Dynamics in Post-Pandemic Architecture: Integrative Literature Review in response to Post-Pandemic Built Environment

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1. Introduction

The COVID-19 (SARS-CoV-2) pandemic altered the everyday routines of millions of people and thus led them to re-evaluate many routine behaviors, including changes in our built environment. During the recent COVID-19 pandemic, time spent at home has increased noticeably, while daily mobility has decreased. (Yağcı Ergün & Nebioğlu, 2022). Such circumstances call into question certain fundamental needs of the sheltering concept, such as the dynamics of architecture and the use of spatial contexts. New requirements are needed for new security systems, protocols, and standards for spatial use.

Considering past events, epidemics, pandemics, and infectious diseases led to important advancements in urban planning, sanitary systems, and architectural designs (Megahed & Ghoneim, 2020). Several epidemics (including the recent three of tuberculosis, cholera, and ebola) highlight the importance of architects and designers in preventing disease spread when we consider their primary modes of transmission: surfaces, water, and air. (Murphy, 2020). The COVID-19 pandemic will undoubtedly have an impact on architectural designs and the rapid changes in users' needs, behaviors, and daily lives in the future. (Alhusban et al., 2022).

Safety and security needs are ranked second after physiological needs in Maslow's hierarchy of needs (Augustin et al., 2009). Therefore, safety and security (including security for users' health) become a fundamental need for concept and design features within the built environment. Security issues for the built environment are related to the prevention and detection of threats carried out and motivated by humans (The American Institute of Architects, 2004). When humans are present in space, security is expected to detect threats, mitigate danger, and protect. Security in

the built environment is also needed in the context of a pandemic to help detect, reduce the risk, and prevent viruses.

To meet the complex challenges associated with the dynamics of post-pandemic architecture, a strategy based on various disciplines related to architecture and the built environment must be developed. Salama (2020) reveals a contextual, transdisciplinary framework that explains pandemics in urban settings. (Salama, 2020). One of the aspects discussed in this framework is architecture with urban dynamics related to: (1) environmental density and the spread of disease; (2) traveling and transportation; and (3) global-local tensions (including urban science and human geography, urban planning, and transportation engineering). Although there are two more aspects (distancing and living-working patterns), this paper focuses on the dynamics of post-pandemic architecture. In order to prevent pandemic spread, changing socio-spatial needs require implicit development and implementation not only at the urban planning level of design, but also in architectural design in the context of a smaller built environment (interior-structure). The interior-structure built environment is becoming one of the ways to prevent its spread, as it is more optimal, more liveable, and more pervasive, and it forms healthy behavior in humans.

The goal of this paper is to identify the dynamics in post-pandemic architecture strategies that affect the built environment in future disease prevention. The spatial problems and user needs that arise with the change in post-pandemic architecture constitute the main starting point of this paper. To answer the objectives of the research in this paper, an integrative system literature review method will be used to classify, identify characteristics, justifying the post-pandemic security variables for built environment, including indicators, factors, and criteria for measuring the variables, to develop a preliminary strategy for dynamic architecture post-pandemic.

There is a research gap for dynamic architecture context between the pre-pandemic and post-pandemic eras. Since the dynamic post-pandemic architecture context is based on abstract ideas, security variables in the built environment are needed. Security variables in the built environment can help improve public space safeguarding (including pandemic protection and user control within the environment). The novelty in this paper is a strategy for dynamics and architecture post-pandemic in terms of security variables. The dynamics of post-pandemic architecture variables will be actualized based on existing variables of security in the built environment (such as access and movement, surveillance, ownership, and so on) and the new variables for security architecture post-pandemic.

2. Preliminary Study

Urban Dynamics in a Pandemic World addresses both the larger global perspective and the ramifications of virus transmission at the city scale. (Maturana et al., 2021). While dynamics in post-pandemic architecture deal with the architectural (interior-structure) ramifications of virus transmission. There are several sub-aspects of dynamic aspects at the urban level as they relate to virus spread and urban health (Maturana et al., 2021; Salama, 2020), including: (1) user density and the effectiveness of density management; (2) peripheries and spread; (3) interaction and connectivity; (4) mobility concerning to pollution, carbon emissions, and mortality rate; (5) access, standard space, and protocol for the use of public facilities; (6) environmental density; and (7) pathways in areas with the high distribution. The difference between the urban level and the interior-structure level is in the spatial-object scale and the processing time. (McClure & Bartuska, 2007). Then, from these topics, there are six sub-aspects related to dynamics in post-pandemic architecture in interior-structure scale, which are as follows:

(1) Density – is the density control that exists within the interior-structure scale.

