Post-pandemic Evaluation on Housing and Its Influence on Future Healthy Housing Preferences

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Abstract

Post-COVID-19 pandemic, the topic of healthy housing continues to develop, one of which is related to the mental health of residents. The purpose of this study is to conduct a post-pandemic evaluation on Indonesian residents' housing satisfaction (HS), frequency of activities (FoA) during quarantine, and residents' future housing preferences (HP) that promote positive mental health. This study also tries to see the causal relationship between the variables influencing certain housing preferences. This quantitative study used an online questionnaire to collect and analyze data quantitatively using multivariate regression analysis. The results showed values for housing preferences were higher than housing satisfaction values. The causal relationships with the strongest influences are *FoA daily* on *HP environmental comfort*, *HS physical space* on *HP physical space*, and *HS acoustic & visual comfort* on *HP semi-outdoor space*. In general, *HS acoustic & visual comfort* and *FoA daily* were the most influencing on residents' preferences.

INTRODUCTION

At present, the pandemic of Coronavirus, known as Covid-19, status has changed to endemic. But our experience during the pandemic starting 2019 to 2022 has left various changes in our lives, one of which is our perspective in interpreting, behaving, and doing activities in our living environment. The pandemic has taught that the living environment, or what we call home, must be sustainable and resilient to deal with possibilities that can occur in the future (Tokazhanov et al., 2020). For a home to be sustainable and resilient, aspects that are a priority for future housing designs are how the dwelling supports the health and well-being of its residents (Akbari et al., 2021; Muhyi & Adianto, 2021; Zarrabi et al., 2021).

The topic of health in architecture has been a concern since the early twentieth century but the studies related to this topic continue to develop until now, especially during and post Covid-19 Pandemic. This health issue is also a concern of the United Nations (UN) and the World Health Organization (WHO) which issued a guideline for healthy housing (WHO, 2018; UN, 2020). According to the WHO, the health aspects that need to be considered in a healthy house are not only physical health but also psychological health or mental health. In Indonesia itself, health in the home environment has already gained attention from the government, proven by the existence of Healthy Housing Requirements through *Keputusan Menteri Kesehatan no. 829/Menkes/SK/VII/1999*. Previous studies have also discussed the link between housing and residents' health (Amerio et al., 2020; Matte & Jacobs, 2000; D'Alessandro et al., 2020; Peters & Halleran, 2020; Akbari et al.., 2021, Torres et al., 2021; Zarrabi et al., 2021; Al-Qaisi, 2022;).

Psychological or mental health in housing especially in the context of the pandemics, has recently become a rising topic in many researches (Amerio et al., 2020; D'Alessandro et al., 2020; Akbari et al., 2021; Torres et al., 2021; Zarrabi et al., 2021). Researchers found that staying indoors for a long time may generate health problems and negative psychological effects, such as boredom, loneliness, and even lead to poor mental health (Akbari et al., 2021; Zarrabi et al., 2021).

Some literature discussing housing and mental health revealed that many housing features have an impact on residents' mental health (Akbari et al., 2021; Zarrabi et al., 2021). According to Akbari et al. (2021), healthy housing indicators that affect residents' mental health are spaces; environmental factors; and function & activities. Another

study by Zarrabi et al. (2021) evaluated the health parameters related to physical health, mental health, and socio-economic lifestyle changes in the residential after COVID-19. The study showed that the healthy housing indicators were natural light, view, acoustic, and open or semi-open space.

As COVID-19 has changed residents' perspective on their living environment, it is necessary to study housing satisfaction and preferences for post-pandemic housing (Akbari et al., 2021; Muhyi & Adianto, 2021; Torres et al., 2021; Zarrabi et al., 2021). This evaluation from residents' perspectives also can be an evaluation to know whether their residence has sufficient quality so that it can be said to be a healthy house, especially in supporting their mental health.

The pandemic has not just changed the way residents perceive their living environment but also their living behavior and needs. (Tokazhanov et al., 2020). Due to the pandemic, residents have made home adjustment behavior, such as "fear of meeting people", "fear of economic recession", and the "stay-at-home lifestyle" (Muhyi & Adianto, 2021). Thus, it is important to know whether their existing home conditions and performances have met their satisfaction (Torres et al., 2021). It is also very important to understand residents' priorities and preferences in housing that can lead to solutions in improving the quality of future healthy housing that promote positive mental health (Zarrabi et al., 2021). Residents' shifted preferences will have an impact on housing marketing as it can be a guide to knowing individuals' goals in choosing, buying, or renting their most suitable home (Akbari et al., 2021; Muhyi & Adianto, 2021).

There has been previous research regarding housing satisfaction and housing preferences and there were also studies that compare these two results in the context of the pandemic (Akbari et al., 2021; Sakina & Setiawan, 2022; Yang et al., 2022). It was found that there was a difference in the gap value between housing preferences and satisfaction levels of existing residential conditions which made it difficult for residents to adjust to being at home during the pandemic (Yang et al., 2022; Sakina & Setiawan, 2022). Housing preferences describe residents' ideal image of their living environment, and if there are differences between satisfaction and preferences, it can lead to disappointment and complaints (Akbari et al., 2021). Although this topic is not new, there were still minimal studies discussing this topic in the housing context in Indonesia.

