Communal space design of high-rise apartments:

a literature review

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Abstract
Satisfactory communal space in high-rise apartments helps to create a harmonious living atmosphere and enhance neighbourhood relations. This review summarises and analyses the research on the design of communal areas in high-rise apartments with consideration of five aspects: space division, universal design, security design, landscape design and decoration design. The aim is to achieve a comprehensive understanding of current design concepts relating to communal space in high-rise apartments and to identify key design considerations that are necessary for the development of sustainable high-rise apartments. The paper proceeds with three objectives: (1) to develop a comprehensive policy for communal space to support the sustainable development of high-rise apartments; (2) to identify research on the building materials that can be used to improve the environment of the communal spaces; and, (3) to identify areas that can improve the planning and management of open spaces in high-rise apartments with the help of existing information technology. Overall, this review provides some useful insights for the sustainable development of high-rise apartments in terms of shared-space design, while revealing gaps in the literature and areas for further research.
Keywords: High-rise apartments, Communal space, Design, Sustainable development

1 INTRODUCTION
Ongoing urbanisation has been a major factor in rapid population growth. Many high-rise apartments were built to simultaneously address the scarcity of land and accommodate increasing housing needs (Reddy 1996; Je & Lee 2010; Holdsworth, Kenny, Cooke & Matfin 2019). High-rise apartments are usually located in premium neighbourhoods and provide amenities such as gyms, sharing rooms, etc., at a relatively affordable price. However, some researchers claim that high-rise apartments lead to a series of social problems including the deterioration in the mental health of the residents (Fanning 1967; Richman 1974), a reduced sense of belonging (Hall 1966; Husaini, Moore & Castor 1991; Cho & Lee 2011), deficient supporting facilities (Deng 2012), and a lack of monitoring that leads to an increased crime rate (Costello 2005; Gifford 2007; Li 2007).

Communal spaces in high-rise apartments are places for residents to interact and communicate. Such spaces comprise two main components: the open area and passageway inside the apartment block, such as the lobby, corridor, public underground parking, elevator, stairs, gym, and other shared areas; and the associated areas outside the apartment block, including the 'public domain interface', semi-open and open courtyards or gardens, and rooftop (NSW Department of Planning and Environment 2015).

High-quality communal spaces are the basis for creating healthy neighbourhood relationships. They help to maintain a sense of belonging and cohesion for residents, and can help to improve social problems that may exist within high-rise apartments (Chang 2015). However, imprudent building planning and/or space design can result in reduced or unused joint spaces (Mahdavinejad, Mashayekhi & Ghaedi 2012). Therefore, flexible communal space design is necessary for providing a positive living environment (Tian 2001).

This type of design was embedded in the typical traditional housing which considers the elements of local topography, climate, and social conditions, that meet basic human needs and conform to the laws of nature (Li 2004; Deng 2012). However, most modern high-rise buildings have met the high-density urbanisation but neglected the traditional design elements (Astuti, Setijanti & Soemarno 2017; Matovnikov, Matovnikova & Samoylenko 2018). By this measure, both modern and traditional housing have their merits and drawbacks. Therefore, it is particularly important to understand both traditional and contemporary design preferences and apply these ideas to the design of communal space to address the above-mentioned problems that exist with high-rise apartments (Franck & Mostoller 1995).

Through a comprehensive understanding of the scholarly design philosophy of communal space in the high-rise apartment, this review seeks to identify any research gaps and develop a research direction for the future. The review will summarise and analyse the research on communal space in consideration of five aspects: space division, universal design, security design, landscape design and decoration design. Three design elements beneficial to the sustainable development of communal space in the future will be proposed.