(2) Peripheries and spread – are controlled through testing and reducing the possible spread within the interior-structure scope.

(3) Interaction - is the closeness of the interaction between users within the interior-structure scope.

(4) Mobility control - is control of the mobility of elements in the built environment such as user, air circulation, humidity, etc.

(5) Access control and prevention through standards and protocols - is standard and access control of elements in the built environment such as user or humidity-temperature indoors.

(6) Prevention through technology and materials – is prevention via technology derived from antivirus materials used indoors.

Combining proactive safety and security viewpoints with the design professional's dedication to safeguarding the public's health (like preventing a pandemic), safety, and welfare can open solutions for the built environment (O'Shea, 2009). The extent to which users can change, alter, or control their environment, on the other hand, has an impact on their sense of security and control within the built environment. In terms of post-pandemic architecture, the dynamic needs to be synchronized with the aspect of security to create a more secure and safer built environment. There are seven security sub-aspects: (1) access and movement (well-defined routes, spaces, and entrances for easy movement); (2) structure (structured place to prevent conflict between); (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 maintenance). (7) Ownership (places with a sense of ownership, respect, and territoriality) (Briggs, 2005).

The next step is to categorize the research articles published in the online database using an integrative systematic review method. Based on the explanation above, there are six keywords regarding the dynamics of post-pandemic architecture based on existing research written by Salama (2020). Using the six keywords above, the next step is to review the findings and implications of the 40 articles with keywords in bold and code the articles based on the six keywords from the dynamic aspects. From the results of this coding, an in-depth analysis and synthesis process is carried out by deepening the coding into various variables of the post-pandemic dynamics architecture, indicators, factors, and measurement criteria, which will then summarize the findings of this research strategy in the "Discussion" section.

3. Methodology

This integrative systematic review focuses on published research articles indexed in online databases. The process of an integrative review used to relate concepts and relevant theories using systematic review. This includes studying the concept of dynamics post-pandemic architecture, exploring the potential for built environment security variables to develop a synthesis of strategy for reducing the risk by developing dynamics architecture post-pandemic through built environment. (Haigh & Amaratunga, 2010; Marion E. Broome, 2000; Torraco, 2005; Y. Zhang et al., 2019). There are three steps for this integrative systematic review: the selection, the coding and classification, and the synthesis, as shown in Figure 1. The first step is a clear selection and identification of the problem that the review using literature search. Literature search should clearly address issues such as search terms, the databases

used, additional search strategies, and the inclusion and exclusion criteria for determining relevant primary sources. The second step is the coding and classification using data analysis process, data from primary sources are ordered, coded, categorized. The third step is the synthesis by summarized and creating strategy of dynamics post-pandemic architecture. Finally, conclusion of reviews can be reported in a table or diagram.

[Figure 1 must be placed here]

3.1 Step 1: The Selection

The selection process was carried out by searching for sources of literature or writting 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 August 2022. The keywords used are "pandemic" and "dynamics". Based on these keywords, we found n = 22,185. The next step is filtering the field of study using: "architecture" "ventilation (architecture)" "architectural design" "building design" "sustainable design," "spatial design," “Atmosphere (Architecture and spatial Design)” n=102 and accessible "open access colour Gold and Green" n=61. Exclusion criteria included articles not written in English or Bahasa Indonesia and articles that were written as editorials (n=56). In light of the inclusion and exclusion criteria, A total of 40 articles were eligible for review using the integrative method. Each of the 40 articles was reviewed independently by the authors, focusing on the dynamic aspects of the urban built environment and interior structures that have been laid out by Salama (2022). Forty of these articles were not researched and thus were eliminated. Forty articles were recommended for inclusion in this review, as shown in Table 1.

3.2 Step 2: The Coding and Classification

The next step is the coding and classification process. There were 8 sub-aspects of urban dynamics (Maturana et al., 2021; Salama, 2020), which are urban density; urban peripheries, and sprawl; connectivity; urban mobility; access, space standards, and protocols; place typologies as potential areas for virus spread; informal settlements and urban poverty; and a reduction in global infrastructure. From the eight sub-aspects in the previous research, only six were discussed and identified as the dynamics of architecture. Therefore, only six sub-aspects are discussed, which are: density; peripheries and sprawl; interaction; mobility; access, space standards and protocols; and the placement of technology and materials. The coding process included screening and reviewing 40 papers to determine which articles fit into which sub-aspects using the Microsoft Excel program. The coding and classification of the contents of the discussion from literature sources are explored according to the dynamic aspect framework and sub-aspects for interior-structure.