The purpose of this study is to make a post-pandemic evaluation of Indonesian residents' housing satisfaction and their frequency of activities during the quarantine period and also to know residents' future housing preferences for healthy housing to promote positive mental health. This paper also aims to see whether there is a relationship, and if so, what variables influence certain housing preferences by looking at the causal relationship. These studies will reveal the reasons for determining residents' housing preferences, and whether there is an influence on their experience while living in their existing homes during quarantine. This research is a continuation of previous research by Sakina & Setiawan (2022). The results of this study will hopefully be valuable information for stakeholders in developing future residential designs that are healthy, sustainable, and resilient.

METHODS

This research was carried out using quantitative research methods that are explanatory (Groat & Wang, 2002). In this research, the cause-and-effect relationship between the independent and dependent variables will be revealed. Housing Satisfaction (HS) on their existing house, and residents' Frequency of Activities (FoA) during quarantine in the pandemic are independent variables, while Housing Preferences (HP) on their future healthy house are dependent variables.

In this research, a total of 231 respondents were received. Data was collected through an online questionnaire which was distributed freely (snowball-random sampling) via social media (WhatsApp, Line, Instagram, Facebook, etc.) to residents in several Indonesian cities. This technique allows us to take advantage of relationships between participants to reach other people (Torres et al., 2021).

Respondents were asked to provide their demographic data and their housing characteristics, then they were asked to evaluate their HS on their existing house in terms of healthy housing and mention the FoA during the quarantine period at home. Respondents were also asked to give a priority scale to several aspects of healthy housing design for their housing preferences (HP). The variables can be seen in Table 1.

In terms of healthy housing that affects residents' mental health, the indicators used by Akbari et al. study (2021) i.e., *space; environmental comfort*; and *function & activities*. *Space* represents the physical quality of rooms, i.e., number, size, etc., while *functions & activities* represent how the house can accommodate various functions & activities of the respondents during quarantine, i.e., rest, domestic chores, entertainment, social interaction, working studying online, exercise. *Environmental comfort* is an aspect related to occupant comfort, including thermal, acoustics, and visual comfort.

The questions given in the online questionnaire are close-ended questions with a semantic-differential method (SD-method) on a scale of one (1) to four (4). A zero scale (0) is added if the respondent does not have this variable

in their existing residence. Each answer pole is in the form of opposing adjectives, namely very dissatisfied to very satisfied, very rarely to very often, and very unimportant to very important. To make it easier for respondents to fill out the questionnaire, positive words are always placed on the right, while negative adjectives are placed on the left. From these questions, numerical data will be obtained which will then be analyzed quantitatively. The example of the SD method questions can be seen in Table 2.

Table 1. List of variables

Variables		Measured Variables
Respondents Characteristics		Gender, Age Range, Education, Marital Status, Employment, Monthly income
Housing Characteristics		Ownership, Residential Type, Number of Floors, Number of Occupants, Duration of residence (years), Indoor Surface Area (m2), Outdoor Surface Area
Housing Satisfaction (HS) and Housing Preferences (HP)	**Space**	Dining room space, Bathroom space, Living room space, Kitchen space, Bedroom space, Parlor space, Terrace/balcony space, Circulation space, Work/ study space
	Environmental Comfort	Natural Lighting, Natural ventilation, Acoustic comfort, Greenspace, View outside
	Function & Activities	Rest, Domestic chores, Entertainment, Working/studying online, Social Interaction, Exercise, Gardening
Frequency of activities (FoA)		Personal Hygiene, Working/studying online, Domestic chores, Rest, Entertainment, Social Interaction, Gardening, Exercise

Table 2. Example of SD method questions

Variables	Example of SD Method questions						
Housing Satisfaction	Your level of satisfaction with the quality of the environment in your home during the pandemic.						
	Very dissatisfied	0	1	2	3	4	Very satisfied
Frequency of Activities	Frequency of activity during the pandemic						
	Very rarely	0	1	2	3	4	Very often

The analysis will be using distribution analysis, principal components analysis (PCA), factor analysis (FA), and multivariate regression analysis. Distribution analysis was used to see respondents' characteristics and their housing characteristics. PCA and FA were used to analyze numerical data for HS on their existing house, residential FoA during quarantine in the pandemic, and HP on their dream house. PCA is used to simplify the overall data without significantly reducing the characteristics of the data (Johnson & Wichern, 1998). FA with the varimax rotation method is used to determine latent variables (dimensions) that represent the measured variables. In the FA, the measured variables were reduced to several latent variables that represented most of the variance of the main principal components. The measured variables included aspects of HS (21 measured variables), FoA (8 measured variables), and HP (20 measured variables). Each latent variable was then analyzed further using multivariate regression analysis to determine the magnitude of the relationship between the independent latent variables HS on their existing house, FoA during quarantine in the pandemic on the dependent variable HP on their future healthy housing to promote positive mental health.

RESULTS AND DISCUSSION

This section will discuss the results of the analysis of respondents and housing characteristics, housing satisfaction (HS), frequency of activities (FoA) during quarantine, housing preferences (HP), and the influence of HS and FoA on HP on future healthy housing to promote positive mental health.

Respondents' Characteristics

The respondents' characteristics in this research can be seen in Table 3. Of 231 respondents, 61% were mostly female in gender and 39% were male. The age of respondents varies and is not much different between ages, the most common being aged 31-40 (28%), followed by 41-50 (24%). In Marital status, 56% of the respondents were married and had children, followed by 30% who were still single. This marital status and the presence of children may impact the activities and needs inside the house during quarantine. In terms of Education, 33% of respondents had a Bachelor's degree followed by 32% with a Master's degree. As for employment, 27% worked for government institutions and 25% in the private sector. Only a few of the respondents were unemployed (0.01%) and retired (0.06%). As for their economic status, 35% have a monthly income of 5 to 10 million, and 33% below 5 million. So, most of the respondents can be classified as middle-class society. The various backgrounds of the respondents may affect their perception and preferences on their living environment.

