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Understanding Behaviour and Space Organization for Sustainable Housing at Pandemic Covid-19

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ABSTRACT

The surge in COVID-19 cases in mid-2021 across several cities in Indonesia saw a rapid increase, with research confirming that the virus spreads primarily through direct contact, including respiratory droplets from coughing and sneezing. In the context of residential settings, the virus exhibits a high rate of transmission, particularly within family units, making family clusters a significant concern, especially in urban areas. This study examines a family in Tangerang living in a small residential space, focusing on understanding their behavior, the organization of their living spaces, and the home's lighting and ventilation systems. Using a phenomenological approach rooted in qualitative research, this study identifies key factors contributing to the potential spread of COVID-19, including: 1) poor ventilation; 2) inadequate natural lighting; 3) frequent use of shared spaces; and 4) the absence of dedicated isolation areas for infected individuals. These findings provide insight into the typologies of homes that may contribute to family clusters. Based on these case study results, this research proposes recommendations for sustainable housing designs that are better equipped to manage pandemic situations. These recommendations include: 1) incorporating isolated rooms; 2) providing access to private outdoor spaces for sunbathing; and 3) relocating public spaces such as living rooms to areas with better air circulation and natural lighting.

Keywords: behaviour, Covid-19, lighting, space, ventilation

1. Introduction

The surge in COVID-19 cases in Indonesia during mid-2021 revealed that family clusters were among the primary contributors to the virus's transmission. According to data from the Emergency Hospital at Wisma Atlet, Central Jakarta, approximately 6% of the weekly increase in confirmed cases was linked to intra-family transmission, as reported by Kompas Daily on May 24, 2021. Similar trends were observed in other countries, including the United States and China, where rapid transmission within household clusters has been widely documented [1][2]. SARS-CoV-2 spreads through direct, indirect, or close contact with infected individuals, often via respiratory secretions expelled during coughing, sneezing, or speaking [3]. Household environments, where individuals live and interact closely, present a significant risk for such transmission, particularly in indoor settings with limited ventilation [4][5].

Medical research has identified several contributing factors to intra-family spread, notably prolonged close contact among household members [6]. Qian et al. reported multiple secondary infections within households where shared indoor spaces were used over extended periods. Furthermore, residential conditions that fall below health standards—such as insufficient natural lighting and inadequate ventilation—have been associated with an increased likelihood of airborne transmission [7]. From an architectural perspective, recent studies have underscored the importance of designing adaptive living environments in response to the pandemic. Proposals include rethinking spatial typologies to prioritize open green spaces, low-rise building configurations, natural lighting, and improved indoor air quality [8][9].

2. Method

A house is ideally a safe and healthy space, capable of protecting its occupants from environmental exposures that may lead to illness [10]. However, the COVID-19 pandemic brought significant changes in human behavior—people began staying at home, working from home, and participating in online learning from within their residences. These behavioral shifts have intensified the importance of understanding virus transmission in domestic settings, particularly the role of household behavior and spatial configuration in facilitating or mitigating intra-family infections. The central research question addressed in this study is: How do the behaviors of family members and the organization of domestic space contribute to the formation of COVID-19 family clusters? This study aims to explore the phenomenon of family cluster transmission in relation to both behavioral patterns and architectural space organization. The findings build upon and confirm previous studies by Leclerc (2020) and Walker (2021), which identified indoor environments as critical in the spread of COVID-19.

To investigate this phenomenon, a qualitative research methodology was adopted, employing a grounded theory approach. Data collection was conducted through field visits to households previously infected with COVID-19 (after recovery was confirmed). In-depth interviews were carried out with all family members to explore both their behavioral routines and the spatial characteristics of their homes. The analytical process involved transcribing the interview data, followed by thematic coding. These emerging themes were then compared and validated with existing theories and prior research. The phenomenological approach, as emphasized by Haddad [10], provides a valuable framework for interpreting the lived experience of occupants and how their interaction with spatial settings may influence health outcomes during a pandemic.

3. Results and Discussion

Living Space

The World Health Organization (WHO) defines living spaces as environments that must (1) meet the needs of the occupants, (2) be accessible and usable, and (3) be sufficiently spacious to accommodate people of varying ages [11]. Capolongo et al. (2020) further refine this by emphasizing that living spaces should offer (1) protected privacy, and (2) comfort and confidentiality for the occupants [12]. However, creating comfortable living spaces that provide privacy in urban areas is not an easy task, particularly when considering the fundamental aspects of well-being and health. This challenge is compounded by the rapid urbanization in Indonesia, where city growth is accompanied by a rising number of urban dwellers. Meeting the demand for sufficient living space becomes a significant burden for city governments, as they attempt to balance the need for housing with limited land availability and high land prices. As a result, affordable housing strategies often focus on minimizing land use and constructing houses with minimum optimum sizes. In peri-urban areas, new housing developments are common, with many vertical houses following the Transit-Oriented Development (TOD) concept; however, landed houses are still in higher demand.

