Recent Preventive Methods to Reduce the Infection Diseases by Air Distributions Control

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Abstract

A novel coronavirus (COVID-19) was detected in China at the final of 2019 and has since caused a worldwide pandemic. This virus is transferred by airborne, sneezing, and speaking. Because COVID-19 is highly infectious through airborne contamination, the high infection risk in the medium environment is a serious problem for both healthcare workers and patients.

This literature – overview provides a description of the methods to reduce infection of COVID-19 such as indoor quality, non-pharmaceutical, and air controllers. The main importance has been on how to enhance the air quality in isolation rooms. The review articles concentrate on theoretical, computational simulation, experimental investigation, or combination. From the discussion of the articles, there exist the locations of ventilation systems (air supply and exhaust opening) that play an important role in reducing the infection risk and the amount of removed or concentrated particles in isolation rooms. Beside that, types of wearing masks and indoor air quality such as temperature and relative humidity are also important issues.

Keywords: Ventilation, Mask, Indoor air, Ultraviolet (UV), Air change per hour, Social distance.

1 Introduction

In advance, as a result of the emergence of infectious and fatal diseases at the same time, by the end of 2019, the first case of the coronavirus appeared in China. Then, the outbreak of the virus began to become internationally. At the beginning of 2020, the World Health Organization announced the threat of a deadly virus and began issuing preventive procedures to reduce the risk of infection. Hence, it has become necessary to create ways to avoid and reduce the transmission of infection. Through this article, most preventive methods are presented to reduce and avoid an increase in the number of infected people. Thus, we can live with them safely. Removal and reduction of airborne particles, due to CO_2 emission in isolation rooms, is important for the infection mechanism of airborne diseases, especially with the emergence of the coronavirus and resulting strains such as delta, omicron, and others. Many researchers studied the performance of ventilation systems in the buildings since the SARS outbreak, such as the study on ventilation efficiency and evaluation of the ventilation performance in isolation rooms by using experimental measurement [1-3] and numerical investigation of ventilation performance for removing particle contaminants [4-6]. The movement of infection-transmitting droplet particles is slowed down by wearing a mask. Proper mask use significantly lessens the spread of illness via aerosol droplets. In addition to wearing the mask appropriately, the amount of aerosol droplets that emerge from the mask depends on its porosity and the total number of pores [7]. Design and assessment of a portable chamber's efficacy in reducing infectious disease transmission. In order to limit the spread of particles from the chamber to a nearby healthcare worker, a portable chamber is a compact isolation chamber that is put on the patient above the bed. In order to prevent the transmission of infection, it is also simple to use and adaptable to varied surroundings [8].

As a result, this paper discusses how to evaluate the performance of different methods to avoid infection with infectious diseases in hospitals. Most of them were confined, the most important of which is maintaining indoor air quality such as temperature and relative humidity of the place, the optimal choice of inlet air and exhaust air positions to avoid the occurrence of swirls of air carrying infection- particles, in addition to providing occupied places with air purifiers such as ultraviolet lamps, and finally an assessment Performance of structural masks.

The main objectives of this study were to end disease outbreaks and protect hospital staff. Metrology has contributed to eradicating the pandemic by evaluating the factors related to the selection of appropriate materials in the manufacture of commercial cloth masks and medical masks, which may help both manufacturers and health institutions in evaluating their effectiveness. In addition to the calibration of measuring devices related to environmental conditions such as pressure, humidity, flow meters attached to respirators, etc.

2 Preventive Methodologies

Figures (1, 2) present methods, which are usually used for preventing infections resulting from infectious diseases through breathing, sneezing, and coughing, such as the new disease spreading all over the world (COVID-19). Firstly; for the ventilation system, whether natural or mechanical (mixed or displacement) ventilation, many researchers of previous studies determined the optimal position of the inlet and outlet opening diffuser to reduce the concentration of airborne substances suspended in infection. Secondly, they determined the speed of droplets (for example diameter ٠.5μm to ٢.5 μm [9]) exiting the source of infection during sneezing, coughing, and talking. They aimed to determine the safe social distance between two people in schools, hospital, restaurants, airplanes, and gyms to avoid the transmission of infection between people while they are in these places.

