

# **Living Space at Pandemic: Understanding Behaviour, Space Organization, and Potential COVID-19 Family Cluster**

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## **Abstract**

The growth of positive cases of Covid-19 in mid-2021 in several cities in Indonesia increasing rapidly, research proves the virus is transmitted through direct contact through the sprinkling of phlegm from an infected person (through coughing and sneezing). In terms of residential, the virus has strong transmissibility within family settings. Family cluster is a new phenomenon, especially in urban areas. Referring from the cases of family cluster, a family who lives in a small house in housing estate in Tangerang, it is necessary to understand the behaviour of family members, space organization, lighting and ventilation system of their house. With a phenomenological approach based on qualitative research, the finding and conclusion of this research, that: 1. Poorly Ventilated; 2. Poorly of Natural Lighting; 3. Frequently shared spaces; 4. No space that allows for full self-isolation, provides an overview of the typology of houses that have the potential to be the cause of family clusters. Learning from existing cases, sustainable housing that is adaptive to a pandemic Covid-19 are : 1. Isolated Room; 2. Having access to private sunbathing area; 3. moving the public space (living room) to an area that has good air circulation and is exposed to natural lighting.

## **Keywords**

Space, Behaviour, Lighting, Ventilation, COVID-19

## **1. Introduction**

Family clusters, one of the high contributors to spread of COVID-19 in Indonesia, Kompas Daily, May 24, 2021, published in Jakarta, family clusters accounted for the number of positive patients increased to 6 percent in the past week Emergency Hospital, SDC Wisma Athletes Kemayoran, Central Jakarta. This phenomena also found in several countries, in United States (US) and China (Song et al. 2020). From China, finding that virus transmitted quickly in the form of family clusters (Zhang et al. 2020). Virus transmitted occur through direct, indirect, or close contact with infected people (WHO 2020). Living together in house have the potential to spread the virus which is transmitted through direct contact through the sprinkling of phlegm from an infected person (through coughing and sneezing), transmission mostly indoor setting (Leclerc et al. 2020), infected person (Walker et al. 2021).

Medical research finding several factors to transmission the virus spread to several individuals who had close contacts. In terms of residential, virus has strong transmissibility within family settings and presence in stool raises concern transmission (Lin et al. 2021). Live in the same room in the long term with patients enlarges the possibility of transmitted, Li et al. (2021) finding three or more cases, the which confirm that sharing indoor spaces with one or more infected persons. Other factors potential for transmitted are typical of housing that do not meet minimum standard health requirements, minimum of natural lighting and poor ventilation, that poor ventilation potentially for spread the virus more and increase of transmitted. Architectural research finding the housing typology that has potential to minimize the transmission of virus, to be carried out, research for new design of living model will generate new adaptive and spontaneous typologies (Ebrahim 2021), with refocusing open space with green area, low-rise buildings and better air quality (Megahed and Ghoneim 2020).

### **1.1 Objectives**

House should be a safe place, house must be able to face exposure from sources that have the potential to cause disease. However, the pandemic changed more, changed people behaviour, stay at home, work from home, learning from home, some studies are urgently needed to investigate transmission of virus, in particular understanding people

behaviour when living together in house, therefore the problem of this research: How the behaviour of family members and space organization potential for causing COVID-19 family clusters? This research aims to understanding the phenomena of family clusters form behaviour and space organization, confirms the research conducted by Leclerc et al. (2020) and Walker et al. (2021).

