DOI: https://doi.org/10.54338/27382656-2022.2-007

Rizka Tiara Maharani[1*], *Dominikus* Aditya Fitriyanto[1]

[1] *Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, Indonesia*

BIOPHILIC DESIGN TO ENHANCE RESIDENCE COMFORT IN COVID ERA

Because of the COVID-19 pandemic, human mobility is limited, and many activities, such as work or school, are relegated to the home, including for apartment residents. As a result, this condition causes unpleasant feelings, which lead to a decline in physical and mental health. The solution from this is to improve room quality inside a limited area of apartment units using a biophilic design approach in order to create a comfortable living space for residents in a pandemic era. This research aims to critically review journals that can help architects or researchers study the ideal apartment design in the pandemic era. The anticipated outcome is the creation of opening and layout criteria that can add comfortable living for residence in a unit apartment at the same time, making it ideal to be applied. Air circulation and sun exposure are used to evaluate the opening, while room position and unit orientation are being used to assess the layout.

***Keywords**: apartment, biophilic, comfort, Covid-19, housing.*

Introduction

Pandemic COVID-19 has changed habits, lifestyles, and regulations for people in the world. This case makes every human have limitations in mobile, activities, working, school, and everything else to be done at home. So, it makes a very big change in every layer of life and has the possibility for people to get fatigued either physically or mentally due to this condition including people who lived in apartments.

Limited spaces and inadequate rooms in apartments have their own challenge to make them comfortable. People's health will receive support from exposure to nature, the sun, and fresh air [1,2]. Aside from that, preventing virus spread may be the most important thing for people today. The apartment has a sharing system, such as ducting, shafts, or corridors, which has the potential to spread the virus [3]. From this standpoint, there is a need to adjust the existing design of apartment units which already have limited space to increase their resilience towards the COVID-19 pandemic and make it comfortable for its residents at the same time. There are several strategies for solving this problem through analysis of both biophilic principles and covid-19 health protocols strategies.

This study focuses on knowing the best criteria of apartment design for facing the COVID-19 pandemic and improving the resident's comfort through biophilic theories. Biophilic was chosen because it will aid in environmental healing and performance improvement from a natural standpoint [4]. Biophilic also provides humans with a sense of comfort, calm, and healing effects on a needed dwelling [5]. As a result, it is critical for assisting people in their homes to feel happy in their daily life routine during the pandemic era. In addition, the novelty of this research is finding the design criteria of housing, especially unit apartments in the pandemic era through biophilic design in order to improve physical and mental health.

Materials and Methods

The design thinking in Fig. 1 began with a problem of limited mobility and regulation in a pandemic area and evolved into a design problem of limited space and inadequate room quality in an apartment. As a result, the design approach is to improve room quality through biophilic design using a literature review method to achieve the goal of design criteria for apartment units based on a biophilic approach in a pandemic area. Moreover, the strategy for searching the literature is to use the ScienceDirect and Google Scholar databases. The following search terms appear in the article title, abstract, or keywords: "apartment", "covid-19", "biophilic", "comfort", and "housing" with combinations like "layout" and "opening".

The next step is to screen titles and abstracts from dozens of journals that have been collected in Zotero and discussed in order to develop a strategy for extracting them into design criteria that can be used in future design strategies. The following questions were used to determine the review criteria: 1. How to make the right opening for air circulation and sun exposure in the apartment unit, 2. How to make a good position of room in apartment unit layout, 3. How to put the green area in the right place in an apartment unit.

