Houses amid COVID-19: Environmental challenges and design adaptation

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Abstract. Pandemics recur every 30 to 40 years. Every pandemic that has ever occurred brings changes in architectural design. This study conducts a literature study of the effect of pandemics on adaptation of the design of the artificial environment. Particularly the influence of the Covid-19 pandemic on changes in human behavior and its adaptation to residential architectural designs. In this paper, a qualitative approach with descriptive analysis methods is used to get a deep and a very basic understanding based on the problem being observed. The uncertain conditions of the Covid-19 pandemic have resulted in humans realizing that they cannot avoid the spread of this virus, so that a new environment and lifestyle are formed to live with this virus in a better way. During Covid-19, a house must adapt so it can effectively protect its residents from infectious diseases and facilitate all activities that were previously carried out outside the house. Some of the adaptations needed for residential design during this pandemic are in: housing characteristics; housing layout; interior, building material and furniture; natural lighting and indoor air quality; exterior, outdoor, and landscape; and value.

1. Introduction
Based on history, pandemics recur every 30 to 40 years. Each pandemic has a different impact and response. The design of buildings and cities has always been affected by the fear of infectious diseases. The Black Death pandemic caused by cholera in 1334-1350 introduced the concept of quarantine for the first time [1]. Quarantine buildings built at that time were called Lazarett. Lazarett serves both as a medical treatment center and a quarantine facility for new arrivals from plague-infested regions [2]. Not only introducing the concept of quarantine, but cholera also encourages a better waste disposal system which needs straight and wide roads. At that time a policy emerged to prevent overcrowding [3].

Unlike the Black Death pandemic, the quarantine building during the tuberculosis pandemic was called a Sanatorium [4]. At that time, good air flow and exposure to sunlight was one way of treating tuberculosis. This led to major changes in the design of buildings in that era [5]. The results of the artificial environment make humans form a new environment. The tuberculosis pandemic coincided with the industrial revolution. Fabricated materials allowed the Sanatorium to be built with long walls and wide windows filling the facade so that sunlight and air flow could enter the building properly [6].
In this era, the design of balconies and terraces the house emerged, followed by the use of ceramics for hygienic bathrooms, and the use of mid-century recliner chairs everywhere [7]. The tuberculosis pandemic has made people aware of the importance of living side by side with the environment to recover from disease. Architecture is even considered a cure for the disease itself [8].

The Covid-19 pandemic is very different from previous pandemics. Technological developments allow humans to have high mobility so that disease transmission becomes very fast and unstoppable. The corona virus, as the cause of the Covid-19 disease, has continued to mutate since Covid-19 was declared a pandemic [9]. Different countries have responded to the COVID-19 pandemic in different ways. China, as the first country to report this virus, responded to it by providing special facilities for the Covid-19 disease. All facilities, such as school buildings, hotels and sports buildings, have been converted into temporary quarantine places. Various policies were issued to suppress the spread of Covid-19, including lockdown, social distancing, use of masks, implementation of health protocols, restrictions on outdoor activities, and stay at home [5]. This digital era is able to supports this situation, as many activities can now be carried out remotely, such as Work from Home (WFH) and School from Home (SFH). The house that was previously prioritized as a place to live and rest has immediately become a place for many activities. A large number of people infected with Covid-19 have overload the capacity of hospitals and quarantine facilities, so homes must also act as places of self-isolation. In the end, the changing living style and uncertain conditions at this time made people realize that the only way to survive is by adapting to the Covid-19 disease or even other infectious diseases in the future. What is needed are more infectious disease-friendly building designs.

This paper aims to conduct a literature study of the effect of pandemics on adaptation of the design of the artificial environment. Particularly the influence of the Covid-19 pandemic on changes in human behavior and its adaptation to residential architectural designs.