In the context of Indonesian social housing, typical house sizes range from a land area of 60 to 90 m^2 and a building area of 36 to 45 m^2. These houses usually feature compact spaces, such as small terraces, two tiny bedrooms, a bathroom, a modest living room, and a kitchen. Given the limited space, many families find it necessary to renovate, often either horizontally (when land permits) or vertically (when land is scarce). The latter, especially in densely populated areas, can lead to poorly organized spaces that compromise health and comfort, often resulting in a loss of cross-ventilation and natural lighting. Figure 1 illustrates the layout of such typical social housing, with a building area of 36 m^2 and a land area of 90 m^2, reflecting the limited space available for renovation and adaptation. Research indicates that housing renovations driven by increased occupancy and changing family dynamics can contribute to the deterioration of indoor air quality and space functionality [13].

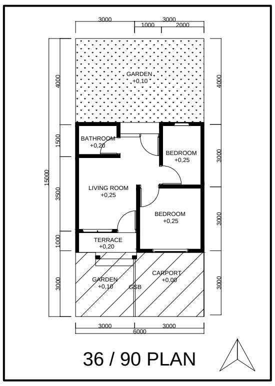

Figure 1 Plan : building area : 36 m^2, land area : 90 m^2

The need for additional space in these homes is driven by growing family sizes, changes in living patterns, and increased social status. While horizontal renovations are often undertaken when sufficient land area is available, vertical renovations—though necessary—tend to lead to poorly planned spaces, which can compromise the health of the household. Studies have shown that the lack of adequate space and exposure to poor environmental conditions such as insufficient lighting and ventilation can negatively affect residents' quality of life. During the COVID-19 pandemic, these issues became even more pronounced, as the need for living spaces that support activities like work from home and learning from home grew, highlighting the need for better space organization and environmental quality [14].

Research in Housing Design At Pandemic Era

Research has shown that the rapid transmission of COVID-19, primarily through respiratory droplets, has made staying at home one of the most effective ways to avoid exposure. A home becomes the safest refuge from the potential spread of this disease. The ongoing pandemic has underscored the importance of various design elements, such as garden spaces, food production areas, social distancing measures, and the therapeutic effects of natural elements like sunlight, air, and views. The focus now is on adjusting architectural design to mitigate transmission risks and foster better living conditions. This can be achieved by incorporating: 1) larger outdoor spaces, such as balconies and terraces; 2) a robust ventilation system and clean air circulation, facilitated by indoor gardens, courtyards, and open-plan designs; and 3) the strategic use of daylight in interiors [15][16][17][18].

Several studies confirm that the virus spreads via aerosols and droplets, emphasizing the importance of effective ventilation. Research indicates that a well-designed ventilation system, particularly the cross-ventilation concept (i.e., openings on opposite sides of a room), can help reduce transmission [4][11]. While active ventilation systems using advanced technologies are beneficial, they may not always be feasible in social or small housing units. Therefore, passive ventilation methods, achieved through thoughtful space organization, represent a practical solution. Architects need to apply their expertise to design spaces that promote healthy airflow and minimize viral transmission risks [4][11][15].

Case Description

LS's family has resided in Tangerang, Indonesia, since 1997, in a house with a building area of 36 m² and a land area of 90 m². In 2002, as the family grew, they undertook a renovation project aimed at adding a bedroom, kitchen, and dining room to accommodate their expanding needs. The renovation was carried out horizontally, utilizing the rear part of the land. However, interviews revealed that the renovation was not designed with optimal space organization. The resulting layout significantly impacted the house's functionality, particularly the guest room, which previously benefitted from ample natural light but now lacked adequate illumination. The middle and rear bedrooms also suffered from insufficient natural lighting. Consequently, the lighting within the house now heavily relies on artificial sources, with the only natural light entering through a small opening in the dining room. This setup also restricts airflow, exacerbating concerns over air circulation. The lack of proper ventilation and exit paths increases the potential for recirculation, and as such, the house became increasingly dependent on artificial lighting.