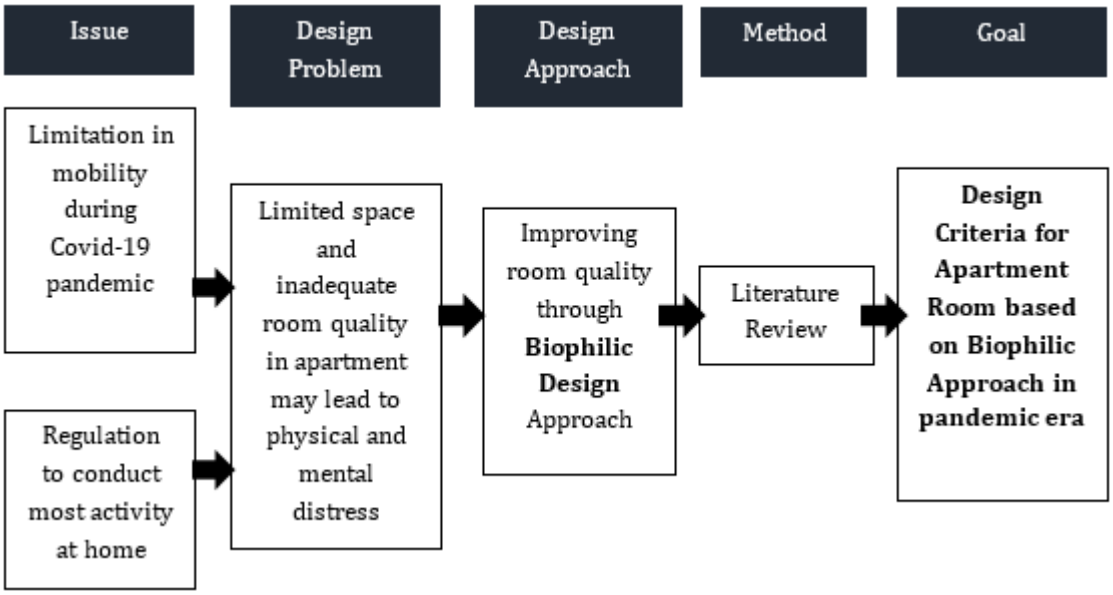


Fig. 1. *Design Thinking*

Results and Discussion

Covid-19 Health Protocol in Housing and Residential

Health protocol has become a new way of life in the world. It also occurred in housing and residential areas as a result of all the activities to be done at home. As a result, through passive design strategies, our housing and residential, including unit apartments, should adapt to this new habit. Priority design strategies should relate to connection to nature, daylight, and fresh air, such as openings for view and air circulation, daylighting, wet area placement, access to nature, and unit size or layouts that allow for physical distancing [2,6,7]. Furthermore, in housing design, there should be a separation between the uncontrollable external world and the internal personal universe that is illustrated in Fig. 2 [8]. It happened because people from outside have the potential to bring the virus or bacteria with them. As a result, they must clean their bodies before entering the living space and meeting the other families in the house.

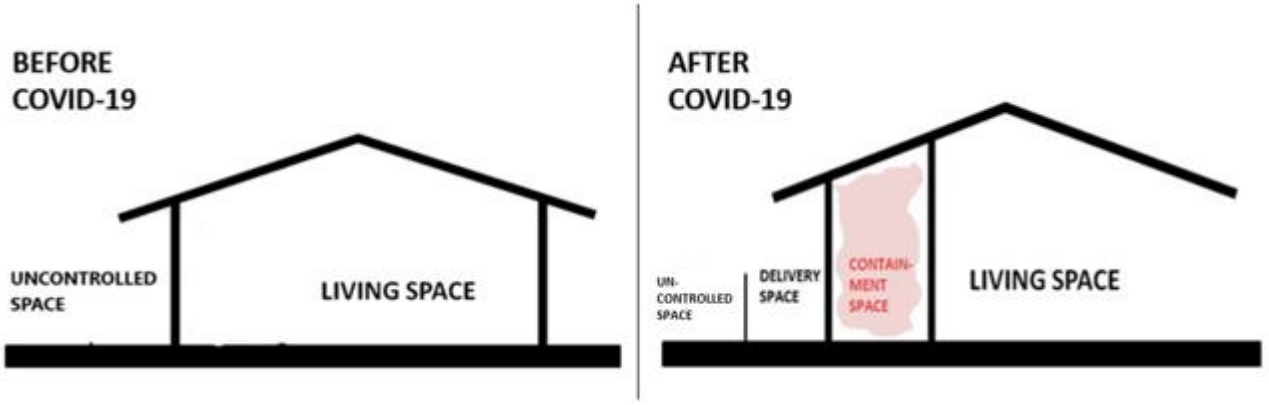


Fig. 2. *Separation Space in Between Uncontrolled Space into Living Space (Source: Spennemann, 2021)*

Unlike a landed house, an apartment is a vertical house in which there are many sharing facilities like public areas or MEP shafts. For a public area like a pool, garden, corridor, or stair, the building management can add the signage for making physical distancing through coloring codes as a marker element or put the water sink to be used to hand wash before entering the area [9]. Then, the MEP shaft is a critical point because even the dwellers don't meet each other in the building but virus can spread through the vertical shaft [3]. So, in the pandemic era, apartments should minimize the sharing vertical shaft system. Each unit should have its own system for reducing the virus spread.

Biophilic Design

Some of the health protocols for covid-19 prevention, such as providing good air circulation, natural ventilation, exposure to daylight, and connection to natural elements, have strong similarities with the Biophilic Design approach. There are several human-nature relationship theories that are related to Biophilic Design, one of them is Attention Restoration Theory. The aforementioned theory discusses that restorative settings contain features that hold their attention with little effort and restores their ability to concentrate, removing an individual from their daily tasks and allowing them to recover from stress [10]. To reach a successful application of biophilic design it is required to follow certain basic principles. They represent and include fundamental conditions for the effectiveness of biophilic design applications [11]. Those principles are:

1. Biophilic design emphasizes continuous and sustained connection with nature,
2. Focuses on human adaptations to their environment that progressively enhanced people's wellbeing over time,
3. Encourages the emotional bonds and sense of places to specific settings and places,
4. Embraces positive bonds between people and nature that heighten an extended sense of responsibility for the communities and correlated nature,
5. Strengthens mutual interconnection and integration with architectural solutions.

