Dynamics in post-pandemic architecture: Integrative literature review in response to post-pandemic built environment

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Abstract
"Dynamics in post-pandemic architecture" refers to dynamics in architecture as implication of disease spread in a building for averting a future pandemic. The highly contagious and rapid spread of COVID-19 has caused changes in the architecture and way of life. The built environment needs proper strategies to act as a facilitator for averting the spread of disease in the future. The implications of disease spread and strategies for dynamics in post-pandemic architecture will be reviewed and discussed in this study. Integrative literature review used in this article is a systematic method to define previous research, relate concepts and relevant studies by reanalyses the data for future research. The first step is systematically clear selection; the second step is coding; the third step is synthesis. The integrative review considered 102 papers (of which 40 were reviewed). It was discovered that there were no articles that incorporated previous study findings comprehensively. Six strategies for future dynamics in architecture post-pandemic are revealed: control of architectural density, control of peripheries and spread, control of interaction, control of mobility, control of access, and new protocols and standards for spatial. Each strategy demonstrated the interaction between dynamics in post-pandemic architecture and security-pandemic variables in built environment. The findings: identification of the dynamics in architecture post-pandemic strategies that affect the built environment in preventing disease spread in the future. This will support future research in defining appropriate future research designs and understanding the need for holistic analysis of the integrated effects of diverse dynamics in post-pandemic architecture.

Keywords
Dynamics, Pandemic, Public space, Future, Interior.
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 security concept of architecture, 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 in post-pandemic architecture, a concept and strategy based on various disciplines related to movement, change and adaptability within architecture and the built environment design 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 in 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). Structures are organized collections of defined spaces that are made of products, have an interior space, and an exterior form. While interior spaces are enclosed within a structure and defined by an organized arrangement of products (McClure & Bartuska, 2007). Therefore interior-structure in built environment is grouping of spaces and products to enhance human activities and have both exterior form and interior spaces. 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 need 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 dynamics in architecture post-pandemic.

There is a research gap for dynamics in architecture context between the pre-pandemic and post-pandemic eras. Since the dynamics in 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 in post-pandemic architecture” in terms of security variables. The dynamics in 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. 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 in post-pandemic architecture, exploring the potential for built environment security variables to develop a synthesis of strategy for reducing the risk by developing dynamics in post-pandemic architecture through built environment (Haigh & Amaratunga, 2010; Marion E. Broome, 2000; Torrance, 2005; Y. Zhang et al., 2019).

Two existing research (in preliminary study) on the dynamics of post-pandemic architecture exist prior to the steps for an integrative systematic review. The first study is regarding how the post-pandemic has affected urban dynamics. The second study is about how existing safety and security strategies become fundamental concepts and design features in the built environment for prevention and detection of threats. These two studies examined how urban planning and safety-security measures were altered in the built environment during the pandemic. These studies are crucial for...
comprehending the scope and basic information of the dynamics concept and security strategies before the pandemic. The integrative review presented in this paper intends to propose a strategy for dynamics in post-pandemic architecture in terms of security variables.

The connection between preliminary study and 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 in post-pandemic architecture. Finally, conclusion of reviews can be reported in a table or diagram.

2.1. Step 1: The selection
The selection process was carried out by searching for sources of literature or writing 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 in lens.org. The next step is filtering the field of study using: "architecture" "ventilation" "building design" "architectural 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 dynamics 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.

2.2. Step 2: The coding and classification
The next step is the coding and classification process. There were 7 sub-aspects of urban dynamics (Maturana et al., 2021; Salama, 2020). From the seven sub-aspects in the previous research in urban design, only six were discussed and identified as the dynamics in post-pandemic 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 dynamics aspect framework and sub-aspects for interior-structure.

2.3. Step 3: The synthesis
The process of synthesis started by breaking down in more detail what sub-aspects of the dynamics in post-pandemic architecture were associated with the security variables in the built environment. There are seven existing security variables (Briggs, 2005) and the possibility of new additional sub-aspects. 40 sources of literature were identified from the perspective of dynamics’ aspects, then sorted and grouped into similar topics to create “dynamics in post-pandemic architecture” 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 dynamics in post-pandemic
Dynamics in post-pandemic architecture: Integrative literature review in response to post-pandemic built environment. The results are presented in Table 3.

3. 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). 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
2. Peripheries and spread
3. Interaction
4. Mobility control
5. Access control and prevention through standards and protocols
6. Prevention through technology and materials

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. Dynamics in terms of post-pandemic architecture needs to be synchronized with the aspect of security to create a more secure and safer 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). There are seven security variables: (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
The 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 dynamics’ 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.

4. Results and discussion

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

Table 1. Review findings and implications for research.