Regarding the COVID-19 pandemic, which began to affect Tangerang in 2021, LS's family, living in a red zone, became one of the first family clusters in the area. In June 2021, four members of LS's family—C1 (male, 55 years), C2 (female, 55 years), C3 (female, 24 years), and C4 (male, 21 years)—were diagnosed with COVID-19. The timeline of events revealed a progressive transmission pattern. C1 first experienced symptoms on June 13, 2021, followed by self-isolation with C2 and C3. A few days later, C1's condition worsened, and after a confirmed diagnosis, C1 was hospitalized on June 15, 2021. The antigen tests for C2, C3, and C4 returned negative results. However, within a few days, C2 exhibited symptoms, including anosmia, fever, headache, and cough, leading to a laboratory-confirmed diagnosis and hospitalization. Subsequently, C3 and C4 also developed symptoms, and their tests confirmed the diagnosis. They both self-isolated at home. This case illustrates the ease of transmission within households, particularly when individuals share common spaces for prolonged periods. The spread from C1 to other family members occurred within 4-7 days after C1's confirmed diagnosis.

Figures 2 and 3 below illustrate the layout of LS's home before and after the 2002 renovation and the subsequent virus transmission mapping within the family. As indicated in Figure 2, the original design of LS's house in 1997 allowed for more open space and natural lighting. However, the 2002 renovation, particularly the horizontal expansion, obstructed airflow and natural light, which were critical in reducing the risk of viral transmission. In Figure 3, the transmission mapping shows how the virus spread through close contact and the shared use of spaces. It is evident that despite the family members' efforts to limit interaction, the confined space and inadequate ventilation facilitated the virus's rapid spread.

The physical configuration of LS's house, as depicted in Figure 2, played a pivotal role in the transmission dynamics observed within the family. The absence of cross-ventilation and natural light, coupled with shared spaces such as the living room, kitchen, and bathroom, created an environment conducive to viral spread. The small openings in the kitchen and limited access to natural light in the rear areas of the house restricted air circulation, thus elevating the likelihood of airborne transmission. In Figure 3, the transmission mapping shows how the virus spread through close contact and the shared use of spaces. It is evident that despite the family members' efforts to limit interaction, the confined space and inadequate ventilation facilitated the virus's rapid spread.

(a) (b)

Figure 2 (a) LS house plan in 1997, (b) LS house plan in 2002

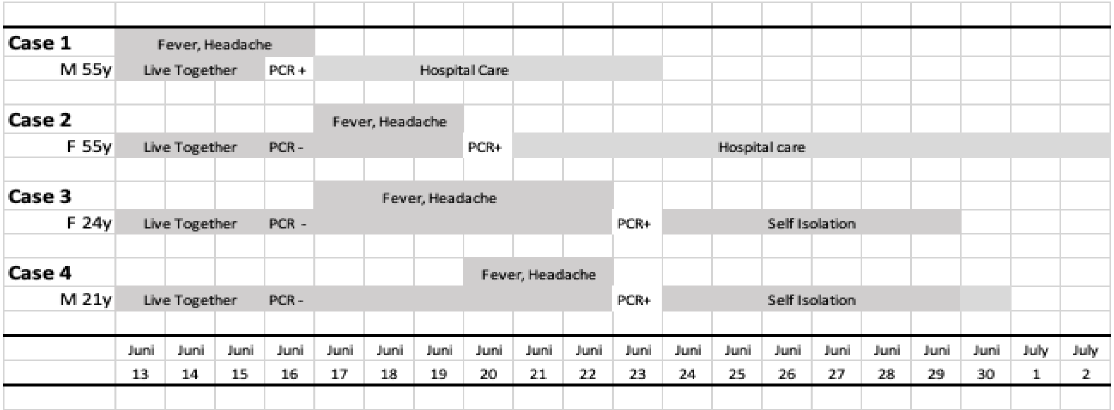

Figure 3 Mapping of transmission of virus in LS family

LS's behavior during the incubation period of the virus also contributed to the high risk of transmission. As a professional musician, LS frequently interacted with others, and even while experiencing symptoms, LS continued engaging in activities such as singing, playing music, and receiving calls. These actions likely increased the production of respiratory droplets, further escalating the risk of transmission within the household. The communal nature of the spaces—such as the family room, kitchen, and bathroom—meant that multiple family members were in close proximity to each other for extended periods, enhancing the likelihood of exposure. Additionally, interviews revealed that even before a confirmed diagnosis, C1 and C2 shared the same bedroom, where they engaged in routine activities such as resting, talking, and watching TV. This close contact, combined with poor ventilation, created a high-risk environment for the spread of the virus.

