

# Investigation on How to Reduce COVID-19 Impacts in Workplaces

**Abderrahim Lakhout\***

*Department of Civil Engineering, Faculty of Engineering, University of Tabuk, Kingdom of Saudi Arabia*

**\*Corresponding author:** Abderrahim Lakhout, Department of Civil Engineering, Faculty of Engineering, University of Tabuk, Kingdom of Saudi Arabia



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## ABSTRACT

This article summarizes what we know and what we need to know about social distancing and its importance in reducing the COVID-19 virus (SARS-CoV-2). Many countries around the world have developed social distancing policies to curb COVID-19 infection rates among their population. The virus that causes COVID-19 is transmitted from human to human, so social distancing is key to mitigating the spread of the illness. According to government and non-governmental organizations reporting on COVID-19 in the literature, there is currently no general consensus regarding social distancing in the workplace. The recommended distances range from 1 to 11 meters. Moreover, neither meteorological parameters nor engineering ventilation methods are taken in account in estimating safe social distancing in the workplace. This study investigates also the importance of using engineering ventilation in healthcare settings, especially during widespread disease outbreaks such as COVID-19. Ventilation can be used to improve indoor air quality in care homes, hospitals, and quarantine locations. Although there are several different types of engineering ventilation, mechanical ventilation is most suitable for reducing the impact and spread of COVID-19 in healthcare and other facilities.

## Introduction

At the end of 2019, a new virus (SARS-CoV-2) appeared in the city of Wuhan, China. It sickened thousands of people first in China and then started sickening thousands of people in other countries, prompting the World Health Organization to declare a pandemic in March of 2020. The WHO called the disease caused by the novel coronavirus "COVID-19", which is short for "coronavirus disease 2019". Over the past several months, COVID-19 has continued to spread around the world, infecting people in more than 150 countries. The rapid expansion of the disease is due to many factors, in particular its biological formation [1], the absence of human immunity, the lack of information concerning the virus, and other physical, chemical and meteorological parameters. Throughout human history, viruses have inflicted misery and disease on humans. Among the most frequently occurring of viruses resulting in widespread disease are coronaviruses, which may cause anything from the common cold to more severe and potentially fatal illnesses such as Severe Acute Respiratory Syndrome (SARS) or Middle East Respiratory Syndrome (MERS).

At the end of 2019, a new (novel) coronavirus appeared in the city of Wuhan, China. The illness caused by this virus was officially

labeled "COVID-19" by the World Health Organization (WHO). COVID-19 stands for "Corona Virus Disease 2019". According to the WHO, the majority of people who are infected with this novel coronavirus experience either mild or moderate illness that does not require treatment in a healthcare setting. However, the virus is more likely to cause severe to fatal illness in the elderly and those with pre-existing medical conditions such as diabetes or chronic respiratory issues. The virus is passed from person to person in a number of ways, including droplet infection when a person with COVID-19 coughs, sneezes, or speaks. These droplets are relatively heavy, do not travel far, and quickly sink to the ground. However, people can catch COVID-19 if they breathe in the infected droplets. Another way that the COVID-19 virus spreads from person to person is via fomites.

When droplets from a person's cough, sneeze, or "talk spray" land on surfaces near the infected person, other people may catch the disease by touching these surfaces (doorknob, elevator button, handrail, etc.) and then touching their face, particularly their mouth, nose and eyes. Virus particles from COVID-19 may stay viable on fomites for up to several days, depending on environmental

conditions. To reduce the impact of COVID-19, most countries around the world have imposed numerous restrictions of movement and socializing on their populations. Some restrictions are very stiff, such as prohibiting people from going outside for several days. Most domestic and international borders are also closed. Even without the threat of contracting COVID-19, governments have been paying more and more attention to air quality over the past few decades, both indoor and outdoor. In fact, indoor air quality is related to outdoor air quality. According to scientific studies [2-5] and recent satellite images, outdoor air quality has improved during the pandemic period.

This is because industrial activity has mostly shut down, temporarily slashing air pollution levels around the world [3-5]. On the other hand, many countries have been extensively using commercial disinfectants. These chemical products can have a negative impact on human health and on-air quality (outdoor and indoor). Some products used as disinfectants, such as chloride, can also have a deleterious effect on stratospheric ozone. Additionally, air quality can be reduced by solid wastes. During a pandemic period, there is an augmentation of solid wastes. However, these wastes may be improperly managed, as is the case now during the COVID-19 pandemic [6]. Solid wastes that are improperly managed can affect air quality and our environment. Hospitals and other care facilities produce a huge quantity of medical wastes [5]. The medical wastes are mainly composed of gloves, masks, textiles, needles, sanitizers, and disinfectants.