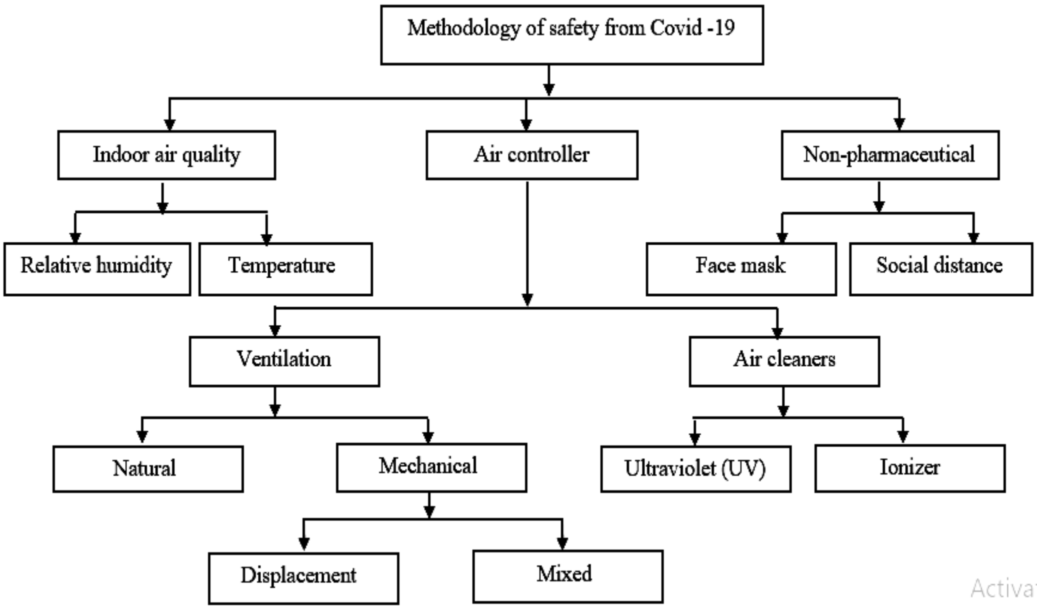


Figure 1: Plan for preventing infection diseases

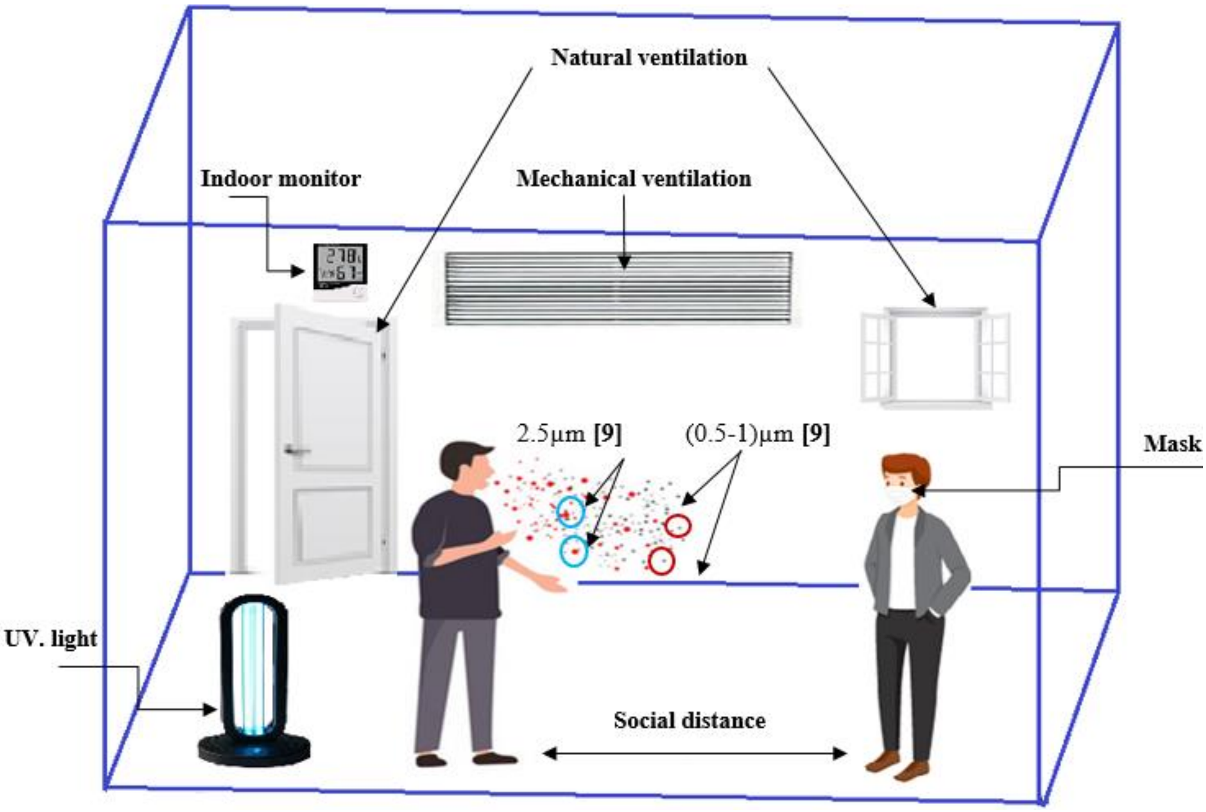


Figure 2: Sketch to explain the precautionary measures against the risk of infection.

3 Review of Published Works

There is a rapid progress in studying the various preventive methods to reduce infectious diseases since their discovery as presented in Fig. 3. A sudden jump is noticed in the number of research after the emergence of the COVID-19 pandemic. The effect of indoor airflow quality in hospitals, such as wind speed, temperature, relative humidity, air balance between inlet and outlet, type of ventilation, mask type, and particle size, play an important role in transmitting infection [10-11]. These methods are reviewed in the following sections.

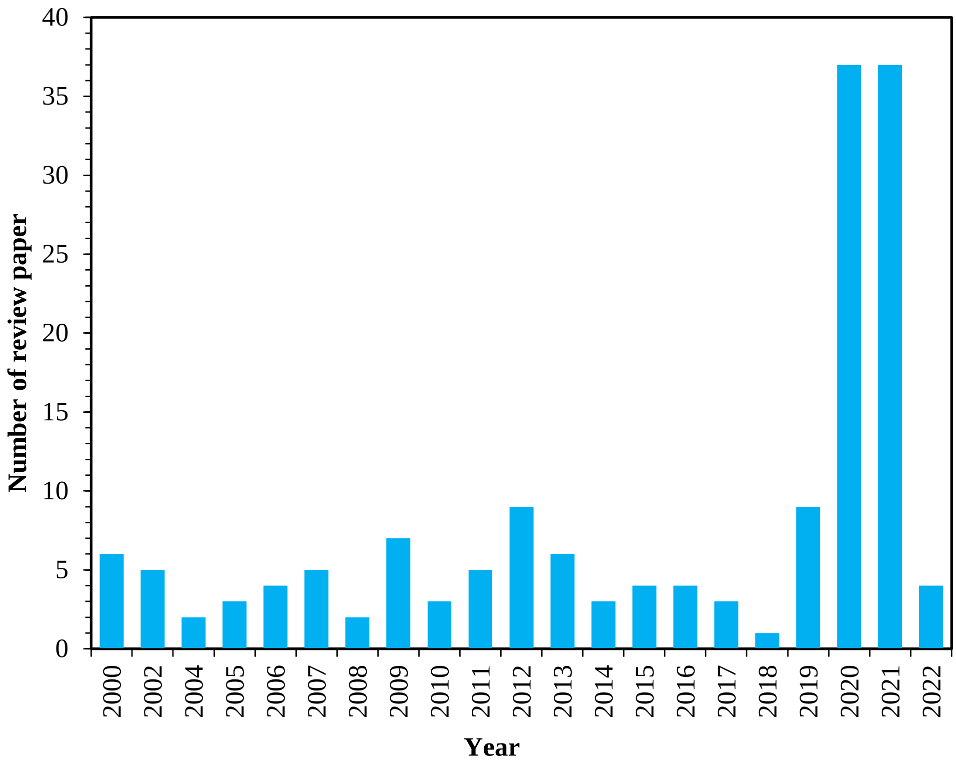


Figure 3: Numbers of published articles for the review of the methods of preventing infectious diseases from 2000 to 2022.

3.1 Indoor Air Quality

Many researchers have explained the active elimination of fine particles from the air [12-14]. Others have an estimate of the indoor pollutants and interior smart ventilation systems [15-17]. By combining the research methodology of the fine particulate concentration and the influence of ventilation systems on indoor airflow, many experiments were carried out to observe the control effect of indoor airflow concentration around the patient as shown in table 1. The droplet transport and deposition are dependent on inlet/outlet relative humidity (RH) from the human mouth [18]. From the previous research, it was possible to reduce the spread of infectious diseases through the minimum velocity region. However, the infection increased in the region of high turbulent kinetic energy [19].