The embodiment of those principles can be found in the 14 patterns of biophilic design. The correlation between biophilic design principles and design patterns can be reached through those relationships as shown in Fig. 3. In the first principle, the relationship with nature can be done by making visual, non-visual, natural systems, and material connections with nature. The second principle for helping human adaptation to the environment can be achieved through providing non-rhythmic sensory stimuli, thermal and airflow variability, and dynamic and diffuse light. Third, emotional bonds and a sense of place can be encouraged by prospect and refuge. Fourth, positive bonds between people and nature through the presence of water, connection with the natural system, and also complexity and order. Last, to strengthen mutual interconnection and integration with architectural solutions is regarding prospect, refuge, mystery, risk/peril. With understanding the correlation, the architect can design the green wall, natural textured material, shadow reflection, daylight, water reflection or etc regarding biophilic design patterns. So, people can have a different experience if they do an activity in a biophilic space.

These patterns are then classified into three categories which are *natural in the space*, *natural analogs*, and *nature of the space* (Table 1). Nature in the space experience can be achieved by creating meaningful and direct links with natural elements, particularly through variative and multi-sensory interactions. Natural Analogues addresses organic, non-living, and indirect evocations of nature. Objects, materials, colors, shapes, sequences, and patterns found in nature, manifest as artwork, ornamentation, furniture, décor, and textiles in the built environment. The nature of space practices is accomplished by the creation of deliberate and engaging spatial configurations mixed with patterns of nature in space and natural analogs.

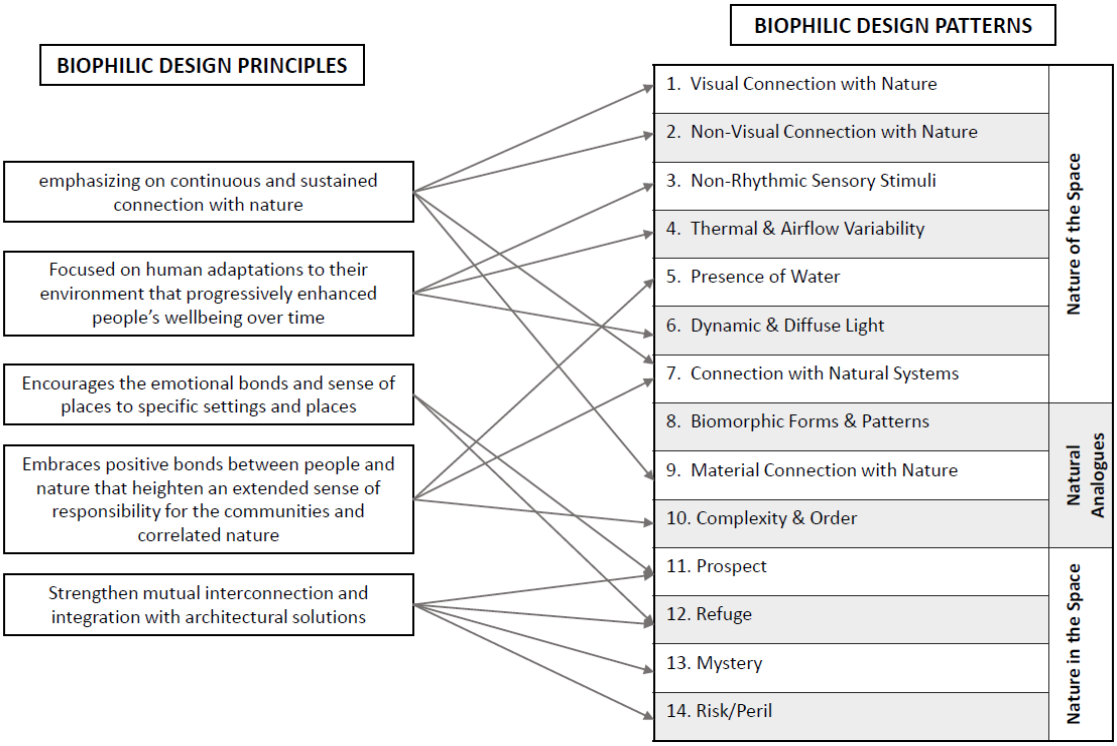


Fig. 3. *The embodiment of Biophilic Design Principles into Biophilic Design Patterns (Source: Author, 2022)*

Successful implementation of biophilic design is also expected to result in a wide range of physical, mental, and behavioral benefits. Physical outcomes include better physical fitness, lower blood pressure, greater comfort and satisfaction, fewer disease symptoms, and better health. The mental benefits range from greater satisfaction and motivation, less stress and anxiety, to better problem-solving and creative thinking. The positive behavioral change includes improved coping and mastery, increased attention and concentration, better social interaction, and less hostility and aggressiveness.

