

Guided by the science

Indoor environments for a pandemic-resilient future



January 2022



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REAL ESTATE TO TACKLE VIRUS RISK

More than 18 months into the COVID-19 pandemic, the hope that we will eradicate the virus has faded. According to the scientific community, it is more likely that COVID-19 will become endemic, meaning we will learn to co-exist with this virus as we do with other respiratory viruses. This means living with a heightened sense of awareness.

Until the COVID-19 pandemic, many workers assumed the air they breathed and the surfaces they touched presented minimal risk to their health. This mindset has now irreversibly shifted, causing these two natural activities to be given much more careful consideration in indoor spaces.

Pandemic-driven, good hygiene behaviors such as hand washing, mask-wearing, and physical distancing may have helped curb the spread of infection. But they have also become sources of disagreement.

These measures have made some people feel physically and psychologically safer in the workplace. For others, they have heightened stress and anxiety at a time when offices, public spaces, schools and colleges, and public transport networks are getting busier.

Organizations, therefore, face the challenge of understanding both the virus's behavior within their buildings and their employees' behavior and how it relates to virus spread. Leadership is now tasked with understanding the science that supports improved public health to ensure employees feel safe and comfortable.

In collaboration with Hines, and building on a long-standing partnership with the Well Living Lab Alliance, the [Well Living Lab](#) (WLL) conducted



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Hines

EXECUTIVE SUMMARY

rigorous scientific studies of the interactions between SARS-CoV-2 (the virus causing COVID-19), the built environment, and human health.

The series of six experimental studies, part of a research program entitled COVID-19 & Beyond: Well Living Lab Safe Indoor Environment Program, included more than 20 scientists from several institutions and focused on the interrelated roles of air- and surface-based transmission of SARS-CoV-2, as well as psychological and behavioral outcomes related to the COVID-19 pandemic. The team focused on topics such as:

- How airborne particles like SARS-CoV-2 travel within a room and how filtration and ventilation impact particle concentrations in the air and accumulation of particles on surfaces.
- How the Environmental Protection Agency's [List N](#) disinfectants impacted the presence, viability, and later replication of SARS-CoV-2.
- How the presence of COVID-19 has impacted psychological and behavioral outcomes as well as SARS-CoV-2 transmission prevention behaviors in the workplace.

Hines presents this paper to share key findings from the Well Living Lab's research and our continued partnership. Our goal is to provide insights for investors, developers, property owners, and occupiers about real estate safety strategies and building design and operations for a pandemic-resilient future.



20
scientists
including those
from the Mayo
Clinic and University
of Minnesota
studied behavior
and air- and surface-
based transmission



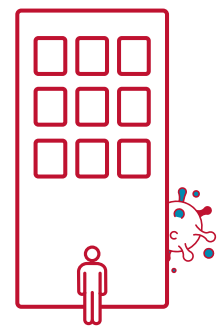
609 Main - Houston, Texas

METHODOLOGY AND EXPERTS

The primary human habitat today is indoors. For this reason, the key research questions pertained to human health, as well as the behavior of particles that could contain SARS-CoV-2, within indoor environments. For example, how does SARS-CoV-2 travel in a room? How can those managing and occupying buildings optimize the physical indoor conditions to hinder the survival and spread of SARS-CoV-2? How can business leaders apply scientific evidence to promote employee physical and psychological health?

The studies involved the exploration of:

- **Elimination** – physically removing hazards by disinfecting high-touch surfaces.
- **Engineering controls** – isolating people from hazards by reducing airborne exposures via HVAC (heating, ventilation, and air conditioning) system operation, portable air purification, and room layout.
- **Availability** and utilization of personal protective equipment (PPE).



