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Changes in Social Distancing within Post-Pandemic Architecture: A Systematic Literature Search and Review

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Abstract "Changes of social distancing in post-pandemic architecture" refers to the changes in spatial distancing and protocols in a building for preventing future pandemics. In 2019, the rapid spread of COVID-19 has caused changes in architecture, especially in social distancing. The built environment needs different strategies to help prevent the spread of disease in the future. Changes in social distancing within post-pandemic architecture will be reviewed and discussed in this study. A systematic literature search and review defines previous research systematically, relates concepts, and reanalyzes data critically. The first step is systematically clear selection; the second step is coding; and the third step is synthesis. The selection considered 109 papers (of which 39 were reviewed). The findings are five strategies for future social distancing in architecture post-pandemic revealed using prevention strategies: standards for integrating a healthy environment; relationships and interactions in users' pattern activity; environment design related to nature; spatial relationships (proxemics); and place attachment. Each strategy demonstrates the connection between social distancing in post-pandemic architecture and security-pandemic variables for built environments that can prevent the spread of disease in the future. These findings will support future research in defining and understanding the need for holistic analysis of changes in social distancing within post-pandemic architecture.

Keywords Future, Interior, Social Distancing, Pandemic, Public Space.

1. Introduction

The COVID-19 (SARS-CoV-2) pandemic has changed millions of people's daily routines, including social distancing and physical separation in the built environment. [1]. During the COVID-19 pandemic, the Indonesian government endeavored to institute social segregation in public and shared areas (the new normal) for the acceleration of COVID-19 mitigation [2]. People have adopted a new normal that entails maintaining physical activity while reducing physical contact and maintaining social distance while implementing health protocols to prevent virus transmission [3], [4]. New spatial protocols, standards, social distancing, and security systems necessitate new requirements.

Urban planning, sanitary systems, and architectural designs have evolved significantly because of past disasters, epidemics, pandemics, and contagious diseases and highlight the significance of architects and designers in preventing disease spread [5] [6]. The current COVID-19 pandemic has an impact on architectural designs and the rapid changes in users' needs, behaviours, and daily lives in the future [7].

It is essential for concept and design elements in the built environment to prioritize health, safety, and security. Health, safety, and security are ranked second in Maslow's hierarchy of needs [8]. Security issues for the built environment are related to the prevention and detection of threats carried out and motivated by humans [9]. In the event of a pandemic, security in the built environment is also necessary to help identify, lower the risk of, and prevent viruses.

Despite the significance of social involvement, the COVID-19 pandemic has limited social connection and forced physical distance. A comprehensive approach that draws on several disciplines related to architectural

distancing and built environment design is needed to address the complex issues raised by post-pandemic social distancing changes in architecture. Salama (2020) reveals a contextual-transdisciplinary framework that explains pandemics in urban settings [10]. One of the aspects discussed in this framework is architecture with socio-spatial interference of distancing measures related to: (1) geographical locations, home zone, and home range; (2) personal attachment, personal space, and proxemics; and (3) COVID-19 links to urban life dialectics. Although there are two more aspects (dynamics [11] and living-working patterns), this paper focuses on the distancing in post-pandemic architecture.

To mitigate the spread of a pandemic, it is necessary to address the evolving socio-spatial requirements, particularly in relation to social distance. Two preliminary studies have examined the changes in social distancing within post-pandemic architecture. The first study examines the impact of the post-pandemic period on urban socio-spatial distancing measures [10], [12]. The second study examines the integration of safety and security measures as essential principles and design elements within the built environment, with the aim of preventing and detecting potential threats [13], [14]. These preliminary studies entail the need for urban and architectural design as one way to prevent its spread and healthy behaviours in humans [15].

A systematic literature search and review method will be used as research methodology to classify, identify characteristics, and justify the post-pandemic security variables for the built environment. The aim is to investigate a novel approach to addressing "changes in social distance in post-pandemic architecture" by considering security variables that can help improve public space safeguarding (including pandemic protection and user control within the environment). The variables will be implemented by considering the existing variables related to security in the built environment and new variables.

2. Methodology

The research methodology employed in this study is a systematic literature search and review. This methodology places emphasis on literature articles indexed on lens.org. The systematic literature search and review methodology is a combination of a systematic literature search and a critical review methodology to culminate in the best synthesis.

This methodology incorporates multiple studies and offers a more comprehensive overview of the subject (the impact of the COVID-19 pandemic on social distancing measures with security variables to effectively reduce risks and promote a strategic synthesis) [16], [17]. The systematic literature search and review presented in this paper intends to propose a strategy for changes in social distancing within the post-pandemic architecture in terms of security variables.

Figure 1. Research Design
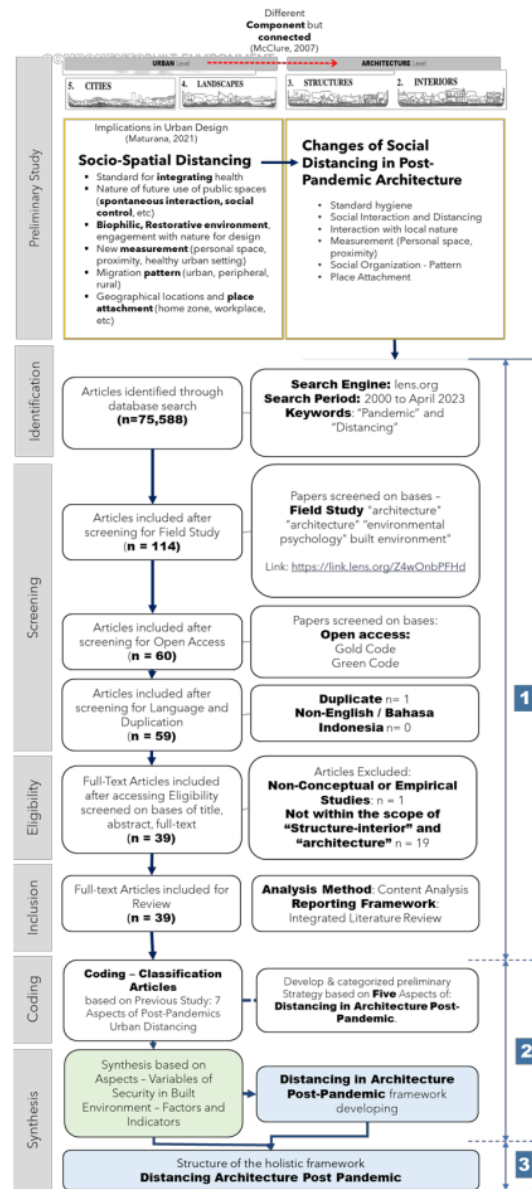
The steps for this systematic literature search and review—the systematic literature selection, the coding and classification, and the synthesis—are illustrated in Figure 1. The first step involves a thorough process of selecting and identifying the problem through a systematic literature search. The literature search includes the identification of appropriate keyword selection, database selection, the implementation of search methodologies, and the inclusion and exclusion criteria for primary sources. The next step involves data analysis using the coding and classification processes. Data obtained from primary sources is