3.2 Air Controller

3.2.1 Ventilation

From the present review of many researchers in this scope, it is concluded that the infection particles concentration of suspended air inside the room depends on the position of the exhaust air opening and the type of ventilation as shown in Table 2. The results show that the best position of the opening exhaust near the patient to prevent infection diffuses.

Table 1: *The effect of indoor air quality on COVID-19 scattering.*

Parameter	Effects of Transmission	Recommendation Values	Ref (s).
Humidity	Increase absolute humidity achieves a slowdown in transmissions. In contrast to this finding, many researchers reported that low relative humidity likely favoured the transmission of COVID-19 and showed an interactive effect between daily temperature and relative humidity on COVID-19 incidence.	40% and 60%	[20-23]
Temperature	The air temperature was considerably linked with COVID-19 transmission at the community level, and oppositely, a few investigations exposed no significant correlation between temperature and transmission of COVID-19. In addition, tropical weather conditions are less conducive to the virus spreading.	23.8 ºC and 26.9 ºC	[24-31]
Wind speed	Reduce air quality, with strong winds; leading to an increase in the number of COVID-19 cases. On the other hand, a new study discovered that low wind speeds are linked to increasing COVID-19 infection and association with wind blows.	Less than 0.25 m/s around the person	[32-37]

Ventilation plays an important role in controlling the contamination level [38]. The type of ventilation affects the type of flow (laminar or turbulent) and the number of emission pollutants between two-bed patients in the hospital. The common ventilation used is the mixing type. The downward ventilation system did not produce a downward laminar airflow, due to the interface of the body thermal plumes and the downward supply airstreams with 4 air change per hour (ACH).

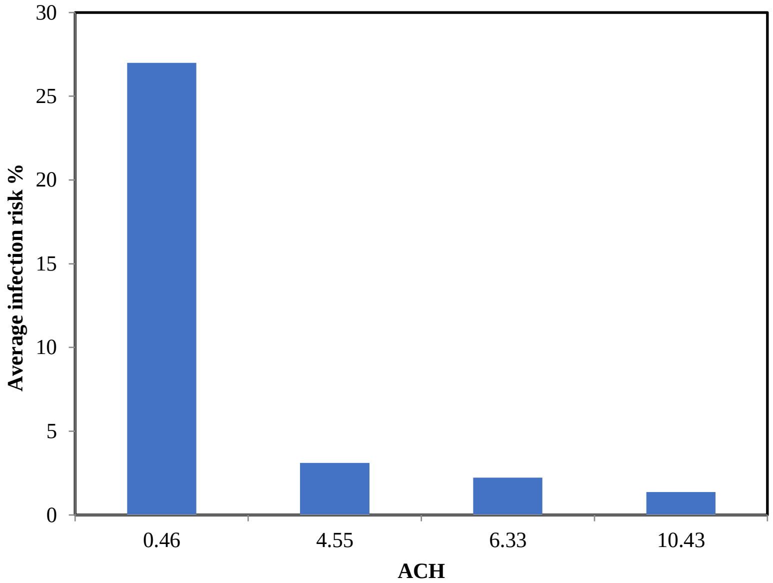


Figure 4: Air change per hour (ACH) vs average infection risk [40].

A mixing ventilation study also, revealed that the bed distances of 1.0, 0.6, and 0.3 m did not make any significant impact on the personal exposure index of the receiving to the other bed patient [39]. For good ventilation in an office building, when using 90% of the return air, the infection risk was 27% for an eight hours stay in the office building. While, when using 100% outdoor air with different ACH. The result shows that the infection risk would decrease from 27% to 3.1% as shown in Fig. (4) [40].

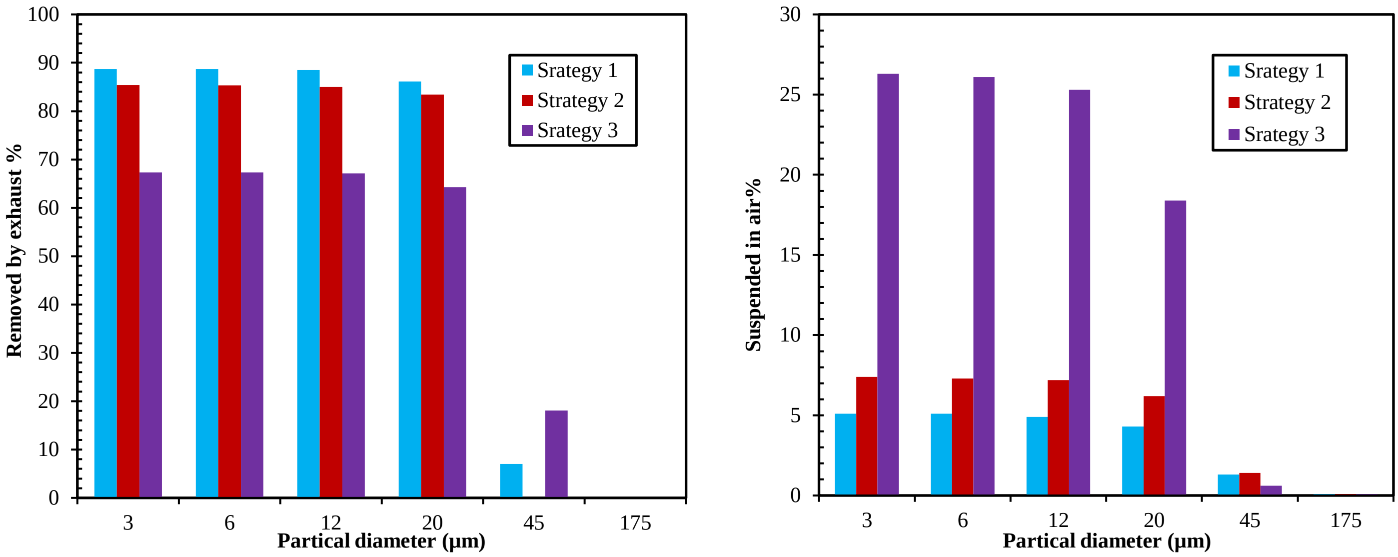
Table 2: *Effect of location of exhaust air opening on the concentration of air suspensions.*