Individual behaviors
are crucial to the
reduction of risk

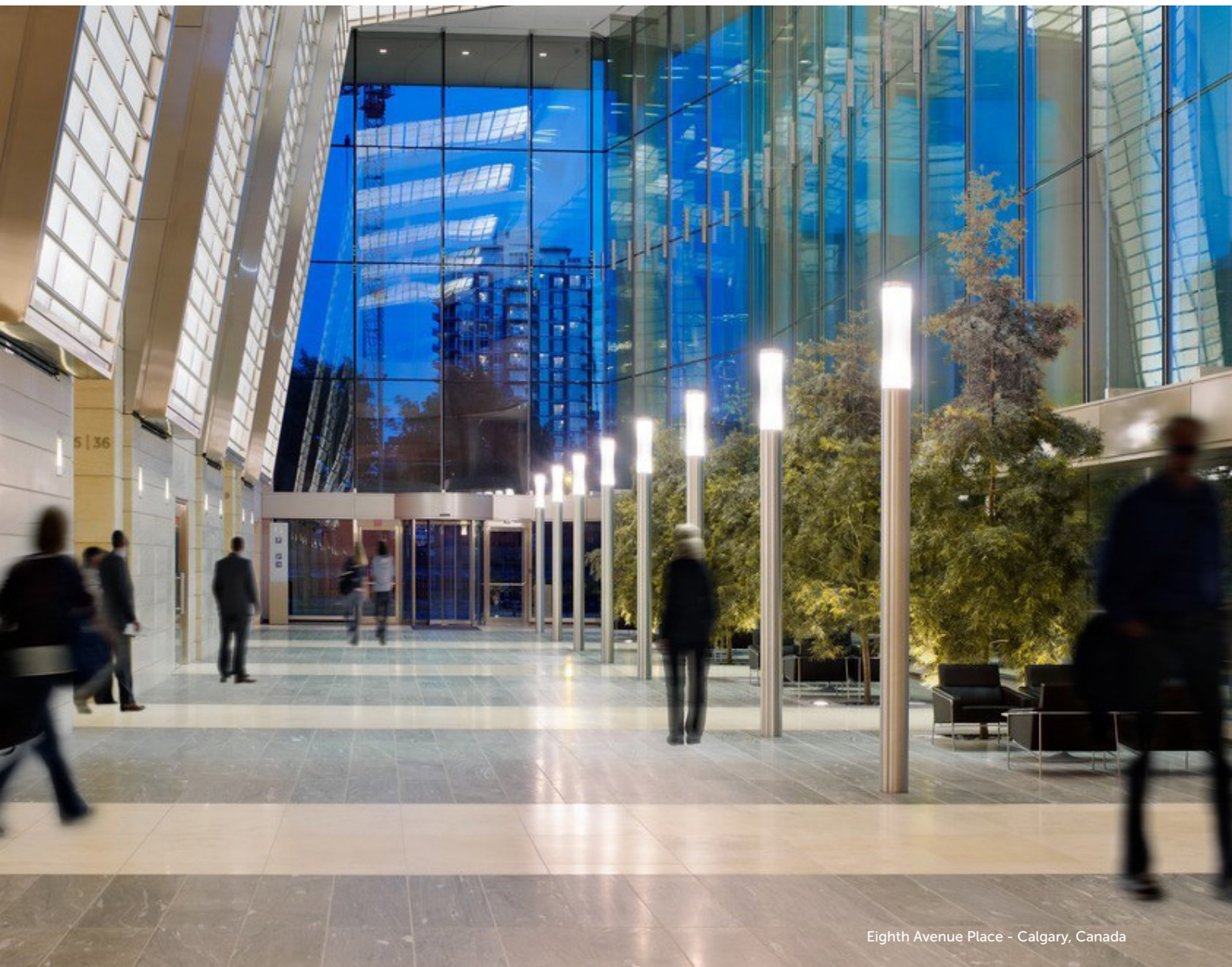
Other factors were layered in as well. Researchers studied worker engagement in SARS-CoV-2 transmission prevention behaviors and responses. This portion of the investigation, which is ongoing, was awarded funding by the University of Minnesota Sustainable Development Goals Initiative Rapid Response Grants Program for projects related to the [United Nations Sustainable Development Goals](#).

With Hines contributing expertise in development, engineering, innovation, and property management, the studies were run by the Well Living Lab and experts from Mayo Clinic and the University of Minnesota.