2. Material and methods

2.1. Research methodology

This paper uses a qualitative approach with descriptive analysis methods. The author begins this study by formulating the main problem in a set of questions (research questions), then proceeds to collect data through literature study. The data obtained are then compiled and processed, so that conclusions can be developed to answer those questions. This approach is used to get a deep and a very basic understanding based on the problem being observed. The research questions can be seen in Table 1.

| Scope | Research Question |
|-------|------------------|
| World Pandemic History | What other pandemics have happened in the past? |
| Health Issue | What is the impacts of health issue of covid-19 pandemic to the human behavior? |
| Nature Transformation amid Covid-19 | Is human response for Covid-19 transmission built new environment? |
| Covid-19 and new living style | What is new environment and new living style in Covid-19 pandemic? |
| Future Architecture | Could Covid-19 leverage building and urban sustainable design? |
| Post-pandemic housing | What is the future of our house? Shoud they adapt to accommodate workspaces and support study to our children? |

The research question for this study is the combination of research questions from two existing researches. Those researches are "Antivirus-built Environment: Lesson learned from Covid-19 Pandemic" conducted by Naagla A. Megahed, et al (2020) and "Covid-19 Could Leverage a Sustainable Built Environment” conducted by Manuel Duarte, et al (2020). In contrast to the two
previous studies, the author focuses this research on adaptation of residential design due to changes in the environment and human behavior during the Covid-19 pandemic.

2.2. Research materials
2.2.1. Historical pandemic

Historically, pandemics have always had an impact on architecture. In other words, Architecture is always shaped by infectious disease. Human fear of infectious diseases and the potential for infection transmission has led to the emergence of the artificial environment. Infectious disease has occurred since the Roman Empire in the second century [5]. In dealing with the outbreak, isolation tents were built close to hospitals, specifically for the infected. In addition, to improve living conditions at that time, a water and sanitation system was constructed which did not exist before. However, limited technology, knowledge, and resources make this solution not applicable worldwide [10].

The Black Death pandemic that caused cholera in the fourteenth century bequeathed the concept of “quarantine”. The word "quarantine" comes from Venice, "quarantena", which means 40 days. Cholera brought changes to the layout of the building. Spacing is required between buildings to prevent an unclean environment [5].

![Image of historical pandemic and its artificial environment](image.png)

**Figure 1.** Historical pandemic and its artificial environment.
The cholera pandemic brought major changes to the design of urban areas, while tuberculosis caused many changes to the design of buildings [5]. During the tuberculosis pandemic, the necessity for good sunlight and air flow is very much needed to treat the disease, so a building design with large and wide openings is necessary. The building is also expected to be clean so that ornaments are no longer used in that era. Villa Savoye, designed by Le Corbusier in the Modern era, placed a sink in the middle of the house and also separated the space between the general and special parts of the house layout as a response to the tuberculosis pandemic at that time [11]. Pandemics always create new environments that provide shifts or changes in architecture, urban, and building design [Figure 1].

2.2.2. Covid-19 and environmental issue
Corona virus was first identified in 1965 by DA Tyrrell and ML Bynoe, researchers from England, and it keeps mutating. In 2002, the coronavirus mutated causing SARS (Severe Acute Respiratory Syndrome). In late 2012, the corona virus mutated again and caused MERS (Middle East Respiratory Syndrome). In late 2019, the corona virus reappeared and caused Coronavirus Disease (Covid-19) [12].

Covid-19 can spread through airborne and droplets when the sufferer exhales or performs activities such as talking, sneezing, laughing, and so forth. Droplets and particles produced will be dispersed in the air and are in spaces or room and can accumulate [13]. This corona virus also stays on materials and surfaces [10], so that other people can be infected when they are in a room where the virus is floating or holding surfaces where droplets are still present. Symptoms caused by the corona virus is varied, ranging from mild, moderate, severe symptoms, and even death, but the rate of recovery is higher when the sufferer is in a healthy environment. Covid-19 can even be cured with home treatments [1], so adaptation of home designs is necessary during Covid-19. This adaptation not only increases the chances of recovery from the patient, but can also reduce the spread of the disease [13].