systematically organized, assigned codes, and categorized accordingly. The third step involves synthesis using summarized information, critical review, and developing a strategic approach that is presented in a tabular format to summarize the conclusions.

2.1 Step 1: The Systematic Literature Selection

The systematic literature selection process was carried out by searching for sources of literature data from books, proceedings, journals, and articles through the website lens.org. The search criteria included research articles written in English, peer-reviewed, and published between January 2000 and April 2023. The keywords used are "pandemic" and "distancing." Based on these keywords, we found n= 75,588. The next step is filtering the field of study using "architecture," "environmental psychology," "built environment" (n= 114), and "accessible" (n= 60). Exclusion criteria included articles that were duplicated, not written in English or Bahasa Indonesia, and articles that were written as editorials (n= 59). Considering the inclusion and exclusion criteria, a total of 59 articles were eligible for review using the systematic literature search and review method. These 59 articles were reviewed independently by the authors, focusing on the changes in social distancing aspects of architecture. 20 of these articles were not connected to the research and thus were eliminated. 39 articles were recommended for inclusion in this review, as shown in Table 1.

2.2 Step 2: The Coding and Classification

Subsequently, the coding and categorization process ensues. Maturana et al. (2021) and Salama (2020) have identified a total of six sub-aspects pertaining to urban socio-spatial distancing [10], [12]. Of the six sub-aspects in the urban socio-spatial distancing research, only five were discussed and identified as the changes in social distancing at the architectural level. The coding process comprised a thorough analysis and assessment of 39 academic papers to determine their compliance with sub-aspects. The discussion's content is coded and classified based on changes in the social distancing aspect framework and its sub-aspects for architecture in literature sources.

2.3 Step 3: The Synthesis

The synthesis process commenced by doing a more comprehensive analysis to identify the specific sub-components of the changes in social distancing in the post-pandemic architecture that are linked to the security variables within the built environment. According to Briggs (2005), there exist seven security variables [18]. Additionally, there is the potential for the inclusion of new sub-aspects in the future. The 39 literature sources were categorized to establish a comprehensive framework. The synthesis process included the inclusion of indicators, variables, and measurement objectives as strategies for changes in social distancing within the post-pandemic architecture, as shown in Table 3.

3. Preliminary Study

Preliminary studies were conducted to comprehend the scope of the concept of social distancing in urban and security strategies before the pandemic. Socio-spatial urban measures about spatial and social distancing measures and protocols at the urban level [12]. There are several sub-aspects of social distancing measures at the urban level as they relate to virus spread and urban health [10], [12], including: (1) standard for integrating health; (2) the nature of future use of public space (spontaneous interactions, social control, relating to personal and public health and safety); (3) biophilic, restorative environment, engagement with nature for design; (4) new measurement (personal space, proximity, health in an urban setting); (5) migration pattern (urban, peripheral, rural); and (6) geographical locations and place attachment (home zone, workplace). Changes in social distancing in post-pandemic architecture deal with the architecture level for the ramifications of virus transmission. The difference between the urban level and the architecture level is in the spatial-object scale and the processing time [15] (see Figure 1.)

Designers need to dedicate themselves to safeguarding the public's health by integrating proactive perspectives on safety and security to protect the well-being of the public through the built environment to the extent to which users can alter or control their environment yet give them a sense of security [19]. It is imperative to align the requirements of changes in social distancing needs within post-pandemic architecture to establish a more secure and safer built environment. There are seven basic security sub-aspects to consider in the context: (1) access and movement (presence of well-defined routes, spaces, and entrances for easy mobility); (2) structure (structured place to minimize the potential conflict); (3) surveillance (all publicly accessible places can be overlooked); (4) physical protection (well-designed security features); (5) activity (appropriate human activity for the location); (6) management and maintenance (security management and regular maintenance of security). (7) Ownership (the presence of ownership, respect, and territoriality in certain locations) [18]. In the preliminary study, two keywords, "pandemic" and "distancing," were used as a literature search, and the outcome of the result will be summarized in the "Result and Discussion" section.

4. Results and Discussion

The coding results are utilized to conduct an in-depth analysis and synthesis process within the context will be discussed in this section. This section describes: the

selection of the literature process; the coding and classification process of variables, and the synthesis of strategies in changes in social distancing within post-pandemic architecture.

4.1 The Selection of Literature for Changes in Social Distancing within Post-Pandemic Architecture

Based on preliminary study above and to comprehensively examine the current state of knowledge, lens.org was used to search for books, proceedings, journals, and articles for systematic literature selection, using the two keywords "pandemic" and "distancing". As explained in preliminary study, Salama et al. (2020) examine the implications of the COVID-19 pandemic on urban architecture, specifically focusing on post-pandemic architectural issues and the changes of socio-spatial and distancing in urban. Salama (2020) argues that forthcoming investigations in design and planning should prioritize

various critical concerns [10].

Maturana et al. (2021) examines the consequences highly transmissible coronavirus and its implications for the field of architecture and urban design, emphasizing the crucial role of health considerations in shaping this post-pandemic in urban level. From the implications are the influence of virus transmission on the urban dynamics, the implementation of social and physical distance, and the impact of the rapid adoption in digital technology in new normal daily life [12].

