The Impact of the COVID-19 Pandemic on the Space Pattern Changes in Buildings

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Abstract. A COVID-19-pandemic has been spreading since early 2020 throughout the world. It has a serious impact on all aspects of human life and has an influence on changes in the pattern of human activities in buildings. This study aims to evaluate the impact of COVID-19 on the changes of occupant behavior and space pattern in buildings through a literature study, online information from the COVID-19 response team, and government and non-governmental organizations. The study results show that activities in buildings are closely related to the risk of spreading the virus, so a design strategy that responds to a pandemic is needed to reduce the risk of infection. It is necessary to develop an air ventilation system that can inhibit virus transmission, changes in spatial and circulation patterns to reduce the risk of transmission, and the selection of building materials that can inhibit the transmission process. Therefore, the role of architects and building designers is very important in realizing buildings that are responsive to pandemics. The results of this study can serve as inspiration for sustainable building design and response to pandemics in the future.

Keywords: Pandemic, COVID-19, Space Pattern, Building Health.

1 Introduction

The current COVID-19 pandemic has resulted in significant changes in the lives of every human being and caused an economic crisis and travel bans in most countries. COVID-19 is a new virus that causes a rare type of pneumonia. The first outbreak was in December 2019 in Wuhan, China [1-3]. Since then, the disease has spread worldwide, endangering human life [2,3]. WHO has called this a global public health emergency [4]. COVID-19 caused the first major global health emergency with severe consequences for health and economies worldwide. The covid pandemic also has negative implications for the comfort activities in the built environment [5].

The coronavirus pandemic is growing continuously on a global scale. Its influence is very significant on all aspects of social life, including restrictions on educational and office activities. The World Economic Forum said that as of April 7, 2020, nearly 3 billion people had to face global lockdowns, and the governments of individual countries made it difficult for people to move to stop COVID-19 infections. The continuous spread of COVID-19 has forced many countries and territories around the world to implement emergency measures such as city closures; suspension of production at industrial facilities; the transition of students to online schools; and the imposition of travel restrictions, all of which affect economic progress and people's lives [6].

Activities in the buildings are a potential source of COVID-19 transmission. Places infected are most found in buildings and transportation [7]. Three main risk factors for frequent building infections are small spaces without ventilation, large crowds, and close contact. Transmission of the COVID-19 virus is prevalent in closed or poorly ventilated buildings [8-10]. Buildings without good indoor environmental quality led to poor health, learning difficulties, and productivity problems [11]. Those are challenges for most homes, schools, and workplaces during the COVID-19 pandemic. It implies that activities in buildings are closely related to virus transmission, especially in crowded and poorly ventilated rooms, so innovative changes are needed to ensure the health and well-being of building occupants [12,13].

The COVID-19 pandemic has caused changes in various aspects, including in the fields of architecture and building interiors. The current building design must comply with architectural and interior design rules that can adapt to the lifestyle of the post-pandemic society, so architects and engineers must think about how to design good buildings to prevent the spread of the virus. Therefore, this paper will discuss the implications of the COVID-19 pandemic on patterns of spatial change and sustainable building design strategies and responses to pandemics. The results of this study can be a lesson in

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taking strategic steps, especially in sustainable building design in the post of COVID-19 pandemics.

2 Research Methods

This study examines the impact of COVID-19 on buildings and the environment using the literature study method, which includes journal reviews from various national and international publishers, information from the COVID-19 response team, and information on government and non-government organizations from the official website. The COVID-19 pandemic is the century's global health challenge, inspiring future behavior changes with positive environmental consequences [14].

According to Takewaki [7], architectural designers and engineers have an important mandate to consider the role of buildings in preventing virus spread and increasing building users' comfort during a pandemic. As a result, this study will also examine the risk of COVID-19 transmission in buildings to gather information on the possibility of modifying building design concepts in response to the pandemic.

3 Result and Discussion

3.1 Building and Covid-19

Virus-infectious places are predominantly found in buildings and transportation. Dietz [15] investigated various factors limiting the likelihood of COVID-19 transmission within a structure, concentrating on ventilation and indoor air quality, illumination, and material surface deposition. Certain indoor air quality conditions, specifically the HVAC (Heating, ventilation, and air conditioning) system [16] or relative humidity [17-18], can influence viral activity, according to a consensus. Other investigations have established a correlation between natural light levels in buildings and viral activity [19] and the effect of wastewater and sewage collection systems on COVID-19 transmission [20].