For example, the hospitals in Wuhan produced an average of 240 metric tons of medical waste per day at the height of their initial outbreak, compared to their previous average of fewer than 50 tons. A sudden drop in IAQ has likely resulted from COVID-19-related effects. Isolating or quarantining at home has become the global norm nowadays to protect people from the virus, but at the same time a lack of information of how the virus spreads and who is susceptible may be leading to poor IAQ [7]. It is worth noting that while the virus can infect people of any age, the hardest hit demographic currently is the elderly, especially those residing in care homes. The engineering ventilation should be designed according to the specifications of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). More details can be found on the ASHRAE website (<https://www.ashrae.org/technical-resources/standards-and-guidelines>). To stop the spread of COVID-19, many measures are suggested to be taken, such as frequent handwashing, avoiding the touching of eyes, nose and mouth, using medical and cloth masks, staying home as much as possible, and following social distancing guidelines.

These measures are being taken in order to protect human health, to reduce the impact of the virus, and to provide an environment that is safe to reopen society. In the present study, our investigations are focused on indoor air quality (IAQ). Addressing IAQ is key to protecting human health in an enclosed building. Most

people spend more than 90% of their time in enclosed residential, industrial or commercial structures. This percentage has risen dramatically during the COVID-19 pandemic, as millions of people have been mandated to stay at home, including working from home. The present paper focuses also on social distancing. According to the WHO, social distancing means maintaining at least a 1-meter (approx. 3-foot) distance between people when interacting in the workplace, shops, parks, etc. Social distancing is an important method for protecting human health and reducing the impact of the disease outbreak around the world. This form of physical distancing is recommended to be applied in schools, airports, restaurants, and healthcare facilities, and in many countries, social distancing has now become mandatory.

According to Prin and Bartels (2020), during the 2009 influenza A (H1N1) pandemic, social distancing contributed to a 23% median decline in the cumulative influenza attack rate in the workplace. Social distancing is important because when someone coughs, sneezes or speaks, they emit small liquid droplets from their nose and mouth. If the person is infected with the novel coronavirus, these droplets can spread COVID-19 to people breathing them in or touching them and then touching their eyes, nose or mouth. During the present study, the importance of social distancing is investigated. The main objective of this paper is to study the positive impact of air profiles in an enclosed building space (operation room). Air flow speed and direction can play an important role in social distancing, and this factor should be taken into account by healthcare authorities. In this study, a series of recommendations is given to protect workers and staff in enclosed buildings as well as people outside the building.

## Engineering Ventilation in Hospital Buildings

### Natural Mode Ventilation

The natural mode ventilation is based on air supply coming through windows and doors. The replacement of indoor air generally occurs under natural conditions in structures that have abundant windows and doors that are not air-tight and induce air currents that move along corridors and in and out of rooms. In this case, there are no conditions for the requirement of pressure to move the air in or out. In care facilities, however, this mode of ventilation cannot be used, as windows are mostly for lighting purposes and cannot be opened, and there are only a few doors. Furthermore, natural ventilation cannot occur in operation rooms, bronchoscopy units, or waiting rooms, all of which typically have no operable windows. There is essentially no control over the indoor air under a natural mode of ventilation, as the dispersion of the air cannot be effectively managed. Hence, any contamination existing in the air can be easily spread throughout the building.

Natural ventilation is therefore not recommended for hospitals and places of quarantine that house infected patients. A recent incidence of high infection occurred in a care home in the province

of Quebec, Canada. All of the staff and residents became infected with COVID-19. The local authorities did not understand this phenomenon, as appropriate distancing was being observed, as well as the wearing of personal protective equipment (PPE). In this case, however, the infection was due to poor quality indoor air that had become contaminated with the virus. The mass of air within a building must be frequently changed according to ASHRAE standards, as building air ages. When air spends too much time in a building, it becomes dangerous for human health. In fact, bacteria and viruses can use the surface of aerosols to spread and thereby infect occupants of these buildings. In the case of the care home in Quebec, the building was not ventilated according to ASHRAE standards.

It was relying on natural ventilation, but this type of ventilation, as mentioned previously, is generally ineffective in large, enclosed buildings. On the other hand, in terms of energy and investment, the natural mode of ventilation is practically free, which is why it is preferred in institutional settings.