Table 1. Patterns of Biophilic Design

1. Visual Connection with Nature: view to elements of nature, living systems, and natural processes	8. Biomorphic Forms & Patterns: symbolic references to contoured, patterned, textured, or numerical arrangements that persist in nature	11. Prospect: unimpeded view over a distance for surveillance and planning
2. Non-Visual Connection with Nature: auditory, haptic, olfactory, or gustatory stimuli that refer to nature	9. Material Connection with Nature: using raw to minimum treated elements to show local ecology and create a distinction of space	12. Refuge: place in which the individual feels safe and protected, a withdrawal from environmental conditions
3. Non-Rhythmic Sensory Stimuli: Habitat, rainwater	10. Complexity & Order: rich sensory information that resembles a natural spatial hierarchy	13. Mystery: partially obscured views or other sensory devices that attract persons to explore further
4. Thermal & Airflow Variability: moderate levels of sensory variability in the environment		

5. Presence of Water: enhancing experience of a place by seeing, hearing, or touching the water		
6. Dynamic & Diffuse Light: variation of light and shadow intensities that change over time as it happens in natural settings		
7. Connection with Natural Systems: awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem		

Source: Author, 2022

Design Criteria for Apartment Units

Implementation of biophilic design principles and covid-19 prevention in the design of apartment units needs more concrete and measurable steps. The first step is to filter the biophilic design patterns that will be utilized based on the suitability of application in the context of apartment units. Based on the analysis in Table 2, there are eight biophilic design patterns that are suitable for covid-19 health protocols analysis. Thermal and airflow variability is related to opening presence both for daylight and fresh air and also independent ventilation system in each unit apartment. Visual connection with nature and connection with the natural system is correlated with opening for daylight, fresh air, and view indirectly. In non-visual connection with nature, daylight is not considered but the opening is important to enter the fresh air. Last, biomorphic forms and patterns, material connection with nature, and refuge can relate to space partition design in containment space. Selected patterns are then applied to the design through the help of proposed design criteria.

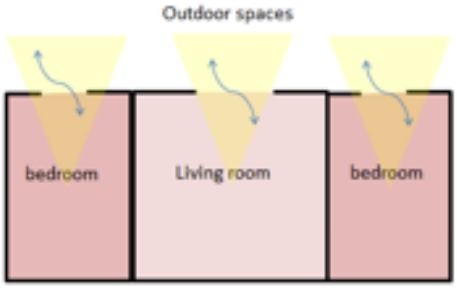
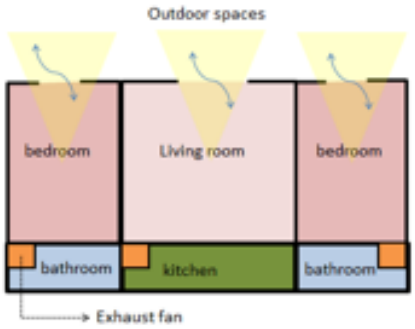
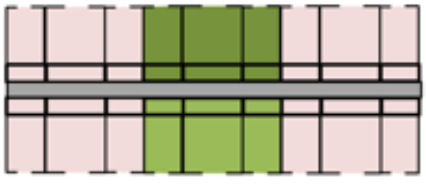
Table 2. The Correlation Between Biophilic Design pattern with COVID-19 Health Protocols

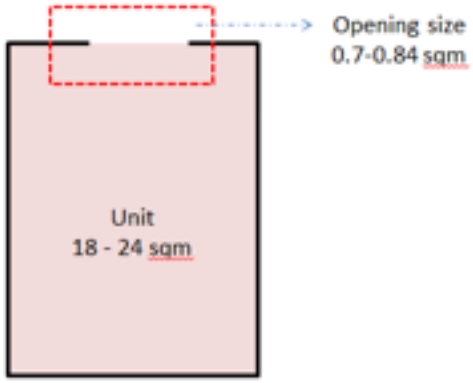
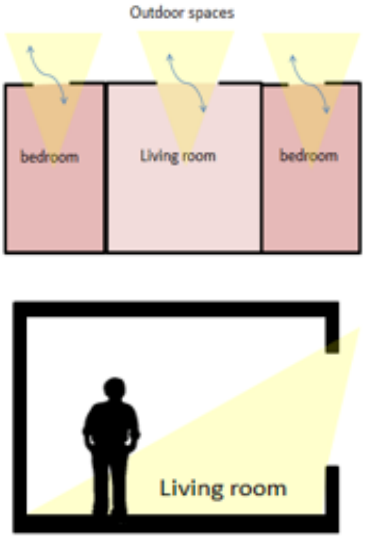
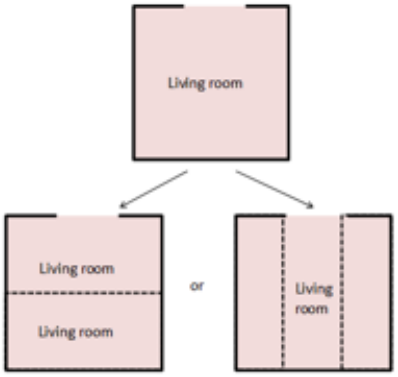
Biophilic Design Pattern		**COVID-19 Health Protocols**			
		Opening for daylight	Opening for fresh air	Space Partition	Independent Ventilation System
1.	Visual Connection with Nature	V	V	-	-
2.	Non-Visual Connection with Nature	-	V	-	-
3.	Non-Rhythmic Sensory Stimuli	-	-	-	-
4.	Thermal & Airflow Variability	V	V	-	V
5.	Presence of Water	-	-	-	-
6.	Dynamic & Diffuse Light	V	-	-	-
7.	Connection with Natural Systems	V	V	-	-
8.	Biomorphic Forms & Patterns	-	-	V	-
9.	Material Connection with Nature	-	-	V	-
10.	Complexity & Order	-	-	-	-
11.	Prospect	-	-	-	-
12.	Refuge	-	-	V	-
13.	Mystery	-	-	-	-
14.	Risk/Peril	-	-	-	-