2   RESEARCH METHOD

This study applies the meta-analysis method in the systematic review to conduct a quantitative analysis of the literature relating to the design of communal space in high-rise apartments. The reasons for this approach are twofold. First, the purpose of the systematic literature review is consistent with the original intention of this review, that is, to comprehensively and accurately identify the progress of the research by integrating the literature in specific research fields (Mulrow 1987; Green, Johnson & Adams 2006). Second, a meta-analysis in the systematic literature review is a standardised review method with normalised research steps (Moher, Liberati, Tetzlaff

& Altman 2009; Hart 2018). These steps are intended to establish a structured search strategy and identify the inclusion and exclusion criteria (Paré, Trudel, Jaana & Kitsiou 2015), to search for research-related literature from multiple sources and databases, and to conduct a quantitative analysis of search results (Hart, 2018). In summary, three steps of literature retrieval — selection, coding and analysis — were adopted to understand the research of scholars.

2.1   Literature search

Based on the academic databases and publications available at the University library, this review involved an extensive literature search through Google Scholar, ProQuest, Scopus, and CNKI (China National Knowledge Infrastructure database). These are considered the four most acceptable full-text databases available for a comprehensive search of disciplines. The reason for choosing CNKI is that valid literature retrieved from Google searches pointed to the CNKI database. Also, the authors understand Chinese, whereas the other three databases are all operated in English.

For the review, the title/abstract/keyword field was selected in the databases to systematically and extensively search articles related to communal areas using keywords and free text words. The search string contained synonyms for three core words: 'high-rise apartments', 'communal spaces' and 'design'. Several free text words, namely: 'landscape', 'environmental behaviour', 'psychology', 'old people' and 'children' were also used. Lastly, 187 articles related to the design of communal space were retrieved.

2.2   Literature selection

All literature needed to be further refined and filtered before its selection for analysis. The selection criteria of this review were as follows. (1) Publications were only retained from journals, conference papers, and theses, and a few reports and book chapters. (2) Articles that could not be retrieved by full-text were excluded. Unfortunately, many of the articles were only available by purchase, and the reviewer did not have the budget to pay for papers. (3) There was no cut-off date set for literature retrieval, with the most recent search being December 2019.

After screening, 106 articles were selected from Google Scholar and 81 articles were retrieved from the other three databases. After excluding 36 articles that were retrieved more than once, and 24 irrelevant articles, a total of 127 papers remained. Following this, 6 articles in languages other than English and Chinese and 32 articles with abstracts only were also excluded. The 89 full-text papers retained for analysis include journal articles (n = 52), theses (n = 23), conference papers (n = 11), and book chapters (n = 3). The main retrieval steps above are illustrated in Figure 1 and all references were imported into EndNote X9.

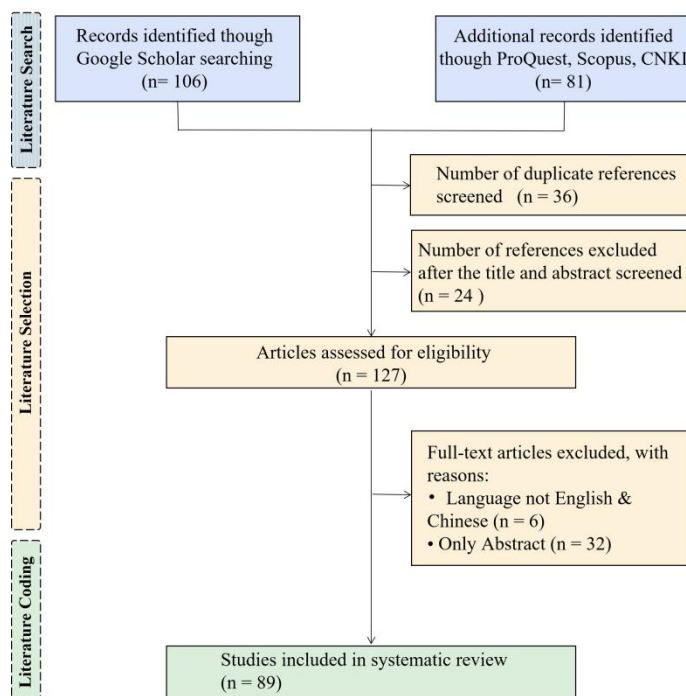*Figure 1: Steps of literature retrieval (Source: Author)*