Position of inlet and outlet	Dimensions (L×W× H)	Methodology	Concentration (ppm)/ μg/m³	Ref.
Ceiling supply air (SA) and exhaust air (EA) 0.2m above the floor.	$16\ m^2 \times 2.6\ m$	Pollutant distribution was investigated using numerical simulations of molecular diffusion. Removal of pollutants inside a negative pressure airborne infectious isolation room equipped with three ventilation strategies were analyzed based on exhaust air locations using gas trace SF_6.	37.4	[41]
Ceiling SA, and ceiling EA.			48.4	
Ceiling SA and the two wall-mounted EA behind the patient's head.			34.8	
Two air supply diffusers and two extract grilles mounted on the ceiling.	$3.35m \times 4.8m \times 2.6\ m$	Using gas trace SF_6 to represent the emission source at a rate of 0.63 l/min. The average concentration was measured at sampling points (six).	64.4	[42]
Two air supply diffusers mounted on the ceiling and two extract grilles to the wall behind the bed at 0.3m above the floor level.			31.3	
Two air supply diffusers mounted on the wall behind the bed and two extract grilles to the wall behind the bed at 0.3m above the floor level.			29	
Mixed ventilation (ceiling supply and return) mounted on the wall near the ceiling and exhaust located on the ceiling. **Displacement ventilation (air supply) mounted on the wall near the floor and exhaust located on the ceiling.**	$3.5m \times 4.5m \times 2.7\ m$	When sneezing and coughing, the source is very often not facing other persons directly. The relative alignment and distance between the source and the receiver play transmission infection levels. In the study, the effect of concentration for two cases (face source to face receive) and (face source to the wall) was studied. Velocity emission is 50 m/s, and droplet diameter is 0.01 μm to 10 μm in the breathing plan.	For 0.01 μm Face-to-face orientation 70 to 65 ppm concentration. Face to wall 90 ppm concentration. For 10 μm, Face-to-face orientation 190 ppm, Face-to-wall orientation 320 ppm concentration.	[43]

One air supply opening at the bottom left and two exhaust openings, one at the top right and the other at the bottom right.	two-dimensional $2.0m \times 1.0m$	Evaluate the effects of each exhaust opening on contaminated indoor air ventilation with different velocity ratios between the exhaust ratio (0.1:0.9, 0.3:0.7, 0.5:0.5, 0.7:0.3).	The concentration is less than 45 ppm for all cases, but the region of lower concentration expanded in direction of the exhaust opening.	[44]
Case (1): Inlet and outlet are on the same sidewall. **Case (2): Inlet and the outlet are on the opposite sidewalls.** **Case (3): Inlet is mounted on the ceiling and two outlets are installed on the sidewall opposite the entrance door.**	$2.44m \times 2.44m \times 2.44m$	Presented a numerical simulation effect of three different ventilations on concentration inside the room with air change per hour 12.3, velocity injection from the patient is 11 m/s and small particle diameter is less than 20 µm.	86.1–88.7% removed by the exhaust for case (1). 83.4–85.4% for case (2). 64.3–67.3% for case(3)	[45]
Inlet opening in the ceiling and exhaust mounted on the west side of the gym.	$173.7m^2 \times 5.1\ m$	Evaluate the concentration of the different aerosol particle diameters from (10 to 0.25 µm) in the gym. The volume of the gym is 886 m^3, and ACH=2.2.	10 – 2.5 µm: 10.03 $\mu g/m^3$ 2.5 – 1 µm: 1.30 $\mu g/m^3$ 1 – 0.5 µm: 1.13 $\mu g/m^3$ 0.5 – 0.25 µm: 0.39 $\mu g/m^3$ Less than 0.25µm: 0.14 $\mu g/m^3$	[46]
The air supply is mounted in the wall and the exhaust is mounted in the opposite wall.	$3.8m \times 4m \times 2.4m$	Studied the relative concentration between two persons face to face with a relative distance of 1m in three cases: Stable, unstable, and neutral	560 – 600 for stable 480 -500 for unstable 490 -520 for neutral	[47]
ceiling supply air and exhaust was located lower wall behind the head patient.	$3.7m \times 2.5m \times 2.5m$	Studied the concentration of gas exhaled from the patient with different air change per hour (12 - 48) in the case of the opening door of the isolation room.	48.811 to 50.81 for 12 ACH 13.19 to 13.40 for 48 ACH	[48]
Nine air supplies mounted on the ceiling, (1-9) exhaust was available; mounted at the ceiling and floor level.	--×--×2.5	Gave a numerical study of the removal particle during human exhaled with the location of exhaust. Trace gas SF_6, air change per hour 12 at air supply, particle different sizes (0.5-20 µm) and volume flow rate from exhaled source 1.2 l/min.	90.4%, removed by exhaust mounted in the ceiling. 29.4%, removing exhaust mounted at the floor level when particle diameter 1 µm.	[49]

The air supply in the middle ceiling, return diffuser in the sides.	$9m \times 9m \times 3m$	Presented a numerical study of aerosol transport in a classroom with particle size 15 µm.	24%–50% removed by the exhaust.	[50]
Model 1: The air supply was mounted in the wall near the ceiling, and the outlet was mounted in the opposite wall behind the patient above the floor by 0.95 m			6.52	
Model 2: The same inlet position(model 1), and the outlet was mounted in the side wall to the right of the patient above the floor by 0.82 m.			16.77	[51]
Model 3: The same inlet position(model 1), and the outlet was mounted on the opposite wall the behind patient above the floor by 0.05 m.	$2m \times 2m \times 2m$	Presented an experimental study of the concentration of gas exhaled from the patient CO_2 with 27 ACH, and -2.5 Pa.	13.45	
Model 4: The same inlet position(model 1), and the outlet was mounted in the same wall in front of the patient above the floor by 0.05 m.			17.31	
Model 5: The same inlet position(model 1), and the outlet was mounted inside the wall to the left of the patient above the floor by 0.25 m.			12.59	
			1 ppm with portable chamber above the patient	[8]

Figure (5a) shows the relation between particle diameter and the ratio of removed particles by exhaust at different mounting positions of exhaust. Notice that the largest percentage of particles was removed at strategy 1, followed by strategy 2, and finally strategy 3. But this percentage decreases with the increases of the particle diameter until it disappears at particle diameter 175 µm, and vice versa with the particle suspended in air Fig. (5b). Notice that the largest value is strategy 3, then strategy 2, and finally strategy 1. It also decreases as the particle diameter decreases until it vanishes at the largest diameter.