99%

virus reduction with
disinfectants used
per manufacturer's
instructions



Eighth Avenue Place - Calgary, Canada



The SQ - Houston, Texas

BENEATH THE SURFACE

The scientific and public discourse regarding COVID-19 safety measures has evolved over the course of the pandemic and varies from nation to nation. Initially, scientists warned about the dangers of contaminated surfaces, but now many are focused on the inhalation of airborne particles, often referred to as aerosols or droplets.

Faced with information that is, at times, confusing or conflicting, property owners and occupiers may wonder whether scrubbing desks, tables, and door handles is effective. Does this do more than offer peace of mind?

Researchers from the Well Living Lab studies used a pipette to place the SARS-CoV-2 on three commonly used surfaces found in homes and offices: stainless steel, laminate wood, and porcelain. Then they analyzed the ability of one medical-grade and one commercial-grade disinfectant to inactivate the virus.

These researchers found that both disinfectants were highly efficacious

at reducing the presence and viability of the virus on public surfaces. In fact, all experiments observed a reduction in the virus's presence, viability, and later replication by more than 99 percent when the disinfectants were used per the manufacturer's instructions.

"We concluded that not only is disinfection in this manner highly likely to eliminate the presence of a virus on any given surface, but it should also render non-infectious any viral component that may remain," said Dr. Zachary Pope, a Research Scientist at the Well Living Lab. "However, prolonged exposure to high-touch, high-traffic surfaces that haven't been disinfected increases the risk of COVID-19 infection. A person is more likely to become infected via a surface if they have repeated interaction with high-touch surfaces," Dr. Pope explained.

"This combined condition of both repeated and prolonged interaction suggests that higher risk surfaces include cafeteria and restaurant tables, desks, and conference tables. Elevator buttons, handrails, and door handles have a lower risk of transmission because, while there may be repeated use, exposure is not prolonged."

Dr. Zachary Pope, Research Scientist, Well Living Lab

So, how relevant is the surface material? Surface studies suggest that plastic is the most concerning material of those tested, with the virus remaining detectable and viable on plastic surfaces for multiple days.

In real life: *An example of the surface transmission route might involve an individual repeatedly touching a dining surface where a viable virus is present in droplets that constitute contaminated fomites. If this individual then uses their hands to eat, the contact between their hands and mouth may allow the virus to gain entry to their body. Over the course of the meal, the amount of the virus entering their body may be of sufficient quantity to cause a COVID-19 infection.*



Plastic
is the most
concerning material
of those tested

From these findings, the researchers developed the following guidance:

- The regular cleaning of prolonged-contact, high-touch surfaces with disinfectants is vital both during the pandemic and during future seasonal respiratory virus outbreaks.
- Frequent sanitizing should be carried out by cleaning teams, but also by employees as part of good health behavior.
- Disinfecting works only as a component of a broader mitigation strategy.
- Companies should prioritize the use of disinfectants certified by the Environmental Protection Agency's [List N](#).

Therefore, the layout of a room also needs careful consideration, particularly areas with frequently touched surfaces and high surface-to-space ratios, such as conference rooms where prolonged interaction with surfaces is likely to occur.