The Covid19 pandemic has also caused many artificial environments [5]. The digital era has pushed for significant changes compared to pandemics that have occurred before. People now has the ability to work and study while staying at home [6]. However, when there is a necessity to leave the house, everyone is required to wear a mask, maintain a distance between individuals of at least 1 meter, and wash hands regularly to prevent the transmission of Covid-19 [14]. If infected with Covid-19, one is required to self-isolate at home for at least 14 days by observing the symptoms of the disease. Moderate to severe symptoms require medical treatment, but asymptomatic to moderate symptoms can be treated at home [15]. WHO recommends that homes have good ventilation and air circulation. During quarantine, COVID-19 sufferers must be in a different room from other family members in order to prevent the transmission. The isolation room is required to have good sanitation and outdoor access [14].

2.2.3. Problems and challenges
Covid-19 forced people to spend most of their time at home because of fears of transmitting the disease. Likewise, when infected, there is an obligation to self-isolate for a certain period of time [15]. Covid-19 isn't simply a health crisis, it is also a design problem. Covid-19 has changed many things, especially residential design. Currently, the house has become an office, school, restaurant, playground, place for sports, quarantine place, and many more [16]. Home is expected to be a place that supports many activities every time and every day.

Unexpected changes during the Covid-19 pandemic not only create challenges for people, but also become an opportunity to review every choice and priority. Infectious diseases have an impact on physical spaces. Human needs also have an impact on the planning process and changes in design. Advances in technology add to the challenges in this process, but can also provide innovative solutions to support new environments.

2.2.4. New living style and future architecture
All the characters, changes, and impacts of Covid-19 certainly produce a new environment and lifestyle. Unexpected conditions during the pandemic require us to be able to live side by side with the pandemic. Architecture can help us adapt to a pandemic [17]. Besides rethinking house building, the
design must also consider how to control the pandemic and has a sustainable design for the future. For example, by providing homes that focus on health and hygiene, setting new home quality standards, having outdoor design priorities, and multipurpose rooms [16].

3. Results and discussion
The house needed during Covid-19 is a house that can effectively protect itself from infectious diseases and facilitate all activities that were previously carried out outside the house [10]. The house must have a suitable and healthy design. Some of the adaptations to residential design during the pandemic are as follows:

3.1. Housing characteristics
Previously, houses were only used as a place to rest after being tired of doing activities outside, but the pandemic has once again placed the house in a special place and put it under the spotlight [2]. The larger the house with all its contents and occupants, the greater the possibility of bringing the virus into the house [18]. Therefore, the essential characteristics of a healthy home are needed, that is a house which has superior indoor air, water, and lighting quality, a house with energy and resource efficiency, affordability, and environmental responsibility [19].

3.2. Housing layout
Spaces whose existence suddenly emerged during the pandemic are space for work and study, because of the urgent need to stay at home, work from home, and school from home [19]. The house must be transformed to provide this space and made closed to avoid interference from outside. A special room that can be used as an independent isolation room when someone in the house is infected is also needed. The room must have a good indoor air quality and natural lighting. In addition, isolation room must be facilitated with in room bathrooms and has access to the outdoors to get sunlight which is useful for increasing sufferer’s immunity. Outdoors access will also prevents sufferers feeling bored in an enclosed space during self-isolation. Furthermore, there is a need for new spaces such as a sanitation room where one can clean himself before entering the house to avoid viruses getting into the house. This space can be a bathroom or a sink that can be used by residents of the house or by guests.

The digital era makes it easier for people to order goods, food, and drinks through online shopping, so a temporary stop is needed before goods are brought into the house to prevent infection and to do disinfecting, both naturally and artificially.

The layout of the house during the Covid-19 pandemic also requires partitions in a room. One of the alternative that can be used is sliding panels, which can be opened and closed as needed [20]. This is different from the previous house concept, which was mostly open-plan spaces. The houses during the pandemic should have wider doorways and corridors, as a physical distancing effort. Finally, in order for the house to be more sustainable in the future, the design of the house must be adaptable and flexible, so that it can adapt when there is a change in needs and lifestyles in the future [21].