2.3 Literature coding
The main task of the literature coding was to extract the research-related data from the identified literature, and to classify and encode the data. The main methods of coding were by title, subtitle, keywords, abstract, research method and conclusion. The coding content consisted of: a) article title; b) researcher/s name/s; c) publication name; d) publication year; e) research field of article; and f) major design elements or ideas mentioned in each study.

3 RESULTS
Table 1 shows the research focus of the identified articles to be centred mainly around four research fields: design, psychology and behaviour, sociology and landscape science.

Table 1: Classification of the Identified literature

Topics	Focused on	Paper No.	Percentage
Design	space design, environmental design, and architectural design	39	44%
Psychology & Behaviour	the relationships between human psychology, behaviour and the environment	13	15%
Sociology	neighbourhood social contact, housing safety, and residents' satisfaction	28	31%
Landscape	sciencepublic space landscape and vegetation	9	10%
		89	100%

3.1 Factors in designing communal space

The design of communal space is an interdisciplinary field. Many determinants need to be considered comprehensively in the planning programme and are emphasised differently from various perspectives. Using a questionnaire survey of 1500 respondents, Malek, Mohammad and Nashar (2018) found that social sustainability, use pattern, place attachment, facilities, safety and security, nature preferences, and activities and accessibility were the main determinants to achieve the quality of open spaces in Malaysia. In the current review, the main factors to be considered are summarised as the following:

(1) The architectural form of high-rise apartments

As an indispensable part of the high-rise apartment, the design of communal space depends on the structure of the building. The main types of architectural features mentioned in the existing research include underground space (Zhao 2007), bottom space (Zhang & Sui 2006; Wei 2015), patio (Chan 2005), courtyard (Wang 2008; Matovnikov et al. 2018), rooftop (Lum 2011), lobby (Noguchi & Tsukidate 2002), elevator lobby (Bee & Im 2016), and high-platform type space (Shen & He 2005). The different methods of space design correspond to different building structures (Lin 2018).

(2) Residents' living needs and habits in age groups

The age span of residents in high-rise apartments dictates that the communal space should be inclusive. Residents' demands for shared areas should consider individual living needs (Engür 2013). Some scholars have applied Maslow's hierarchy of needs (Xiong 2000; Itma 2018), which requires that sheltered and comfortable living spaces meet the basic physiological and safety needs of humans (Sajad, R. A. & Sajad, S. A. 2016). After these basic needs are satisfied, people pay more attention to the spiritual satisfaction of housing, that is, they need to feel a sense of belonging and respect in the living environment, which is known as self-actualisation needs. Residents of different age groups have certain needs in terms of physiology and psychology. Children (Coley, William, Sullivan & Kuo. 1997; Sharghi, Maulan, Salleh & Salim 2014) and the elderly (Temelová & Slezáková 2014; Tang 2015) have higher requirements for a better quality of shared spaces. Therefore, for these age groups, safety and usability are the two major design factors to be considered (Zhang 2007; Zhang & Wang 2012). Furthermore, while young people and office workers prefer outdoor or public entertainment areas, they also seek to relieve the pressures of work through high-quality communal spaces in their apartment blocks, although they maintain a low demand for the communal space (Baharuddin 2017). It is evident that a comprehensive understanding of different users' personality traits and living habits in residential buildings (Astuti et al. 2017; Feng 2016), especially traditional living habits (Wang 2008), can provide a valuable reference for the spatial layouts, which can be made more suitable for the behavioural needs of residents (Lee, Li, Chen & Liu 2005; Engür 2013).