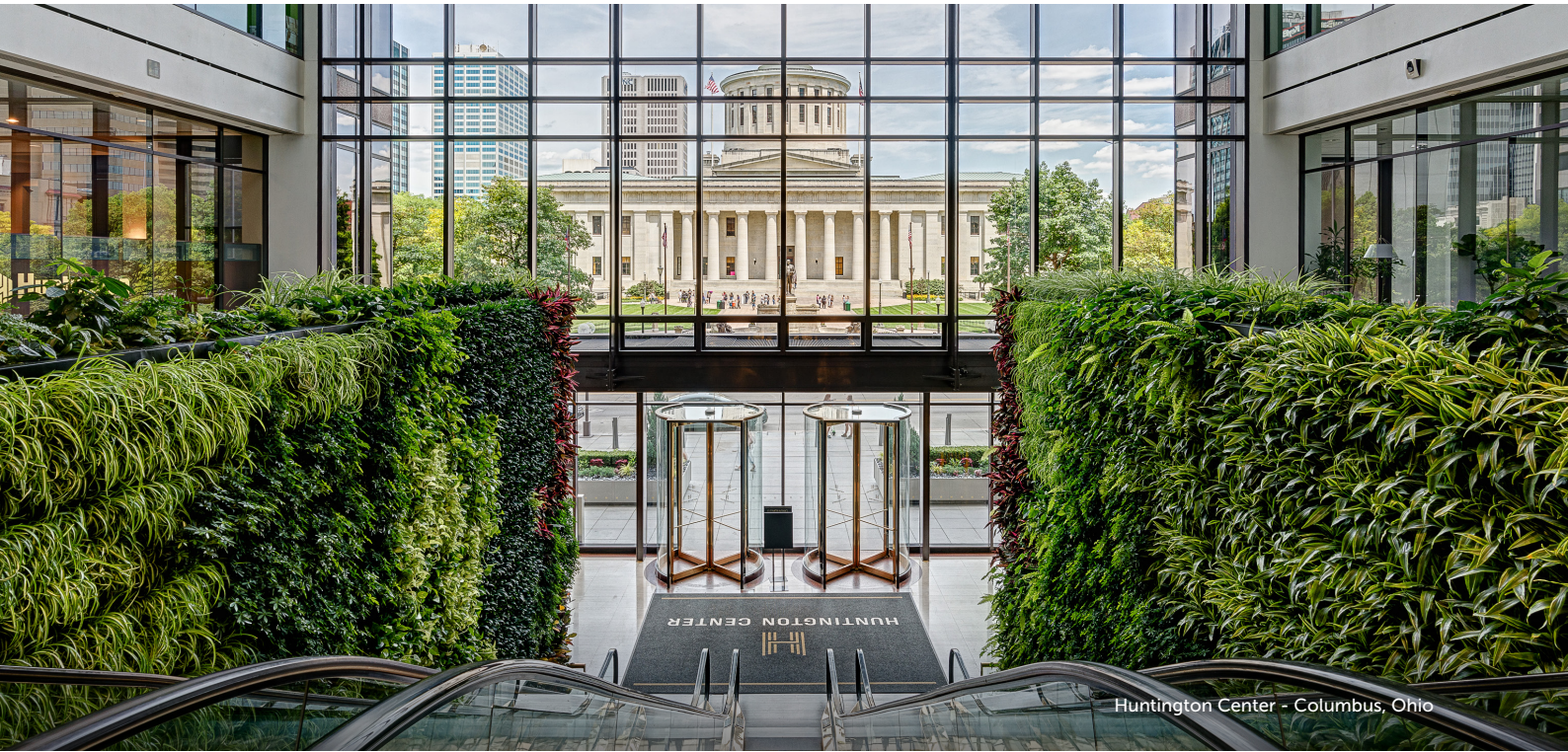
While cleaning is essential, so too is rethinking the number of tables and surfaces, as well as ventilation, filtration, physical distancing, and mask-wearing.

“Surfaces with the highest risk of contributing to transmission are those that have both high traffic and prolonged interactive exposure, assuming there is enough viral load present on the surface.”

Dr. Zachary Pope, Research Scientist, Well Living Lab



Disinfecting
should be
part of a broader
mitigation
strategy



Huntington Center - Columbus, Ohio

A BREATH OF FRESH AIR

Founded by Gerald D. Hines, a mechanical engineer, Hines has had an unwavering commitment to improving the built environment and healthy indoor air quality for decades, and the topic has been an area of heightened interest over the course of the pandemic. All are eager to find the most energy-efficient way to heat, cool, and clean air.

COVID-19 has added a new and pressing dimension to indoor environmental quality with concerns about airborne transmission of respiratory diseases like COVID-19. As employees head back to their offices, business leaders are asking questions such as: how far can filtration and ventilation systems go in reducing the spread of SARS-CoV-2 around a room?

As part of the COVID-19 & Beyond program, Well Living Lab and University of Minnesota researchers tackled this question by expelling a fluorescent tracer liquid from a mechanical breathing simulator at a specific particle size distribution mimicking the particle sizes most

likely to contain SARS-CoV-2. They then evaluated how changes to room operation (ventilation and filtration) and layout (spacing) impacted airborne particle concentration and accumulation of particles onto different surfaces within the room. This approach enabled a simultaneous investigation into air- and surface-based transmission.