## 2. Literature Review

### 2.1 Living Space

WHO define that living space must be in order (1) meet the needs of occupants (2) be accessible and usable (3) be large enough to comfortably accommodate people of different ages (WHO 2002). Research by Capolongo et al. (2020) define that living space are space with (1) protected privacy; (2) comfortable and confidential for occupant. In fact, to provide comfort large enough, protected of privacy in living space in urban area, it's no easy, especially coupled with the requirement fundamental aspect of well-being and health. It becomes a burden for the city government, when the development of cities in Indonesia happened so fast and the growing number of city dwellers due to urbanization, particularly efforts to meet the living space as a prime requirement. Another fact, the price of land in the city more expensive, in order to meet the needs of affordable housing need strategy, extensive house and land with the minimum optimum size is the must. The buffer city in the peri-peri area is the area most filled with new housing developments, quite a lot of vertical houses with the TOD concept have been built, but landed houses are still more in demand. What are the characteristics of social housing in Indonesian? No matter how small the dimensions of the house should be: a house is designed based on the combination of comfort and safety. In fact, efforts to meet these standard are sometimes ignored. From data, some of typical social housing in Indonesia, built with the concept of land area : 60 M<sup>2</sup> - 90 M<sup>2</sup> and building area : 36 M<sup>2</sup> – 45 M<sup>2</sup>, with limited area, the available space are : small terrace, two small bedroom, toilet, small living room and small kitchen, as described in Figure 1.

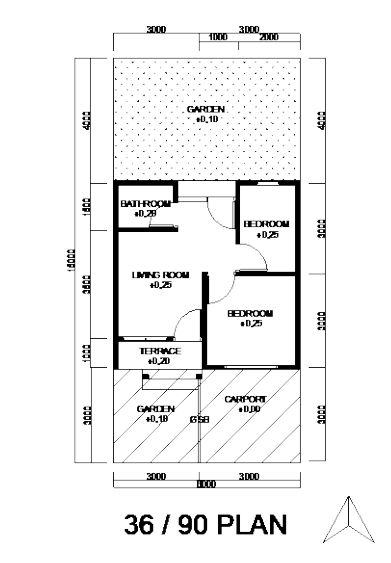


Figure 1. Plan Building area: 36 M<sup>2</sup>, Land area : 90 M<sup>2</sup>

The family's need for additional space is unavoidable, renovation process is carried out, both horizontally and vertically. For enough land area, renovation done by horizontal, for limited land area renovation done by vertically. Change factor dominated by the number of occupant increases (Raviz et al. 2015), another factors are change the pattern of activity, increase in status social. Sometimes process of renovation not designed by good space organization, previously healthy space becomes unhealthy, had cross ventilation becomes non-existent. Research proves problems of lack of space: Lack of adequate security and light/noise pollutions were reported to affect their dwellings (Adediran et al. 2020). Adaptation is a wise decision of the city members to survive in the city, especially during a pandemic, when staying at home, Work From Home and Learning From Home is the recommended choice.

## 2.2 Research in Housing Design at Pandemic Era

Research finding that the spread of this disease, which is transmitted by respiratory tract, has been very rapid. Staying at home being an option to avoid exposure to the virus, home is the safest place from the potential transmission disease. The current pandemic highlights on the importance of garden space, food production, social distancing and the healing effects of natural elements (sunlight, air, view). The pandemic makes all knowledge strive to cure and minimize transmission, architecture research finding that space organization becomes important by implementing: 1. outdoor space, balconies, terraces with larger dimensions; 2. implementing a good ventilation system and clean air circulation through creating indoor gardens, courtyards and leaving open-plan spaces; 3. using daylight in design (Erdogan et al. 2020).

Several research prove that the virus transmits through aerosols and droplets, according to some research, strategy to minimize transmission can actually be done by implementing a good ventilation system, implementing the concept of cross ventilation (opening on two sides of the room) is the idea for air circulation (Lecrec et al. 2020; Capolongo et al. 2020). An active ventilation system using technology can be done, but the facts it is not easy, especially for social housing or small housing, therefore passive ventilation systems through space organization are a smart choice, in this case the ability of architects as designers to design a good space organization is needed.

## 3. Methods

To understanding the phenomena this research conducted with qualitative method and using grounded theory approach. Data collection is done by visiting infected people (when they are declared cured) within a certain time and conducting interviews with all family members and understanding the spatial organization of their homes. The analysis is done by doing transcript from the interview and clarify it with the theory or the previous research.