Table 3. Respondents' characteristics

Variables		freq	%	Variables		freq	%
Gender	Female	141	0.61	**Employment**	Unemployed	3	0.01
	Male	90	0.39		Student	29	0.13
Age Range (y.o.)	<20	12	0.05		Teacher	19	0.08
	20-30	52	0.22		Housewife	23	0.10
	31-40	64	0.28		Private sector	57	0.25
	41-50	55	0.24		Government	63	0.27
	>50	48	0.21		Entrepreneur	21	0.09
Education	High school	28	0.12		Professional	2	0.01
	Diploma	8	0.03		Retired	14	0.06
	Bachelor	77	0.33	**Monthly income (Rupiah)**	<5.000.000	75	0.33
	Master	74	0.32		>20.000.000	18	0.08
	Doctorate	44	0.19		11.000.000 – 15.000.000	38	0.16
	Single	70	0.30		16.000.000 – 20.000.000	18	0.08
Marital Status	Married	32	0.14		5.000.000 – 10.000.000	82	0.35
	Married w/ children	129	0.56				

Housing Characteristics

From Table 4 it can be seen respondents' housing characteristics. The majority of the respondents were homeowners (87%) and only a few were renting the house (13%). The ownership of the house may also affect respondents' decision-making when evaluating the existing house or their future housing preferences. 59% of the respondents lived in urban-rural housing also known as "kampung" and 36% of respondents lived in clustered or gated housing. Different typologies of housing with different characteristics may also affect different ways of respondents perceiving their living environment.

In terms of duration of residence, 52% have lived in their house for more than 10 years while 25% have only lived for 1-5 years. The number of occupants in the house mostly showed 31% have 4 occupants and 24% have 5 occupants. This result is probably because most of the respondents were already married and had children. The number of occupants may also affect the crowding in the house, their activities, and use of space, which can influence their satisfaction and preferences for housing.

In terms of the number of floors, most of the respondents lived in low-rise houses with, 48% in only 1-floor houses and following with 44% living in 2-floor houses. As for the total area of indoor surface, 24% has 61-90 m2 houses and 20% 91-120 m2 houses. Only 0.04% of respondents lived in less than 36 m2 houses. This shows the majority has a medium house area. From outdoor surface area, the results showed the majority only had 5 to 20 m2 but following the second dominant answer were 26% who had more than 40m2 of outdoor areas. These various results of indoor and outdoor surface areas of the house may affect the availability of spaces and activities inside the house.

Table 4. Housing characteristics

Variables		freq	%	Variables		freq	%
Ownership	Owner	201	0.87	**Duration of residence (years)**	<1	16	0.07
	Tenant	30	0.13		1-5	58	0.25
Residential Type	Clustered	83	0.36		6-10	38	0.16
	Urban/ Rural Housing	137	0.59		>10	119	0.52
	Apartment	7	0.03	**Indoor Surface Area (m2)**			
	Public Housing	4	0.02		<36	10	0.04
Number of Floors	1	111	0.48		36-60	38	0.16
	2	101	0.44		61-90	55	0.24
	3	14	0.06		91-120	47	0.20
	4	2	0.01		121-150	28	0.12
	>4	3	0.01		151-180	24	0.10
Number of Occupants	1	8	0.03		>180	29	0.13
	2	26	0.11	**Outdoor Surface Area (m2)**	<5	35	0.15
	3	35	0.15		5-20	79	0.34
	4	72	0.31		21-30	29	0.13
	5	55	0.24		31-40	29	0.13
	>5	35	0.15				

Housing Satisfaction (HS)

For the HS variable, PCA and FA analysis was carried out. From the PCA result, three (3) principal components were obtained. Furthermore, the results of the PCA were analyzed by FA using the varimax rotated components method which resulted in the three (3) latent variables of HS, i.e., functions and activities, physical space, and acoustic & visual comfort. All latent variables represent 21 measured variables with a cumulative percentage of 64.347% and have eigenvalues of >1. The results of FA on HS can be seen in Table 5, the labeling of this latent variable adopts Akbari et.al (2021)'s research but with modifications according to the results of grouping measured variables.

The first latent variable *functions & activities* represents how the house can accommodate various functions and activities of the respondents during quarantine (i.e., rest, domestic chores, entertainment, social interaction, working studying online, and exercise) with the support of good natural lighting and natural ventilation into the house. The result of the measured variables in this latent variable is slightly different from that of Akbari et.al (2021), where natural lighting and natural ventilation in their research are included as environmental variables. The second latent variable *physical space* represents the physical quality of rooms, i.e., number, size, etc. This latent variable consists of the space of the dining room, bathroom space, living room, kitchen, bedroom, parlor, terrace/ balcony, circulation, and work/ study room. The last latent variable, *acoustic & visual comfort* consists of measured variables that support comfort in terms of acoustic and visual residents such as acoustic comfort, greenspace, gardening, and view outside.

The results in Table 5 indicated that the mean value of all three latent variables of residents' satisfaction with their existing homes does not reach the value of 3. From these results, it can be concluded that residents are not very satisfied with the current condition of the quality of their housing, especially during the pandemic.