From the conceptual approaches of Salama et al. (2020) and Maturana et al. (2021) in urban level, and after thorough literature review of 39 articles (see table 1.), only five aspects are related to the architecture level: (1) Standard for integrating healthy environment in architecture; (2) Relationship and interaction in users' pattern; (3) Environment Design related to nature, (4) Spatial relationship (proxemics), and (5) Place Attachment for architecture.

Table 1. Review Findings and Implications for Research

Ref	Cite Count	Review findings and implications for research with keywords in bold (selected)	Aspect 1		Aspect 2		Aspect 3		Aspect 4		Aspect 5	
			Layout for healthy - antropometric	Layout for healthy - ergonomic	Social interaction	social control	direct related to the nature	Indirect related to the nature	Personal-private	Proximity	Zoning at workplace	Zoning at home
[20]	210	Since 90% of humans spend their time in the built environment, Covid-19 transmission can be risky due to occupant density and indoor activities that boost **social interaction**.			1	1			1	1	1	1
[5]	210	Possible changes to the built environment after the pandemic: population density, residential size, level of **social distancing, shared facilities, housing characteristics**.		1	1	1	1	1		1		
[10]	59	Experiences such as the concept of home zone, home range, attachment to place, personal space and proximity to nature are important concepts to be considered by the built environment.					1	1			1	1
[21]	47	Healthy, safe, and sustainable housing recommendations: accessible green elements and spaces, **flexibility, adaptability, density in buildings, redefining sustainable architecture principles and patterns, comfortable indoor air quality and temperature**, water management, municipal waste management, payment for automation and electromagnetic fields, building materials and finishing.		1			1	1	1	1		1
[22]	44	Mixed-use neighborhoods with **easy access to destinations** should be pedestrian-friendly and safe.					1					
[23]	40	There are several ways to prevent disease transmission through the built environment, namely: **through the environment** (light, water, air, thermal, acoustic) and **healthy building materials, healthy behavior** (washing hands).	1	1			1	1				
[24]	37	Long-term strategy to reduce pandemic: designing flexibility in space, rethinking typology and the existence of shared spaces, service network, re-planning health emergencies, increasing stakeholder awareness regarding public health factors							1	1		
[25]	32	The higher density of the built environment will increase the direct and indirect contact between people, and proximity distance.	1	1	1	1						
[26]	29	**Social contact** is a way of transmitting the virus through the air. The duration of contact and the chance of meeting can decrease with distance			1	1						

Ref	#	Description										
[27]	24	The density model is a useful tool for conducting **risk assessments** in buildings. The EXPOSED model calculates the user's possible exposure based on the **density model** output			1	1						
[28]	20	The characteristics of the built environment can help characterize COVID-19 risk at the **community level**.					1	1				
[29]	19	This article emphasizes **restorative social and environmental design** by prioritizing windows and views, lighting, rooms designed for good sleep, quality and natural ventilation, social distancing, and reducing overcrowding.		1	1	1	1	1				
[30]	16	Environmental domains that are friendly to elderly users are Housing, **Social participation, Respect and social inclusion,** Communication and information, community support and health services, **Outdoor space and buildings**, Transportation, Financial situation, and financial situation.	1	1			1	1				
[31]	16	This article presents a **social distancing framework** that can help maintain, **unify, manage, and reduce physical interactions** and the result is that this framework works effectively to unify social distancing between users.			1	1			1	1		
[32]	13	Public markets and restaurants are the two built environments that affect the transmission of COVID-19 in the second phase (**the phase of strict social distancing and the phase of moderate distancing**).			1	1			1	1	1	1
[33]	12	Steps to stop the spread of the epidemic include lockdown, **social distancing, control**. Contact and control movement in controlling the outbreak	1	1	1	1				1		
[34]	10	Due to the need for social distancing, the streets in the city experience changes in the pattern of socio-space such as mobility (addition of cycling areas), recreation, **physical distancing in congested** areas.			1	1			1	1		
[35]	10	**Hygiene-scale; person-distance-isolation scale; interior room scale-control air through ventilation; moisture and humidity**; small-large housing; public space between buildings-**social interaction; work-telecommunication; size and dispersion; shopping-proximity** scale-down; transport-roads, bicycles, shared mobility and robotic taxis and the scale of mixed use in the environment.	1	1	1	1	1		1	1		
[36]	10	This article provides results and proposals in the form of lower limits for static and **dynamic space allocation and social distancing** in retail space.	1	1						1		
[37]	10	The design of transit stations needs to take the **physical distance** factor into account.			1	1						
[38]	10	This essay examines COVID-19 emergency isolation room architecture. Several factors were considered when designing this space: **modular and adaptable; workspace for prevention and treatment; made of easily available materials**; done by skilled contractors; able to protect medical staff; technologically advanced; can move; efficient in time and schedule	1	1	1	1	1	1				
[12]	9	Distance procedures have several city-level implications: (1) **health integration standards**; (2) future use of public space, including spontaneous **interaction, social control,** passive/active involvement in personal and public health and safety; (3) enforcement of **Biophilic design, restorative environments, and** nature engagement standards; (4) **new design and size** standards **for a healthy** city; and (5) potential seasonal migration patterns.	1	1	1	1	1	1	1	1	1	1
[39]	7	The COVID-19 mitigation strategy impacts air quality, traffic, and traffic incidents. This strategy has a negative impact on **physical activity, mental health, home isolation** and access to transportation, especially public transportation.			1				1	1		1
[40]	4	**socioeconomic characteristics** play a more important role in the spread of COVID-19 than **population density** and other built environment characteristics			1				1	1		
[41]	4	There are 4 factors that influence the increase in the spread of the virus at the city level, namely the **proportion of urban population**, monthly consumption, number of workers and **distance** from the capital city			1			1			1	
[42]	4	In terms **of distance**, for spaces where seating capacity is very important (such as schools, universities, restaurants) then the **arrangement of the equilateral triangle-based** seat pattern provides a better solution than the arrangement of seats in rows and columns.	1	1	1	1						
[43]	4	In the context of COVID-19 prevention, the **quality of the environment and healthy buildings** have a significant impact	1	1			1	1				
[44]	3	This article is about increasing **social distancing in public spaces automatically** using an application for automatic distance.			1	1						
[45]	1	Basic relationship of human movement due to the COVID-19 Pandemic: (1) **human movement** (speed/flow with density behavior) (2) **interaction between road users** (collision avoidance, queuing mechanism, route choice).	1		1	1			1	1	1	1
[46]	1	**Interventions on social distancing,** school and workplace closures, mass			1	1			1	1		