The number of people in buildings, influenced by the building's design and program, occupancy patterns, and interior activities, promotes the buildup of microbes associated with humans [21]. Increased indoor activities and occupant densities may improve social interaction and connectedness through direct contact between individuals [22] and environmental-mediated contact with abiotic surfaces (fomite transmission or passive vectors). A study of COVID-19 environmental contamination found the virus on practically every touchable surface in hospitals hosting COVID-19 patients [23], and surveys in hospital rooms with isolated COVID-19 patients revealed considerable environmental contamination wider [24-25].

The COVID-19 pandemic has had several consequences for buildings, including: (1) Activities in buildings, such as offices, schools, sports facilities, houses of worship, and some businesses, have been limited or even suspended. (2) Simple layout changes to adjust spacing and circulation. (3) The use of transparent barriers like plastic and glass limits direct contact, particularly in commercial structures and public services. (4) Establishing working hours (work shift system) to reduce space user density. (5) Organizing the visitor queue by splitting the time or establishing a distance and restricting the number of visitors. (6) Arranging building access by segregating entrances and exits, checking body temperature, and providing hand washing places [5].

3.2 Building Health

The COVID-19 pandemic is raising public awareness of the vital link between the indoor environment and health. Healthy buildings are always a necessity, especially during quarantine. When people spend a long time indoors, adequate ventilation is needed to limit the transmission of viruses and an optimal space layout to allow for the application of physical distance. It demonstrates the importance of designing and operating buildings that can support the health and well-being of occupants. Therefore, designers need to consider effective solutions to create healthier room conditions.

The COVID-19 pandemic will affect the future design and operating guidelines [26]. The results of the study by Awada et al. [27] show that the majority (75%) of respondents think that spatial patterns and building conditions are closely related to the health of residents during the pandemic. It indicates that the COVID-19 pandemic will be able to create a revolution in the field of healthy buildings after the pandemic. Researchers and practitioners from all related fields should utilize this to create a movement that will be sustainable in the future. In the new normal, it is necessary to emphasize the consideration of the health and welfare of the occupants in designing, constructing, and operating buildings. It requires continuous review, development, and promotion, so building professionals support the idea [28].

Awada's research results also show that most respondents believe future building design, construction, and operation will focus more on occupant health due to the pandemic experience. It shows that the COVID-19 pandemic is a catalyst for a healthy building movement. This situation highlights for building professionals that buildings are not adequately equipped to fight airborne viruses or to maintain healthy conditions for occupants during quarantine and stay at home. The pandemic provides an essential lesson that integrating health considerations with building design, construction, and operation is an urgent need [27].

3.3 Sanitation Improvement

Good sanitary conditions in the room are urgently needed when people are on lockdown in their homes to avoid viruses [29]. One of the essential factors in sanitation is the availability of clean drinking water and a good wastewater management system [30-31]. Coronaviruses are persistent in water and wastewater [32], so wastewater management needs to be carefully

designed considering the possibility of spreading the virus through sewage to the environment, although the transmission rate is lower. It is recommended to maintain and treat infected wastewater in an adequately managed or designed wastewater treatment plant [33]. A well-planned and appropriate sewerage design can reduce the potential risk of viral contamination of wastewater [34].

The position of the bathroom is also vital to note. The quarantine process in each house implies the importance of each bedroom being equipped with a bathroom so that there is no interaction with other room occupants. So far, middle-low housing uses the shared bathroom to save on construction costs, but with this pandemic and home quarantine, each bedroom has necessarily equipped a bathroom to prevent contamination with other residents. In addition, the bathroom outside is essential, which functions as a place for bathing and washing hands before entering the house.

3.4 Ventilation Improvement

The high spread of COVID-19 indoors has become the basis for improving the ventilation quality and occupants' circulation in the room. Virus droplets can stay in the air for hours [35], so good air circulation is needed to reduce the risk of infection in the room. So, it is necessary to increase natural ventilation, use windows that can be controlled automatically, and arrange a wider circulation area to reduce direct contact. Scientists warn that contact surface contamination is another way for some viruses to spread between humans [36]. Thus, new technological innovations are needed to use "touch-free" systems such as automatic doors, hands-free light switches and air conditioner remotes, antibacterial fabrics and coatings, and sound-activated elevator design [27].