LS's family case underscores the critical role of space organization and environmental factors in the transmission of COVID-19. Poor ventilation, inadequate natural lighting, and the frequent sharing of spaces were key factors that contributed to the family cluster. These findings align with existing research that emphasizes the importance of spatial configurations that support adequate ventilation, natural lighting, and the possibility of isolation when needed. The LS family's experience offers valuable lessons in housing design, particularly the need for isolated rooms, access to outdoor spaces, and flexible space layouts that can adapt to the challenges posed by pandemics. The findings from the LS family case highlight the significant impact of space organization and environmental factors on the transmission of COVID-19 within households. Moving forward, residential designs must prioritize ventilation, natural lighting, and space flexibility to mitigate the risk of virus transmission. As the pandemic continues to shape the way we live, the lessons from this case will guide the development of more resilient and adaptable housing solutions in the future.

Behaiour, Space Organization and Family Cluster : Learning from LS Family

The World Health Organization's report on July 9, 2020, affirms that COVID-19 transmission occurs via direct or indirect contact, as well as close proximity interactions. These include the exchange of bodily fluids such as saliva or respiratory droplets expelled through activities like coughing, sneezing, speaking, or singing by an infected individual. In understanding LS's daily routine, an interview revealed that LS, a musician, frequently engages with a large number of people, which LS believes could have contributed to the infection, particularly when health protocols were not strictly followed during these interactions. Additionally, LS enjoys singing, a hobby that continued even during the incubation period of the illness, often shared with family members. Activities such as watching television in the living room, which also serves as a family area, are common habits in LS's household. Notably, LS, a community leader, is also accustomed to speaking loudly on the phone during calls, which could further exacerbate the risk of virus transmission due to the increase in respiratory droplets released.

This behavior, especially the loud conversations and singing, likely contributed to the spread of droplets within the household, increasing the risk of contamination of shared surfaces such as remote controls and furniture. The close proximity of family members, particularly in a shared living space during the incubation period, significantly heightened the likelihood of transmission. Furthermore, the design of LS's home, with poor ventilation and limited natural light, created an environment conducive to the virus spreading.

Q: What actions do you take when experiencing symptoms of fever and cough, and which rooms do you use during this period?

A: "I rest in the bedroom with my wife and continue my daily activities as usual. This includes receiving phone calls, playing music, and singing. I also spend time sitting in the living room while watching TV, and I move around the house to use the kitchen, bathroom, and dining room for meals."

(LS, resident of Tangerang)

LS's behavior during the incubation period at home increased the likelihood of virus transmission. Activities such as singing and receiving phone calls with high intonation produced a substantial number of droplets, which, along with coughing and sneezing, further exacerbated the risk of transmission. Several studies have demonstrated that a range of activities—including coughing, sneezing, breathing, and speaking—can release large quantities of respiratory droplets that can remain in the air or settle on surfaces such as tables, TV remotes, and other commonly touched items [19][20]. During the incubation period, C1 and C2 shared the same bedroom for several days. Despite C1's subsequent hospitalization, transmission from C1 to C2 occurred, followed by transmission to C3 and C4. This likely happened because C1 and C2 used the same equipment and stayed in close proximity before C1 was PCR-confirmed positive. Prolonged cohabitation in a confined space with an infected person significantly amplifies the risk of transmission [3].

The renovation undertaken in 2002 at LS's residence converted the previously open space at the rear of the house into built-up areas. This expansion had adverse effects on both the ventilation and lighting systems. Specifically, it resulted in poor airflow and restricted natural light from entering the rooms.

Q: How would you describe your home?

A: "It's quite closed off. The door is only located at the front, and natural light is limited, primarily coming through the glass windows at the front. There is a small opening in the kitchen for ventilation, but both the middle and master bedrooms lack natural light. All the spaces are shared by the entire family."

(LS, live in Tangerang)

Q: Is there any natural lighting in the house?

A: "Only the front bedroom and part of the living room receive natural light. The openings are few, and only limited light enters those rooms. Some rooms depend entirely on artificial lighting."