(a) (b)

Strategy 1: Inlet and outlet are on the same sidewall
Strategy 2: Inlet and the outlet are on the opposite sidewalls
Strategy 3: Inlet mounted on the ceiling and two outlets are installed on the sidewall opposite of the entrance door

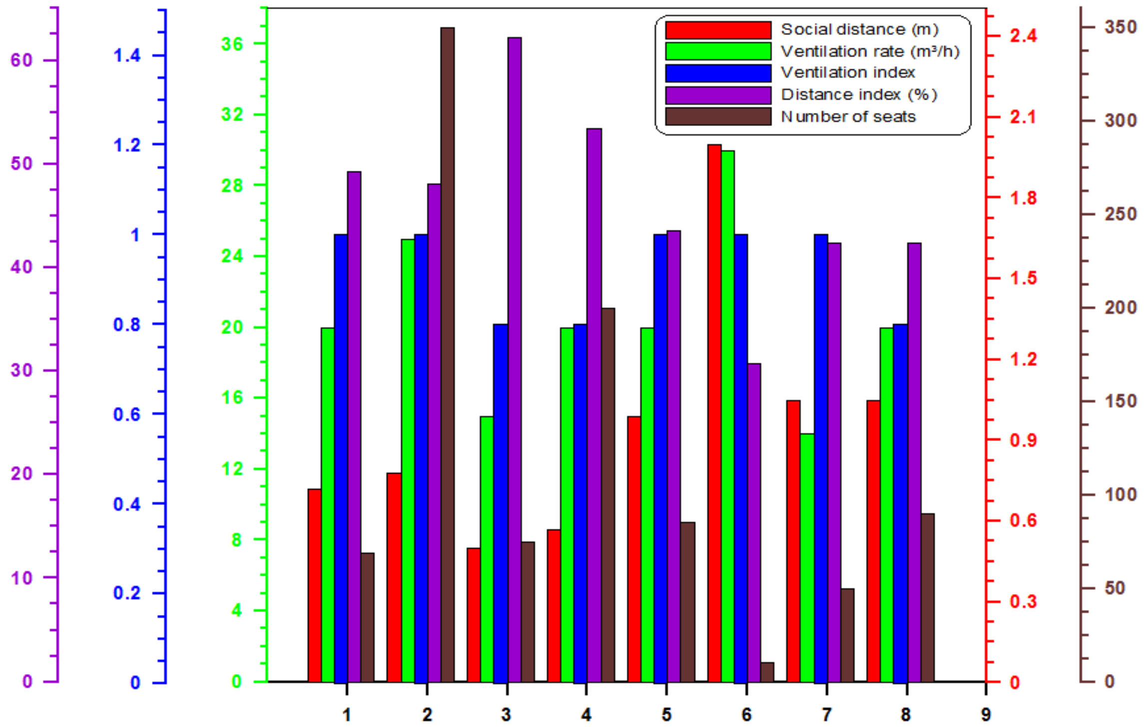
Figure 5: Particle removed and suspended in air versus particle diameter at 12.3 ACH (a): Partical removed by exhaust with different partical diameter, (b): Partical suspened in air with different partical diameter [45].

Some researchers studied the effect of room design on contamination removal and thermal conform. For a general design, considering the performance of the room on both thermal comfort and contaminant removal, it can be concluded that when the supply grilles are mounted in the center of the room, the better the performance of this parameter [52]. Figure (6) explains the difference between public places in terms of applying precautionary measures to reduce the risk of infection. The distance index (P_d) is calculated from equation (1), where it is a function of the social distance (d). While the ventilation index represents the system–dependent air distribution efficiency in a space [53].

$$P_d = \frac{-18.19\,ln(d)+43.276}{100} \tag{1}$$

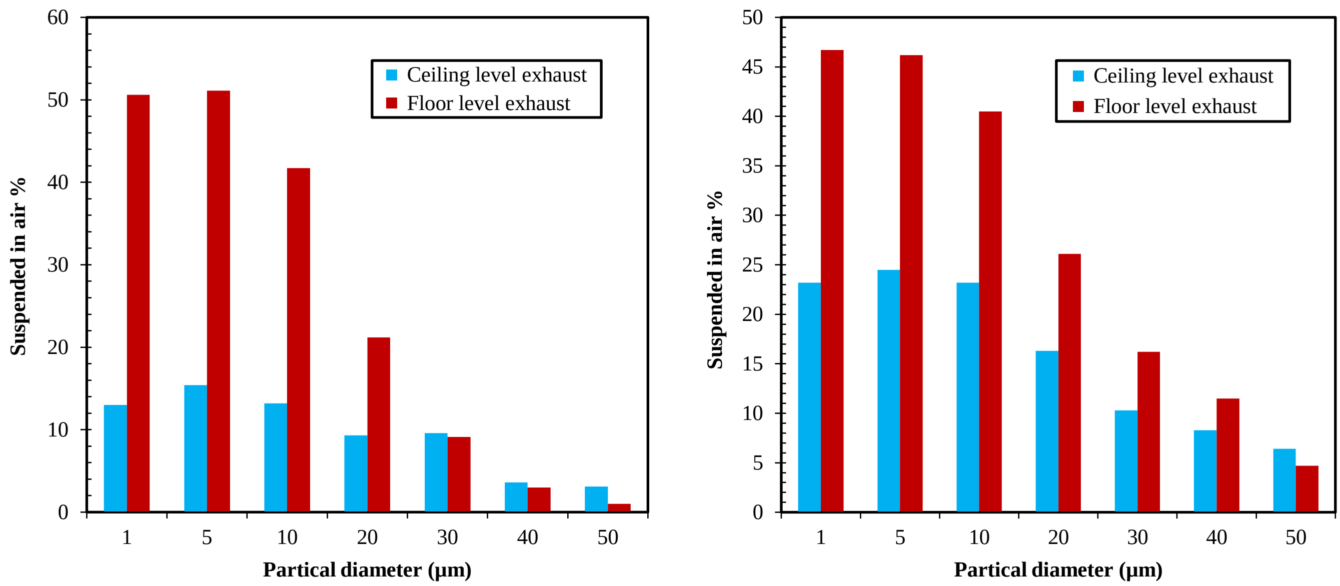
From figure 6, it was concluded that the rate of ventilation increases in places with small areas such as offices, compared to large areas such as long buses. This is due to the concentration of infection–carrying substances increasing as a result of the lack of a larger area for spread. This reason has been translated into social distancing. We note that the largest social distance is recommended in places with small areas.