3.3 Step 3: The Synthesis

The process of synthesis started by breaking down in more detail what sub-aspects of the dynamic architecture post-pandemic were associated with the security variables in the built environment. There are seven security variables (Briggs, 2005), namely: (1) access and movement; (2) structure; (3) supervision; (4) physical protection; (5) activity; (6) management and maintenance; (7) ownership; and the possibility of new additional sub-aspects. 40 sources of literature were identified from the perspective of dynamics, then sorted and grouped into similar topics to create a dynamic architectural post-pandemic framework. The framework was defined in terms of variables, indicators, and factors. The existence of indicators, factors, and measurement objectives aim to clarify the discussion of the variables that appear and

create strategies for a dynamic architecture post-pandemic. The results are presented in table 3.

4. Results and Discussion

This section describes: the selection of the literature process for dynamics post-pandemic architecture; the coding and classification process of variables, and the synthesis of strategies in dynamics post-pandemic architecture.

4.1 The Selection of Literature for Dynamics in Post-Pandemic Architecture

To consolidate the state of the art, researchers have explored the theory regarding dynamics in post-pandemic; security for health outcomes in the built environment to describe building design features that influence the dynamics in post-pandemic architecture. The use of various disciplinary theories is justified because there is no theory evaluates dynamics in post-pandemic architecture aspects holistically. Outlining this can be developed into strategies for dynamics in post-pandemic architecture in the form of risk assessments as well as strategies for managing and designing the built environment.

Salama et al. (2020) discuss post-pandemic architectural considerations as well as the nature of the new normal living and working patterns in urban design as a result of the COVID-19 pandemic. According to Salama (2020), future design and planning studies should focus on several key issues, including urban dynamics from the perspectives of human geography, transportation, and urban design; socio-spatial effects and urban life from the perspective of environmental psychology; and new environments to accommodate contemporary living and working styles from an ethnographic angle. (Salama, 2020)

Maturana et al. (2021) focus on the implications of urban dynamics and COVID-19. The authors discussed the contagious coronavirus public health crisis and how

health is a key factor in the creation of architecture and urban design. The effect of virus propagation on the urban environment (urban dynamics), the method used to reduce social and physical distance are put into practice, and how rapid adoption of digital technology affects a new normal life are just a few implications highlighted by the authors. To establish a new norm that incorporates flexibility and adaptability, the writers also mentioned the necessity of adoption and redesign. (Maturana et al., 2021)

Following the conceptual approaches of Salama et al. (2020) and Maturana et al. (2021), we propose six aspects of dynamics in post-pandemic architecture. Originally there were seven aspects of dynamics in urban space (Maturana et al., 2021), but after a thorough analysis and literature review of 40 articles (see table 1.), only six aspects are related to the interior-structure.

[Table 1. Must be placed here]

From the literature review, 20% of articles discussed “Density”, 20% of articles discussed “Peripheries and Spread”, 5% of articles discussed “Interaction”, 32% of articles discussed “Mobility”, 20% of articles discussed “Access, spatial standard and protocols” and 3% of articles discussed “Antivirus Building Materials”. The summary and explanation of the six aspects are:

(1) Density – Density control that exists within the interior-structure scale. There are two things related to density, namely the density of air in the room to prevent disease spread and the density of users. Air density control is necessary because of the potential for post-pandemic diseases to spread via aerosols in the air. The way to control it is by improving the air quality in the room (for example, by providing a HEPA filter on artificial air and providing openings to allow natural air movement in the room). Control of user density is necessary because of the potential for the

spread of infectious diseases through humans via droplets. The way to control the rate of spread is by settling the amount of human density in one room.

(2) Peripheries and spread – controlled through testing and reducing the possible spread within the interior-structure scope. There are two things related to boundaries and distribution, namely: limits and distribution of air in space and boundaries and distribution through user activities. Airborne control and distribution limits are necessary because of the potential for post-pandemic diseases to spread via aerosols in the air. The way to control it is by improving indoor air quality. Because of the potential for infectious disease transmission through humans via droplets, user activity must be limited and distributed. The way to control the rate of spread is through violent user activity to reduce the spread of disease in one room.

(3) Interaction - is the closeness of the interaction between users within the interior-structure scope. There are two things related to density, namely, close interaction and not-close interaction. What is meant by "close interaction" is interaction that occurs between two or more people who know each other and have a special relationship (such as husband and wife, parents and children, close friends, etc.). The control this close interaction is provided by providing a separate area for this user. What is meant by "not close interaction" is an interaction that occurs between two or more people who do not know each other. Control in these close interactions through the completion of user activities and behavior. This is necessary because of the tendency of human psychology to imitate and follow the behavior of fellow human beings.