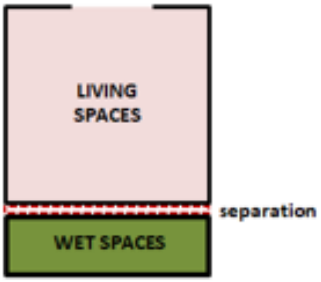
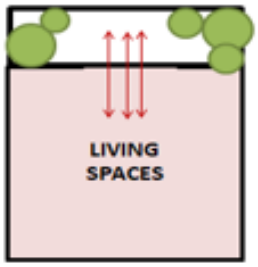
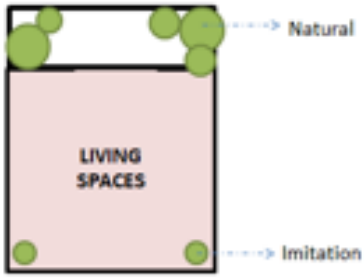
The design criteria for apartment units are created by reviewing many journal articles in order to determine several aspects, such as the facade/window opening, layout configuration, and presence of green spaces. All

three are needed because they can make the design that refers to biophilic design principles as mentioned before and also health protocols during pandemic covid-19. Table 3 is the reference synthesis that can be used for a proposed design.

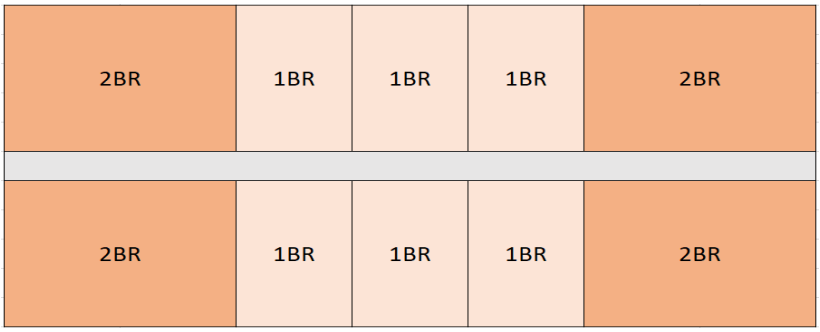
Table 3. Reference findings and synthesis

No	Findings	Reference	Proposed Design Criteria
	A. Façade/Window Opening		
1.	The use of daylight in the workplace showed the possibility of reducing the feeling of fatigue. It is interesting to note that although the presence of greenery has an impact on the subjective perception of drowsiness, physiological tests indicate that the presence of daylight has an objective impact on the reduction in drowsiness. Daylight is needed to refer to biophilic design patterns such as visual connection with nature, thermal and airflow variability, dynamic and diffuse light, connection with natural systems. Daylight is also in COVID-19 health protocols necessary.	[4]	Providing sufficient windows and openings which allow daylight to reach the work/study that make shadow reflection and also natural light in the room. Through daylight, the room will keep the humidity so that it avoids virus accumulation. 
2.	Natural ventilation through window openings is preferable to mechanical ventilation. It will allow changes in air and daylight to enter the house. The room should have a high humidity level so that viruses and particles do not stick to it. If there are some rooms with mechanical systems, they should have speed exchanges so the air can change quickly (covid-19 health protocols). Natural ventilation is also needed in biophilic design patterns in visual connection with nature, non-visual connection with nature, thermal and airflow variability, connection with natural systems.	[12-14, 2]	Providing natural ventilation and window opening in work/study/bedroom/living area and mechanical system with the exhaust in bathroom or kitchen. Opening in a room also changes the air process and makes a room healthier. 
3.	Natural ventilation in a tropical climate is considered pleasant when the opening faces north or south and the flow of air indoors varies between 0.6-1.2 m/s. Natural ventilation is needed in biophilic design patterns and also in covid-19 health protocols.	[15]	The layout of the building should optimize the north-south orientation. If not possible, some design treatment should be applied to avoid direct exposure to east-west sunlight. 