## 4. Results and Discussion

### 4.1. Case Description

The Prophecy of LS as a professional keyboardist, from 1997, LS family lived in Tangerang, Indonesia, they live in building area: 36 M<sup>2</sup> and land area : 90 M<sup>2</sup>. In 2002, along with the increase of family members, LS family decided to renovate, adding a bedroom, kitchen and dining room that could meet the family's needs, as described in Figure 2 (in 1997, before renovation) and as described in Figure 3 (in 2002, after renovation).

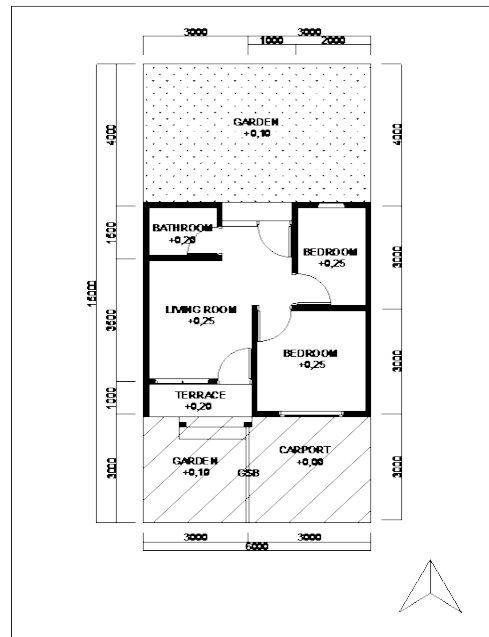


Figure 2. LS House Plan in 1997

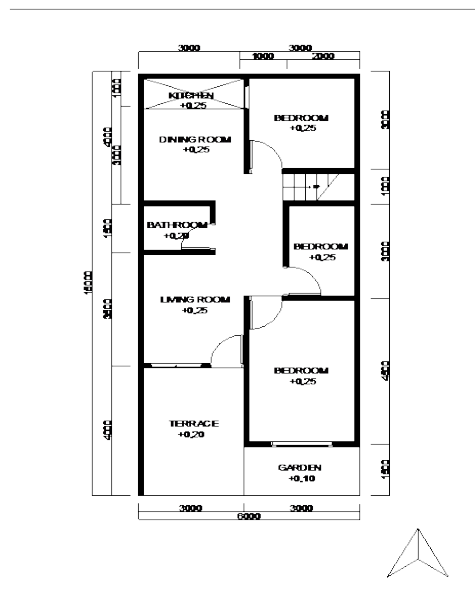


Figure 3. LS House Plan in 2002

The renovation is carried out horizontally on the land in the back area, from the interview, process of renovation was not designed with a good space organization. Results of the renovation had an impact on the guest room, previously had natural lighting, currently unavailable, as well as the middle and the back bedroom. The impact of the renovation, the lighting in the house tends to rely on artificial lighting and the potential for recirculation due to the lack of exit paths is very likely to occur, only a small opening is available on the back side of the dining room which is expected to be able to air circulate and natural lighting enter. Regarding the COVID-19 pandemic that entered the residential area in Tangerang- Indonesia, the housing area, where LS's family lives was designated as red zone. In June 2021, LS's Family, consisting of C1 (Male/55 Years), C2 (Female/55 Years), C3 (Female/24 years), C4 (Male/21 years) laboratory-confirmed diagnosed. This family was designated as the first family cluster in the region. Interviews conducted with C1 can be seen below.

Q : did your family become a family cluster?

A : "...our family becomes a first family cluster in this housing area..."