(3) Human psychology and behaviour

A consideration of human psychology and behaviour is essential when designing communal spaces. A reasonable space layout is not only conducive to more functional areas, but also to the benefit of neighbourhood communication (Zhao 2007; McMurtrie 2012). The psychologist Derk de Jonge proposed the boundary effect, in which people tend to socialise at the edges and corners of open spaces to gain a sense of domain (Han 2007). Similarly, the anthropologist Hall (1966) suggested that 1.2 to 3.6 metres is the most socially appropriate distance for humans. Gehl (2011) believed that communal spaces should be designed according to our daily activities. According to the theory of neighbourhood typology, the sociologists Perry, Blumenfeld and Bardet agreed that the size of a neighbourhood group should be considered to be no more than 12 households for the establishment of healthy interpersonal relationships (Li 1999). These verified scientific conclusions are based on the human psychology and behaviour mode, and have a guiding function in the design of communal areas.

(4) Surrounding environment

It is clearly stated in the NSW Apartment Design Guide (ADG) (NSW Department of Planning and Environment 2015) that the design of communal space should cater to the development of surrounding communities and/or the urban environment. This is because the surrounding environment can help to integrate the housing development into the broader urban and community landscape (Franck & Mostoller 1995; Tribhuwaneswari, Darjosanjoto & Rachmawati 2016). Thus, consideration of the natural environment, such as greening, climate, and other factors, is indispensable (Chan 2005; Chang 2015).

(5) Culture and religion

Cultural and religious factors in the design of communal space can enhance the residents' sense of belonging on the spiritual level (Zhang & Wang 2012). This is especially so in countries and regions that receive large numbers of immigrants, where the heterogeneity of language and culture seem to have a meaningful impact on the harmony of the neighbourhood (Forrest, La Grange & Ngai-Ming 2002). Integrating culture and religion into the physical spatial characteristics of the built environment can improve neighbourhood interaction between different cultural backgrounds (Abbaszadeh, Ibrahim, Baharuddin & Salim 2009). Changes in culture can affect the relationships between residents within social space (Abbaszadeh et al. 2009; Itma 2018) and lifestyle (Hadi & Bin 2013). In a mono-cultural country, traditional culture should be embedded into the design of communal space to maintain people's traditional life and good relations within the neighbourhood (Abbaszadeh et al. 2009; Itma 2018). It can also reduce the negative impact of modern housing on residents' traditional lives (Itma 2018). Modern elements are more suitable to highlight the cultural atmosphere of communal space in multicultural countries, because of their universality.

3.2 Research approach

Different approaches have been adopted by researchers based on various disciplinary standpoints. From the perspective of design, some scholars followed the three main steps of the literature review, field research and case study. In particular, architectural simulation (Wang & Bay 2008), pattern design (Park, Kim & Lee 2007) and other digital model design methods were developed. Cho and Lee (2011) verified the feasibility of the conceptual model of communal space through living projects. From the perspective of sociology, most researchers focused on investigation and evaluation, setting up multiple variables, and pointing out the shortcomings of the architectural projects to improve the communal area (Kim 2003; Lee 2007; Sharghi et al. 2014). From the perspective of psychology and behavioural studies, scholars have evaluated human actions in an existing shared area by testing the residents' actual behaviours (Tanaka, Yamada, Nakamura, Ishii & Watanabe 2013), and established a dynamic model (McMurtrie 2012) to explain the influence of space on human interaction and psychology. From the perspective of landscape science, some scholars used Computational Fluid Dynamics to study the correlation between micro-climate factors of communal space and the open-space layout of residential areas (Yin 2013).

4 DISCUSSION

This discussion focuses mainly on the characteristics of traditional residential shared areas and sustainable development strategy in communal space design with consideration of five aspects: space division, universal design, security design, landscape design and decoration design.