According to Yuliana, [37] “engineering adaptation” is also one effort to prevent the covid-19 virus spread; installing barriers or partitions between workers and guests, between co-workers who are next to or opposite each other. Generally, this glass barrier is used in office buildings that serve the community a lot, such as banks, licensing offices, tax offices, Etc. Based on observations in office buildings in Indonesia, this glass barrier system is widely installed as a room partition to avoid direct contact with other people, so this can be the basis for future room design considerations.

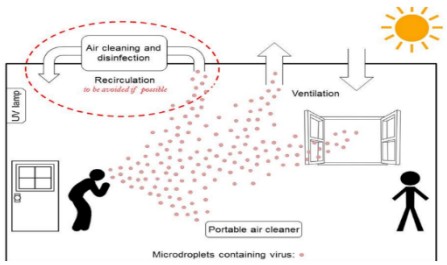

Fig 1. Illustration of Covid-19 Ventilation System. (Source: Covaci, 2020)

Covaci [38] recommends several strategy air circulation systems to reduce the risk of COVID-19: (1) Ensure that room managers, hospital administrators, and infection control teams know that maximizing a good room ventilation system is a way to control and reduce the risk of COVID-19 infection, (2) Improve existing ventilation by improving air inlets to increase the speed and effectiveness of natural ventilation, (3) Prevents indoor air recirculation by increasing fresh air circulation from outside, (4) Added a portable air cleaner equipped with a mechanical filtration system to catch microdroplets, (5) Prevent crowds and maintain social distancing (Fig. 1).

3.5 Interior Adaptation

The COVID-19 pandemic has forced most of the population to be trapped in their homes, trying hard to change their space to meet multiple needs: relaxation, work, physical activity, study, Etc. Inadvertently, the house is demanded flexibility and adaptability [39]. A fast and robust internet connection is vital in designing and constructing smart homes and creating the necessary comfort for living. It meets the different needs of the new household realities, especially the ability to work and study from home while being isolated for long periods [40].

Working from home is becoming a daily activity for many employees as companies are forced to switch to remote work. For most companies, this is the first time they experience collaboration, operation, and online communication from home via virtual communication technology [41-42]. The main challenges faced during the lockdown and working from home are staying organized, time management, collaboration, and social interaction [43]. The proper arrangement of the workspace at home will be more considered during the pandemic and in the future. The organization of the rooms and the layout of the house will change. Work areas will be segregated, including comfortable furniture, large windows, and blackout curtains. Good technical equipment and sound insulation will be essential features of a comfortable workplace at home [44-45].

Before the pandemic, open living rooms were trendy, but during the pandemic, the function of the living room underwent a significant change due to restrictions on social interaction; even many living rooms were converted to study rooms and work online. In addition, an open living room that is directly connected to the family room and access to the kitchen was popular before the pandemic, but now a private room is more needed to limit interactions at home, especially during self-quarantine. According to [46], many people find it difficult to find private space when the whole family is at home. So that in the future, privacy considerations are essential for realizing the comfort and health of residents.

Changes in building standards post-covid-19 will require a multidisciplinary approach. Significant changes expected to occur in building design include greener spaces, better ventilation and air intimacy,

improved water and wastewater management, introduction of touchless technologies and antimicrobial materials, better solid-waste management, social distancing within the home, and lightweight architecture and flexible building designs.

4 Conclusion

The COVID-19 pandemic has caused changes in various aspects, including in the fields of buildings. The COVID-19 pandemic has forced most residents to stay at home; they try hard to change their space to meet various needs such as relaxation, work, physical activity, study, etc. Thus, building requirements must be adapted to the new realities of the COVID-19 pandemic. The study results show that indoor activities are closely related to the virus spreading risk, so a pandemic-responsive design strategy is needed to reduce the risk of infection. It is necessary to develop an air ventilation system that can inhibit virus transmission, changes in spatial planning and circulation patterns to reduce the risk of transmission, and the selection of building materials that can inhibit the transmission process. Therefore, the current building design must consider architectural and interior design rules that can adapt to the lifestyle of the post-pandemic society, and the health aspect must be an essential consideration in a post-pandemic sustainable development strategy.

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