4.	The minimum value of Air Change per Hour (ACH) to reduce virus spread via aerosol ranged between 0.5-1.0 $ACH = (Q/V)*3600$ V: room volume (m^3) Q: natural ventilation value (m^3/s) $Q = 0.025*A*v$ A: opening area (m^2), v: velocity at opening (m/s) 0.025: multiplying factor (constant) The opening is needed in covid-19 health protocols for making an independent ventilation system for each unit apartment that is related to airflow variability in the biophilic design pattern.	[15]	Required opening size between 0.7-0.84 m^2 for a unit with a floor area 18-24 m^2 (common size for studio unit) 
	B. Layout Configuration		
1.	The use of daylight in the workplace showed the possibility of reducing the feeling of fatigue. It is interesting to note that although the presence of greenery has an impact on the subjective perception of drowsiness, physiological tests indicate that the presence of daylight has an objective impact on the reduction in drowsiness (biophilic design pattern). As mentioned before, daylight is also needed in covid-19 health protocols.	[4]	The layout arrangement should locate the work/study area as such to receive proper daylight 
2.	People are forced to stay at home due to the lockdown regulation. As a result, all activities will take place in the house, altering each family member's privacy (covid-19 health protocols). To bring connection with nature, the room should be considered with biomorphic form and patterns, material connection with nature, and refuge.	[7,14,16]	The living room should adapt to this condition in order to create a flexible room with element nature material. 

3.	To prevent the virus from spreading, the WHO recommends separate sanitation. Furthermore, a buffer or containment space between the uncontrollable external world and the internal personal universe must be established (covid-19 health protocols). To bring connection with nature, a separate room should be considered with biomorphic form and patterns, material connection with nature, and refuge.	[8,14]	The housing layout strategies should have a separate room for cleaning the body before entering the main live spaces in the house. In a separate room can apply the material that connect with nature and give a safe feel for people to clean their bodies from viruses that bring outside. 
4.	The room should have access to nature to assist people in treating their mental and physical health (biophilic design pattern). Opening for accessing the nature outside is needed for covid-19 health protocols due to daylight and fresh air requirement.	[2,7]	The live spaces should have direct access to the greenery area either balconies or vertical gardens. The opening is needed here for accessing the greenery, daylight, and fresh air. 
	C. Presence of Green Space and Natural Element		
1.	There is a decrease in stress levels and increased wakefulness in the afternoon with the presence of greenery (biophilic design pattern). As mentioned before, the opening is needed for accessing greenery and fresh air.	[4]	Locate greenery or green space either natural or imitation nearby work/study area. The opening is needed for accessing greenery outside and also for getting fresh air from outside. 
2.	Housing design strategies should prioritize more livable spaces with views of green space (biophilic design pattern). Greenery is also helping the fresh air requirement for helping fresh air supply in unit apartments (covid-19 health protocols).	[6]	The balconies can be used to put the natural green spaces. 
Source: Author, 2022			

The next step is an elaboration of synthesis of proposed design criteria into an easy-to-read guideline. The previous criteria, then simplified into the following notations: window/opening = A, layout configuration = B, and presence of green space = C. Come after each criterion are the number of proposed points in accordance with Table 3. The guideline can be seen in Fig. 3 for 1 BR and Fig. 4 for 2 BR. Furthermore, in the wet area, there is ducting for helping exchange air circulation in the wet area. The ducting system is made individually for each unit. This purpose is to avoid the virus spread which is vulnerable to occur if a sharing system is made.