Ref		Description										
		gatherings and movement are beneficial for the containment of the virus.										
[47]	1	This article writes that **racial/ethnic differences affect mobility patterns** which have an impact on reducing the spread of the virus	1	1	1	1			1			1
[48]	1	The condition of the house and water-sanitation-dirty water infrastructure, **natural lighting, ventilation,** and room hygiene conditions affect the transmission of COVID-19.	1				1	1				
[49]	1	This article addresses: speculation about how the current crisis and its management (i.e., **lockdown measures and social distancing** in the use of public spaces in accelerating or slowing the spread of the virus in different contexts.			1	1						
[50]	0	IoT (Internet of Things) technology, an **automation system that supports social distancing** and helps prevent pandemics	1		1				1	1		
[51]	0	IoT (Internet of Things) technology enables **contactless shopping, social distancing while shopping**, including contactless payments.			1	1			1	1		
[52]	0	A new way of communicating is carried out at the architectural bureau related to **social distancing and physical** distancing which are considered effective as a method of preventing the Covid-19 pandemic.			1	1			1	1	1	1
[53]	0	The built environment that has **green spaces and pedestrian and cycling infrastructure** is perfect for supporting quality of life during a pandemic					1	1				
[54]	0	Due to the COVID-19 pandemic, buildings are considered as a **place for transmission routes** (i.e., through contact, droplet, and air).			1	1			1	1	1	1
[55]	0	ICT tool technology helps to reduce public interactions and social distancing			1	1					1	1
			19%		30%		17%		22%		12%	

From the literature review above, 19% of articles discussed "Standard for integrating healthy environment in architecture", 30% of articles discussed "Relationship and interaction in users' pattern activity", 17% of articles discussed "Environment Design related to nature", 22% of articles discussed "Spatial relationship (proxemics)", 12% of articles discussed "Place Attachment for architecture". The summary and explanation of the five aspects are:

(1) "Standard for integrating healthy environment in architecture" is the standard design layout and space to integrate a healthy environment for preventing disease spread in architecture through ergonomic and anthropometric design standard. There are two things related to the standard layout spaces that integrate a healthy environment, namely through anthropometric design standards (designed taking into account the size of the human body [56], [57] and the ergonomic design standard (engineered taking into consideration the physical and mental comfort of humans during activity [58], [59] The impact of the pandemic has affected the design of ergonomics and anthropometry for integrating in a healthy environment.

(2) "Relationship and interaction in users' pattern activity" are limitation of user activity pattern through controlling social interaction (close and spontaneous) and social control which meant by restricting the users' pattern of activity for social interaction through the presence of architecture elements to limit user interaction patterns, for example the design of chairs that provide a secure social distance [60], [61]. For example, use wayfinding to direct the user to move in the same pattern and direction [62].

(3) "Environment Design related to nature" is standard design layout and space that considers the principles of natural environment to prevent and limit the spread of disease in architecture. There are two things related to this: directly related to nature and indirectly related to nature. Designs that take account of nature like biophilic designs have health impacts on users [63], [64]. A design standard with biophilic design principles will help reduce and control the spread of diseases. Biophilic designs will let users directly and indirectly interact with nature by breathing in fresh air, letting the sunshine on them without any filters, using natural materials like stone and wood inside the architecture, or using nature sound effects like the sound of waterfalls to make the experience even more realistic.

(4) "Spatial relationship (proxemics)" is changes standard design and spatial relationship for personal space and proximity to prevent the disease spread in architecture. There exist two interconnected concepts in this context: personal space and proximity space. Personal space refers to the physical distance, influenced by interpersonal relationship [65]–[67]. Prevention through proximity space refers to the spatial and social relationships that exist between individuals and their interactions within a given context [65], [68], [69]. Pandemics have an indirect impact on the dimensions of our personal space and proxemics during interpersonal interactions.

(5) "Place Attachment for architecture" is prevention of disease spread through concept of environmental psychology and emotional attachment between user and place in home and workplace. Pandemics have a significant impact on individuals' connection to their area, their relationship, and their emotions toward the environment because of mobility limitations and environmental changes, the user's perception of safety,

and the need to maintain physical and mental health [70].

The relevant studies from the reviewed paper, shown in Table 1, have shown that there are five aspects changes in social distancing in post pandemic architecture. The findings in these steps are required to support the early identification of changes in social distancing in post pandemics architecture's variables.

4.2 The Coding and Classification Aspects Changes in Social Distancing within Post-Pandemic Architecture

Following the completion of the literature study on the changes in social distancing within post-pandemic architecture, as documented in Table 1, the subsequent phase involves the coding and categorization of 39 scholarly papers. Five aspects of changes in social distancing within post-pandemic architecture need to be transformed into variables to facilitate their integration within the realm of built-environment design [71], [72]. Variables refer to the distinguishing attributes of abstract concepts, whereas indicators are means of assessing or quantifying these variables. Hence, a meticulous process was undertaken to code and classify these five aspects, encompassing variables, factors, and indicators, with the aim of formulating framework strategies for the changes in social distancing within post-pandemic architecture.

The evaluation of coding and classifications was conducted to analyze the changes in social distancing within post-pandemic architecture. This analysis was based on a comprehensive review of 39 scholarly works. The papers underwent coding and classification processes to analyze the potential variables related to changes in social distancing within post-pandemic architecture.

As indicated in the preliminary investigation, there has been a lack of discussion regarding the incorporation of preventive measures against pandemics and health concerns in security architecture. Therefore, the literature must be coded and classified for the interrelationships between the characteristics of post-pandemic architecture, changes in social distancing practices, and security variables. The exiting security variables [9], [18], [19] namely: physical elements: (1) access movement; (2) structure; (3) surveillance; (4) physical protection; pattern context: (5) activity; (6) management and maintenance; psychological context: (7) existing ownership and the possibility of new additional variables. The results of the coding and classification based on sub-aspects changes in social distancing within post-pandemic architecture are presented in Table 2.

