little fans that are spun by the airflow; the higher the fan speed, the higher the airflow. Most coffee industry professionals have little experience thinking about airflow, however, so it is strongly encouraged that you hire a certified HVAC professional to assess your CFM of fresh (outside) air into your space.

We figured out the CFM of fresh air, now how do I calculate the ACH?

Let's say your HVAC technician measured it and concluded you're getting 300 CFM into your retail space. This might sound like a lot, but let's calculate the ACH, using the following formula:

$$ACH = \frac{F}{V} = \frac{300 \text{ ft}^3/\text{min}}{9000 \text{ ft}^3} \times \frac{60 \text{ min}}{1 \text{ hr}} = 2 \text{ per hr}$$

So, in this example your café is only getting 2 ACH, which is definitely inadequate for a typical retail space with people in it. The CDC recommends a minimum of 2 ACH for closets and pantries not occupied by people. This space needs to increase its ventilation.

I'm an employee, not a manager. Do I really need to calculate the ACH?

No, that really should be the responsibility of your managers. But you definitely should ask them, "Hey what is the air changes per hour in the café?" If they don't know, that is a really, really bad sign—it means they aren't thinking about the safety of their employees. Send them this document, and encourage them to assess the ACH.

Improving Ventilation

We have ceiling fans. Can we turn them on full speed to increase the ventilation?

Ceiling fans move the air around, but they don't directly help with ventilation. Remember, ventilation is the rate of fresh air from outside being delivered to your space. Ceiling fans recirculate the air that's already there. A visual analogy would be a few drops of red food coloring in a bathtub. If somebody says "I'm going to clean this up by stirring it rapidly," obviously that won't work: all it does is mix the food coloring around, turning the water pink. To clean up the water, you need to drain it and add fresh water. Same thing with ventilation and air: just mixing it around inside the room with a ceiling fan doesn't get rid of it, you need to deliver fresh air.

We also have ductless air conditioning units (or heating units). Do those improve ventilation?

No. Standard wall mounted units are "ductless" in the sense that they don't have any ducts to draw in fresh air from outside. Instead they pull in room air, cool it (or heat it), and pump it back into the room. This doesn't remove pathogen laden aerosols from the room, it just recirculates them around (like the ceiling fans). Many outbreaks in retail establishments have been associated with ductless AC units.

Does this mean we should turn off the ceiling fans and ductless AC units?

Not at all—these provide thermal comfort for the room occupants, which is important. You should keep them going.

But then how do we improve the ventilation? Can we just open a window?

Yes! In situations where you can keep windows or doors open, you definitely should keep them open—that is by far the easiest and way of improving ventilation. You can also use ceiling fans, floor fans, or window-mounted AC units or fans to help move the fresh air in and stale air out.

My manager says to keep the doors and windows closed because it saves energy. Is that true?

In the middle of a global pandemic spread via airborne transmission, it is "penny wise, pound foolish" to focus on heating/cooling energy losses versus protecting the health of your employees and customers. The manager should consider the costs associated with the name of their establishment being reported in local media with a large outbreak of COVID-19... not to mention the possibility of they themselves becoming infected.

Because of the air quality outside, it's not really possible for us to open the windows. What should we do then?

Turn on the ventilation wherever you can; for example, most bathrooms have ceiling vents, so turn them on and leave them on. Presumably you also have mechanical ventilation with a central air handling unit that has filters to clean up the outside air. You should increase the supply ratio (how much fresh "supply" air is delivered). If you don't know how to do this with your system, you should work with an HVAC technician to increase it.

I hired an HVAC technician, and they said that they can increase the "supply air" from outside to increase our air changes per hour. Should I tell them to go ahead?

Yes. Modern HVAC systems "recirculate" a certain fraction of the indoor air, because it's already heated (or cooled) to the desired temperature and makes the system more energy efficient. In many systems you can change the percentage of fresh "supply" air from outside, so that less air from inside (that is potentially contaminated with virus) is recirculated. It is recommended that you increase the supply air as much as practicable for your system.

I'm still skeptical—I haven't heard much about ventilation and COVID-19. Are you sure I need to worry about it?

Yes. You don't need to take my word for it – after much initial confusion and controversy, the CDC has finally acknowledged the role of poor ventilation in transmission of COVID-19. [Here are the CDC detailed suggestions for ventilation.](#)



Cleaning Your Air

Aside from increasing our ventilation rate, is there anything else we can do?