Keyplan

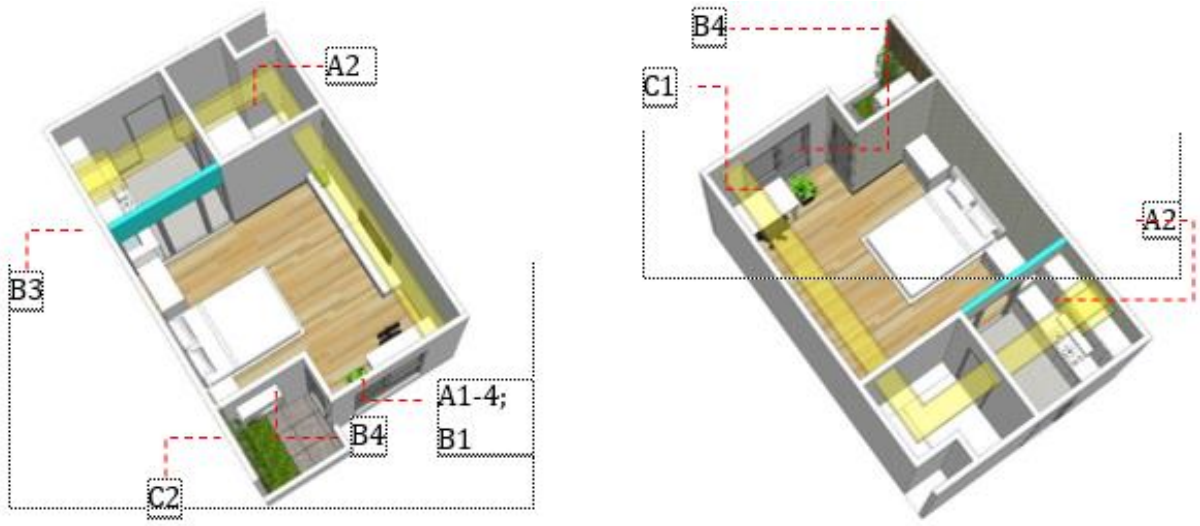


Fig. 3. *Guidelines for studio/1BR unit*

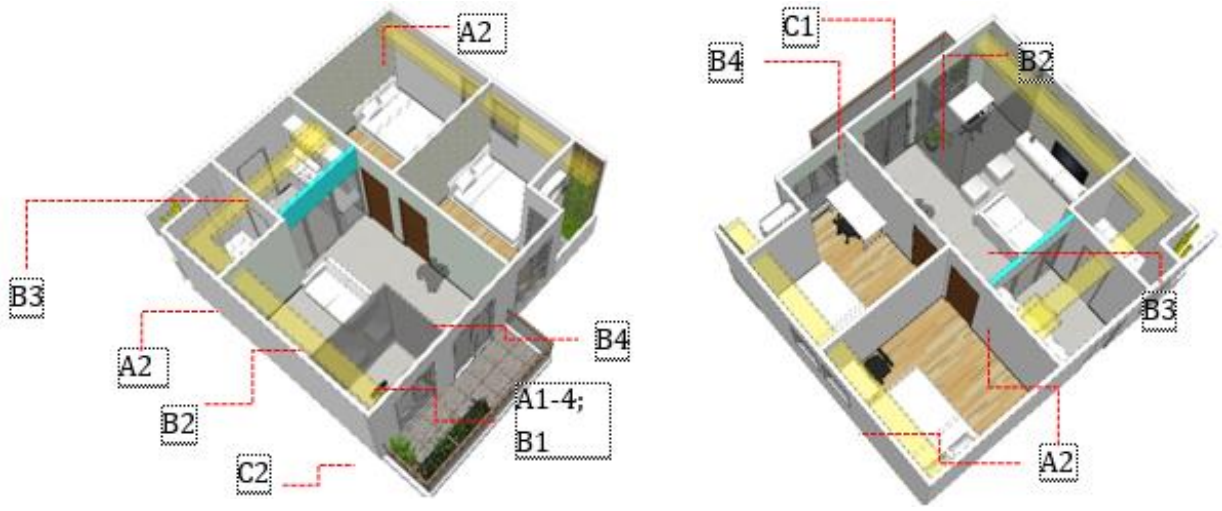


Fig. 4. *Guidelines for 2BR unit*

Conclusion

Pandemic covid-19 is unavoidable and will last for a long time. As a result, as a human, it is critical to co-exist and anticipate virus spread, including in the home. One way to deal with it is to arrange for a comfortable place to live. Furthermore, biophilic is used to improve the resilience of buildings, both physically and mentally. Here is the conclusion of the research literature that was conducted:

1. Openings for air circulation and natural light are essential. The air should change quickly, and sunlight should enter the living areas. This is to avoid the high humidity in the room, which can make viruses easily stick.
2. Because of the opening requirement, the layout room, particularly for lives and work, should be located to receive adequate daylight and natural light. Furthermore, the layout of the space must be flexible in order to meet the needs and privacy of all activities carried out at home.
3. Layout design necessitates the separation of wet and living spaces. The wet area is close to the door so that visitors from outside can easily clean their bodies before meeting the rest of the family in the house.
4. Existing greenery should be placed near living and working areas. During a stay at home, it is necessary to bring calm and refreshment to the surroundings. The possible space to put greenery is in the balcony or service ledge for the outdoor AC unit. Hence, the balcony becomes an indispensable feature to be provided in an apartment unit.

References

[1]. M.B. Andreucci, A. Loder, M. Brown, J.Brajković, Exploring Challenges and Opportunities of Biophilic Urban Design: Evidence from Research and Experimentation. Sustainability, 13 (8), 2021, 4323. DOI: https://doi.org/10.3390/su13084323

[2]. T. Peters, A. Halleran, How Our Homes Impact Our Health: Using a COVID-19 Informed Approach to Examine Urban Apartment Housing. Archnet-IJAR: International Journal of Architectural Research, 15 (1), 2020, 10-27. DOI: https://doi.org/10.1108/ARCH-08-2020-0159

[3]. S.E. Hwang, Possible Aerosol Transmission of COVID-19 Associated with an Outbreak in an Apartment in Seoul, South Korea, 2020. International Journal of Infectious Diseases, 4, 2021.