Table 5. Factor analysis of housing satisfaction on their existing house

Measured variable	Mean	Factor loading	Eigenvalue	% of variance	Cum %	Cronbach's alpha
Factor 1: Functions & Activities	2.99		10.436	26.137	26.137	0.920
Rest	3.35	0.808				
Domestic chores	3.10	0.767				
Entertainment	3.08	0.750				
Natural Lighting	3.09	0.744				
Natural ventilation	2.94	0.671				
Working/studying online	2.92	0.669				
Social Interaction	2.80	0.638				
Exercise	2.67	0.606				
Factor 2: Physical Space	2.87		1.955	23.744	49.881	0.901
Dining room space	2.87	0.781				
Bathroom space	2.93	0.779				
Living room space	3.03	0.755				
Kitchen space	2.89	0.733				
Bedroom space	3.23	0.693				
Parlor space	2.79	0.610				
Terrace/ balcony space	2.87	0.606				
Circulation space	2.59	0.573				
Work/ study space	2.61	0.517				
Factor 3: Acoustic & visual comfort	2.60		1.121	14.466	64.347	0.857
Acoustic comfort	2.38	0.697				
Greenspace	2.62	0.671				
Gardening	2.69	0.564				
View outside	2.67	0.561				

The largest mean value is the house's ability to accommodate *functions & activities* with a total mean value of 2.99. The function and activity that residents feel most satisfied with is rest. More time at home means residents have more opportunities to rest and the current homes can accommodate these activities quite well.

Meanwhile, the lowest total mean value is in the *acoustic & visual comfort* factor where the value is 2.60 and the lowest measured variable is acoustic comfort. The result shows that most of the residents assess the acoustic conditions in their existing house as poor. Negative acoustic and visual quality inside the house are found to affect the mental health of residents (Akbari et al., 2021; Alhadedy & Gabr 2022; Amerio et al., 2020; Muhyi & Adianto 2021; Birer et al., 2022; Peters & Halleran, 2020; Navaratnam et al., 2022). Several researches showed that housing

nowadays needs personal space with good acoustics to support productive activities like remote working in the house (Amerio et al., 2020; Muhyi & Adianto, 2021; Birer et al., 2022). Visual comfort also becomes a priority in future housing. Previous studies showed that viewing greenery has a psychological impact on reducing negative mental health problems (Akbari et al., 2021; Peters & Halleran, 2020; Navaratnam et al., 2022).

Frequency of Activities (FoA) during Quarantine in the Pandemic

The FoA during quarantine is also thought to influence their satisfaction and preferences for housing. From PA and FA, 2 latent variables were found which had an eigenvalue >1 and a cumulative percentage of 64.41%, frequency of activities for daily (*FoA daily*) and frequency of activities for hobbies and social (*FoA hobbies & social*). This latent variable represents 8 measured variables of activities inside the homes during the quarantine.

The latent variable *FoA daily* includes activities that are commonly conducted inside the house including personal hygiene, working/studying online, domestic chores, rest, and entertainment. The second latent variable and *FoA hobbies & social* consist of activities that are considered other leisure activities inside the house such as social interaction, gardening, and exercise.

From Table 6 it can be seen that the highest mean value was for *FoA daily* in 3.16 with the most intense activities being personal hygiene and working/studying online. Due to the pandemic, residents' awareness of preventive behaviors such as washing hands, and changing clothes after leaving the house increases (Yang et al., 2022). Apart from that, work and school activities must be carried out remotely from home, thus the frequency of the activities has risen during the pandemic.

Table 6. Factor analysis of the frequency of activities

Measured variable	Mean	Factor loading	Eigenvalue	% of variance	Cum %	Cronbach's alpha
Factor 1: Freq. of Daily Activities	3.16		4.22	41.96	41.96	0.61
Personal Hygiene	3.35	0.87				
Working/studying online	3.27	0.84				
Domestic chores	3.06	0.76				
Rest	3.18	0.69				
Entertainment	2.94	0.66				
Factor 2: Freq. of Hobbies & Social Activities	2.19		0.94	22.46	64.41	0.88
Social Interaction	1.95	0.90				
Gardening	2.21	0.52				
Exercise	2.40	0.50				

As for *FoA hobbies & social*, it is very rarely done by residents during the pandemic. It can be seen from the total mean value which is only 2.19 with the lowest measured variable being social interaction. Stay-at-home regulations and social distancing mean that the time to socialize directly with other people was greatly reduced. A previous study found that the limitation of social interactions during quarantine caused negative mental health effects on residents such as feelings of loneliness and boredom (Peters & Halleran, 2020).

Housing Preferences (HP) for Future Healthy Housing

Even though the measured variables asked were almost all the same as HS, the results after carrying out PCA and FA with varimax rotation for HP were different. Five (5) latent variables were found, i.e., *environmental comfort, physical space, function & activities, semi-outdoor space,* and *productive space*. So, the 3 latent variables, it is more or less the same as previous research (Akbari et al., 2021), but there are 2 new variables, namely the need for *semi-outdoor space* and *productive space*. This shows that for future healthy housing, respondents have more demands from their current housing design. All of these latent variables have eigenvalues >1 and have a cumulative percentage of 72.19% of all of the data. The results of the FA can be seen in Table 7.