Through summarising the relevant literature, the patterns characteristic of communal spaces in traditional housing design were understood in the following ways. First, communal space is directly connected with the street and has a high degree of conformity with the surrounding environment of the city (Abbaszadeh et al. 2009). Second, communal areas connect public and private space, and play a transitional role. Multiple path nodes create space with hierarchical characteristics (Wang 2008). In Eastern and Western countries, the layout of the communal areas in traditional housing is different. In Western countries, the communal space lies between two semi-open private courtyards and is usually used as a driveway (Turkington, Van Kempen & Wassenberg 2004; Fong & Paul 2011). In Eastern countries, the communal space is a courtyard shared by several families, which may include a semi-open mini porch (Li 2007; Deng 2012). In the latter instance, the communal space connects a broader range of public and private domains, and the continuous multi-level spatial network gradually strengthens the formation of the spatial domain (Deng 2012; Chang 2015). The authors have illustrated the layout schematic diagram of traditional residence in Eastern and Western country, as shown in Figure 2.
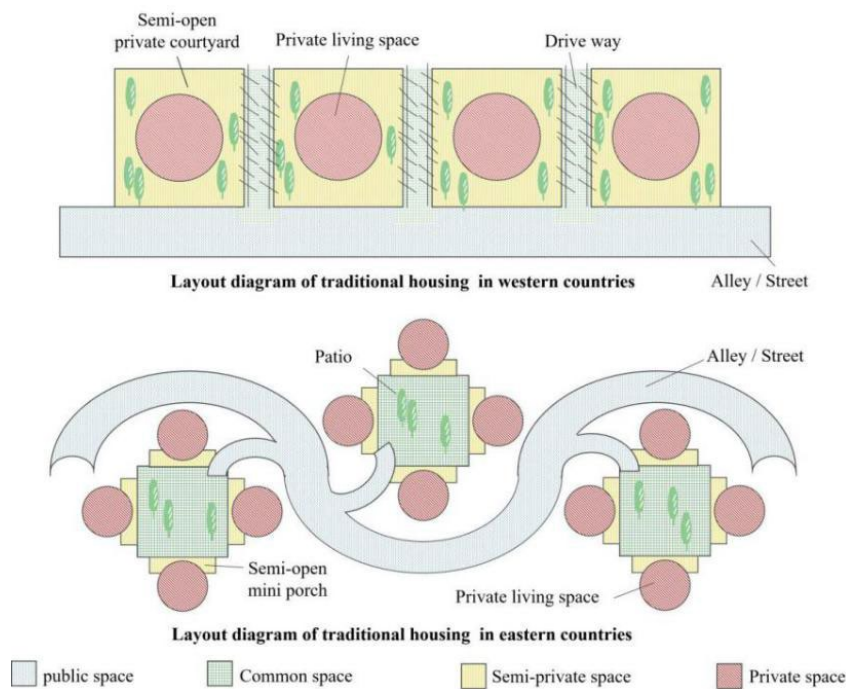
Figure 2: Layout schematic diagram of traditional residence in Eastern and Western country (Source: Author)

Third, traditional communal space is multi-functional. Due to the small indoor areas of traditional houses, the use of shared areas has expanded to integrate daily life, and entertainment and neighbourhood social activities, among other things (Li 2016). Lastly, there is a diverse implantation of natural elements. Due to the grounding characteristics of traditional housing, the communal spaces have a higher native vegetation coverage rate (Wu 2014). Given the communal space characteristics of traditional housing, scholars have posited several design strategies as follow.