(LS, live in Tangerang)

The layout of LS's house reveals that the only available opening for fresh air to enter is through the main door at the front of the house, with limited airflow in the middle and rear sections of the house. Additionally, a small opening in the kitchen space is one of the few areas allowing for air circulation. These limitations in ventilation, combined with poor natural lighting, compromise the indoor air quality, which could contribute to viral transmission. Research has found that a cough can produce approximately 3,000 droplets, and a sneeze can release up to 40,000 droplets [21]. In such enclosed spaces, these droplets can remain suspended for extended periods. Transmission between individuals in indoor settings has been described, with an incubation period ranging from 2 to 10 days at room temperature [22]. Certain coronaviruses, including SARS-CoV-2, can survive on surfaces for up to 28 days, especially in cooler temperatures [23]. Smaller droplets may linger in the air, potentially contaminating surfaces or floating in the atmosphere. Studies also show that SARS-CoV-2 can survive in aerosol form for up to three hours after being expelled into the air, with survival duration decreasing at temperatures above 30°C [24]. The persistence of these particles on surfaces is influenced by various factors such as aerosol properties, airflow, and specific virus characteristics [25].

This figure 4 highlights the limitations in the house's ventilation and lighting systems. LS's home, particularly the bedrooms and other interior spaces, suffers from poor natural ventilation and insufficient light penetration. With limited openings for fresh air to enter and a lack of cross-ventilation, the air quality inside the house is compromised, which could contribute to viral transmission. Additionally, the reliance on artificial lighting indicates a lack of natural light sources, further exacerbating the indoor environmental conditions. These conditions are significant in explaining the increased risk of transmission of airborne viruses such as SARS-CoV-2.

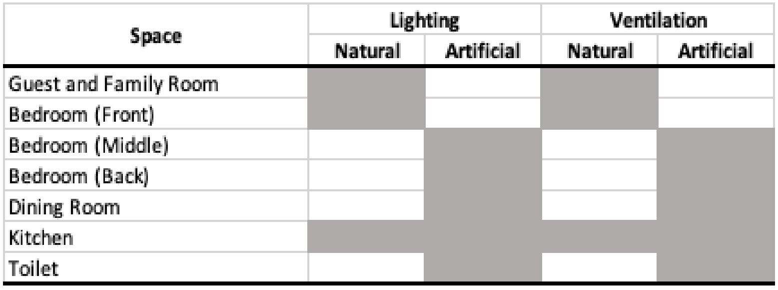

Figure 4 Room, lighting and ventilation

Q: How would you describe the condition of your bedroom?

A**:** "Our bedroom is located at the back of the house with a small window leading into the dining room. It lacks natural lighting, has poor ventilation, and relies on an air conditioner for cooling."

(LS, resident of Tangerang)

C1's behavior during the incubation period—such as coughing, breathing, and speaking loudly on the phone—likely contributed to the transmission of the virus, as droplets and aerosols could adhere to nearby surfaces, including shared equipment and household items. The relatively confined living conditions may have worsened this risk. Transmission risk is heightened by factors such as high occupancy, long exposure durations, loud vocalizations, and poor ventilation [26]. According to the interview, several rooms, such as the back bedroom, bathroom, and dining room, were shared by C1 and C2 on a daily basis, which, combined with long durations of use, increases the likelihood of viral transmission. Research supports this, showing that toilets—often used frequently during the pandemic—may contribute to aerosol transmission if not used correctly [27]. Moreover, C1's movement through the home likely contributed to particle transmission across surfaces, with viruses documented on items such as sink faucets and shower handles [28].

This figure 5 illustrates how various spaces in LS's home are frequently shared by multiple family members. During the pandemic, the family spent considerable time in close proximity within the same rooms, such as the bedroom, dining room, and bathroom. These shared spaces, coupled with long durations of use and poor ventilation, created an environment conducive to the transmission of SARS-CoV-2 among family members. The lack of isolation spaces further contributed to the spread of the virus within the household.

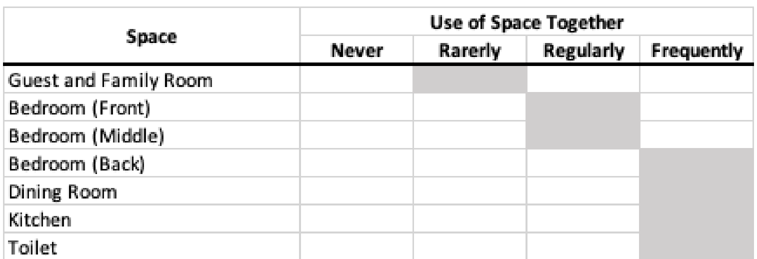

Figure 5 Use of space together

During the incubation period, prior to the PCR test, C1 still had interactions with neighbors in the open space in front of the house.