### **Mechanical Mode of Ventilation**

This forced mode of ventilation requires equipment, energy, maintenance, and technicians. The advantage of mechanical ventilation is that IAQ can be controlled, along with the air pressure. This means that the changing of air within a building can be adjusted to adhere to ASHRAE standards. To freshen the IAQ, indoor air is extracted from the building via an exhaust fan. The mode of mechanical ventilation systems mainly comprises supply fans (which enable the entrance of outdoor air into a building) and exhaust fans (which extracts air out of a building). Mechanical ventilation is recommended for care homes, hospitals, quarantine places, other healthcare facilities, and residential long-term care facilities.

### **Mixed Mode of Ventilation**

In this mode, natural and mechanical ventilation are combined to provide the desired flow rate. A technician can switch to mechanical ventilation when the natural ventilation cannot guarantee the desired flow. This mode of ventilation is recommended for care homes and residential long-term facilities. In other healthcare settings, such as hospital wards in older facilities, mechanical ventilation is not usually required, as freshening the air through openable windows is the preferred solution.

### **Air Treatment**

The current COVID-19 pandemic has brought building exhaust air to the attention of authorities. Exhaust air can affect outdoor air quality and infect populations, especially if comes from care homes, hospitals, care facilities, and residential long-term facilities where infectious disease is present. This air should be treated before venting it outdoors. However, the reality is that the exhaust air of medical facilities or quarantine places is not treated and escapes outside

to infect other sectors of the population. A suitable engineering solution is to collect this air and consider it Class 4 according to ASHRAE standards. Class 4 air refers to air with potentially dangerous particles, bio-aerosols or gases at concentrations high enough to be considered harmful. Consequently, any exhaust ducts which carry these potentially harmful Class 4 contaminants should be negatively pressurized, thereby preventing potentially hazardous exhaust air from impacting people outside the building and its environs.

In the case of hospitals, care homes, other care facilities and quarantine places, the minimal distance between exhaust and supply should be 5 meters, according to ASHRAE standards, and the outflow of contaminated air should be a minimum of 5 liters per second per square meter. The positioning and placement of the exhaust and supply air are critical to these calculations. The positioning is chosen according to a simulation of the contamination spread. In the present study, the engineering solutions are specifically proposed to reduce the impact of COVID-19 in hospitals, care homes, and other care facilities.

### **Medical Wastes**

The medical sector generates copious amounts of different kinds of wastes. This includes discarded surgical gloves, surgical instruments, needles used to give shots or draw blood, masks, sanitizers, disinfectants, gowns, eye protectors (goggles or face shields), other PPE, and medications [8,9]. Medical wastes are classified as hazardous wastes on the basis of their biological, chemical, and physical properties. These materials are either toxic, reactive, ignitable, corrosive, infectious or radioactive, which means they should be stored in a safe place before being moved to their final waste-treatment location and disposed of. The location of waste storage within healthcare premises must be properly determined and sized [10]. It should also be under negative pressure, as these wastes can infect an entire building and its occupants. Hence, medical wastes should be professionally treated according to local bylaws and in adherence to the international convention of hazardous wastes. There are a number of engineering techniques for treating medical wastes, including incineration, thermal treatment, biological treatment, landfilling, neutralization, macro-encapsulation, and deep well disposal [11].

### **Social Distancing in Hospitals**

Based on our investigations of the WHO website, social distancing as recommended by the WHO is 1 meter (3 feet) for the following reasons: "People can catch COVID-19 by touching contaminated surfaces or objects, and then touching their eyes, nose, or mouth. If they are standing within 1 meter of a person with COVID-19, they can catch it by breathing in droplets coughed out or exhaled by them. In other words, COVID-19 spreads in a similar way to the flu." How many meters we should we leave between us and other people in schools, shops, healthcare facilities, parks, etc.?

In exploring a broad range of scientific works on the topic, we could find no consensus among the information concerning measurement of social distancing [12-19]. Several articles describe, define and give advantages of social distancing during the COVID-19 pandemic [12-20] and also discuss the benefit of social distancing to reduce the impact of COVID-19 (Figure 1), but the precise measurement is not yet agreed upon by experts in the field.