(4) Mobility control - is control of user mobility, mobility of diseases in the air, mobility of dew rate and humidity in the room, mobility of natural sunlight entering, mobility of UV-C rays in the room, and mobility of disease mobility on the elements. elements that are within the scope of the structure-interior. Control of human mobility/movement within the interior-structure is necessary to limit the possibility of spreading disease among users through a mutual contact. Control of the mobility of airborne diseases is needed to help reduce the spread of these diseases. This is done by increasing the rate of air movement in the room and increasing the entry of fresh air into the room. Controlling dew rate and indoor humidity is necessary to help reduce disease spread caused by humidity and mold indoors. This is done by improving air quality by controlling air humidity and dew levels in the room. Controlling the movement of natural sunlight indoors is necessary to help reduce disease by killing disease by using natural UV rays and increasing the body's immunity (through natural UV-C rays and vitamin D). Prevention through the mobility of UV-C rays, which are obtained naturally through sunlight and unnaturally through UV-C rays. Control of disease movement through droplets on the surface of objects is carried out by using antiviral building materials.

(5) Access control and prevention through standards and protocols - is user access control and prevention through new built-environment standards, humidity-temperature indoors, and health protocols for self-protection in interior structures. Control over user access is carried out by limiting user access within the interior structure.

(6) Prevention through technology and materials – is prevention via technology derived from antivirus materials used indoors. This is necessary because of the possibility of disease spreading through droplets present on the surface of the material within the interior structure.

The relevant studies from the reviewed paper, shown in Table 1, have shown that there are six aspects of dynamics in post-pandemic architecture. The findings in these steps are required to support the early identification of Dynamics in Post-Pandemics Architecture's variables.

4.2 The Coding and Classification Aspects of Dynamics in Post-Pandemic Architecture

After the literature review of the aspects of dynamics in post-pandemic architecture identified and carried out in the literature, as shown in Table 1, the next step is the coding and classification of 40 articles. Based on the initiative's findings in the previous chapter, there are six aspects of dynamics in post-pandemic architecture at the abstract concept level. These aspects (abstract ideas) need to be developed as variables so they can be used in built-environment design (Barrett et al., 2015; Y. Zhang et al., 2019). Variables mean identifying characteristics of abstract aspects, while indicators are ways of measuring or quantifying variables. Therefore, the coding and classification of these papers were carefully carried out up to variables and indicators in order to develop framework strategies for dynamics in post-pandemic architecture.

The coding and classifications were evaluated on the basis of aspects of dynamics in post-pandemic architecture by using 40 articles. These articles were coded and classified into variables of dynamics in post-pandemic architecture using Microsoft Excel. Through a process of coding the potential variables and classifying

the characters in more detail regarding variables of the dynamic aspect associated with the security's variables in the built environment.

Controlling in Security architecture is a feature, structure, or method of designing a physical product, software, building, town planning, or system for interaction with users that aims to impose or limit user behavior (Atlas, n.d.; Hopper, 2009; O'Shea, 2009; The American Institute of Architects, 2004; Zamani, 2019). Before the pandemic of COVID-19, the theory of security architecture is always concerned with crime and CPTED. The theory of security has discussed the prevention of pandemics and health problems at spatial border needs such as airports and harbours. Now the prevention of pandemics and health problems needs to be applied in most places (from the residential, workplace, and public places) in the built environment.

Briggs in O'Shea (2009) describes how the design of a built environment as expected to be able to provide user needs, provide protection and a sense of security for users without sacrificing innovation and intervention, and can keep crime away. This should be a priority in design strategies' development (Lockton & Stanton, 2010). There are 7 variables that are the basis for consideration in applying the concept of security in a built environment. (Briggs, 2005; O'Shea, 2009; The American Institute of Architects, 2004).

Since the concept of security has not yet discussed the form of prevention from pandemics and health issues, hence, it is important that the dynamics of post-pandemic architecture characteristics are considered in relation to each other and security variables. The identification and coding of dynamics of post-pandemic architecture characteristics described in the extant literature were used to develop strategies further, discussed below. The security variables (Briggs, 2005; O'Shea, 2009; The American Institute of Architects, 2004) namely: physical elements: (1)

access movement; (2) structure; (3) supervision; (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 of the dynamics of post-pandemic architecture are presented in the following table (see Table 2.)