Similar experiments using the above methods were completed in different room configurations, including a 1,300-square-foot (120.8-square-meter) open office, a 175-square-foot (16.3-square-meter) conference room using a single low-cost portable air purifier, and a 900-square-foot (83.6-square-meter) classroom using three portable air purifiers.

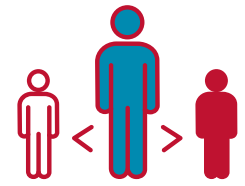
Even physical distancing was considered in these experiments to see if there was a marked increase in particle exposure risk when an individual stood next to the infected source versus being six or more feet away, as the CDC recommends to reduce exposure to potentially infectious particles.

Airborne particle concentration and accumulation of particles on surfaces were tested using MERV 8 filter and normal HVAC ventilation and using a MERV 14 filter and advanced HVAC ventilation.

“The results showed that central HVAC ventilation and filtration systems are impactful,” said Dr. Meng Kong, a Research Scientist at the Well Living Lab. “In addition, portable air purifiers are another way of supplementing clean air delivery to indoor spaces, along with ventilation by opening windows and doors where possible,” he said.

There is also a low risk that particles can be recirculated over long distances through HVAC systems. It is unlikely that particles would remain viable and airborne long enough to travel through the return air plenum, the air handling unit, the air filters, and coils and then be reintroduced into the space.

However, there is a caveat here, Kong explained. “In general, an HVAC ventilation and filtration system is not effective in clearing potentially infectious particles within approximately two meters of distance from someone who is potentially infectious.”



Careful
consideration should
be paid to rooms'
layouts

“Particle behavior and inactivation within three feet of an infected source are minimally influenced by HVAC. Therefore, mask-wearing when at close proximity is crucial.”

Linhao Li, Research Analyst, Well Living Lab

What follows is the guidance arising from the findings, applied to an office context. Ventilation and filtration are impactful. The delivery of more clean air into a space should be prioritized through:

- When feasible and weather-permitting, increasing outside air intake by the HVAC system (volume and/or runtime).
- Using higher MERV-rated filters when practical.
- Seeking advice and assistance from an industrial hygienist or HVAC expert.
- Ensuring occupancy levels allow for an approximate six-to seven-foot space between individuals.
- Planning the space well and using oversized rooms or spaces where possible.
- Advising mask-wearing when the vaccination status of attendees is unknown.



Airborne transmission
is a bigger source of infection than surface transmission



609 Main - Houston, Texas

ON GOOD BEHAVIOR

In our vision of the future of work, we must place an even higher emphasis on people's health by prioritizing holistic care, which includes both physical health and psychological safety.

Additionally, to reduce risk and prevent transmission, workplace behaviors today must help contain the spread of SARS-CoV-2 and other respiratory viruses. The social acceptance of mask-wearing, limited office movement, and hand/surface disinfection protocols may reduce virus spread and prevent an office from becoming a hotbed for disease transmission.

Global business leaders' concerns around the built indoor environment are threefold:

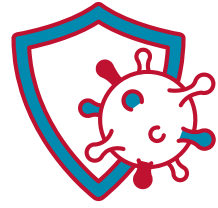
- Their employees may contract airborne viruses at work.
- Employees may perceive coming to work as a risk.
- Mass isolation within a company may disrupt productivity.

To help companies inform care for employees as they return to the office, Well Living Lab and University of Minnesota researchers focused on the psychosocial and behavioral outcomes pertaining to working before and during the pandemic.

They are conducting a longitudinal, year-long survey of 3,607 US employees from eight companies in which Hines invited its employees to participate voluntarily. Participants are being surveyed at the three-month, six-month, and 12-month marks, according to the **CAPTURE** survey,* which measures mindsets and perceptions of productivity, safety, stress, and respiratory disease prevention behaviors.