(LS, live in Tangerang)

Suspicion of contracting, when initial symptoms (cough and fever) were experienced by C1 on June 13, 2021, self-isolation was carried out by C1 living together with C2 and C3, C4, activities were limited inside the house and around the house. A few days later, C1's condition worsened. On June 15, 2021, C1 laboratory-confirmed diagnosed and immediately hospitalized. The results of the antigen swab test for C2, C3 and C4 were declared negative. The impact of living together, a few days later C2 felt the symptoms (anosmia, fever and headache and cough), C2 laboratory-confirmed diagnosed, C2 was immediately admitted to the hospital. Meanwhile, the antigen swab test for C3 and C4 was declared negative. A few days later, C3 and C4 also felt the typical symptoms, C3 and C4 confirmed diagnosed, and C3 and C4 self-isolated in their homes, as described in Figure 4. Transmission from C1 to C2, C3 and C4 takes 4-7 days after C1 laboratory-confirmed diagnosed. The process of transmission is possible because they live together

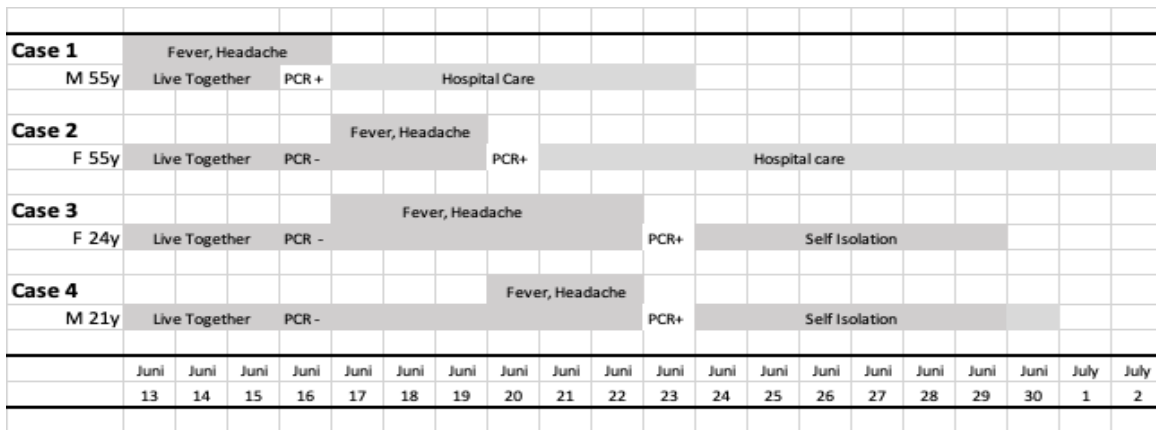


Figure 4. Mapping of Transmission of Virus in LS Family

#### 4.2 Behaviour, Space Organization and Family Cluster: Learning from LS

WHO report, July 9, 2020, based on research proving that virus transmission can occur through direct contact, indirect contact, or close contact with an infected person through secretions such as saliva and respiratory tract secretions or respiratory droplets expelled when an infected person coughs, sneezes, talks, or sings. Understanding LS' daily behaviour, from the interview it was revealed that LS is a musician who works by meeting many people, LS suspects that the meeting without implementing a strict health protocol was the trigger for LS getting disease. In addition, singing is the hobby of LS, even when LS's incubation period is still doing these activities with his family, watches TV together in the living room which also functions as a family room is the habit of LS family. LS is one of the community leaders who talking over the phone with a high intonation when he received a call from another party.

Q : what do you do when there are symptoms of fever and cough and what rooms do you use when symptoms occur?

A : "...Resting in the bedroom with my wife and doing routine activities as usual, receiving calls, playing music while singing, sitting while watching TV in the living room, going to the kitchen, bathroom and eating in the dining room..."

(LS, live in Tangerang)

LS' daily behaviour during the incubation period at home, has the potential to trigger the transmission of virus, singing and receiving calls with high intonation has the potential to produce large numbers of droplets, not to mention the coughing and sneezing experienced. In several investigations, the number of droplets produced by various activities (coughing, sneezing, breathing, phonation, etc.) (Liu et al. 2020). Aerosols and droplets produced have the potential to stick to the surface of tables, TV remotes, and other household appliances. Before laboratory-confirmed diagnosed, C1 and C2 lived in the same room for several days. "Resting in the bedroom with my wife and doing routine activities as usual", it proves, although C1 is already being treated at the hospital, transmission from C1 to C2 occurs, as well as transmission from C2 to C3 and C4. The potential for transmission is very possible because when C1 was in the incubation period (before the PCR test) he was in the same room and used the same equipment as all family members. Live in the same room in the long term with patients enlarges the possibility of transmitted (WHO 2020).