[Table 2. Must be placed here]

The characteristics of sub-aspects dynamics identified in Table 2. summarize the variables identified in the literature. The integrated review papers presented in Table 1 were coded and classified according to the impact of particular variables. Below are the details finding:

1. 'Density regarding the disease on air' discussed in 29 papers (Abbas & Gursel Dino, 2021; Anghel et al., 2020; Azuma et al., 2020; Bakhtiyari et al., 2020; Brittain et al., 2020; Crawford et al., 2021; Dbouk & Drikakis, 2021; Duill et al., 2021; Fezi, 2021; Foster & Kinzel, 2021; Frumkin, 2021; Gao et al., 2016; Gbadamosi et al., 2020; Grydaki et al., 2020; He et al., 2021; Huang et al., 2021; Knibbs et al., 2011; Laddu et al., 2021; Mittal et al., 2020; Mueller et al., 2020; Nasir et al., 2016; Ronchi et al., 2020; Sadrizadeh & Holmberg, 2014; Sharghi & Asadi, 2020; Singh & Verma, 2021; Smieszek et al., 2019; Sopeyin et al., 2020; Srivastava et al., 2021; W. Yang & Marr, 2011; F. Zhang & Ryu, 2021) impacted in a variable "indoor environmental climate," which controlling air movement, lowering pollutant levels, and improving indoor air quality become critical to preventing virus density in the air. This can be done by taking CO^2 measurements, counting the occupancy levels, crowd density, observed mitigations, opening windows, and room volume.

2. ‘Density on users and human activity’ discussed in 16 papers (Abbas & Gursel Dino, 2021; Azuma et al., 2020; Duill et al., 2021; Fezi, 2021; Foster & Kinzel, 2021; Frumkin, 2021; Kummitha, 2020; Nasir et al., 2016; Papadaki et al., 2020; Pinter-Wollman, Jelić, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; L. Tang et al., 2021; Y. Yang et al., 2021; F. Zhang & Ryu, 2021; Zordan & Tsou, 2020) impacted the variable ‘Access and Movement’ which controls user density; the variable of ‘surveillance’ where controlling visibility in layout and in user’s density; variable of ‘activity’ where controlling the user’s activity and variables ‘management maintenance’ in space become important. These four variables are impacted by the wide and visibility of the room, the pathway, the wall and furniture pattern, and the quality of checkpoints (for fever checkpoints, forced closure, quarantines) in reducing density.
3. ‘Peripheries & Spread of the disease on air’ discussed in 30 papers (Abbas & Gursel Dino, 2021; Anghel et al., 2020; Azuma et al., 2020; Bakhtiyari et al., 2020; Brittain et al., 2020; Crawford et al., 2021; Dbouk & Drikakis, 2021; Duill et al., 2021; Fezi, 2021; Foster & Kinzel, 2021; Frumkin, 2021; Gao et al., 2016; Gbadamosi et al., 2020; Grydaki et al., 2020; He et al., 2021; Huang et al., 2021; Jarvis, 2020; Knibbs et al., 2011; Laddu et al., 2021; Mittal et al., 2020; Mueller et al., 2020; Nasir et al., 2016; Ronchi et al., 2020; Sadrizadeh & Holmberg, 2014; Sharghi & Asadi, 2020; Singh & Verma, 2021; Smieszek et al., 2019; Sopeyin et al., 2020; Srivastava et al., 2021; W. Yang & Marr, 2011; F. Zhang & Ryu, 2021) were impacted by a variable "indoor environmental climate." The indicators are similar to the aspect of disease density on air, where containment and control of air movement, reduction of pollutant levels, and improvement of indoor air quality become important to the periphery and prevent virus spread on air. This can be

done by taking CO^2 measurements, counting the occupancy levels, crowd density, observed mitigations, opening windows, and room volume.

4. ‘Peripheries & Spread based on Human Activity’ discussed in 14 papers (Azuma et al., 2020; Duill et al., 2021; Foster & Kinzel, 2021; Frumkin, 2021; Kumar & Morawska, 2019; Kummitha, 2020; Nasir et al., 2016; Papadaki et al., 2020; Pinter-Wollman, Jelić, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; L. Tang et al., 2021; Y. Yang et al., 2021; Zordan & Tsou, 2020). The variables "access and movement," which concern containment of the user's activity and movement; "surveillance," which controls visibility in layout and the user's activity and movement; "ownership," which concern allowing the user's hierarchy, territory, and sense of ownership; "activity," which concern appropriate boundaries for the user's activity; and "management and maintenance," which concern providing peripheries in space, which be These six variables are impacted by the width and visibility of the room, the pathway, the wall, and furniture pattern, and the quality of checkpoints (for fever checkpoints, forced closures, and quarantines) in improving perimeters and containing the spread.
5. ‘Close Interaction Between Users’ discussed in 13 papers (Azuma et al., 2020; Bakhtiyari et al., 2020; Duill et al., 2021; Foster & Kinzel, 2021; Frumkin, 2021; Kumar & Morawska, 2019; Laddu et al., 2021; Papadaki et al., 2020; Pinter-Wollman, Jelić, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; L. Tang et al., 2021; Zordan & Tsou, 2020), and ‘not close interaction: user’s behavior that imitates other users’ discussed in 11 papers (Azuma et al., 2020; Bakhtiyari et al., 2020; Foster & Kinzel, 2021; Kumar & Morawska, 2019; Laddu et al., 2021; Papadaki et al., 2020; Pinter-Wollman, Jelić, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; L. Tang et al., 2021; Zordan & Tsou, 2020). These two