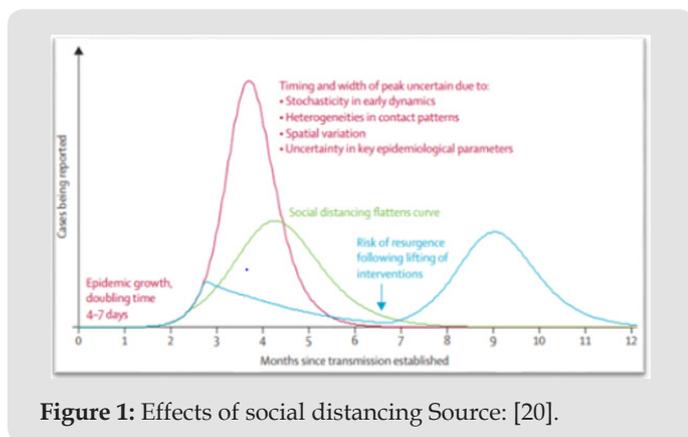


Figure 1: Effects of social distancing Source: [20].

Unlike the WHO’s recommendations, some studies suggest a social distancing measurement of 2 meters between people [21, 22], while another study found that, based on simulations, the droplets (100-200µm) can be transported between 8 to 11 meters by the action of turbulent air flow [23]. This distance can also be changed according to droplet diameter (Figure 2). In other study [24], a droplet with a 100µm was transported up to 3 meters in less than 1 second. Generally, the majority of the countries in the world are encouraging people to stay home throughout the pandemic. The slogan “Stay Home” has been used widely to limit human contact. Many countries have also imposed more restrictive measures, such as isolation and quarantine. However, social distancing is not determined explicitly by the authorities and governments. Recently, many countries and local authorities set out their plans for a phased ending of coronavirus lockdown, with many of the measures imposed including social distancing.

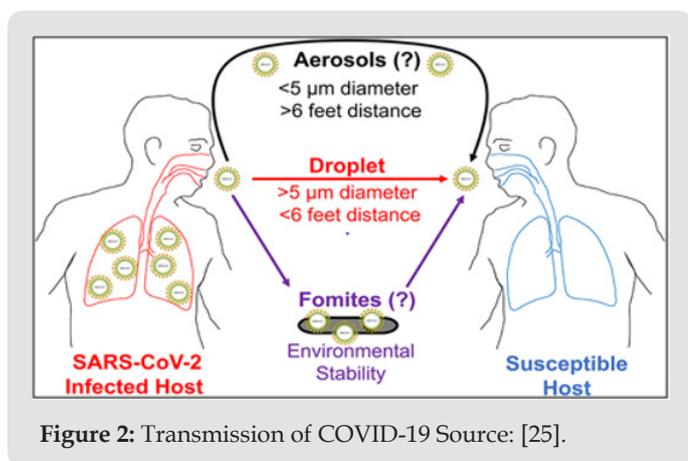


Figure 2: Transmission of COVID-19 Source: [25].

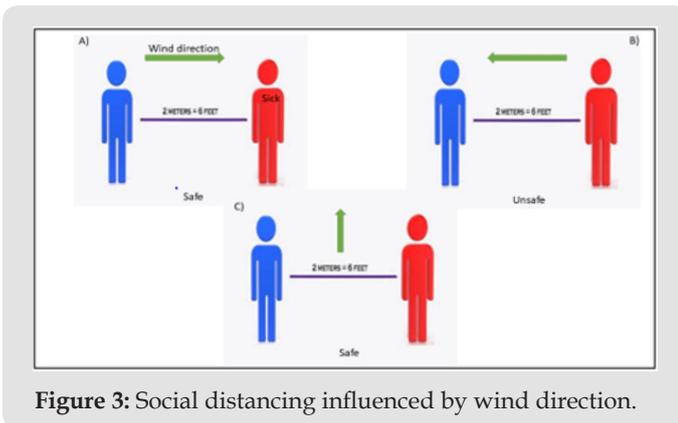
According to our investigation, physical distancing differs from country to country. For example, in the United States, the Centers for Disease Control and Prevention (CDC) and the Occupational Safety

and Health Administration (OSHA) have recommended a spacing of 6 feet between people to decrease the spread of COVID-19 in the workplace [25,26]. In Singapore, non-medical people who spend a prolonged period within 2 m of a confirmed case must self-isolate for 14 days [27]. Canadian authorities are requiring a 2-meter distance in most public and commercial locations, and Middle Eastern countries also require 2-meter spacing. In Europe, Col. Rodney Coldren, chief of Preventive Medicine Services, Public Health Command Europe, is asking people to stay as far away from each other as possible. There is as yet no consensus in Europe concerning social distancing. In France, the distance is 1 meter, while in Germany the distance is 1.5 meters.