Table 7. Factor analysis of housing preferences on their existing house

Measured variable	Mean	Factor loading	Eigenvalue	% of variance	Cum %	Cronbach's alpha
Factor 1: Environmental Comfort	3.37		9.10	19.31	19.31	0.91
Natural ventilation	3.60	0.86				
Natural Lighting	3.59	0.85				
View outside	3.28	0.78				
Greenspace	3.33	0.78				
Acoustic comfort	3.03	0.70				
Factor 2: Physical Space	3.44		1.88	16.86	36.18	0.86
Bathroom space	3.52	0.79				
Kitchen space	3.38	0.77				
Bedroom space	3.70	0.75				
Dining room space	3.16	0.68				
Living room space	3.43	0.67				
Factor 3: Function & Activities	3.26		1.22	15.90	52.07	0.87
Rest	3.66	0.69				
Entertainment	3.38	0.68				
Domestic chores	3.25	0.67				
Working/studying online	3.46	0.67				
Social Interaction	2.83	0.57				
Exercise	2.96	0.57				
Factor 4: Semi-outdoor Space	2.97		1.15	13.11	65.18	0.75
Circulation space	3.10	0.74				
Gardening	2.68	0.65				
Terrace/ balcony space	3.12	0.60				
Factor 5: Productive Space	3.39		1.09	7.02	72.19	
Work/ study space	3.39	0.87				

The latent variable *environmental comfort*, contains the same measured variables as Akbari et al.'s research (Akbari et al., 2021), namely natural ventilation, natural lighting, the view outside, green space, and acoustic comfort. All of these measured variables support occupant comfort in terms of thermal, acoustics, and visual. The second latent variable, *physical space,* consists of the space qualities in the main rooms of the house including the bathroom, kitchen, bedroom, dining room, and living room. The *function & activities* latent variables include how the house can accommodate various functions and activities of the respondents during quarantine which include rest, entertainment, domestic chores, working/studying online, social interaction, and exercise. The next latent variable was *semi-outdoor space*, which consists of circulation space, gardening activities, and terrace/balcony space. When residents have the experience of being quarantined at home and not being able to go anywhere, they end up preferring housing that has more open or semi-open space to relax and enjoy nature (Akbari et al., 2021; Peters & Halleran, 2020). The last latent variable, *productive space*, shows the current phenomenon where housing is not only a place

to rest but can be used to work and carry out other productive activities (Alhadedy & Gabr, 2022; Rachmawati et al., 2021).

According to the mean values, it can be seen that the value of each latent variable is almost and even the majority is more than 3, and at the same time is higher than the previous housing satisfaction value. This shows that residents have higher expectations for their housing in the future. The gap between satisfaction and preferences can lead to complaints and disappointment for residents (Akbari et al., 2021; Sakina & Setiawan, 2022). Indonesian residents' biggest priority is *physical space* with 3.44, followed by *productive space* with 3.39, and then *environmental comfort* with an average mean value of 3.37.

For *physical space*, the most important measured variable is the bedroom. Residents prioritize the space qualities of this room for their future homes. After COVID-19, adequate space become a fundamental aspect of health and well-being in the living environment (D'Alessandro et al., 2020). Indoor spaces are demanded to accommodate various activities of family members comfortably. Poor housing conditions with inadequate space will affect negative psychological issues and increase feelings of depression (Amerio et al., 2020). The feature of flexibility has become one of the findings that were important in future housing spaces (D'Alessandro et al., 2020; Alhadedy & Gabr, 2022; Yang et al., 2022). For bedrooms, it was found that residents needed more than one bedroom, where some bedrooms can function as normal rooms for resting and other bedrooms can be multifunctional if needed, either for isolating unhealthy family members or for working or studying (D'Alessandro et al., 2020; Al-Qaisi, 2022).

The high results of residents' assessments for *productive space* also reinforce the importance of the need for space to work or study in future housing. With current technological advances and the many remote and hybrid activities, the existence of productive space with private, non-distracted space at home is much needed (Muhyi & Adianto, 2021).

Environmental comfort is also important, especially natural ventilation and natural lighting. Natural light and natural ventilation are known to be passive strategies to achieve indoor thermal comfort and support the health of indoor residents (Peters & Halleran, 2020; Navaratnam et al., 2022). Good air quality also helps to prevent viruses and diseases from spreading inside the home with airflow and air exchange.

The Influence of Housing Satisfaction (HS) and Frequency of Activities (FoA) During Quarantine on Housing Preferences (HP)

All latent variables, from HS on their existing house, FoA during pandemics, and HP were analyzed using multivariate regression analysis to determine their causal relationships. In the principle of causation, the independent variable as the "cause" happened before the dependent variable or "effect" (Chambliss, 2006). Residents can have preferences for their dream post-pandemic house after experiencing quarantine in their existing house and carrying out various activities during the pandemic. Therefore, in this study, HS and FoA were treated as independent variables, and the HP on their future house was treated as the dependent variable.

The results of the multivariate regression analysis show a significant causal relationship between the independent and dependent latent variables, where the model's p-value mostly resulted in <0.0001 or significant. However, the R square values are quite low (<0.6) so the accuracy of predicting these results in representing the data is still lacking. This may be caused by the possibility of respondents' answers being very varied for each question variable. The causal relationship between the latent variables is shown by the regression coefficient (β) along with the p-value. In general, almost all independent variables have a causal relationship with the dependent variable. The results of the analysis can be seen in Table 8.