sub-aspects were influenced by the variables "access and movement," where containment of the user's close interaction between families and friends, and non-close interaction between strangers in the pathway and corridor become important; variable "ownership," where allowing the user's hierarchy, territory, and sense of ownership changes the interaction between families and friends; and variable "activity," where concern appropriate interaction as user's activity between families, friends, and strangers.

6. 'Mobility on Users' discussed in 12 papers (Azuma et al., 2020; Duill et al., 2021; Foster & Kinzel, 2021; Kumar & Morawska, 2019; Kummitha, 2020; Nasir et al., 2016; Papadaki et al., 2020; Pinter-Wollman, Jelic, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; V. Tang et al., 2021; Zordan & Tsou, 2020). The variables "access and movement," which is concerned with containing the user's movement; "structure," which is controlling the user's mobility through the structure in the built environment (walls, furniture, signage); "surveillance," which is controlling the user's mobility through natural visibility in space; "activity," which is concerned with creating appropriate user's mobility and activity; "management and maintenance," which is concerned in providing peripherals in space and 'hygienist behavior' which is concerned with the user personal protection (using mask or face mask, hand sanitizer, etc). These six variables are impacted by the width and visibility of the room, the pathway, the wall and furniture pattern, the quality of checkpoints (for fever checkpoints, forced closures, and quarantines), and individual protection.
7. 'Mobility of air in indoor air system' discussed in 30 papers (Abbas & Gursel Dino, 2021; Anghel et al., 2020; Azuma et al., 2020; Bakhtiyari et al., 2020; Brittain et al., 2020; Crawford et al., 2021; Dbouk & Drikakis, 2021; Duill et al., 2021; Fezi,

2021; Foster & Kinzel, 2021; Frumkin, 2021; Gao et al., 2016; Gbadamosi et al., 2020; Grydaki et al., 2020; Huang et al., 2021; Jarvis, 2020; Knibbs et al., 2011; Laddu et al., 2021; Mittal et al., 2020; Mueller et al., 2020; Nasir et al., 2016; Ronchi et al., 2020; Sadrizadeh & Holmberg, 2014; Sharghi & Asadi, 2020; Singh & Verma, 2021; Smieszek et al., 2019; Sopeyin et al., 2020; Srivastava et al., 2021; W. Yang & Marr, 2011; F. Zhang & Ryu, 2021) were impacted in variable 'Indoor Environmental Climate' where controlling the mobility of disease, decreasing the pollutant levels and improving the condition indoor air quality become important to prevent the virus spread on air. This variable is connected to the variable density and periphery-spread of density on air.

8. 'Mobility of natural system' is divided into 3 parts. 'Mobility on humidity' discussed in 11 papers (Bakhtiyari et al., 2020; Brittain et al., 2020; Frumkin, 2021; Gbadamosi et al., 2020; Mecenas et al., 2020; Mittal et al., 2020; Nasir et al., 2016; Sharghi & Asadi, 2020; Sopeyin et al., 2020; Srivastava et al., 2021; F. Zhang & Ryu, 2021); Mobility on natural light' discussed in 7 papers(Abbas & Gursel Dino, 2021; Bakhtiyari et al., 2020; Brittain et al., 2020; Frumkin, 2021; Nasir et al., 2016; Sharghi & Asadi, 2020; Sopeyin et al., 2020) and 'mobility on UV-C System' discussed in 4 papers (Abbas & Gursel Dino, 2021; Jarvis, 2020; Sharghi & Asadi, 2020; Srivastava et al., 2021). This mobility on the natural system was impacted by variable 'Indoor Environmental Climate', variable 'humidity' and variable 'natural light'. The need of controlling natural systems can be done by controlling humidity in the indoor air quality, improving the natural light, and improving of the natural UV-C in the built environment can help reduce the mobility of disease in the built environment.