Chinese authorities have stipulated 1-meter distancing in schools, but social distancing measures in Japan are quite lax. From the above, it is clear that there is no international consensus on social distancing. To date, social distancing ranges between 1 to 2 meters but can also be as high as 11 meters in relation to droplet spread. The international rules established by authorities, healthcare, and local governments are practically the same for outside (i.e., parks) as for inside (i.e., enclosed workplaces). Numerous factors should be taken in account to determine social distancing, including meteorological parameters such as wind and air flow direction, temperature, and humidity. Unfortunately, the CDC, OSHA, and WHO have not considered these parameters when declaring their rules. Some countries require barriers between workers or staff in workplaces, and these barriers are considered sufficient to make the workplace “safe”.

However, while such barriers can reduce the spread of the virus, they cannot stop it, as the virus can float through air currents. In certain workplaces, infected air can bypass physical obstacles and be driven by air flow velocity and direction. These factors change from one workplace to another depending on the mode of ventilation used (natural, mechanical, or mixed). Wind and air flow profiles can also change according to the nature of the barriers and obstacles. Therefore, the ventilation strategy adopted at a workplace can play an important role in determining the type of social distancing that should be used. Social distancing parameters should not be fixed (that is, the same for all places and all people at all times), but instead be able to be altered according to meteorological parameters, temperature profiles, the profile of the air flow, and the position and debit of ventilation (in the case of mechanical or mixed mode of ventilation). Thus, the positioning of workers and staff should be based on parameters that are relatively unique to each workplace (Figure 3).

As depicted in Figure 3, the direction of the air flow within a building can play a crucial role in determining the spread of the virus in the workplace. Hence, the correct positioning of workstations and care beds is essential. In hospitals or other healthcare facilities in particular, air flow profiles in the rooms should be used to reduce the transmission of the virus to staff and patients. This technique can also be useful for dental clinics.



**Figure 3:** Social distancing influenced by wind direction.

## Conclusion

Air quality is an important factor that can profoundly influence human health. More attention should be given to the IAQ in care homes, quarantine locations, hospitals, and residential long-term facilities, as these places house a vulnerable population that can be easily infected. To reduce the impact of COVID-19 during the current pandemic, aerosols, particulate matter, viruses and bacteria can be removed from building air with a suitable ventilation design. The ventilation approach should be designed according to ASHRAE standards and be under the consultation of highly qualified engineers and researchers. In medical facilities, including places of quarantine, the mixed mode of ventilation is optimal. As well, the ASHRAE standard should be respected with regard to the exhaust and supply air. Exhaust flow air should be at least 5 liters per second per square meter, and a surface of at least nine meters square should be guaranteed to each patient. Moreover, patients who are confirmed to be COVID-19 positive should be separated from other patients and housed in a room under negative pressure.

Furthermore, the exhaust air from this room should be treated, as without treatment this air can be dangerous and contaminate other residents both inside and outside the facility. In the future, more attention should be paid to engineering ventilation as a means to improve air quality in enclosed buildings. Additionally, the position of exhaust and supply air should be investigated, as the suitable positioning of these air flows can improve IAQ immensely and reduce the impact of viruses. It is also recommended that ventilation be stopped during the night in care facilities. At the beginning of the COVID-19 pandemic, the majority of social, educational, healthcare, economic and industrial activities temporarily ceased operations. As well, international boundaries were closed to stop the spread of the novel virus among vulnerable populations. Now, with the passing of the first wave of illness, the majority of countries have decided to reopen most activities gradually throughout the summer.

To prepare for the reopening, policies are being developed and imposed, with social distancing being one of the most important and ubiquitous. The concept of social distancing was defined and

explored in this paper, first by reviewing the literature related to the idea and then by considering it from a technical perspective, according to the most recently published scientific papers on social distancing, the recommended distance range between people should be anywhere from 1 to 11 meters, depending on the activity being engaged in. This measure is based on numerical simulations of the propagation of 100  $\mu\text{m}$  droplets. However, for most countries, social distancing has been set at 1 to 2 meters. For social distancing measures in the workplace, positioning of workers, staff, shoppers and patients should depend on a variety of factors, including meteorological parameters, air flow profiles and velocity, and the impact of the engineering ventilation.

According to our investigations, the social distancing measures as required by most established policies are insufficient to protect human health in workplaces and reduce the spread of COVID-19. In some workplaces, barriers have been erected between workers and staff, but these physical obstacles are ineffective if air flow velocity and direction are not taken in account.

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Abderrahim Lakhout. Biomed J Sci &amp; Tech Res



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