Five characteristics of communal space design were identified as presented below:
4.1 Space division
(1) Setting up shared platforms in adjacent floors of high-rise apartments to form 'terrestrial space' *(Qu & Yang 2009; Engür 2013). The idea behind this design is to divide the large population into smaller neighbourhoods for purposes of proximity (Xiong 2000; Chua 1995). In high-rise buildings, proximity is one of the main determinants in promoting neighbourhood interaction (Bochner, Duncan, Kennedy & Orr 1976). However, residents may unconsciously avoid the social interaction between neighbours in high-density living environments (Li 2003). Multi-level sharing platforms, such as the sky gardens or the sky streets, can form natural places for daily communication between residents (Tian 2001).*

(2) Establishing the communal space pattern with service at its core, and improving its identifiability. *Weiner (1984) believed that the division of communal*

space should take service as the core element and set up communication floors that can accommodate various conveniences. It is conducive to residents' public gatherings and interactions at different levels. Bay (2004) evaluated the surveys of Bedok Court in eastern Singapore and showed that the semi-open space with the front courtyard as a serviced area could actively encourage a more natural lifestyle. Huang and Wang (2004) proposed a layout of communal spaces akin to cell structures; that is, a core site providing services or activities for residents is determined according to the building structure and residential circle. This layout of communal spaces can be divided into central and eccentric areas from the building, but mostly located at the first level structure. Lee (2011) pointed out that the main lobbies and channel hubs should be planned as the core spaces, such as a social hub or a leisure activity area because chance encounters between residents may lead to social interaction.

*(3) **The accessibility and orientation of the path should be made clear and used to form a spatial context with a cohesive force** (Li 2004; Wu 2014). Gestalt psychology mentions that the establishment of an environment cannot be separated from three elements: centre, path and field (Li 1999). The home is the centre of every inhabitant's mind, and the path is the way to reach the centre (Li, 2004), and the shared area (field) is the node in the path. Huang (2006) used behavioural observation methods to investigate the impact of courtyard design on social interaction over the course of 21 days in three high-rise residential projects. The results show that the number of resident interactions in path and node far more than any other design elements in the courtyard. In communal space, residents can find a psychological path with a sense of security and belonging through the relative positioning of space. Li (2004) proposed that setting shared spaces on different private levels of the residents' home paths achieved order and hierarchy in vision and psychology. Sharghi et al. (2014) suggested that the path setting should be based on the preference of residents' daily behaviours. Park et al. (2007) and Engür (2013) pointed out that connecting the horizontal passages and vertical lines of communal space to tree-like structures can reinforce people's inner sense of home.*

*(4) **Effectively using the redundant space in apartment blocks to build a shared space that conforms to the building pattern forms and hierarchical relationship of the space.** The design idea is to set up the communal space coinciding with the edge effect (Tian 2001; Lin 2018) and social distance in the valid path of residents returning home (Zhang & Lawson 2009; Li & Feng 2011; Chang 2015): examples include the elevator lobby (Huang 2012), stair corner (Kim 2014), or some small extension platform (Foth & Sanders 2005). These redundant spaces can supplement the deficiency of social spaces in the apartment (Chua 1995; Li 2003). Bee and Im (2016) proposed the planning concept of "less is more". They used the elevator lobby on each floor as a shared space to create a sense of belonging. Jin (2017) suggested that the transitional area of the existing residence should be regenerated in a low-cost way. The closed scale of a shared area increases the opportunities for social*

interaction between neighbours and avoids wasted communal spaces (Huang & Wang 2004; Li 2007; Han 2007; Chen 2007).