From the existing plans of LS house, that the renovation process carried out in 2002, caused the open area on the back side become into built area, the addition of space had an impact on the ventilation system to become poor ventilation, the impact on the lighting system was the lack of natural lighting entering the room.

Q : How about your home?

A : "...Very closed, the door is only in the front area and natural lighting only relies on glass windows in the front, there is a small opening in the kitchen area for air circulation. The bedroom (middle area) and master bedroom have no natural light. All the existing space is used together with the whole family..."

(LS, live in Tangerang)

Q : Whether natural lighting can get into the house?

A : "...Only the front bedroom and part of the living room can get natural lighting, only a few openings that can enter natural lighting sufficiently, some rooms rely on artificial lighting..."

(LS, live in Tangerang)

From LS's house, it can be seen that the opening for fresh air to enter is only possible from the main door on the front side of the house. The position of the room in the middle and the back of the room is very unlikely to get clean air flow. The small opening in the kitchen space is one opening that allows air flow, as described in Figure 5, and the use of space can be seen in Figure 6.

Space	Lighting		Ventilation	
	Natural	Artificial	Natural	Artificial
Guest and Family Room				
Bedroom (Front)				
Bedroom (Middle)				
Bedroom (Back)				
Dining Room				
Kitchen				
Toilet				

Figure 5. Room, Lighting and Ventilation

Space	Use of Space Together			
	Never	Rarely	Regularly	Frequently
Guest and Family Room				
Bedroom (Front)				
Bedroom (Middle)				
Bedroom (Back)				
Dining Room				
Kitchen				
Toilet				

Figure 6. Use of space together

Research finding, a cough produces approximately 3,000 droplets, a sneeze releases an estimated 40,000 (Fitzgerald et al. 2020). With the enclosed space conditions, the droplet will be gone in a long time. Transmission from human-to-human at room temperature have been described with incubation times between 2-10 days (Kampf et al. 2020). Some veterinary coronaviruses can even hang around for up to 28 days in low temperatures. These particles can be attached to any other person or clothing or surfaces around them, but some of the smaller particles can remain in the air. Research further revealed that the virus could survive in droplets for up to 3 h after being coughed out into the air (van Doremalen et al. 2020), duration can be shorter at a temperature of 30 C or more (Akram 2020). Possible aerosol stay long enough in the surface caused by: (1) aerosol or droplet properties; (2) indoor airflow; (3) virus-specific factors; and (4) host-specific factors (Kohanski et al. 2020).

Q : How is the condition of your bedroom?

A : "...Our bedroom, located on the back side with a small window leading to the dining room, lack of natural lighting, poor ventilation and relying on Air Condition..."

(LS, live in Tangerang)

Referring to research finding, C1's behaviour during the incubation period, coughing, breathing and talking when receiving a phone call, has the potential to be attached to equipment around it, both used independently and used together. Relatively closed house conditions has the potential to cause transmission of the virus. This indoor transmission risk may have been increased because of high occupancy, long duration, loud vocalization, and poor ventilation, as described in Figure 6. From the interview results, some of the existing rooms, such as the back bedroom, bathroom, dining room tend to be used by C1 and C2 together every day, with a long duration of use, transmission is very likely to occur, research proves the same thing, during pandemic, toilets are a daily necessity but may promote

faecal-derived aerosol transmission if used improperly (Ding et al. 2020). In addition, the movement of C1 when at home causes particle transmission to occur on the surface it passes through, study also documented virus on protective apparel or floor surface (Guo et al. 2020). Virus was found on surface (e.g. sink, faucet, and shower handle) collected from a bathroom (Tang et al. 2020). During the incubation period, before the PCR test was carried out, it turned out that C1 still had time to meet neighbours in the open space in front of the house. The meeting in the open space that has good air circulation and filled with natural light during the day, the potential for transmission did not happen.