Some investigators studied the effect of the type of ventilation on the concentration ratio of breathing for air supply (mixed) and exhaust mounted on the ceiling for mixing ventilation (MV), and air supply mounted on the wall and exhaust mounted on the ceiling for displacement ventilation (DV). The respiratory frequency was set at 15min^{-1} with difference emissions from 15 and 30 m/s and three breathing rates were 7 LPM, 15 LPM, and 23 LPM [54-56]. It was concluded that the best performances were for exhaust mounted on the ceiling as well as for decreased percentage of a particle suspended in the air with an exhaled velocity of 0.12 m/s as shown in Fig. (7). Beside that, the concentration decreases with mixed ventilation and increases with displacement ventilation, Fig. (8).



1. Ceiling supply, floor return (long bus) 2. Ceiling supply, floor return (aircraft cabin) 3. Ceiling supply, floor return (public bus) 4. Ceiling supply, floor return (subway) 5. Ceiling supply, floor return (high-speed train) 6. Ceiling supply, floor return (office) 7. Ceiling supply, floor return (classroom) 8. Ceiling supply, floor return (restaurant)

Figure 6: Comparison between safety parameters of air distribution inside different areas [54], [57-58].



(a) (b)

Figure 7: Relation between particle diameters and particles suspended in the air with different exhaled velocities (a) Exhaled velocity 0.12 m/s , (b) Exhaled velocity 2 m/s [54].

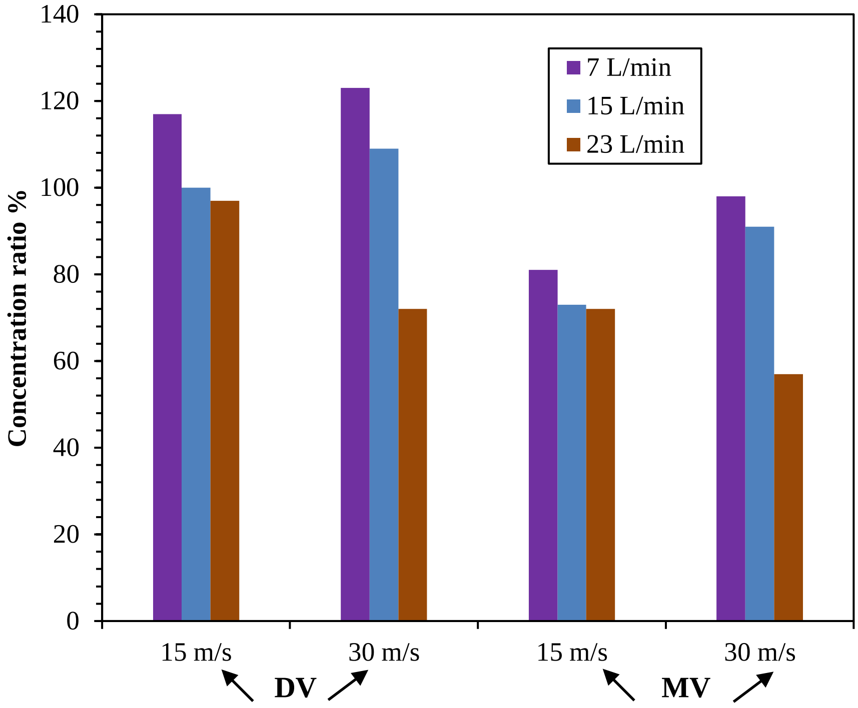


Figure 8: Comparison between mixed and displacement ventilation with different breathing rates [54].

The stratum ventilation performance is rather good in anti-airborne infection for a small to medium room with multiple occupants [59]. Computational studies were carried out for the dispersion of exhalation pollutants in one, two, and three-bed hospitals and the influence of healthcare walking on airborne transmission in a six-bed isolation room. Healthcare worker motion has some effect on airborne transmission. This effect is important when designing the ventilation system [60-64].

From the literature review, the exhaust opening mounted in the ceiling performs much better in controlling airborne transmission than the exhaust opening mounted at floor level with the same air change rate. By increasing the air change per hour and decreasing the supply air velocity, we can reduce the transmission of airborne bacteria [65].

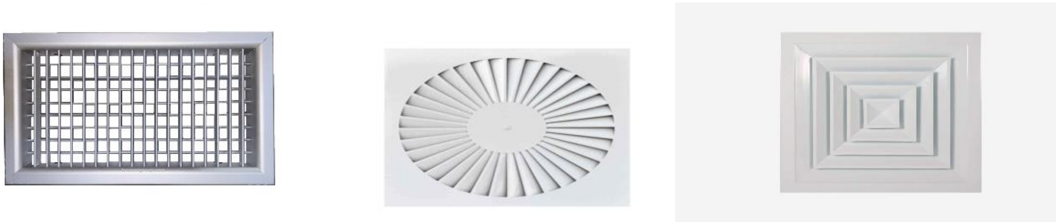
Others carried out an experimental investigation of the effectiveness of directional airflow on air volume escape from the isolation room when opening the door. When directional airflow decreases, the air volume escape decreases [66].

Some researchers studied the ventilation system in the classroom by using a mass balance between cleaning the air and CO_2 concentration as the sole indicator of airborne transmission risk [67-69].

Some researchers conducted a numerical simulation to study the effect of different separation distances between two men (0.35 m, 0.50 m, 0.80 m, and 1.10 m) on the mean concentration between them, and the maximum separation distance between the two men (L= 0.80 m and 1.10 m). This is most likely due to the non-stationary nature of the airflow pattern in the area compared to lower separations of 0.35 and 0.50 m [69].

A numerical simulation was carried out for aerosol transmission on a Boeing 737 airplane, using shields of full-size flight that reduces particle deposition on travelers in aggregate by 41- 45% depending on particle size. Besides, reducing travelers' capacity to 40 travelers reduces the fraction of aerosol particles deposited on travelers (excluding source) by 45% compared to the full capacity case without shields [70]. Some investigators evaluated the average normalized concentrations on the surface charge and not charge. When the objective surface was not charged (0 kV), the average normalized concentrations on the surface increased by 67 % for charged droplets. When the target surface was highly charged (19 kV), the average normalized concentrations were increased more than two times for the charged droplets [71].

The type of air diffuser, Fig. (9), influences the air pattern and the likelihood of infection transmission. The square diffuser has high efficiency compared to the swirl, and grille diffuser for air distribution. Swirl diffuser reduces contaminant concentration more than grille and square diffusers [72].