From the result showed a significant causal relationship between *FoA daily* (β = 0.49, p = <.0001) and *HS acoustic & visual comfort* (β = 0.15, p = 0.0136) in causing *HP environmental comfort*; *HS physical space* (β = 0.26, p = 0.0003) and *HS functions & activities* (β = 0.26, p = 0.0077) resulted as the dominant factors in causing *HP physical space*; *FoA daily* (β = 0.49, p = <.0001) caused *HP function & activities*; *HS acoustics & visual comfort* (β = 0.39, p = <.0001) and *FoA hobbies & social* (β = 0.221, p = 0.0018) showed to be the cause of *HP semi-outdoor space*; and lastly the result showed *FoA daily* (β = 0.22, p = 0.0317) and also *HS acoustic & visual comfort* (β = 0.15, p = 0.0319) were the dominant factors causing *HP productive space*.

According to the overall results, the causal relationships with the strongest influences are *FoA daily* on *HP environmental comfort, HS physical space* on *HP physical space*, and *HS acoustic & visual comfort* on *HP semi-outdoor space*. Furthermore, independent variables that mostly influence HP are *HS acoustic & visual comfort* and *FoA daily*. To simplify the result of the analysis, a model is used to explain the causal relationships between the variables (Figure 1). The significant results verify that residents' experiences during the pandemic and their satisfaction with their housing conditions to support their quarantine period influenced their future housing preferences.

HP environmental comfort (i.e., natural ventilation, natural lighting, the view outside, greenspace, acoustic comfort) was dominantly affected by the result of residents *FoA daily* (i.e., personal hygiene, working/studying

online, domestic chores, rest, and entertainment) and also *HS acoustic & visual comfort* (i.e., acoustic comfort, greenspace, gardening, and view outside). Previous result shows the frequency of daily activities inside the house has risen during the pandemic, either for doing domestic chores, resting, doing hobbies or even to work and study. From the post-pandemic evaluation, the residents assess the acoustic and visual conditions in their existing houses as poor. These results underlie respondents' expectations for their dream house where they tend to desire a house with better environmental comfort to be able to carry out activities comfortably. Previous studies have shown how environmental comfort was found to be a necessity by residents since the Covid-19 pandemic. It can support the physical and mental health of the residents and also their productivity (Peters & Halleran, 2020; Akbari et al., 2021, Zarrabi et al., 2021; D'Alessandro et al., 2020; Muhyi & Adianto, 2021; Wardhani & Susan, 2021; Alhadedy & Gabr 2022; Navaratnam et al., 2022; Sakina & Setiawan, 2022; Rachmawati et al., 2021; Maclennan et al., 2021). As an additional value, the possibilities of openings to allow natural light and airflow became positive factor in residents' well-being and also supported to reduce the transmission of viruses inside the house (Al-Qaisi, 2022; Peters & Halleran, 2020; Akbari et al.., 2021; Wardhani & Susan, 2021).

Table 8. Multivariate regression analysis between housing satisfaction and frequency of activities on housing preferences

Dependent Variables / Independent Variables	*Housing Preferences (HP)*									
	Environmental Comfort		**Physical Space**		**Function & Activities**		**Semi-outdoor Space**		**Productive Space**	
	Rsq=0,26 Pvalue <0,0001		*Rsq=0,14 Pvalue <0,0001*		*Rsq=0,13 Pvalue <0,0001*		*Rsq=0,24 Pvalue <0,0001*		*Rsq=0,07 Pvalue 0,0056*	
	β	P	β	P	β	P	β	P	β	P
Housing Satisfaction (HS)										
Functions & Activities	-0.02	0.83	0.26**	0.0077	0.06	0.53	-0.04	0.65	-0.17	0.10
Physical Space	-0.08	0.22	0.26***	0.0003	-0.14	0.06	0.06	0.38	0.02	0.75
Acoustic & visual comfort	0.15*	0.0136	-0.03	0.60	-0.06	0.38	0.39***	<.0001	0.15*	0.0319
Frequency of Activities (FoA)										
Daily	0.49***	<.0001	-0.002	0.98	0.32**	0.0016	-0.01	0.91	0.22*	0.0317
Hobbies & Social	0.02	0.77	0.001	0.99	0.13	0.09	0.221**	0.0018	-0.04	0.56

Note: *p<0.05; **p<0.01; ***p<0.001

HP physical space which consists of the space qualities in main rooms was found to be highly influenced by the results of occupant evaluations on *HS physical space* (i.e., number, size, etc.) as well as *HS functions & activities* during quarantine (i.e., rest, domestic chores, entertainment, social interaction, working studying online & exercise). As the result for housing satisfaction, either physical space or functions and activities does not reach the value of 3, indicating the respondents were unsatisfied with their existing house. During quarantine, respondents were found to be adjusting their existing house either by re-arranging, re-sizing, or even adding more spaces in their house to be able to carry out various activities at home (Asharhani & Gupitasari, 2021; Nurrahmada et al., 2023; El-Husseiny, 2021). Respondents then preferred their house to have better physical space, especially in the main rooms including the bathroom, kitchen, bedroom, dining room, and living room. The changes during quarantine have affected how residents wanted the physical space of their future houses would be. As adequate space is related to the feeling of being comfortable or uncomfortable in the living environment, it became a fundamental aspect of health and well-being (D'Alessandro et al.). Healthy and sustainable house needs to have additional rooms including an indoor bathroom for possibilities of isolation, flexible and multi-purpose rooms, and organized space between common and private zones to minimize noise pollution (Zarrabi et al., 2021; Al-Qaisi, 2022; Akbari et al., 2021; D'Alessandro et al., 2020; Wardhani & Susan, 2021; Alhadedy & Gabr, 2022; Amerio et al., 2020; WHO, 2018).