Q : does C1 still do activities outside the home?

A : "...Yes, do activities in front of the house with some neighbours by using a mask..."

(LS, live in Tangerang)

Q : what can be concluded?

A : "...After I (C1) confirmed diagnosed, a few days later all my family (C2, C3, C4) declared positive, while neighbours who meet me in open space, laboratory- not confirmed diagnosed..."

(LS, live in Tangerang)

### 4.3 Sustainable Housing: Lesson Learn From Case

When Virus Covid still exist around us, the pandemic is forcing many people to keep doing activities at home, work from home, learning from home, research show it takes a healthy condition of the indoor environment, the indoor environment, bulk airflow is impacted largely. The house is finally a place that is expected to be able to provide security and comfort, the house is expected to be able to adapt to the covid transmission process. The family home of the future will evolve to be more resilient and more adaptable needs. Residential spaces and their transformations need to be further explored to provide future design guidelines that will improve the quality of life. Learning from the case of the LS family which became a Family cluster, aerosols and droplets produced when talking, singing and using the same equipment and being in the same room, master bedroom (in back area), dining room, kitchen dan toilet, , allowed fast transmission, and this process occurs in the space due to factors including : 1. the space used frequently ; 2. poorly of natural lighting ; 3. poorly ventilation, as described in Figure 7.

Space	Lighting	Ventilation	Use of Space
	Artificial	Artificial	Frequently
Guest and Family Room			
Bedroom (Front)			
Bedroom (Middle)			
Bedroom (Back)			
Dining Room			
Kitchen			
Toilet			

Figure 7. Room with lighting, ventilation and use of space

Pandemic is a multi-dimensional phenomenon, learning from the transmission of the virus, generated many new things, a lot of engineering done to the environment in which we live become more secure and comfortable. During a pandemic, human behaviour changes and adapts, the occurrence of pandemics leads to a new perception of health and well-being with an emphasis on the built environment, the impacts on living spaces ranging from public places and residential neighbourhoods to more private places such as homes and work environments. Work From Home, Learning From Home is becoming a new habit, research is being carried out, some space engineering is being carried out and adding new facilities that never existed before, such as hand washing facilities., visitors or residents enter the house to wash hands in the front yards (Putra 2020). When conventional things are unreliable, technology will take on a role, residential houses should provide certain health and safety protective such as the application of new touchless technologies (Tokazhanov et al. 2020), avoiding air recirculation and avoiding overcrowding using existing systems (Kampf et al. 2020). Research proves that a good cross ventilation system is expected to reduce transmission, realizing this, houses should have access to green open spaces and more flexible accessible and visible green space (Shahbazian 2021). From space organization, another thing to pay attention to is (1) window placement; (2) lighting levels (3) bedrooms designed; (4) living rooms with better indoor air quality, with a focus on natural ventilation; (5) access to nature (6) unit sizes and layouts that enable physical distancing and prevent crowding (Peters and Hallerran 2021). In

terms of spatial configuration, in-between spaces such as balconies and openings become central in designing residential units (Valizadeh and Iranmanesh 2021).

Architecture is space, the art of arranging space, the organization of space, from a horizontal view identified by the organization of space arranged to meet the needs of occupants, in architecture research, flexible spaces and natural ventilation and are crucial. Therefore, some important suggestions for Architects and Planners in order to implement:

1. Isolated Room, each house should have one bedroom that will be used as a self-isolation room, single rooms should ideally be placed for infected patients, research finding that self-isolation space if the need arises (Spennemann 2021), equipped with a bathroom, has direct access to the outdoor space, to avoid the patient's footprints as a virus transmission area, research documented that virus finding in floor surface (Guo et al. 2020);
2. Having access to private sunbathing, the Covid healing process can be added with sunbathing, access to sunbathing and space for it to be provided, sunbathing is good therapy for increase the immune system (Marwah and Marwah 2020);
3. What's interesting is what LS Family did to minimize transmission, moving the public space (living room) to an area that has good air circulation and is exposed to natural lighting.