Q: Did C1 continue activities outside the home?

A: "Yes, I spent time outside in front of the house with some neighbors, wearing a mask."

(LS, resident of Tangerang)

Q: What can be concluded from this?

A: "After I (C1) was diagnosed, a few days later all my family members (C2, C3, and C4) tested positive, while the neighbors who met me outdoors did not get diagnosed in the laboratory."

(LS, resident of Tangerang)

The meeting that took place in an open space with good air circulation and natural light during the day did not result in transmission. This suggests that the open-air environment with natural ventilation may have reduced the likelihood of transmission, in contrast to the confined indoor spaces where the family members spent much of their time.

Sustainable Housing : Lesson Learn From Case

As COVID-19 continues to circulate, the pandemic has forced many individuals to adapt by conducting daily activities at home, including work and learning. Research underscores that a healthy indoor environment plays a critical role in minimizing the spread of the virus, with airflow being one of the most significant factors impacting air quality. The home, once solely a place of comfort, is now also expected to act as a space that provides both safety and adaptability to the ongoing pandemic. The future family home will need to be more resilient and better equipped to meet evolving needs in response to public health challenges [29][30]. Residential spaces and their design transformations need further exploration to provide updated guidelines for future architectural practices, enhancing overall quality of life.

From the case of the LS family, which became the first documented family cluster in their area, we see that certain behaviors and space organizations can significantly impact viral transmission. Aerosols and droplets generated by speaking, singing, and sharing equipment, all within confined spaces such as the master bedroom, dining room, kitchen, and toilet, facilitated rapid virus transmission. These conditions were compounded by poor natural lighting, inadequate ventilation, and frequent use of shared spaces, further exacerbating the risk of infection [31][32]. Figure 6. Lighting, Ventilation, and Use of Space highlights the critical role that lighting, ventilation, and effective space organization play in reducing the spread of airborne pathogens. Inadequate ventilation and lighting systems, common in many urban homes, can create environments conducive to viral transmission. The case study of LS demonstrates how these environmental factors, coupled with frequent sharing of spaces by multiple family members, increased the likelihood of widespread infection.

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

Figure 6 Lighting, ventilation and use of space

The pandemic has created new challenges and led to innovations in how residential spaces are conceived. Human behavior has adapted to these new conditions, with a growing focus on health and well-being as integral elements of the built environment [33][34]. As remote work and learning become the norm, new adaptations in space design have emerged, such as the addition of hand-washing stations outside homes [33]. When conventional methods fail, technology plays a crucial role, and residential spaces must incorporate health and safety features, including touchless technologies and systems that prevent overcrowding and air recirculation [34][35]. Research indicates that well-designed ventilation systems can reduce the risk of airborne transmission, and housing designs should prioritize access to green spaces and flexible layouts that promote both physical distancing and enhanced air circulation [36]. Architectural design must also address several key considerations, including optimal window placement, lighting levels, the design of bedrooms to improve air quality, living rooms with a focus on natural ventilation, access to nature, and space layouts that allow for physical distancing and prevent overcrowding [37][38]. In this context, architects must consider the spatial configuration of homes, emphasizing the importance of balconies and open spaces that promote better air quality and physical distancing [39].

To further adapt residential spaces to pandemic conditions, several recommendations emerge. First, every home should include at least one bedroom designated for self-isolation purposes. Ideally, this room should be equipped with its own bathroom and have direct access to outdoor space to prevent contamination of common areas. Research shows that isolation spaces are crucial for reducing transmission risks [40]. Additionally, providing access to private sunbathing areas can support the healing process, as sunbathing has been shown to boost immune function [41]. The LS family adapted by relocating their living room to an area with better air circulation and natural light, which helped minimize transmission risks by improving environmental quality. Research also highlights the importance of shared spaces, such as bathrooms and toilets, which can be high-risk areas for viral transmission. Improper use of toilets, particularly in poorly ventilated areas, can promote aerosol transmission [42].

4. Conclusion

The findings of this research align with previous studies that have explored the dynamics of virus transmission in residential settings. This research highlights that transmission is most prevalent in indoor environments, particularly when individuals share living spaces for extended periods. In the case of the LS family, the design of the home played a significant role in facilitating transmission. Key factors that contributed to this include inadequate ventilation, which poses a high risk for the spread of airborne pathogens; insufficient natural lighting, which can exacerbate poor air quality; and the frequent use of shared spaces such as bathrooms, which are essential but can increase the likelihood of aerosol transmission. Additionally, the absence of designated isolation rooms meant that infected family members were unable to separate from others, increasing the potential for virus transmission within the household. These findings underscore the need for improved housing designs that prioritize ventilation, natural lighting, and the ability to self-isolate to better prevent the spread of infectious diseases in the future.