<table>
<thead>
<tr>
<th>No</th>
<th>Reference</th>
<th>Citing Works</th>
<th>Review findings and implications for research with keywords in bold (selected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>(Wang et al., 2020)</td>
<td>536</td>
<td>The movement of the Covid-19 virus is an important factor for understanding the movement of indoor droplets in the HVAC system. This virus is transmitted through respiratory droplets, which can reach indoor spaces through various pathways, including HVAC systems. The movement of indoor air can affect the distribution and concentration of indoor virus particles. The movement of indoor air can be influenced by factors such as air exchange rates, air flow patterns, and ventilation strategies. The study found that the indoor air movement can affect the movement of Covid-19 virus particles in indoor spaces.</td>
</tr>
</tbody>
</table>

P2 (W. Yang & Man, 2021) 185
P3 (W. Wang et al., 2020) 122
P4 (Ahn et al., 2020) 63
P5 (W. Yang et al., 2020) 52
P6 (Ghosh et al., 2020) 44
P7 (Nakar et al., 2020) 40
P8 (Nakar et al., 2020) 44
P9 (Nakar et al., 2020) 40
P10 (Nakar et al., 2020) 40
P11 (Poh et al., 2020) 42
P12 (Gao et al., 2020) 29
P13 (Sadikbayeva et al., 2020) 29
P14 (Gergovik et al., 2020) 23
P15 (Poh et al., 2020) 19
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P17 (Sadikbayeva et al., 2020) 9
P18 (Mark et al., 2020) 9
P19 (Schröter et al., 2020) 8
P20 (Angkel et al., 2020) 8
P21 (Lund et al., 2020) 7
P22 (Ginghi & Vesin, 2020) 6
P23 (Franklin et al., 2020) 6
P24 (Occhipinti et al., 2020) 5
P25 (Dong et al., 2020) 4
P26 (Gowen et al., 2020) 4
P27 (Gul et al., 2020) 3
P28 (Miller et al., 2020) 2
P29 (Crawford et al., 2020) 2
P30 (Bennett et al., 2020) 2
P31 (Ouff et al., 2020) 2
P32 (Wrench et al., 2020) 1
P33 (Zhang & Yue, 2020) 1
P34 (Ghumre & Asadi, 2020) 1
P35 (Tang et al., 2020) 1
P36 (Y. Yang et al., 2020) 1
P37 (Zhan et al., 2020) 1
P38 (Ghemhre & Asadi, 2020) 1
P39 (Papakakos et al., 2020) 1
P40 (Rhee, 2020) 1

P1 Ouff et al. (2020) | 2 | Factors that influence and limit the impact of the spread of indoor airborne particles in indoor spaces include room size, air exchange rates, air velocity, and air turbulence. Multiple openings have a higher impact on reducing the risk of infection than changing the type of door. |

P2 Wrench et al. (2020) | 1 | Basic relationship of human movement due to the Covid-19 Pandemic. (1) Human movement (2) Interaction between null users. |

P3 Zhang & Yue (2020) | 1 | The factors that affect the pattern of airflow in the room in the effect of ventilation on the indoor environment. |

P4 Ghumre & Asadi (2020) | 1 | A study on the evaluation of indoor air quality in hospitals. Multiple openings have a higher impact on reducing the risk of infection than changing the type of door. |

P5 Tang et al. (2020) | 1 | Human movement in the area around the home environment has an impact on the high air turbulence. |

P6 Y. Yang et al. (2020) | 1 | Factors that make the environment resistant to pandemics: 1) personalized urban design, 2) decent housing, resilient building systems, proximity between work and home, blended travel, diverse travel options and city facilities and activities according to population density. |

P7 Zhan et al. (2020) | 1 | There is no relationship between behavioral campaign theory and attitudes, preferences and psychological domains in urban spaces, since only changing variables and green spaces. |

P8 Ghumre & Asadi (2020) | 1 | It is found a relationship between behavioral intention and physical-environmental factors that influence health-promoting and protection-related behaviors in the indoor design scope. Elements that affect indoor control, reduce stress and improve health-related behaviors, including air, surface color, opening and seating density, openness and common areas, windows and ventilation for natural light and ventilation, open space for movement, activities, physical and social contact. Different age groups need different places to reduce stress. |

P9 Papakakos et al. (2020) | 1 | There are three options for building design (1) pedestrian design (2) e-mail (3) anti-epidemic design. The study found a relationship between use movement and strategies to institute high risk of public transmission. |

P10 Rhee (2020) | 1 | Architecture and cities are needed to prevent and mitigate future pandemics through indoor control, housing approaches, public spaces, green area design, work areas, transportation, and open space neighborhoods. |
ments 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.