Table 2. Change of Social Distancing in Post-Pandemic Architecture Characteristics identified in previous studies and Its Relationship to Variables in built environment.

Socio-Spatial Distancing Post-Pandemic (Urban)	Social Distancing in Post-Pandemic Architecture	Detail Discussion Changes of Social Distancing in Post Pandemic Architecture	Category of Security	Variables for Changes of Social Distancing in Post-Pandemic Architecture (connect to security design aspects)	
				Previous Security Aspects	New
Standard for integrating health.	Standard for integrating healthy environment in structure interior.	Layout for healthy environment through anthropometric. [12], [23], [25], [27], [30], [33], [35], [36], [38], [42], [43], [47]	Prevent	Physical elements (physical protection)	
				Pattern Context (management & maintenance)	
			Prevent		hygienist behavior
		Layout for healthy environment through ergonomic [5], [12], [23]–[25], [29], [30], [33], [35]–[38], [40], [42], [43], [47]–[50]	Prevent	Physical Elements (access movement; structure; supervision)	
				Pattern context (activity)	
					Ergonomics Fixture for architecture
the nature of future use of public space (spontaneous interactions, social control, relate to personal and public health and safety.	Relationship and interaction in users' pattern activity.	Social interaction (close spontaneous interaction) [5], [12], [20], [25]–[27], [29], [31]–[35], [37]–[39], [42], [44]–[47], [49], [51], [52], [54], [55]	Prevent	Physical Elements (access movement; structure; supervision)	
				Pattern context (activity)	
					hygienist behavior
		Social control [5], [12], [20], [25]–[27], [29], [31]–[35], [37], [38], [42], [44]–[47], [49]–[52], [54], [55]	Prevent	Physical Elements (access movement; surveillance; physical protection)	
					hygienist behavior
				Psychological Context (ownership)	
				Pattern context (activity)	
biophilic, restorative	Environment Design related	Direct related to nature [10], [12], [21]–[23], [28]–[30], [35], [38], [43], [48], [53],	Prevent		Air Quality
					Natural Light

environment, engagement with nature for design.	to nature.	[73]			Sound
					Temperature
		Indirect related to nature [10], [12], [21], [23], [28]–[30], [37], [38], [43], [48], [53], [73]	Prevent	Physical Elements (structure; surveillance; physical protection)	
				Pattern Context (management and maintenance)	
					Access to nature
					Natural Material and Fixture for architecture
New measurement (personal space, proximity, health urban setting).	Spatial relationship (proxemics).	Personal-private [12], [20], [21], [24], [31], [32], [34], [35], [39], [40], [45], [46], [50]–[52], [54]	Prevent	Psychological Context (ownership)	
				Pattern context (activity; management and maintenance)	
					Digital-Virtual Space Relationship
		Proximity [5], [12], [20], [21], [24], [31]–[36], [39], [40], [45]–[47], [50]–[52], [54]	Prevent	Physical Elements (access movement; structure; surveillance)	
			Control		Digital-Virtual Space Relationship
Geographical locations and place attachment (home zone, workplace).	Place Attachment for architecture.	Zoning at workplace [10], [12], [20], [27], [32], [37], [52], [54], [55]	Prevent	Psychological Context (ownership)	
				Pattern context (activity)	
					Digital-Virtual Space Relationship
		Zoning at home [10], [12], [20], [21], [27], [32], [39], [47], [52], [54], [55]	Prevent	Psychological Context (ownership)	
				Pattern context (activity)	
			Control		Digital-Virtual Space Relationship
migration pattern (urban, peripheral, rural).					

Table 2 presents a summary of the security variables identified in the research pertaining to the features of sub-aspects changes of social distancing. The following information presents the findings of the changes observed in the sub-aspects of social distancing in the context of post-pandemic architecture:

(1) "The design standards for anthropometry in post-pandemic design" discussed in 12 papers. The variables: 'physical protection' - A hygienic safety feature and element to protect humans, by setting a CCTV at a human body temperature; 'maintenance management - to supports the optimization of the use of features and elements for hygienic safety; 'hygienic behavior" - incorporate various features and safety elements to optimize hygienical behaviors such as placing hand sanitizers.

(2) "The design standards for ergonomics in post-pandemic design" are discussed in 19 papers. The variables are: "access and movement": the user's access and pleasure of movement; "structure": user comfort when engaged in structural-supported activities in the built environment; "surveillance": relating to natural surveillance for user comfort; "activity": comfort support for user activity; and "ergonomically related architecture element": related to supporting user comfort ergonomically.

(3) "Social interactions" discussed in 25 articles. The variables: "access and movement" - related to user access and remote movements for the safety of communication when interacting; "structure" - relating to user comfort when interaction is supported with structures in a built environment; "surveillance" - relating to natural surveillance for users' social interaction; "activity" - support of social interaction to user activity; "hygienic behavior" - associated with user hygienical behaviors such as the use of masks.

(4) "Social Control" discussed in 25 articles. The variables: "physical protection" - a hygienic security feature and element to help the social control of the user; "access and movement" - control of user activity and movement; "surveillance" - controls visibility in user layout and social control; "ownership" - the existence of user hierarchy, territory, and sense of ownership to help social control; "activity" – relate to appropriate limitations to user activity; "hygienic behavior" - user hygiene behaviors such as no shake hand.

(5) ''Design standards directly related to nature' are discussed in 14 articles. The variables: 'Indoor Environment Climate' relates to indoor air quality; 'natural light' is associated with sunlight; 'natural UV-

C' in the room; 'humidity and temperature' relate to user comfort (24-degree temperature) and reduce the growth of viruses; "sound" maintains the mental health of the user from distracted sound.

(6) "Design standards indirectly related to nature" is discussed in 13 articles. The variables are: "structure" refers to elements in the built environment (walls, furniture, name boards) that resemble nature; "surveillance" refers to the need for natural surveillance to provide a sense of security for mental health; "physical protection" refers to features and security elements that resemble nature; "management and maintenance" refers to maintenance management that supports the optimisation of the use of natural features and elements; "access to nature" refers to the elements of architecture that resume nature, such as connecting with outdoor areas; "natural material and fixtures" refers to natural material and fixtures in architecture for user immunity and mental health.