9. ‘Mobility of droplets on building material surface’ discussed in 8 papers (Azuma et al., 2020; Brittain et al., 2020; Gbadamosi et al., 2020; Jarvis, 2020; Mittal et al., 2020; Mueller et al., 2020; Nasir et al., 2016; Sharghi & Asadi, 2020) were impacted in variable ‘hygienist building materials’ by controlling the choice of building materials and coatings of indoor surface on walls, floor and furniture can prevent the virus spread on air.
10. ‘Access, spatial standard and protocols: Users’ access discussed in 12 papers (Azuma et al., 2020; Duill et al., 2021; Foster & Kinzel, 2021; Kumar & Morawska, 2019; Kummitha, 2020; Nasir et al., 2016; Papadaki et al., 2020; Pinter-Wollman, Jelic, et al., 2018; Ronchi et al., 2020; Sharghi & Asadi, 2020; V. Tang et al., 2021; Zordan & Tsou, 2020). The variable "ownership," where allowing the user's hierarchy, territory, and sense of “activity” changes the access and protocols of users.
11. ‘Access, spatial standard and protocols: self-protection’ discussed in 5 papers (Bakhtiyari et al., 2020; Foster & Kinzel, 2021; Kumar & Morawska, 2019; Mittal et al., 2020; Sharghi & Asadi, 2020) were impacted in variable ‘hygienist behavior’ where the degree with varied protection to improve hygienist behavior using diversity and a number of tools.
12. ‘Access, spatial standard, and protocols: new standards for built environment’ discussed in 14 papers (Abbas & Gursel Dino, 2021; Bakhtiyari et al., 2020; Duill et al., 2021; Fezi, 2021; Frumkin, 2021; Kumar & Morawska, 2019; Kummitha, 2020; Mittal et al., 2020; Nasir et al., 2016; Papadaki et al., 2020; Pinter-Wollman, Jelić, et al., 2018; Sharghi & Asadi, 2020; Shenton et al., 2019; W. Yang & Marr, 2011). The variables "access and movement," which is concerned with containing the user's access and following protocols; "structure," which is

controlling the user's access through the structure in the built environment (walls, furniture, signage); "surveillance," which is controlling the user's access through natural visibility and protocols in space; "management and maintenance," which is concerned in providing access, spatial standard and protocols in space.

13. 'Access, spatial standard and protocols new standards for humidity and temperature' discussed in 12 papers (Abbas & Gursel Dino, 2021; Bakhtiyari et al., 2020; Duill et al., 2021; He et al., 2021; Kumar & Morawska, 2019; Mecenas et al., 2020; Nasir et al., 2016; Ronchi et al., 2020; Sharghi & Asadi, 2020; Shenton et al., 2019; Sopeyin et al., 2020; Srivastava et al., 2021; F. Zhang & Ryu, 2021) were impacted in variable 'humidity and temperature' where the need of controlling of natural systems can be done by controlling humidity and temperature in the indoor air quality (warm and wet climates seem to reduce the spread of virus).
14. 'Antivirus Building Materials & Droplets on Surface of Building Materials' discussed in 6 papers (Brittain et al., 2020; Gbadamosi et al., 2020; Jarvis, 2020; Mittal et al., 2020; Mueller et al., 2020; Sharghi & Asadi, 2020) were impacted in variable 'hygienist behavior' where the degree with varied protection to improve hygienist behavior using diversity and number of tools.

According to these findings, there are 7% of articles discuss the variable 'Access and Movement', 2% of articles discuss the variable 'structure', 5% of articles discuss the variable 'surveillance', 6% of articles discuss the variable 'ownership', 8% of articles discuss the variable 'activity', 5% of articles discuss the variable 'management maintenance', 41% of articles discuss the variable 'indoor environmental climate, 3% of articles discuss the variable 'hygienist behavior', 10% of articles discuss the variable 'humidity and temperature', 3% of articles discuss the variable 'natural light', 2% of

articles discuss the variable ‘UV-C System’ and 6% of articles discuss the variable ‘hygienist building materials’ (see Figure 2)

[Figure 2. Must be placed here]

4.3 The Synthesis: Strategies for Dynamics in Post-Pandemic Architecture

The process of synthesis started by breaking down in more detail the perspective of dynamics in post-pandemic architecture, coding, and classifying and grouping similar topics to create a dynamic architectural post-pandemic framework. The framework was defined in terms of "variables," "indicators," and "factors." The "variables" have been explained in a previous sub-chapter. In this sub-chapter, we will explain in more detail the existence of indicators, factors, and measurement objectives to clarify the discussion of the variables that appear and create strategies for a dynamic architecture post-pandemic. The results are presented in table 3.