Characterizing
Awareness
Preven**T**ion and **U**nderstanding
Responses and
Experiences

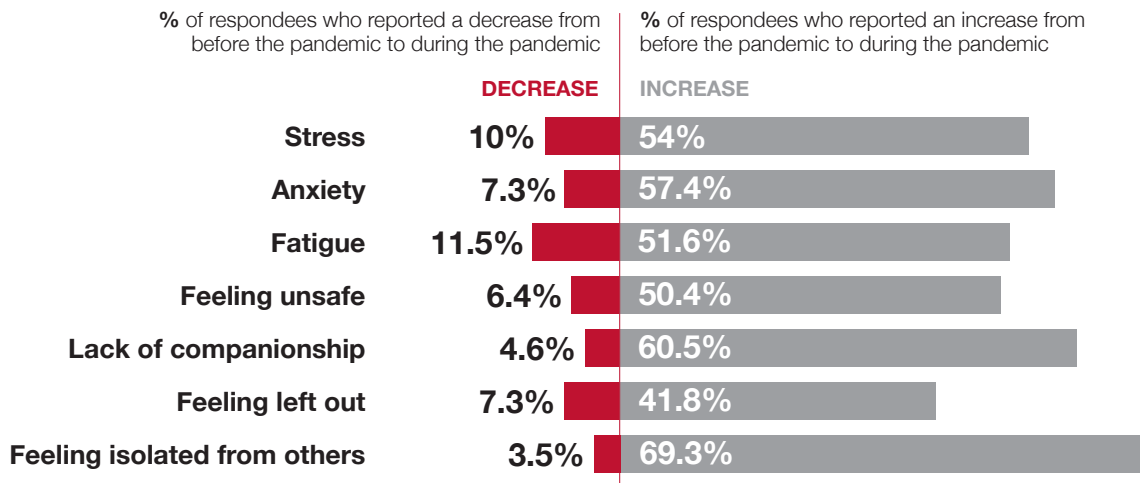
**This survey was delivered via the Mayo Clinic Qualtrics platform and deployed between November 20, 2020, and February 8, 2021, allowing a three-week window for responses from each company's employees.*