Yes—you can also “clean” the air that’s already inside.

How do we clean the air?

The simplest and most cost-effective way is “filtration.” You might be familiar with the filters that you need to periodically replace in your central air handling unit—you put it in clean, and a few weeks or months later, you pull it out to replace and it is covered with dust. The filter grabbed the dust so that you could breathe cleaner air.

Those filters will block the virus?

It depends on the type of filter. Remember, the virus is carried along on respiratory particles about 1 micrometer in diameter, so your filter needs to be able to capture such small particles.

How do I tell whether my filter is good enough?

The standard rating system for filters is called “Minimum Efficiency Reporting Value,” or MERV. The system is that lower numbers are less efficient (and cheaper) and higher numbers are more efficient (and more expensive). For example, a MERV of 6 is a very basic and coarse filter that only grabs relatively big pieces of dust and pollen. The virus-laden respiratory particles will go right past it. In contrast, a MERV of 14 is a very fine filter that will capture almost all of the 1 micrometer respiratory particles that we’re worried about.

What MERV rating should our filters have?

The COVID-19 task force for ASHRAE (a professional organization that deals with indoor air quality) recommends a MERV rating of at least 13. There is a caveat: it does take more power to push air through a fine MERV 13 filter compared to a coarse MERV 6 filter. It is highly recommended that you talk to an HVAC technician to make sure your system can handle the finer filter, especially if your air system is older.

Unfortunately, we don’t have access to our building’s central air handling unit, so we can’t change the filter. Is there some other way to clean the air in our café?

Yes—it is strongly recommended that invest in a portable air purifier. These are stand-alone units that you can plug into a regular electrical outlet. The way they work is by pulling in room air with a fan and forcing it through a HEPA filter (which is the highest standard of filter), thus putting clean air back into the room.

How do I know whether an air purifier is powerful enough to make a difference in my café?

First you want to make sure it has a true HEPA filter. Then, you want to look at its “Clean Air Delivery Rate,” or CADR. This is measured in cubic feet per minute (CFM), just like the ventilation rate discussed above. For example, a “Levoit Core 300” air purifier has a maximum CADR of 135 CFM. Recall our example above where we had a 900 sq. ft. café with 10 ft ceilings, and 300 CFM of fresh air ventilation, yielding 2 ACH. If we bought two of these Levoit air purifiers, that would effectively add $135 \times 2 = 270$ CFM of clean air, and thus almost double the effective ventilation rate to 3.8 ACH.

Are air purifiers expensive?

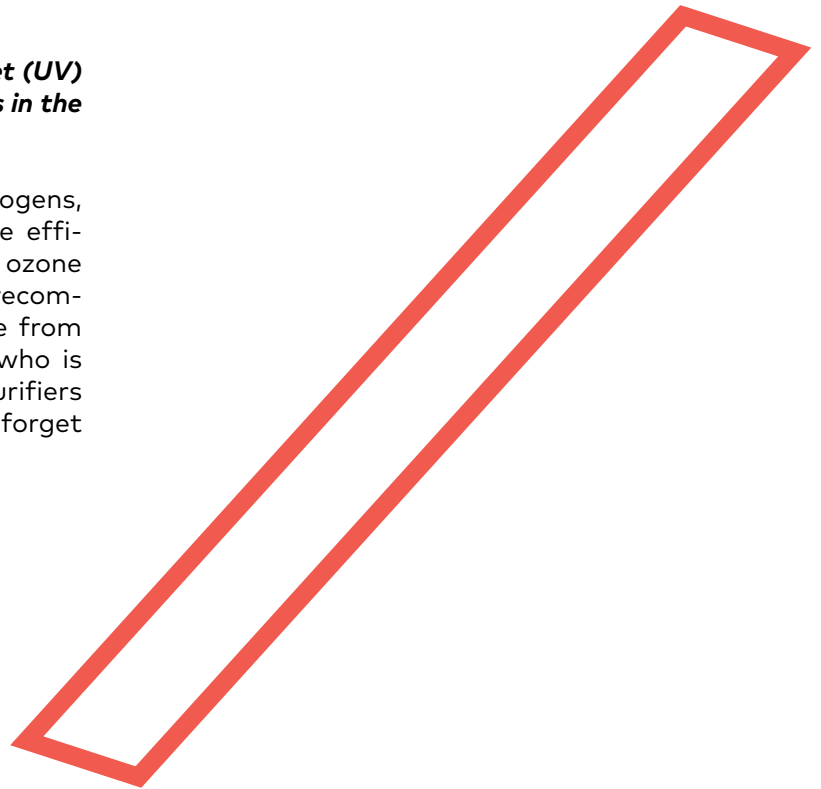
Not really—you can get a good air purifier for about US\$100, and they require very little labor in upkeep—maybe 5 minutes once a month to vacuum the pre-filter, and once a year or so to replace the HEPA filter (which takes about 2 minutes and costs about US\$25). [The NY Times Wirecutter](#) has detailed reviews of different air purifiers.