3.3. Interior, building material and furniture
The home materials and furniture selected to used during the Covid-19 pandemic should be hygienic and anti-bacterial materials that can be easily cleaned, to prevent any place from becoming a source of infection when touched by others [10]. Certain materials can also shorten the lifetime of the corona virus attached to its surface [3], such as Cooper [5]. The choice of interior design must be done very carefully because it is most likely to cause the spread of the virus and make the virus stay. Being indoor where the environment is not good and ventilation with outside air is inadequate will increase the risk of disease infection [13]. The selection of furniture that can be used for example is hands-free door opening. It is necessary to avoid materials that can make the virus stay for a long time such as wood, carpets, rugs, and fabric sofas, and choosing furniture that is easy to clean. Materials and home
furniture simply adjust to the needs, so that the furniture in the house in the future will be minimal or limited. The use of bright and clean colors will also become a trend again to reflect hygiene.

3.4. Natural lighting and indoor air quality
Natural lighting affects the lifetime of the corona virus. Sunlight can make corona virus inactivate on surfaces rapidly and can be a natural disinfectant for materials contaminated with the virus [22]. Relative humidity to 40-60% and air conditioning (HVAC) system, can influence virus activity [10]. It can impact all potential spread virus in the airborne. Improving ventilation system by ensuring 100% separation between intake and exhaust air, is indispensable as the main strategy in suppressing the spread of the virus inside the house. Type of heating with proper placement can make the virus does not settle on the surface of the material in the house therefore can suppress the spread of the virus [13].

3.5. Exterior, outdoor, and landscape
Prior to the Covid-19 pandemic, gardens and exterior landscapes were considered luxurious spaces [23], but the pandemic has made them essential [24]. Outdoor spaces turn into usable places, such as a place for sunbathing to get sunlight, a place for fitness and relaxation, a place for working and studying, and a multi-functional garden for hobbies or even for growing food-producing plant. Garden and green outdoor can reduce stress and anxiety, increase motivation and positive thoughts that are needed by the body to boost immunity. Balconies will be used again and humans will spend some of their time outdoors. Therefore, outdoor design becomes the main focus in the home landscape during the pandemic [23]. The exterior design of the house must support its interior design to create a good environment, inside and outside the house.

3.6. Value of the house
Pandemic makes people aware that everything has a value. The question is what is the value of our house? The house should provide shelter and comfortability for its residents in doing their activities. The design of the house and being in it will be different when the house has value. The circular design concept can be an option, where there is a continuous cycle of use and re-use, creation and re-creation. People must be responsible for the design, material selection, construction process, and life of the building where they lived [25]. The house not only must be comfortable for its users, but also must provide comfort for the neighborhood and environment [26]. The use of local products, low cost wasteful production, and houses with minimal energy consumption can also be an option in making a comfortable home.

4. Conclusion
Every pandemic that has ever occurred in the world brings changes in architectural design, as well as the Covid-19 pandemic. Unlike the previous pandemics, the era of globalization and digitalization has caused the spread of viruses that cannot be prevented. The uncertain conditions of the Covid-19 pandemic have resulted in humans realizing that they cannot avoid the spread of this virus, so that a new environment and lifestyle are formed to live with this virus in a better way, for example by using masks, physical distancing, and staying at home. Covid-19 causes most people to stay at home. What if this is not temporary but forever?

The house that was previously prioritized as a place to live and rest has immediately become a place for many activities. The better digital era also supports activities that can be carried out remotely, such as work, study, selling, and shopping. These new activities certainly change the design concept and layout of the previous house. The house must also have good indoor air quality and natural lighting so that the virus does not settle in the house. Moreover, the pandemic realizes that everything must have value, and the value of the house is to become an inseparable unit between building users, neighborhoods, and their environment.
The concept of house is expected not only as a house that is responsive to the pandemic, but also as a house that is adaptable and flexible in all eras and conditions. This research is expected to be a guide in designing sustainable homes, both during the pandemic or post-pandemic.

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