HP semi-outdoor space is a preference of residents which consists of circulation space, gardening activities, and terrace/balcony space, has been strongly influenced by the results of *HS acoustic & visual comfort* and also *FoA hobbies & social* such as leisure activities inside during quarantine such as social interaction, gardening, and exercise. During quarantine, limitations in outdoor activities mean they need green space or semi-outdoor spaces such as terraces and balconies to support healthy lifestyles, like exercising, socializing, and gardening (Sakina & Setiawan,

2022). Viewing greenery is also known to have a psychological impact on reducing mental health issues such as stress and emotional states (Akbari et al., 2021; Peters & Halleran, 2020; Navaratnam et al., 2022). But from the result of residents' satisfaction, the visual comfort of their existing house was considered low. Therefore, for their future house, they see the existence of semi-outdoor space as important.
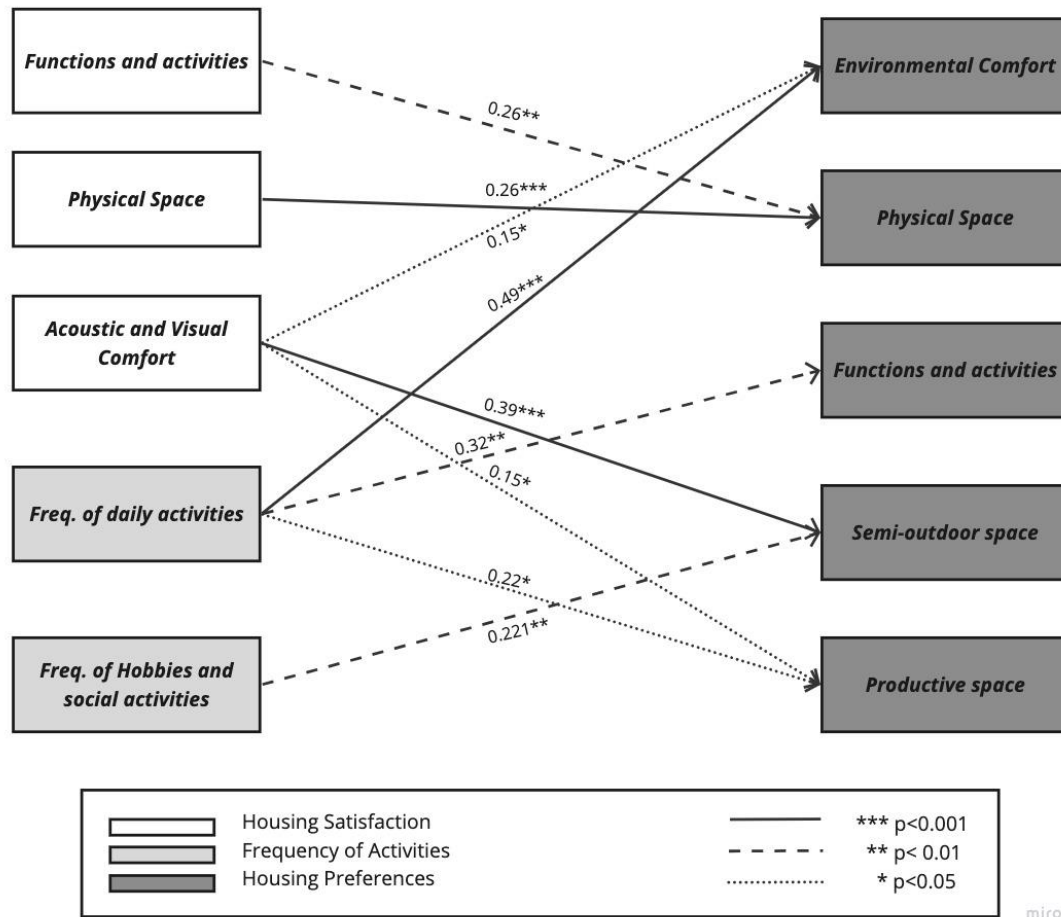

Fig. 1. Causal relationships between housing satisfaction and frequency of activities on housing preferences
(Source: author)

HP function & activities include how the house can accommodate various functions and activities of respondents which include rest, entertainment, domestic chores, working/studying online, social interaction, and exercise., This was caused by *FoA daily*. Based on the assessment, *FoA daily* was the most carried activity by residents during quarantine with personal hygiene and working/studying online becoming the most frequent activities. So, based on the result, the residents surely want the house to be able to comfortably accommodate various activities, especially those related to daily activities that are most often carried out at home. Due to the pandemic, residents' healthy habits such as washing hands, and changing clothes after leaving the house increased (Yang et al., 2022). Future houses can accommodate by providing a powder room or additional bathroom located near the entrance. Another activity that has become important to be carried out in a living environment is hybrid working. Hybrid working or even work from home (WFH) have become common now, and therefore, future home needs to facilitate those needs, either with a special room for home office, multifunction rooms, or acoustic design solution for noise pollution (Alhadedy & Gabr, 2022; Birer et al., 2022).