Overall, the design of an available multi-level communal space allows residents to feel an orientation similar to traditional housing (Li 2016; Adiyanti, Nareswari & Suryandono 2018). Spatial stratification is not only a mechanism to control land use but also a potential link with social networks that foster neighbourhood communication and provide security (Drucker & Gumpert 1991; Li 2003). The authors have illustrated the above views by the diagram presented in Figure 3.
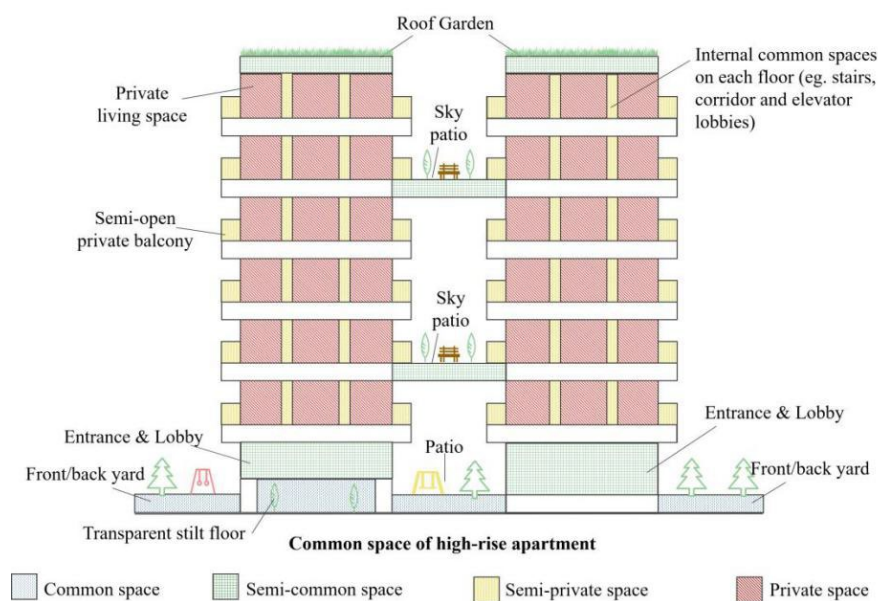

Figure 3: Schematic diagram of communal space of high-rise apartments (Source: Author)

4.2 Universal design

Universal design is the most basic design principle in urban public space, with the purpose of providing fair access to all users (Choa, Hab, Lima & Chongb 2018). The universal design of communal space mainly considers the right for all to use shared space and facilities. The shared space should fully consider the residents' age and the frequency and length of time of their activities to reasonably arrange the function of the space (Kim 2003; Wu, Tao & Ni 2004; Astuti et al. 2017). For example, children and the elderly always use the communal space in the morning and afternoon, while young people prefer morning or evening. Children and older people tend to socialise in groups, while young people's social space is full of isolated or quiet space (Holland, Clark, Katz & Peace 2007). Therefore, the satisfaction of spatial rights for different age groups can be distinguished from the spatial hierarchy and time but is not absolute (Feng 2016; Yu 2018). For the use of public facilities, the universal design should consider the physiological needs of different groups and consider them

from a usability standpoint (Tang 2015; Yu 2018), for example, by installing handrails in corridors or stairs, and ramps at the entrance. Natural environment characteristics of communal spaces are influential social variables that affect residents' emotions and behaviours (Molana 2016). It is critical to provide safe, convenient and liveable environments for the elderly, children, and the disabled (Rahravi Poodeh & Pouriaye Vali 2014; Choa et al. 2018).

4.3 Security design

Security is a crucial factor for consideration in the design of communal space. In terms of designing the general layout of communal spaces, Xiong (2000) proposed to separate the traffic intersection from residential units and establish an effective evacuation safety channel to avoid the impact of fire on vertical movement. In terms of local area design, it is necessary to avoid blind corners or weak visual lines of sight to reduce the possibility of hiding criminals. Additional lighting and monitoring facilities in the shadows are also important safeguards (Yuen 2004). Coley et al. (1997) and Prihatmanti and Taib (2018) argued that natural factors such as trees and flowers could increase opportunities for residents to interact socially. Informal interactions increased the sense of familiarity and responsibility between residents and strengthened the monitoring of outdoor areas (Abbaszadeh et al. 2009; Bee & Im 2016; Aziz, Ahmad & Nordin 2017). Also, maintaining the interrelationship and independence between shared and private spaces is crucial for the protection of privacy (Swapan, Marinova & Bay 2018). Sarkissian, Bateman, Hurley and Young (2013) and Andrews, Warner and Robson (2018) believed that children's play areas in communal space should be large enough to be located away from private areas because children are not cognisant of privacy when they are playing.