(7) "Personal-Private Space Standards" discussed in 16 articles. The variables are: "ownership": the distance to a privacy space that has changed due to the pandemic; "activity": the prevention of spread through the user's activity in his personal space; "maintenance management": supporting the security needs in the personal space; and "digital-virtual space relationship": the viewing distance in the digital space with the reality that shows the user's personal space.

(8) "Proximity space standard" discussed in 20 articles. The variables are: "access and movement": the control of user activity and movement related to keeping distance when there is interaction between users; "structure": structural elements in the building environment (walls, furniture, name boards) as protection from the spread of diseases derived from user interaction; "surveillance": control of surveillance

in the layout related to user interactions; and "digital-virtual space relationship": the needs of users with cameras in a digital space with reality..

(9) "Place attachment – Workplace Zone" discussed in 9 articles. The variables "ownership": the zone of distance at the workplace that has changed due to the pandemic; activity": the prevention of spread through user activity in the work area; "digital-virtual space relationship": the need for remote-close distance of the camera to the user in the digital space with the workplace.

(10) "Place attachment – Home Zone" discussed in 11 papers. The variables are: "ownership": the zone of distance in the residence that has changed due to the pandemic; "activity": prevention of spread through the user's activity at home; "digital-virtual space relationship": the need for the remote distance of the camera from the user in the digital space with the home.

According to these findings, there are 8% of articles discuss the variable 'Access and Movement', 10% of articles discuss the variable 'structure', 13% of articles discuss the variable 'surveillance', 9% of articles discuss the variable 'ownership', 7% of articles discuss 'physical protection', 14% of articles discuss the variable 'activity', 9% of articles discuss the variable 'management maintenance', 8% of articles discuss the variable 'hygienist behavior', 2% of articles discuss the variable 'ergonomically-related architecture element', 2% of articles discuss the variable 'indoor environmental climate, 2% of articles discuss the variable 'humidity and temperature', 2% of articles discuss the variable 'natural light', 2% of articles discuss the variable 'acoustic', 1% of articles discuss the variable 'access to nature', 1% of articles discuss the variable 'hygienist building elements and materials' and 9% of articles discuss the variable 'digital-virtual space relationship' (see Figure 2)
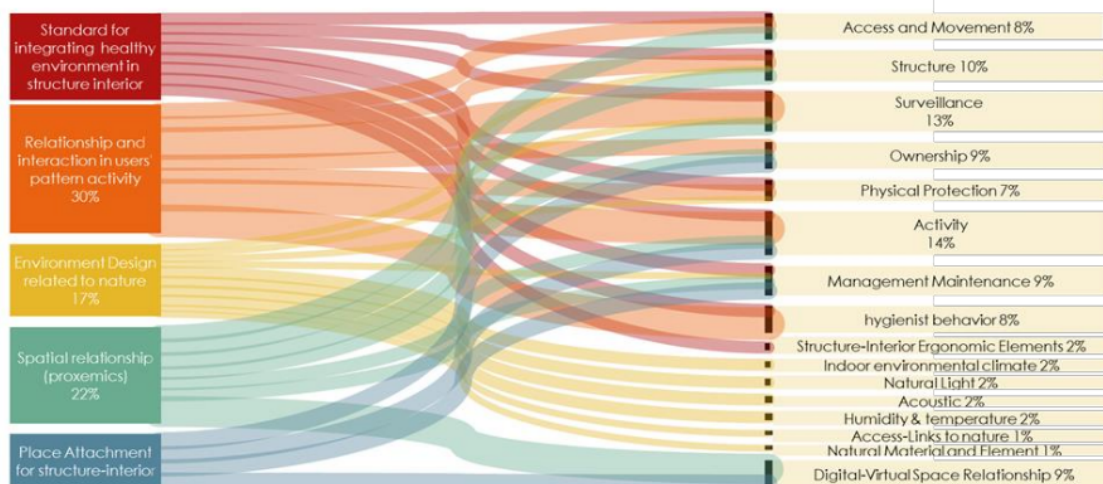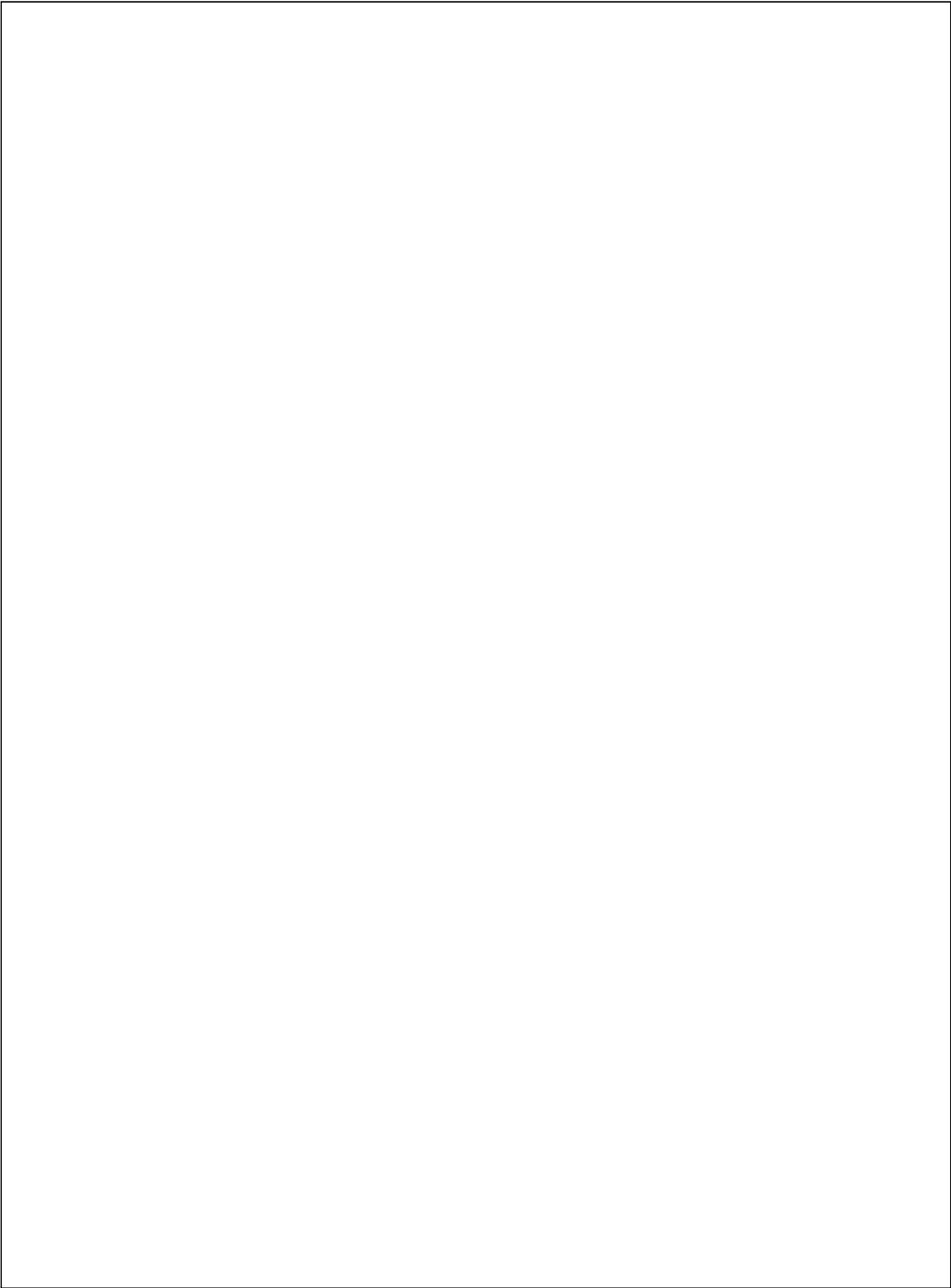