## **5. Conclusion**

The findings of this research reinforce the findings of Leclerc (2020); Walker (2021); Qian et al (2021). This research proves that: transmission phenomenon mostly indoor setting, live in the same room, and in the long term with infected person in home enlarges the possibility of transmitted. From the design of the LS house, transmission is possible because: 1. Poorly ventilated, poorly ventilated considered to be high risk (Leclerc et al. 2020); 2. poorly of natural lighting; 3. frequently shared spaces, such as toilets, toilets are a daily necessity promote aerosol transmission (Ding et al. 2020); 4. There is no room that allows for full self-isolation, so the infected person must carry out activities together with other residents in the same room.

## **References**

- Song, R., Han, B., Song, M., Wang, L., Conlon, C. P, Dong, T., Tian, D., Zhang, W., Chen, Z., Zhang, F., Shi, M., and Li, X., Clinical and epidemiological features of COVID-19 family clusters in Beijing, China, *Journal of Infection* vol. 81, pp. e26-e30, 2020.
- Zhang, H., Chen, R., Chen, J., and Chen, B., COVID-19 transmission within a family cluster in Yancheng, China. *Frontiers in Medicine*, vol. 7, pp. 387, 2020.
- World Health Organization *Transmission of SARS-CoV-2: implications for infection prevention precautions: scientific brief* (No. WHO/2019-nCoV/Sci\_Brief/Transmission\_modes/2020.3), 2020.
- Leclerc, Q. J., Fuller, N. M., Knight, L. E., Funk, S., and Knight, G. M., What settings have been linked to SARS-CoV-2 transmission clusters? *Wellcome open research*, vol. 5, pp. 83, 2020.
- Walker, I., Francisco, P., and Werling, E., *Reducing COVID-19 Transmission in Homes*, Lawrence Berkeley National Laboratory, California, 2021.
- Lin, G. T., Zhang, Y. H., Xiao, M. F., Wei, Y., Chen, J. N., Lin, D. J., Wang, J. C., Lin, Q. Y., Lei, Z. X., Zeng, Z. Q., Li, L., Li, H. A., Zheng, Y., Li, Q. Q., Zhen, H. Z., Jin, Y. M., Wu, Q. X., Zhang, F., and Xiang, W., Epidemiological investigation of a COVID-19 family cluster outbreak transmitted by a 3-month-old infant, *Health Information Science and Systems*, vol. 9, pp. 1-10, 2020.
- Li, Y., Qian, H., Hang, J., Chen, X., Hong, L., Liang, P., Li, J., Xiao, S., Wei, J., Liu, L., and Kang, M., Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant, *MedRxiv*, 2020
- Abd Elrahman, A. S., The fifth-place metamorphosis: the impact of the outbreak of COVID-19 on typologies of places in post-pandemic Cairo, *Archnet-IJAR*, vol. 15, pp. 113-30, 2021.
- Megahed, N. A., and Ghoneim, E. M., Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture, *Environmental Research*, vol. 193, pp. 110471, 2021.
- World Health Organization, *International workshop on housing, health and climate change: Developing guidance for health protection in the built environment – mitigation and adaptation responses* (World Health Organization), 2022.
- Capolongo, S., Rebecchi, A., Buffoli, M., Appolloni, L., Signorelli, C., and Fara, G. M., COVID-19 and cities: From urban health strategies to the pandemic challenge, A decalogue of public health opportunities, *Acta Biomedica*, vol. 91, pp. 13-22, 2020.