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 occupancy density. 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 occupancy 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 occupancy 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 in user activities and occupancy. 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 peripheries the dirty air using several tools and improving the indoor air quality by creating peripheries’ element for improving natural air movement in the room. The potential for infectious disease transmission through humans via droplets, therefore user activity must be limited and distributed. The way to control the rate of spread is through creating interior-structure’s elements to limit user’s activity and capacity in area before entering the interior-structure.

3. Interaction - is the closeness of the interaction between users within the interior-structure scope. There are two things related to interaction, 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.
ments 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.

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 dynamics aspect associated with the security's variables in the built environment.

As mentioned in preliminary study, the concept of security has not yet discussed the form of prevention from pandemics and health issues, hence, it is important that the dynamics in post-pandemic architecture characteristics are considered in relation to each other and security variables. The identification and coding of dynamics in 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; pat-
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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 of sub-aspects dynamics in post pandemic architecture (see Table 3).

1. "Density regarding the disease on air" discussed in 29 papers, 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 CO2 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, 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 based on Human Activity' discussed in 14 papers. The variables “access and movement,” which concern containment 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 CO2 measurements, counting the occupancy levels, crowd density, observed mitigations, opening windows, and room volume.

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The characteristics of sub-aspects dynamics identified in Table 2.
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, and 'not close interaction: user's behavior that imitates other users' discussed in 11 papers. 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. 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 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; Mobility on natural light' discussed in 7 papers and 'mobility on UV-C System' discussed in 4 papers. 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 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. 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 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. 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
13. 'Access, spatial standard and protocols new standards for humidity and temperature' discussed in 12 papers, 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 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).

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 "dynamics in post-pandemic architecture" 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 dynamics in post-pandemic architecture. The results are presented in Table 4.

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

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**Table 3. Findings of sub-aspects dynamics in post-pandemic architecture characteristics and its relationship to variables in built environment.**

<table>
<thead>
<tr>
<th>Sub-aspect dynamics</th>
<th>Variables</th>
<th>Indicators</th>
<th>Factors</th>
<th>Measurement Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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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 factors 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.

Based on the result, there are some adjustments, changed and new security variables for dynamics in post-pandemic architecture. The conclusion of the changed and strategies of Dynamics in post-pandemic architecture as mentioned below:

- Density aspects related to security context (variables: access and movement, surveillance, activities, maintenance management) and
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- Aspects of peripheries and spread related to security context (variables: surveillance, activity, access, movement, maintenance, and ownership management) and new variable: Climate and Nature (Indoor Air Quality)

- Aspect of interaction related to the previous security context (variables: activity, access, movement, maintenance, and ownership management) and new variable: Climate and Nature (Indoor Air Quality)

Table 4. Dynamics in post-pandemic architecture: variables, indicators, factors, and measurement criteria.

<table>
<thead>
<tr>
<th>Variable/Indicator/Factor</th>
<th>Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Air Quality</td>
<td>Data collected from various sources, including ambient air quality monitoring stations and indoor air quality surveys.</td>
</tr>
<tr>
<td>Surveillance</td>
<td>Camera footages, logs and reports of the surveillance system.</td>
</tr>
<tr>
<td>Activity</td>
<td>Attendance records, activity logs, and digital footages.</td>
</tr>
<tr>
<td>Access-Movement</td>
<td>Access logs, movement schedules, and security protocols.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Maintenance reports, repair logs, and equipment usage records.</td>
</tr>
<tr>
<td>Ownership Management</td>
<td>Ownership agreements, property management plans, and maintenance contracts.</td>
</tr>
</tbody>
</table>

Table 4 (continued).
and ownership)

- Aspect of mobility is related to the security context (variables such as structure, supervision, activities, maintenance management, physical protection, and ownership) and new variables (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) and new variables (Hygienic behavior, humidity and room temperature, hygienic building material surfaces)

- Behavior of Antivirus Building Materials in the new variables (Hygienic Building Materials)

5. Conclusion

The literature review on the dynamics in post-pandemic architecture is growing rapidly. The relationship between the dynamics’ 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 dynamics in post-pandemic architecture. The previous security variables are having adjustment and still used in dynamics in post-pandemic architecture. For example: “access and movement” variable is orientating to limit people accessing the building and controlling the movement of people (using physical and social distance). The new variables in dynamics(s) post-pandemic architecture are in natural environment context (indoor environmental climate, humidity and temperature, natural light, UVC-System) and behavior context (hygienist behavior form the users and usage of hygienic building materials). In conclusion, there are adjustment in previous security variables and additional strategies for Dynamics in post-pandemic architecture.

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.

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