[4]. J. Ayuso Sanchez, T. Ikaga, S. Vega Sanchez, Quantitative Improvement in Workplace Performance through Biophilic Design: a Pilot Experiment Case Study. Energy and Buildings, 177, 2018, 316-328. DOI: https://doi.org/10.1016/j.enbuild.2018.07.065

[5]. Y.M. Ardiani, A.G. Prawata, A. Sholihin, Application of Biophilic Architecture in Apartment Design. IOP Conference Series: Earth and Environmental Science, 426, 2020, 012105. DOI: https://doi.org/10.1088/1755-1315/426/1/012105

[6]. A. Amerio, A. Brambilla, A. Morganti, A. Aguglia, D. Bianchi, F. Santi, L. Costantini, A. Odone, A. Costanza, C. Signorelli, G. Serafini, M. Amore, S. Capolongo, COVID-19 Lockdown: Housing Built Environment's Effects on Mental Health. International Journal of Environmental Research and Public Health, 17 (16), 2020, 5973. DOI: https://doi.org/10.3390/ijerph17165973

[7]. D. D'Alessandro, M. Gola, L. Appolloni, M. Dettori, G.M. Fara, A. Rebecchi, G. Settimo, S. Capolongo, COVID-19 and Living Space Challenge. Well-being and Public Health Recommendations for a Healthy, Safe, and Sustainable Housing. Acta Bio Medica Atenei Parmensis, 91 (9-S), 2020, 61-75. DOI: https://doi.org/10.23750/abm.v91i9-S.10115

[8]. D.H. Spennemann, Residential Architecture in a Post- Pandemic World: Implications of Covid-19 for New Construction and for Adapting Heritage Buildings. Journal of Green Building, 16 (1), 2021, 199-215. https://doi.org/10.3992/jgb.16.1.199

[9]. Y.K. Dewangga, S.Y. Amijaya, H. Viadolorosa, The Dynamics of Urban Public Space Perception in the New Normal Era. Journal of Architectural Research and Design Studies, 5 (1), 2021, 1-9. DOI: https://doi.org/10.20885/jars.vol5.iss1.art1

[10]. D. Stevanofska, Health-Promoting Multi Family House. A New Biophilic House Design in Gothenburg: Master thesis, Chalmers University of Technology, 2019.

[11]. S.R. Kellert, E. Calabrese, The Practice of Biophilic Design, 2015. DOI: https://www.biophilic-design.com/

[12]. R.K., Bhagat, M.S. Davies Wykes, S.B Dalziel, P.F. Linden, Effects of Ventilation on the Indoor Spread of COVID-19. Journal of Fluid Mechanics, 903, 2020, F1. DOI: https://doi.org/10.1017/jfm.2020.720

[13]. A. Ratnasari, I.S. Asharhani, Indoor Air Quality, Thermal Comfort And Ventilation Aspects as Reference on Housing Adaptation During Pandemic. Journal Arsitektur Arsir, 2021. DOI: https://jurnal.um-palembang.ac.id/arsir/article/view/3646

[14]. G. Tokazhanov, A. Tleuken, M. Guney, A. Turkyilmaz, F. Karaca, How is COVID-19 Experience Transforming Sustainability Requirements of Residential Buildings? A Review. Sustainability, 12 (20), 2020, 8732. DOI: https://doi.org/10.3390/su12208732

[15]. N. Suwarno, B. Prayitno, Optimalisasi Penghawaan Alami Rusunawa Bertingkat Tinggi Paska Pandemi. Jurnal Arsitektur Komposisi, 15 (1), 2021, 1-7. DOI: https://doi.org/10.24002/jars.v15i1.4769

[16]. D.M. Bettaieb, R. Alsabban, Emerging Living Styles Post-COVID-19: Housing Flexibility as a Fundamental Requirement for Apartments in Jeddah. Archnet-IJAR: International Journal of Architectural Research, 15 (1), 2020, 28–50. DOI: https://doi.org/10.1108/ARCH-07-2020-0144

Rizka Tiara Maharani, Master of Architecture *(Indonesia, Surabaya) - Universitas Pembangunan Nasional "Veteran" Jawa Timur, Faculty of Architecture and Design, Lecturer at the Department of Architecture, rizka.tiara.ar@upnjatim.ac.id*

Dominikus Aditya Fitriyanto, Master of Architecture *(Indonesia, Surabaya) - Universitas Pembangunan Nasional "Veteran" Jawa Timur, Faculty of Architecture and Design, Lecturer at the Department of Architecture, dominikus_aditya.ar@upnjatim.ac.id*

Received: 22.03.2022
Revised: 31.03.2022
Accepted: 01.04.2022