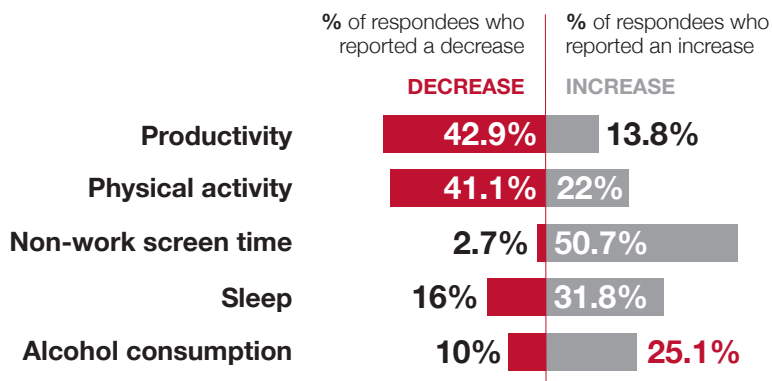
MERV 8
filters are
90%
effective

Changes from before to during the COVID-19 pandemic

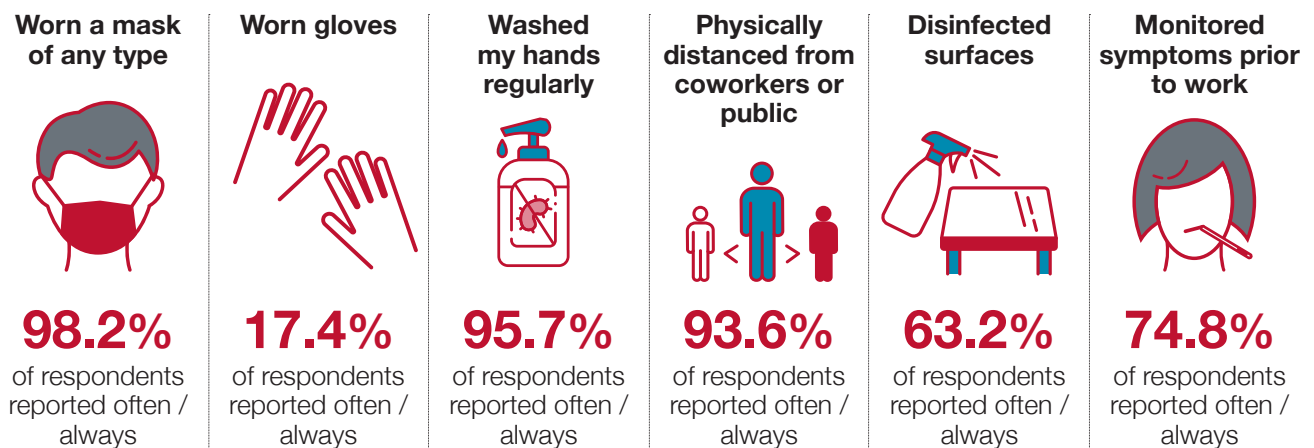
Psychosocial responses



Behavioral responses



Workplace precautions taken over the past month



“Our results shed light on how important it is to support and care for employees’ psychological health, as well as promote their engagement in health-promoting behaviors like good sleep and adequate physical activity, particularly during the pandemic.”

Araliya Senerat, Research Analyst, Well Living Lab

The findings inform the following behavioral principles:

- Prioritize and assist individuals as they adjust back into their normal routines – particularly at work.
- Encourage engagement in good health behaviors (such as increased physical activity), which may simultaneously improve psychological outcomes.
- Continue to promote respiratory and hygiene etiquette and symptom monitoring; survey respondents are seemingly supportive, so it is now up to organizations to increase awareness of the importance of these behaviors.

This study supports other recent research by Hines on the future of the workplace. The Hines paper [Achieving the Great Return](#) highlighted the value of high-quality physical work environments: access to natural light, good indoor air quality, space for physical distancing, live plants, and natural décor. Such Grade A office environments can offer both physical and psychological safety.

“Quantitative and qualitative data gathering will become the cornerstone of real estate management, informing leadership of how a physical space is responding to its people’s needs. For example, how efficient are the air filtration system, the ventilation, and the temperature control? Are the meeting room, desk, and space booking systems encouraging appropriate capacities?”

David Steinbach, Global Chief Investment Officer, Hines

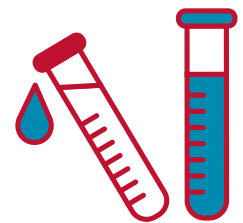


SUMMARY

The COVID-19 & Beyond: Well Living Lab Safe Indoor Environment Program is ongoing as the pandemic evolves and new virus strains emerge. Thus far, the COVID-19 & Beyond research supports the well-accepted view that airborne transmission is a bigger source of infection than surface transmission.

However, the program's research has and continues to delve deep into this statement to reveal that the interplay between airborne and surface transmission should be of the utmost consideration when designing and operating an indoor environment. Furthermore, the behaviors of individuals using the building are crucial to the reduction of risk.

There are many factors that can conspire to make an enclosed space a concern regarding COVID-19 including the quality and location of the ventilation system, the proximity of the infected person and the person's actions (e.g., talking, shouting, exercising, or sneezing), the amount of time spent in the room, the frequency and longevity of contact with potentially contaminated surfaces, and the viral load on selected surfaces.



HEPA filters
can remove
99.97%
of airborne
particles

“Strikingly, even with regimented cleaning and high-quality HVAC systems supplemented with air purifiers, if physical distancing or mask-wearing is not adhered to in certain situations, the risk of transmission increases.”

Clayton Ulrich, Senior Vice President, Corporate Operations and Engineering Services, Hines

The science underscores the priorities Hines has for wellbeing. Hines has diligently conducted cleaning and disinfection of high-touch surfaces, and, prior to the study, the Innovation team initiated a review of touchless technologies across building types, from offices to residential-for-rent to logistics spaces.

Technologies Hines continued to focus on during the pandemic in recognition of their well-being benefits include:

- Mobile access control
- Biometric access for visitors
- Touchless elevator controls
- Destination dispatch elevators
- Automatic door openers
- Hands-free door handles
- Touchless technologies throughout bathrooms
- Visitor check-in and property access
- Touchless parking arrival and departure



**Behavioral
norms**
are changing

“The behavioral working norms have been disrupted by the COVID-19 pandemic. What were once automatic behaviors, such as choosing where to sit in meetings and whether to stop and chat in the coffee bar, have become more conscious decisions that can ultimately accelerate or intervene in the spread of the virus in the workplace.”