Figure 2 – Relationship between Aspects Changes of Social Distancing in Post-Pandemic Architecture

4.3 The Synthesis: Strategies for Changes in Social Distancing within Post-Pandemic Architecture

The synthesis process began with a more thorough examination of the many features of changes in social distance within post-pandemic architecture. This entailed breaking down the issue into components, then organizing and categorizing related concepts to create a framework that explicitly addressed changes in social distancing within post-pandemic architecture. The framework was divided into three sections: "variables," "indicators," and "factors." The concept of "variables" was already explained in a previous sub-chapter. This sub-chapter seeks to provide a more thorough explanation of the indicators, components, and measuring targets that lead to a better understanding of factors connected with strategies for implementing changes in social distancing within post-pandemic architecture. (see Table 3.)

Table 3 – Changes of Social Distancing in Post-Pandemic Architecture Variables, Indicator, Factors and Measurement Criteria

Variables of Security-Pandemic Theory	Indicators of Security-Pandemic Theory	Factors of Security-Pandemic Theory	Measurement Criteria	Connected to Aspects				
				(1) Standard for integrating healthy environment in architecture	(2) Relationship and interaction in users' pattern	(3) Environment Design related to nature	(4) Spatial relationship (proxemics)	(5) Place Attachment for architecture
Access and movement	The presence of pathway access and object orientation with distinct destinations for distancing	The Wide of pathway and orienting pathway (eg.one-way routes and width circulation 2650 mm)	Well-defined routes, space and entrance that provide convenient movement without compromising security;	√	√		√	
Structure	The degree to which accessibility to organized spaces - various users for distancing, avoidance, and space delineation	The zoning in the room and orienting of the room	level of human accessed structured without causing conflict and appropriate to the location	√	√	√	√	
Surveillance	How well the surveillance setup gives a visual distance	The Wide of room and visibility	all publicly accessible spaces are overlooked	√	√	√	√	
Ownership	How much access hierarchy, ownership, boundary, and personalization the architecture provides	layout, floor area, furniture layouting (e.g., apply radius 2 meters of social distancing)	promote a sense of ownership, respect, territorial, responsibility, and community		√		√	√
Physical Protection	Good security features for hygienist architecture elements to safeguard and avoid touch.	Number of hygienist architecture's elements	More and better quality	√	√	√		
Activity	The degree to which the users have an appropriate distancing; activity on space and the pattern of close and social contact	appropriate architecture elements (e.g., Walls, floor pattern and furniture pattern) to ease users' mobility (e.g., forced closure, voluntary quarantines)	level of human activity is appropriate to the location				√	√
Management maintenance	The extent of flexible distancing designs space management and upkeep	Control and the quality of checkpoint for flexible distancing management	Designed with management and maintenance in mind	√		√	√	√
Ergonomically related architecture element (NEW)	The extent to which users are sufficiently far, space activity and close and social contact. How well architecture supports physical health and comfort	Quality of Architecture Elements (e.g., Furniture, Fixture and equipment)	Ergonomic and good quality of architectures appropriate for users	√				

Variable	Indicator	Measurement	Criteria					
Indoor environmental climate (NEW)	The extent of air change control	CO2 measurements, occupancy levels Room Volume Opening window size and position	More contact with fresh air and better-quality natural air			√		
Hygienist Behavior (NEW)	How much the room allows different protection to promote hygienic behaviour for personal protection and social interaction distancing	visual diversity and number of tools to help improve hygienist behavior	well-defined rooms to provide hygienist behavior such as provide sanitizing area.	√	√			
Humidity & Temperature (NEW)	Quality and quantity of solar heat the room receives	Orientation and shading control	room with the sun heat (whether by orientation or shading)			√		
Natural Light (NEW)	Quality and quantity of natural light in the space can	Natural Light orientation	Larger windows with direct sunlight but not creating glare			√		
	Controllability of room lighting	Glazing area	More and better quality					
Acoustic (NEW)	Noise disturbance frequency	noise from the environment outside	large distance from busy areas			√		
Access-Links to nature (NEW)	Access to natural elements by users	Access to nature	Access to the outside. Plants, wooden furniture, and stone elements in the room			√		
	Vistas of nature through the window	View out	Windowsills below user's eye level and interesting or green near and far views					
Hygienist Natural Material and Fixture for Architecture (NEW)	The extent to which architecture supports physical and mental wellbeing using hygienist natural material	Quality of Architecture Elements Material and fixture (e.g., Furniture, Fixture, and equipment)	Good quality of architectures appropriate for users			√		
Digital-Virtual Space Relationship (NEW)	Camera distance and angle reveal digital personal-private space in virtual space.	The camera distance and virtual angle	Well-appropriate personal-private space that provide convenient physical view in the virtual space				√	√