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6. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. All data used in this study were obtained in a transparent and ethical manner, and no financial or personal relationships influenced the research process or its outcomes.

References

[1] R. Song, B. Han, M. Song, L. Wang, C. P. Conlon, T. Dong …. and X. Li, (2020). Clinical and epidemiological features of COVID-19 family clusters in Beijing, China. *Journal of Infection*, **81(2)**, 26 – 30 (2020).

[2] H. Zhang, & R. Chen, J. Chen and B. Chen, COVID-19 Transmission Within a Family Cluster in Yancheng, China. Frontiers in Medicine (2020). 7. 387. 10.3389/fmed.2020.00387.

[3] World Health Organization. (2020). *Transmission of SARS-CoV-2: implications for infection prevention precautions: scientific brief, 09 July 2020* (No. WHO/2019-nCoV/Sci_Brief/Transmission_modes/2020.3). World Health Organization.

[4] Leclerc, Q. J., Fuller, N. M., Knight, L. E., Funk, S., Knight, G. M., & cmmid covid-19 Working Group. (2020). What settings have been linked to SARS-CoV-2 transmission clusters?. *Wellcome open research*, *5*. https://doi.org/10.24114/antro.v5i2.14922

[5] Walker, I., Francisco, P., & Werling, E. (2021). Reducing COVID-19 Transmission in Homes

[6] Lin, Gt., Zhang, Yh., Xiao, Mf. *et al.* Epidemiological investigation of a COVID-19 family cluster outbreak transmitted by a 3-month-old infant. *Health Inf Sci Syst* **9,** 6 (2021). https://doi.org/10.1007/s13755-020-00136-2

[7] Li, Y., Qian, H., Hang, J., Chen, X., Hong, L., Liang, P., ... & Kang, M. (2020). Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant. *MedRxiv*.

[8] Abd Elrahman, A.S (2021), "The fifth-place metamorphosis: the impact of the outbreak of COVID-19 on typologies of places in post-pandemic Cairo", Archnet-IJAR,Vol. 15 No. 1, pp. 113-130. doi.org/10.1108/ARCH-05-2020-0095

[9] Megahed, N. A., & Ghoneim, E. M. (2020). Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture. *Environmental Research*, 110471. doi.org/10.1016/j.envres.2020.110471

[10] Haddad, E. (2010), "*Christian Norberg-Schulz's phenomenological project in architecture*", Architectural Theory Review, Vol. 15 No. 1, pp. 88-101, doi: 10.1080/13264821003629279

[11] World Health Organization (WHO) International workshop on housing, health and climate change: Developing guidance for health protection in the built environment – mitigation and adaptation responses. October 2010. Meeting

[12] Capolongo S, Rebecchi A, Buffoli M, Appolloni L, Signorelli C, Fara GM. COVID-19 and cities: From urban health strategies to the pandemic challenge. A decalogue of public health opportunities. Acta Biomed. 2020;91:13-22. doi: 10.23750/ abm.v91i2.9515

[13] Raviz, S. R. H., Eteghad, A. N., Guardiola, E. U., & Aira, A. A. (2015). Flexible housing: The role of spatial organization in achieving functional efficiency. *ArchNet-IJAR: International Journal of Architectural Research*, *9*(2), 65.

[14] Adediran, A., Oladejo, S. O., Akinwande, T. O., Ajibade, S. S. M., & Moveh, S. (2020). Housing quality standard and Covid-19 pandemic: A call for attention in Nigeria. *Journal of Science, Engineering, Technology and Management ISSN: 9989-7858*, *2*(2).

[15] Erdoğan, S. K., Birinci, N., & Birol, G. (2020) .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)

[16] Makhno, S. (2020). Life after coronavirus: how will the pandemic affect our homes. *Dezeen*

[17] Hipwood, T. (2020). Coronavirus: an architect on how the pandemic could change our homes forever. *The Conversation*

[18] Ramadhani, F. H. (2020). Literature Review: Healthy Home as The New Normal for Covid-19 Preventionalthy Home As The New Normal For Covid-19 Prevention. *Jurnal Kesehatan Lingkungan*, *12*(1si), 1-10.