(a) **(b)** **(c)**

Figure 9: The type of air supply (a): Grill, (b): swirl, (c): square diffuser [72].

The influence of ambient conditions on the transport and evaporation of respiratory droplets in the indoor room is important. The cold and humid conditions become an alarming zone for droplet spread more than dry conditions [73]. In order to remove gas with bacteria (GWB) effectively, three outlets opening are used in the isolation room; mounting one on the ceiling above the patient's head, and the other two outlets on each side wall of the bed with 3 ACH [74]. The negative pressure variations affect the exclusion of contaminants in the isolation room. To keep steady pressure levels, creating a sealed and continuous pressure check may be required [75]. Computational simulation of the exhaled droplets, during transmission indoors, has been presented by a number of researchers with different strategies for the position of the exhaust diffuser. As for the positions of installing the air inlet and exit diffuser, it is preferable to mount the air inlet diffuser in the ceiling and exit opening near the floor level [76-81].

3.2.2 Air Cleaning

Some researchers proposed a methodology to reduce contamination risk from airborne droplets in isolation rooms. From the research studies, it was found that there is evidence that COVID-19 when suspended in air, is sensibly easy to inactivate using ultraviolet (UV) light at 254 nm [82].

Although there is a decrease in the proportion of air pollution and germs when installing UV light, statistical studies showed that this decrease was not consistent [83]. Many testing has concluded that UV can successfully inactivate COVID-19 aerosols deposited on porous mediums and solid surfaces [84].

UV units are highly recommended, due to the minimum changes to existing ventilation systems for air distribution and additionally the minimum energy cost. The infection risk in the office is below 2% in the case of exit UV [85]. Table 3 explains the different air cleaning, including sunlight, Ultraviolet (UV) light, solar radiation, UV+ Filter Fibrous-filter, and hybrid electrostatic filtration system (HEFS).

Figure (10) shows the comparison between different seniors in the gym when operating sports, ventilation, and air cleaning on concentration inside the gym. The higher particle concentration appears during the case (sport ON) because, during exercise, the particle diameter is within a range (2.5-10 µm). on the contrary, while not exercising, with ventilation ON, and air cleaning ON, the particle concentration finishes. For particle diameters less than 0.25 µm, the particle concentration is nearly stable.

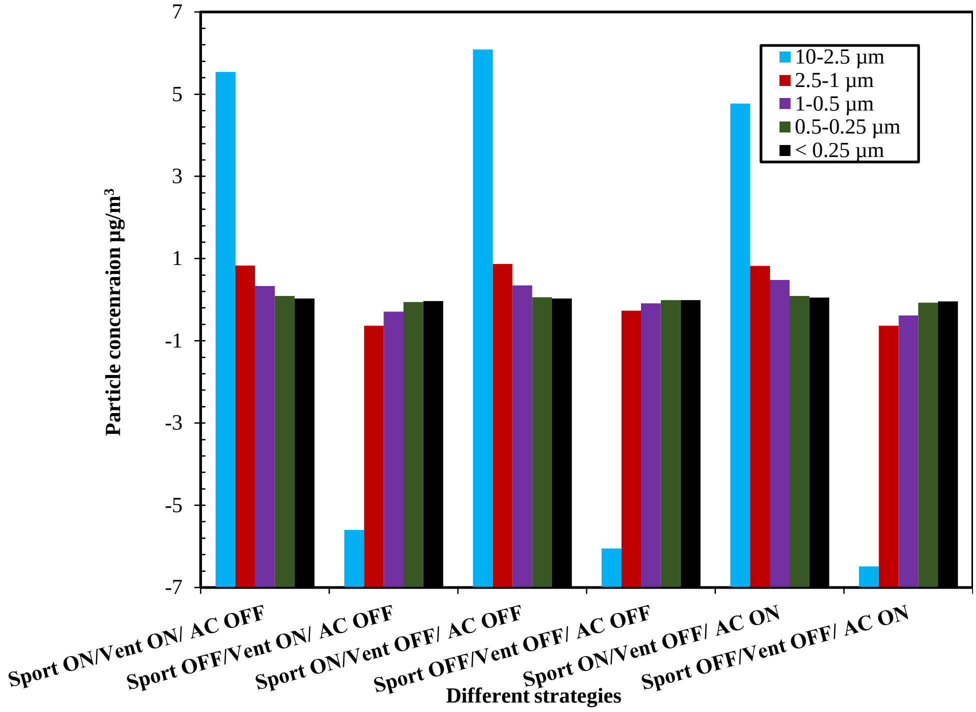


Figure 10: Comparison between different strategies in the gym [46].

Table 3: *The difference between air cleaners*

Method	Practical diameter (µm)	Direction	Absorption %	Energy consumption (w)	Irradiation wavelength (nm)	Ref.
Sunlight	1-9	perpendicular to the surface	0 – 11	-	302	[86]
Ultra-violet (UV) light	1- 5- 9	perpendicular to the surface	0 – 10 – 18	-	260	[87]
Solar radiation	-	perpendicular to the surface	inactivation	-	300	[88]
UV+ Filter	0.1 -2.5	perpendicular to the surface	100	483	-	[88]
Fibrous-filter	0.1 -2.5	perpendicular to the surface	100	286	-	[88]
Hybrid electrostatic filtration system (HEFS)	0.1 -2.5	perpendicular to the surface	100	44.1	-	[88]

3.3 Non-pharmaceutical

3.3.1 Face mask

Since the outbreak of the COVID-19 pandemic, World Health Organization has recommended citizens adopt face mask-wearing and social distancing. However, before presenting the types of mask, it is a must to know the velocity and particle diameter that exits from the source as shown in table 4. The results concluded that the particle concentration depended on particles diameter. The particles concentration is increased with particles diameter decreases. Accordingly, the type of mask (used to filter airborne virus particles) is determined in table 5. The fitted filtration efficiency (FFE) for each mask is calculated according to equation (2). The results explain that the mask type N100 is more efficient compared with different masks and follows FFP3+N99 with constant particle diameters of 0.3 µm.

$$FFE= \frac{1-behind\ the\ mask\ partical\ concentration}{ambient\ parical\ concentration} \times 100 \quad (2)$$

3.3.2 Social distance

The safe social distance has been set by the World Health Organization, which is 1m. But, through previous studies, it was concluded that this distance is not sufficient to prevent transmission of infection, and this distance was recommended. As the mask porosity increases, the social distance decreases. With a constant ACH [7], it is noticed that the social distance when wearing the mask is reduced to about one-third compared to when not wearing the mask, as shown in Table 6.