Based on these findings, there are some adjustments and new security variables for changes in social distancing within the post-pandemic architecture. Below is a synthesis of variables, indicators, and factors:

- "Access and Movement" refers to the ability to access a specific path or object of orientation. Measurement elements and criteria: clearly defined routes, spaces, entrances, and paths that facilitate the movement, accessibility, and containment of both individuals and diseases.
- "Structure" refers to the degree to which a location is organised and minimises the occurrence of conflicts. Measurement and criteria used for assessing it encompass the zoning, orientation, and structural elements of a room, including walls, floors, and furniture for human motion throughout the space, ensuring a harmonious and conflict-free environment.
- "Surveillance" is determined by the degree to which the monitoring process offers suitable sight of natural elements within the layout. Measurement and criteria: the dimensions of the space and the portion of space disregarded for visibility.
- "Ownership" refers to the degree to which the built environment incorporates elements such as hierarchy, ownership, limits, and personalization. Measurement and criteria: fostering a sense of ownership, personalisation, and privileges include the layout, floor space, and furniture arrangement.
- "Physical Protection" refers to the number of well-designed security features to improve personal protection and avoid contact. Measurement and criteria: the more and better quality of security features that effectively support personal protection for users.
- "Activity" refers to the degree to which the user possesses the necessary activity, mobility, access, and spatial configuration. Measurement and criteria: specific aspects within a building environment that effectively support the activities of users and are pertinent to the given site.
- "Management maintenance" refers to an evaluative metric that assesses the extent to which management has effectively implemented procedures for the maintenance of physical spaces. Measurement and criteria: the control and quality elements for the needs of management and maintenance.
- "Ergonomically related architecture element" refers to indicators that are associated with the interior structural components utilised to improve human well-being, comfort, and emotional state. Measurement and criteria: the quality of internal structural elements that provide

the ergonomic support of the user's body.

- "Indoor environmental climate" encompasses several indicators that are used to measure factors such as carbon dioxide levels, humidity levels, crowd density, room volume, and the size and position of window openings. Measurement and criteria: preventing the transmission of infectious diseases inside indoor environments by controlling the quality of the air conditioning system.
- "Hygienist behavior" is a term used to describe a range of measures aimed at enhancing hygiene practices. Measurement and criteria: variety and the available methods aimed at enhancing sanitary conduct.
- "Humidity and temperature"—the indicator is related to the degree of central humidity and cooling system in the room. Measurement and criteria: thermostat and air conditioner central control for human comfort and health.
- "Natural light" refers to many indicators that pertain to the regulation, amount, and characteristics of natural lighting within interior spaces. Measurement and criteria: orientation of natural light; portions of glass that do not receive direct sunlight but have larger windows.
- "Acoustic" refers to signs that are associated with the frequency of sound disruptions, which have the potential to strengthen the immune system of the individual.
- "Access to nature" refers to the measure of consumers' ability to engage with the natural environment, either through a window or other means. Measurement and criteria: quality and quantity of access to natural elements, natural materials in the interior, and access to the landscape.
- "Hygienist natural building elements and materials" pertains to the selection of building materials and interior surface treatments for walls, floors, and furniture. Measurement and criteria: the quality and amount of construction materials to enhance hygiene within the space.
- "Digital-virtual space relationship" refers to the correlation between the virtual environment and the physical world. Measurement and criteria: the camera's distance and angle, which influence the personal and private perspective of the room within the virtual application.

5. Conclusion

The relationship between the changes in social distancing's aspects and the need for security in the built environment has been elevated and is growing rapidly. Before the pandemic, security in built environment helped improve the public space by safeguarding it from crime. But during and after the pandemic, the concept of security changed and needed adjustment.

After some study and a literature review, this paper has identified the changes in social distancing within post-pandemic architecture and strategies that affect the built environment in future disease prevention. Social distancing is more than keeping a distance between us and others while engaged in activities; it is also isolating, allowing space to connect with nature for better mental health, integrating healthier spaces, and connecting hybrid activities in architecture. Five aspects of changes in social distancing within post pandemic architecture: Standard for integrating healthy environment in architecture (variables: access and movement, structure, surveillance, physical protection, maintenance management, hygienist behavior and ergonomically-related architecture element); Relationship and interaction in users' pattern (variables: access and movement, structure, surveillance, physical protection, activity, and ownership, hygienist behavior); Environment Design related to nature (variables: structure, surveillance, physical protection, and management maintenance; Indoor environmental climate, humidity and temperature, natural lighting, sound, access to nature, and Hygienist building elements and materials); Spatial relationship proxemics (variables: access and movement, structure, surveillance, management maintenance, activity, and ownership, Digital-virtual space relationship); Place Attachment for architecture (variables: ownership, activity, and management maintenance; Digital-virtual space relationship.)

Based on conclusion, the existing security variables in previous studies need to be adjusted (example: "access and movement" variable is orientating to limit people accessing the building and controlling the movement of people (using physical and social distance) and there are new security variables for changes in social distancing within post-pandemic architecture: The new variables: natural environment context (indoor environmental climate, humidity and temperature, natural light, acoustic and access to nature); behavior context (hygienist behavior and hygienist building elements and materials) and cultural context (Digital-virtual space relationship).

Some limitations of this study are as follows: some papers not written in English or Bahasa were excluded; some other aspects such as dynamics and the pattern of living and working in the new normal are not discussed; the articles included in this review are up to April 2023 (and there is the possibility of new articles). This paper provides a current critical literature review and a strategy for future research in the field to improve understanding of the changes in social distancing in security design-related fields. Recommended future studies are: (a) there is a need to evaluate changes in social distancing as a design of the built environment; (b) there is a need for better and more comprehensive social distancing evaluation of health, safety, and security implications in the built environment.

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results of this research can be useful for ITS and PCU in particular and for society in general.

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