[Table 3. Must be placed here, there are 3 tables part 1, 2 and 3]

Based on these findings, below is a synthesis of variables, indicators, and factors:

- "Access and Movement": The indicator is the presence of access to pathways and orienting objects. The factor and measurement criteria are based on well-defined routes, spaces, entrances, and pathways that provide movement, access, and peripheries to humans and disease.
- Structure: The indicator is the degree to which places are structured and do not cause conflict. The factor and measurement criteria are the zoning, orientation, and structure of the room (wall, floor, furniture) that structure human mobility without causing conflict.

- "Surveillance"—The indicator is the degree to which surveillance provides appropriate natural visual visibility through the layout. The width of the room and the spaces overlooked for visibility are the factors and measurement criteria.
- Ownership—The degree to which the built environment provides a hierarchy, a sense of ownership, boundaries, and personalization is the indicator. The layout, floor area, and furniture layout are the factors and measurement criteria to promote a sense of ownership, personalization, and territoriality.
- "Activity"—The indicator is the degree to which users have an appropriate activity, mobility, access, and spatial configuration of space. The factor and measurement criteria are appropriate elements of the built environment that facilitate user activity and are appropriate to the location.
- "Management maintenance"—The indicator measures the extent to which management has provided appropriate space maintenance. The factors and measurement criteria are control and quality, and they are designed with management and maintenance in mind.
- "Indoor environmental climate"—the indicator is related to the pollutant level and air conditions. The factors and measurement criteria are CO2 measurements, occupancy levels, crowd density, room volume, and opening window size and position to reduce or prevent the spread of infectious disease.
- "Hygienist behavior"—The indicator is related to varied protection to improve hygienist behavior. The factors and measurement criteria are the amount of diversity and the tools to help improve hygienist behavior.

- "Humidity and temperature"—The indicator is related to the degree of central humidity and cooling system in the room. The thermostat and air conditioner central control are the factor and measurement criteria.
- "Natural light"—The indicator is related to the control, quantity, and quality of natural lighting in the room. The natural light orientation and glazing area with no direct sunlight but a larger window are the factor and measurement criteria.
- UV-C System: The indicator is related to the degree of control of the UV-C system in the room. The better qualities of UV-C lighting power are the factor and measurement criteria.
- "Hygienic building materials"—The indicator is related to the choice of building materials and the coatings of indoor surfaces on walls, floors, and furniture. The factor and measurement criteria are the quality and quantity of building materials used to help improve room hygiene.

5. Conclusion

The literature review on the dynamics in post-pandemic architecture is growing rapidly. The relationship between the dynamic aspects and the need for security in the built environment has been elevated and is growing rapidly. Before the pandemic, security as a 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. The aspect dynamics in post-pandemic architecture also need to be adjusted based on this need.

After some study and a literature review, this paper has identified the changed dynamics in post-pandemic architecture and strategies that affect the built environment in future disease prevention. Some of the security variables in previous studies need to be adjusted, and there are new security variables for post-pandemic

dynamics. The conclusion of the changed and strategies of Dynamics post-pandemic architecture, as mentioned below:

- Density aspects related to security (variables: access and movement, surveillance, activities, maintenance management) and new context: Climate and Nature (Indoor Air Quality)
- Aspects of peripheries and spread related to security context (variables: surveillance, activity, access - movement, maintenance, and ownership management) and new context: Climate and Natural (Indoor Air Quality)
- Aspect of interaction related to the previous security context (variables: activity, access, movement, and ownership)
- Aspect of mobility is related to the Security Context (variables such as structure, supervision, activities, maintenance management, physical protection, and ownership) and the New Context (behavioral, hygienic behavior, climate, and nature) (indoor air quality, humidity, room temperature, natural lighting, UVC-System, hygienic surfaces of building materials, and so on).
- Aspects of access, spatial standards, and protocols related to the security context (variables: structure, supervision, activities, access and movement, management of care, and ownership) Behavior (Hygienic Behavior, Humidity and Room Temperature, Hygienic Building Material Surfaces)
- Behavior of Antivirus Building Materials in the New Context (Hygienic Building Materials)

Some limitations of this study are as follows: some papers not written in English or Bahasa were excluded; some interesting aspects such as distancing and the pattern of living and working in the new normal are not discussed; the articles included in this

review are up to August 2022 (and there is the possibility of new articles). This paper provides a current state-of-the-art review of current research in the field, as well as a strategy for future research in the field to improve understanding of the dynamics aspect in design-related fields.

Dynamics in Post-Pandemic Architecture: Integrative Literature Review in response to Post-Pandemic Built Environment

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