Table 4: *The difference between types of sources of transmission.*

Droplet source transmission	Velocity (m/s)/ or volume flow rate (L/s)	Number of droplets	Diameter (µm)	Concentration (Particle/cm^3)	Ref(s).
Speaking	3.9	112- 6720 during speaking	16.0	0.004 - 0.223	[89]
Speaking	4.07	-	0.1 - 16	1.2	[90-91]
Speaking	-	-	3.5 – 5.5	0.04 -0.16	[92]
Speaking	-	-	0.3 - 20	1.1	[93]
Coughing	11.7	947 – 2085 per cough	13.5	2.4 - 5.2	[89]
Coughing	5,10, 15	-	1–2000	-	[90], [94-96]
Coughing	30/7	-	0.1 – 0.5 0.5 - 1	80000 20000	[97-102]
Sneezing	30/4.5	-	1 - 5	5000	
Sneezing	15, 20, 25	-	1–2000	-	[94-97]

Table 5: *The difference between mask types.*

Mask type	Material	Particles diameter µm	Fitted filtration efficiency (FFE) %	Ref(s).
N100	Non-woven fabric	≥ 0.3 µm	99.97	[103-104]
(Filtering Face-piece) FFP1	Non-woven fabric	≥ 0.3 µm	80	[103-104]
N95	Non-woven Polypropylene fabric.	≥ 0.3 µm	95	[103-106]
Surgical mask	Non-woven fabric	3	60%–80 %	[107-108]
FFP2	Non-woven fabric	≥ 0.3 µm	94	[103-104]
FFP3+N99	Non-woven fabric	≥ 0.3 µm	99	[103-104]
	Mix cotton	25 nm	70	[109]
	100% cotton	23 nm	50.9	[109]
Home-made mask	Medical	25 – 23 nm	91.45- 89.5	[109]
	Hybrid fabrics	< 300 nm	80	[110]
	Hybrid fabrics	>300 nm	90	[110]
2-layer mask	Nylon	-	60.3	[111]
2-layer mask and 1 filter	Nylon	-	74.4	[111]
Cloth Face Mask	Usually cotton	0.3 µm	0	[112]

Table 6: *The social distance according to droplet diameters.*

Type state	Droplet diameter (µm)	ACH/ Velocity	Social distance (m)	Time residence (sec)	Porosity %	Ref(s).
Exhaled	10	-	≤ 1	300	-	[113-118]
breathing	1	-	≥ 2	30,000	-	[113-118]
Violent exhalation	< 200		0.7	0.34	-	[119]
During talk	0-1500	-	1.6-3	-	-	[120]
	> 0.1mm	-	2-6	-	-	[120-121]
Turbulent gas during a sneeze	-	/10-30	7–8	-	-	[122]
Coughing and sneezing case	-	-	30	-	-	[123]
Sneeze	< 100		1.2	1	-	[119]
Sneeze	< 100		1	1	-	[124-125]
Sneezing case	-	-	8	-	-	[57]
Normal cough	-	16	0.7	-	-	[126-127]
Breathing, coughing, and sneezing	-		6	-	-	[128-130]
Breathing, coughing, and sneezing (classroom)	50	-	2.4	-	-	[49]
Safety social	-	-	1.6-3	-	-	[131]
distance	-	-	1-3	-	-	[132-136]
(breathing, coughing, and sneezing)	-	-	1.5 -2	-	-	[137]

Coughing or sneezing case	-	/10-50	6	-	-	[120-121]
Exhaled breath (No wearing mask)	-	16	0.68	-	-	[138-139]
Surgical mask	-	16	0.3	-	-	[139]
N95 mask	-	16	0.15	-	-	[139-140]
Sample mask	-	-	0.22 – 0.4	-	-	[[139-140]
Without mask (cough)	-	-	2.62	-	-	[19], [47], [74]
Medical mask	-	-	0.48	-	-	[127]
Non-medical mask	-	-	0.78	-	-	[141-142]
Without a mask (turbulent cough flow)	-	/8	0.7	-	-	[142]
Cough(without mask)	100	/10	1.8-2.4	0.5	-	[143-144]
Exhaled breath (No wearing mask)	0.5 - 2.5	12	1.75	50	-	[7]
Exhaled breath (wearing mask)	0.5 - 2.5	27	0.4 0.4 0.45 0.35 0.6 0.3	50	93 29 38 11 16 6	[7]

4 Non-pharmaceutical

All previous studies are not accompanied by the value of uncertainty, as well as the measuring devices used. Certainly, more research is needed to give design recommendations that take water vapour and CO_2 exits during exhaled stroke into account as well as volatile matter and turbulence intensity inside the room. In addition to methods for treating the mask until is used more than once.

5 Conclusions

The objective of this many types of research reduces the dispersion of the infection inside the isolation room in addition to minimizing the risk of infection for the healthcare worker. Ventilation by creating negative pressure inside the room, air change per hour, and maintaining the wearing of a mask are all these factors important, which are efficient approaches to reduce the spread of particles inside the room to the nearby healthcare worker. It is also easy to implement and can be used in different environments to avoid the spread of infection. Two review articles were used in this subject study. The first review article [85], discusses the deposition of particles indoors, and the other [104], discusses the protection of the respiratory system from aerosols. From the previously presented and discussed results, the following conclusions may be put forward

- For the ventilation system, according to previous studies, mixed ventilation is preferred instead of displacement ventilation in terms of reducing the value of the concentration of materials in the air that carry infection.
- As for the positions of installing the air inlet and exit diffuser, it is preferable to mount the air inlet diffuser in the ceiling and exit opening near the floor level.
- Use an ultraviolet lamp parallel to the ventilation system to remove and inactive air pollution concentration inside the room.
- For the theoretical and experimental investigations, particles with different diameters have a different suspended state in the walking case. Both studies indicate that the particle suspension velocity of 1.0 – 3.0 μm is the fastest and the largest in the amount of suspension in the air, whereas the suspension of 0.5 – 1.0 μm particles is the smallest
- Social distance depends on air change per hour. When increasing ACH, the particle concentration decreases.
- Preventive procedures must be applied, such as wearing a medical mask and maintaining a safe social distance, especially in places that have poor ventilation.
- With a constant ACH, it is noticed that the social distance when wearing the mask is reduced to about one-third compared to when not wearing the mask.

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