[19] Liu J, Liao X, Qian S, Yuan J, Wang F, Liu Y, et al. Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China, 2020. Emerg Infect Dis. 2020;26:1320-3

[20] Chan JF-W, Yuan S, Kok K-H, To KK-W, Chu H, Yang J, et al.(2020) A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet; 395 14-23. 4.

[21] Fitzgerald, D. A., Nunn, K., & Isaacs, D. (2020). Consequences of physical distancing emanating from the COVID-19 pandemic: An Australian perspective. *Paediatric Respiratory Reviews*, *35*, 25-30

[22] Kampf, G., Todt, D., Pfaender, S., & Steinmann, E. (2020). Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *Journal of hospital infection*, *104*(3), 246-251. https://doi.org/10.1016/j.jhin.2020.01.022

[23] van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med. 2020;382:1564–7.

[24] Akram, M. Z. (2020). Inanimate surfaces as potential source of 2019-nCoV spread and their disinfection with biocidal agents. *Virusdisease*, *31*, 94-96.

[25] Kohanski, M. A., Lo, L. J., & Waring, M. S. (2020, October). Review of indoor aerosol generation, transport, and control in the context of COVID-19. In *International forum of allergy & rhinology* (Vol. 10, No. 10, pp. 1173-1179). https://doi.org/10.1002/alr.22661

[26] Miller, S.L., Nazaroff, W.W., Jimenez, J.L., et al.,2020. Transmission of SARS-CoV-2 by inhalation of respiratory aerosol in the Skagit Valley Chorale superspreading event. 2020:2020.06.15.20132027

[27] Ding, Z., Qian, H., Xu, B., et al. 2020. Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital. medRxiv 2020:2020.04.03.20052175

[28] Guo Z.-D., Wang Z.-Y., Zhang S.-F. Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020. *Emerg. Infect. Dis. J.* 2020;26:1583.

[29] 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., & Shi, X. (2020). Aerosol transmission of SARS-CoV-2? Evidence, prevention and control. *Environment international*, *144*, 106039. https://doi.org/10.1016/j.envint.2020.106039

[30] Matar El Raachini, E. (2021). *The Next Generation Residential Space* (Doctoral dissertation, Wien). doi : 10.34726/hss.2021.90740

[31] Brizuela, N.G., García-Chan, N., Pulido, H.G. and Chowell, G. (2020), "Understanding the role of urban design in disease spreading", March 19, bioRxiv, pp. 2-14.

[32] Salama, A. 2020. "Coronavirus Questions That Will not go Away: Interrogating Urban and Socio-Spatial Implications of COVID-19 Measures [Version 1; Peer Review: 3 Approved]." *Emerald Open Research* 2 (14), 117. doi:10.35241/emeraldopenres.13561.1

[33] Putra, I.D.G.A.D. (2020), "'Stay at home' for addressing COVID-19 protocol: learning from the traditional Balinese house", Archnet-IJAR: International Journal of Architectural Research, Vol. 15 No. 1, doi: 10.1108/ARCH-09-2020-0187.

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

[35] Alhusban, A.A., Alhusban, S.A, Alhusban, M.A (2021), "How the COVID 19 pandemic would change the future of architectural design", *Journal of Engineering, Design and Technology*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/JEDT-03-2021-0148

[36] Shahbazian D. Housing and urban design for COVID-19 pandemic; design for prevention of virus spread. J Prev Epidemiol. 2021;6(1):e02. doi: 10.34172/ jpe.2021.02.

[37] Peters, T and Hallerran, A (2021), "How our homes impact our health: using a COVID-19 informed approach to examine urban apartment housing", *Archnet-IJAR*, Vol. 15 No. 1, pp. 10-27. https://doi.org/10.1108/ARCH-08-2020-0159

[38] Valizadeh, P., & Iranmanesh, A. (2021). Inside out, exploring residential spaces during COVID-19 lockdown from the perspective of architecture students. *European Planning Studies*, 1-16.

[39] Amos Rapoport (1969). House and Form Culture. Engle Wood Cliffs N. J.: Prentice Hall

[40] Spennemann, D. H. (2021). 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), 199-215. https://doi.org/10.3992/jgb.16.1.199

[41] Marwah, A., & Marwah, P. (2020). Coronavirus (COVID-19): A protocol for prevention, treatment and control. *J App Nat Sci*, *12*(2), 119-23

[42] Ding, Z., Qian, H., Xu, B., et al. 2020. Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital. medRxiv 2020:2020.04.03.20052175