Where should I place the air purifier(s)?

If you have open windows or doors, you don't really need one—it doesn't do any good to clean up fresh air from outside (in terms of protecting against viral pathogens). But if your café is closed up and only mechanically ventilated, it is best probably to put the purifier(s) in close proximity to the employees who are spending hours there, likely somewhere near the register or the espresso machine (or wherever the employees are). It is much safer to breathe air that just came out of the HEPA filter than it is to breathe air exhaled by possibly infected people.

I see lots of advertisements about ultraviolet (UV) light systems or ozone systems that kill virus in the air. Should our café invest in those?

Although UV light and ozone do kill pathogens, they take much more expertise to operate efficiently. More importantly, both UV light and ozone can be harmful to humans. These are not recommended unless you have expert assistance from a neutral third party (i.e., not somebody who is selling you the system). In contrast, air purifiers are fool proof—you just turn them on and forget about them.



Limiting Exposure

I've heard so much about the "Six Feet Rule," but you haven't mentioned that at all. Why not?

The "Six Feet Rule" (where you should stay at least six feet away from others) is intended to protect against "large" respiratory droplets (the ones you can see by eye) emitted when somebody coughs or sneezes. It's difficult for those droplets to travel much further than six feet. There is a huge amount of evidence, however, that the much smaller aerosol particles emitted just by breathing or speaking are what transmits COVID, and these can travel much further than six feet. So, you definitely should follow the Six Feet Rule, but don't assume that standing more than six feet away will keep you safe.

How then can I limit my exposure?

As mentioned above, wear a mask. Also, increase the ventilation in your café, and invest in air purifiers. Finally, consider policies to limit the duration of exposure.

What do you mean by duration of exposure?

The longer somebody is in your café, the more time they have to emit respiratory particles into the air. So you should enact policies and procedures to minimize that time as much as possible.

How do we do that?

Recall that outside is safer than inside, so whenever possible, have customers form lines outside on the sidewalk, rather than inside the café. If you have online ordering, consider setting up your system so that customers can be alerted when their order is ready, so that they can walk in, immediately grab the order, then walk out, in as short a time as possible. Likewise, maximize outdoor seating and minimize indoor seating.

It's snowing outside, we need to use indoor seating. What can we do?

First, address the ventilation and air purification action items above. Next, insist that customers wear a mask except when actively taking a sip—it is not that hard to pull down your mask, take a sip, then put your mask back up. Don't allow customers to camp out all day over a single cup of coffee without a mask. Consider enacting a policy where on the top of every hour, all customers need to vacate the tables to allow an employee to clean it. Most customers will appreciate the attention to cleanliness, and it will provide a natural "break" point for customers to get up and leave.

What about the employees? They're in the café for eight hours straight.

This is why it's so important to have flexible policies with regard to illness. If you are the manager or CEO, carefully assess your policies to make sure you are not penalizing employees for calling in sick, or otherwise incentivizing them to ignore what they think is just a sniffle or minor cough and to show up to work anyway.

Oftentimes before opening or closing there is only one employee in the café. Do they still need to wear a mask?

The short answer is yes. If they are cleaning, there is some chance that their movement will knock virus contaminated aerosol particles (i.e., contaminated dust) back into the air where they can inhale it. It is safest to treat any environment the public has access to as possibly contaminated—it takes little effort to wear a mask.

Other Questions

I have more questions—where can I ask them?

Please watch [the webinar video](#) that covers the same material as presented here. If you still have questions, please reach out to the science coordinators at the SCA who have been organizing periodic live Q&A sessions, where we'll be happy to discuss more specific questions you might have.

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