- Raviz, S. R. H., Eteghad, A. N., Guardiola, E. U., and Aira, A. A., Flexible housing: The role of spatial organization in achieving functional efficiency, *Archnet-IJAR: International Journal of Architectural Research*, vol. 9, pp. 65, 2015.
- Adediran, A., Oladejo, S. O., Akinwande, T. O., Ajibade, S. S. M., and Moveh, S., Housing quality standard and Covid-19 pandemic: A call for attention in Nigeria, *International Journal of Science, Technology & Management (IJSTM)*, vol. 2, 2020.
- Erdoğan, S. K., Birinci, N., and Birol, G., Housing approaches after the global crisis: The pandemic and the house of the future. In IDU SPAD'20 International Spatial Planning and Design Symposium, p. 105, 2020.
- Liu, J., Liao, X., Qian, S., Yuan, J., Wang, F., and Liu, Y., Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China, 2020, *Emerging Infectious Disease*, vol. 26, pp. 1320-3, 2020.
- Fitzgerald, D. A., Nunn, K., and Isaacs, D., Consequences of physical distancing emanating from the COVID-19 pandemic: An Australian perspective, *Paediatric Respiratory Reviews*, vol. 35, pp. 25-30, 2020.
- Kampf, G., Todt, D., Pfaender, S., and Steinmann, E., Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents, *Journal of Hospital Infection*, vol. 104, pp. 246-51, 2020.
- van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., and Williamson, B. N., Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1, *The New England Journal of Medicine*, vol. 382, pp. 1564-7, 2020.
- Akram, M. Z., Inanimate surfaces as potential source of 2019-nCoV spread and their disinfection with biocidal agents, *Virus disease*, vol. 31, pp. 94-6, 2020.
- Kohanski, M. A., Lo, L. J., and Waring, M. S., Review of indoor aerosol generation, transport, and control in the context of COVID-19, *International Forum of Allergy & Rhinology*, vol. 10, pp. 1173-9, 2020.
- Ding, Z., Qian, H., Xu, B., Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital, *MedRxiv*, 2020.
- Guo, Z., Wang, Z. Y., and Zhang, S. F., Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020, *Emerging Infectious Disease Journal*, vol. 26, pp. 1583, 2020.
- Tang, S., Mao, Y., Jones, R. M., Tan, Q., Ji, J. S., Li, N., Shen, J., Lv, Y., Pan, L., Ding, P., Wang, X., Wang, Y., MacIntyre, C. R., and Shi, X., Aerosol transmission of SARS-CoV-2? Evidence, prevention and control. *Environ. Int.* vol. 144, p. 106039, 2020.
- Putra, I. D. G. A. D., Stay at home' for addressing COVID-19 protocol: learning from the traditional Balinese house, *Archnet-IJAR*, vol. 15, 2020.
- Tokazhanov, G., Tleuken, A., Guney, M., Turkyilmaz, A., Karaca, F., How is COVID-19 Experience Transforming Sustainability Requirements of Residential Buildings? A Review, *Sustainability*, vol. 12, p. 8732, 2020.
- Shahbazian, D., Housing and urban design for COVID-19 pandemic; design for prevention of virus spread, *Journal of Preventive Epidemiology*, vol. 6, p. e02, 2021.
- Peters, T., and Halleran, A., How our homes impact our health: using a COVID-19 informed approach to examine urban apartment housing, *Archnet-IJAR*, vol. 15, pp. 10-27, 2021.
- Valizadeh, P., and Iranmanesh, A., Inside out, exploring residential spaces during COVID-19 lockdown from the perspective of architecture students, *European Planning Studies*, pp. 1-16, 2021.
- Spennemann, D. H., Residential Architecture in a post-pandemic world: implications of COVID-19 for new construction and for adapting heritage buildings, *Journal of Green Building*, vol. 16, pp.199-215, 2021.
- Marwah, A., and Marwah, P., Coronavirus (COVID-19): A protocol for prevention, treatment and control, *Journal of Applied and Natural Science*, vol. 12, pp. 119-23, 2020.
- Ding, Z., Qian, H., Xu, B., Huang, Y., Miao, T., Yen, H. L., Xiao, S., Cui, L., Wu, X., Shao, W., Song, Y., Sha, L., Zhou, L., Xu, Y., Zhu, B., and Li, Y., Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital. *MedRxiv*, 2020.