HP productive space is one of the residents' needs after the pandemic which is influenced by *FoA daily* and *HS acoustic & visual comfort*. Since the pandemic, home is not only a place to rest and gather with family but also for productivity. Looking at the data, most respondents are employed and some are students, so they have experience with teleworking or tele-studying activities, and it has become part of their daily activities. In the future, remote and hybrid activities will also become common, so respondents will need a special space to work at home (Alhadedy & Gabr, 2022). As the result of the evaluation on the overall satisfaction values of the existing house was below 3, and the acoustic and visual comfort resulted as the lowest, therefore in future housing these aspects should be considered more, especially in productive spaces. During the pandemic, residents carry out various activities simultaneously at the same time so they need personal space with good acoustic conditions to minimize noise pollutions (Sakina and

Setiawan 2022). Poor conditions in housing could decrease working performance, thus increasing the risk of mental illness such as depressive symptoms (Amerio et al., 2020; Navaratnam et al., 2022). The spaces of productivities need to be adequate in terms of size, flexible, and pay attention to environmental features such as having visual access to greenery, good acoustics, and also having good natural lighting and ventilation (D'Alessandro et al., 2020; Akbari et al., 2021; Alhadedy & Gabr, 2022).

The long period of quarantine has made residents value the living environment more. Onwards, home is not just a place to rest and do domestic chores but also an environment to carry out healthy lifestyles and hybrid working or studying, which has become part of their daily routines. These shifted behaviors and needs will be the basis of decision-making in designing future healthy and sustainable homes.

The acoustic and visual comfort which were found to be related to most of the housing preferences also underline the importance of these aspects in future homes. Contradictory, the existing housing condition does not support this requirement, as shown by the low result of residents' satisfaction in terms of the quality of acoustic comfort, greenspace, gardening, and view outside. As we can analyze from respondents' housing characteristics, mostly lived in urban areas, either in clustered or rural housing known as "kampung". The main characteristics of houses in the urbanizing area are it has limited plots of land and limited access to nature (Yin, et al., 2020). Results of the online questionnaire also revealed that most respondents only have around 5-20 m2 of outdoor surface area, which already includes carports, terraces, balconies, gardens, backyard, etc. Having access to greeneries, either visually or physically, has proven to have a positive impact on residents' physical and physiological health (Akbari et al., 2021; Peters & Halleran, 2020; Navaratnam et al., 2022). As for acoustics, before the pandemic, the design of the living environment didn't prioritize this aspect due to the minimal activities carried out at home. But during and after the pandemic, the residents had discovered the importance of good acoustic design especially for productive rooms. Many studies discovered how poor environmental quality, including noise pollution, could cause negative stress and annoyance that could lead to health problems (Zarrabi et al., 2021; Akbari et al., 2021; Alhadedy & Gabr, 2022; Amerio et al., 2020). One way to solve this is by paying attention to the spatial organizations of quiet zones (to rest and productivity) and active zones (living room, dining room, etc.) of the house (Amerio et al., 2020; Muhyi & Adianto, 2021; Birer et al., 2022).

CONCLUSION

This paper aims to make a post-pandemic evaluation of Indonesian residents' housing satisfaction (HS), their frequency of activities (FoA) during quarantine, and residents' future housing preferences (HP) on healthy housing to promote positive mental health. This paper also wants to see whether there is a relationship, and if so, what variables of HS and FoA influence certain HP through the causal relationship. The study resulted in three latent variables representing HS, two latent variables for FoA, and five latent variables for HP.

The results for HS generally showed Indonesian residents were not satisfied enough with the existing condition of their houses during the pandemic, and the most dissatisfied was for *acoustics & comfort*. For FoA, *FoA daily* was the most intense activities carried out during the pandemic and the two most frequent activities were personal hygiene and working/studying online. The result for HP shows the values for all latent variables were higher than HS values, which indicates residents have higher expectations for their housing in the future. Indonesian residents' biggest priority is physical space, productive space, and environmental comfort.

After conducting multivariate regression analysis to see the causal relationship between HS and FoA on HP, it was verified that residents' satisfaction with their existing housing and their frequency of activities during quarantine influenced their future healthy housing preferences. the causal relationships with the strongest influences are *FoA daily* on *HP environmental comfort, HS physical space* on *HP physical space*, and *HS acoustic & visual comfort* on *HP semi-outdoor space*. Furthermore, independent variables that mostly influence HP are *HS acoustic & visual comfort* and *FoA daily*. The results further strengthen the importance of designing a living environment with adequate spaces, providing greeneries and good acoustic quality in supporting daily activities in future healthy housing.

For future sustainable and resilient healthy housing, some design recommendations can be presented as follows:

- Paying attention to passive design strategies like building orientation and openings for good indoor quality such as sufficient natural lighting, natural ventilations and thermal comfort.
- Have at least one additional room with an indoor bathroom for isolating sick family members.
- Providing multipurpose room with flexible features (i.e., foldable doors, partition, movable furniture, etc.)
- Organizing space layout by separating private zones and common zones to avoid noise pollution
- Providing private semi-outdoor spaces (i.e., terraces, balconies, etc.) for enjoying fresh air, exercising, socializing, gardening, or other hobbies.
- Designing rooms with visual access to greeneries.
- Locating a powder room or additional bathroom near the entrance.

- Providing a productive space or home office with good visual access and sound insulations for better acoustics.

The validity of this research still needs to be tested with further research. There are still many possibilities for future research, for example by increasing the number of respondents, limiting the respondent criteria to find out specific housing preferences, or choosing certain limitations on the research location so the results can be more contextual. The results of this study will hopefully be valuable information for all of the stakeholders, architects, designers, planners, and even the government in developing future housing designs that are healthy, sustainable, and resilient.

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