Clayton Ulrich, Senior Vice President, Corporate Operations and Engineering Services, Hines

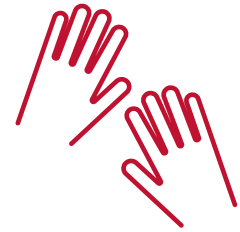
Led by its dedicated Innovation team and Conceptual Construction Group, Hines was well-positioned to swiftly implement new touchless technologies to help alleviate the disruptive impact of the devastating COVID-19 pandemic.

Hines Engineering Operations Standards have been carefully formed around industry best practices and regulations through built environment expertise amassed over the last 60 years. This framework is regularly updated and reviewed to ensure that it is relevant and responsible in today's world, and several of these standards are specifically focused on the indoor environment.

We know, now more than ever, how to create environments for productive, happy, and healthy people. Hines aims to remain on the cutting edge by partnering with organizations, institutions, individuals, product and services providers, architects, and in-house experts.

Considering the study's findings, developers, investors, property owners, and occupiers must reconsider spaces and their purposes under an umbrella mitigation strategy of air, surface, and behavior. Although all three strands require dedicated focus, it is important that they are tackled in the same breath.

The Well Living Lab, founded as a collaboration of Delos and Mayo Clinic, is dedicated to identifying how indoor environments impact human health and wellbeing. It conducts scientific research with human subjects in a simulated real work environment and shares practical findings that can be applied to improving indoor spaces, where people spend approximately 90 percent of their time.



Hines swiftly
implemented new
**touchless
technologies**

GLOSSARY OF TERMS

Aerosol refers to fine particulate matter that is larger than a molecule but small enough to remain suspended in the atmosphere for at least several hours.

Fomites are objects or materials which are likely to carry infection such as clothes, utensils, and furniture.

HEPA is a type of pleated mechanical air filter. The acronym stands for high-efficiency particulate air (filter). This type of air filter can remove at least 99.97 percent of dust, pollen, mold, bacteria, and any airborne particles over 0.3 microns in size.

HVAC is short for heating, ventilation, and air conditioning and refers to the systems used for moving air between indoor and outdoor areas in both residential and commercial buildings.

List N is a list of disinfectant products that the United States Environmental Protection Agency expects will kill all strains and variants of COVID-19 when used according to the label directions.

MERV stands for the minimum efficiency reporting value of a mechanical air filter. The number denotes the efficiency of the air filter at its lowest-performing level. A MERV 8 filter is the most commonly used version in commercial buildings and industrial workspaces. It is effective in controlling mold spores, hairspray, and dust and is 90 percent effective on particles between three and 10 microns in size.

A pandemic is a disease outbreak that spans several countries and affects a large number of people and is commonly, although not exclusively, caused by a virus.

SARS-CoV-2 is the virus that causes the disease COVID-19.

ABOUT HINES

Hines is a privately owned global real estate investment firm founded in 1957 with a presence in 255 cities in 27 countries. Hines oversees investment assets under management totaling approximately \$83.6 billion.¹ In addition, Hines provides third-party property-level services to more than 367 properties totaling 138.3 million square feet. Historically, Hines has developed, redeveloped, or acquired approximately 1,486 properties, totaling over 492 million square feet. The firm currently has more than 171 developments underway around the world. With extensive experience in investments across the risk spectrum and all property types and a foundational commitment to ESG, Hines is one of the largest and most-respected real estate organizations in the world. Visit www.hines.com for more information.

ABOUT THE WELL LIVING LAB

The Well Living Lab, founded as a collaboration of Delos and Mayo Clinic, is dedicated to identifying how indoor environments impact human health and well-being. It conducts scientific research with human subjects in simulated real-world and field environments and shares practical findings that can be applied to improving indoor spaces where people spend approximately 90 percent of their time. The Lab has 5,500 square feet of sensor-rich, reconfigurable space adjacent to Mayo Clinic in Rochester, Minnesota. Learn more at welllivinglab.com.

¹Includes both the global Hines organization as well as RIA AUM as of June 30, 2021.