4.4 Landscape design

Scholars have considered the strategies for the landscape design of communal space from two viewpoints. On the one hand, scholars believed that landscape design can partially improve the natural climate of the apartment area, especially in cold areas (Noguchi & Tsukidate 2002; Yin 2013) and also tropical regions (Bay 2004; Jamaludin, Hussein & Tahir 2018). Leng and Yuan (2012) and Feng (2016) pointed out that the planting of the natural landscape could improve the light and wind environment of communal spaces and result in more people staying for longer. Some scholars recommended the strategy of implementing multi-storey planting and greening into the shared space. Matovnikov et al. (2018) argued that multi-layer plants alter the microclimate and the radiation connected to the building, and that planning features that mimic nature can improve the ecological performance of high-rise residential areas. Prihatmanti & Taib (2018) proposed that the addition of green rooves and vertical greening systems in high-rise apartments effectively reduce the heat island effect. This design approach has ecological and aesthetic benefits and

solves the problem of food security in urban environments. It also has the potential for broad application in limited greening spaces and improves the thermal comfort of high-rise buildings. Chan (2005) proposed that landscape design should integrate hanging gardens into the surrounding environment. Fong and Paul (2011) suggested that planting activities could encourage residents to participate in the management of shared gardens and socialise with others. Shen and He (2005) used computer-aided design in the design and simulation of the physical conditions of the site, which helped to make the communal space environment more natural.

4.5 Decoration design

In communal space, the decorative effect of integrating diversity can enhance residents' sense of identity and belonging (Lum 2011). Li (2004) set up some special space treatment effects in the elevator lobby, entrance lobby, and other areas, such as decorating the ceiling with modern lighting points and lines, to enhance perceptions of the space. Ghanbari (2018) added some cultural and religious design elements in the shared space to meet the demands of residents for a traditional feel. Yu, Sui, Bai and Jiao (2018) suggested that the decoration effect of shared areas should be visual and novel, and the colour collocation could distinguish different leisure function and used population. Smith (2012) advised that changes in materials, lighting, sound and ceiling height could be used in the decoration process to create a high-quality visual and audible communal space.

5 RESEARCH GAP

5.1 Research on the relevant policies of communal spaces

High-quality communal space cannot be separated from the support of governmental policies (Glaeser & Sacerdote 2000; Chan 2005; Wang 2018). Many scholars mentioned how the planning and development of shared areas in high-rise apartments lacked policies for guidance. In terms of spatial planning and quality, Matovnikov et al. (2018) indicated that the general planning stage of high-rise apartments should be formed under an orderly policy orientation. Bakaeva (2018) argued that the quality of communal spaces should be improved through building policies, and that the ratio of shared to private space under the optimal comfort level needed to be clarified. In terms of building standards, Andrews et al. (2018) pointed out that there are no clear child-friendly policies in the building guidelines of several Australian states, especially in communal areas, which is unfair to the development of children in high-rise apartments. From the perspective of economic benefits, housing policy also affects the planning of communal space. Bin Abdul Razak and Alias (2015) studied the main determinants in the development of landscape architecture in Malaysia and found that policy-makers could benefit from better understanding the relationships between landscape, architecture and property development. There are disputes among

various stakeholders on the actual area of shared spaces, since the housing price, in China, for example, is measured by the unit of square metres. Tang (2017) proposed that in the construction of residential communal space, national legislation should provide explicit support, such as the conversion method of shared areas, space management, definitions of communal space property rights and obligations of various stakeholders. Clear policy orientation is the legal guarantee of market operation. Levin, Arthurson and Zierschalso (2014) summarised the reasons for the failure of Melbourne's 'Carlton redevelopment project (stage 1)', pointing out that the different views and economic interests of the tenants, government officials, private developers and private residents on the redevelopment project harmed the implementation of the priority design principle. Li (2007) argued that government departments should give developers and designers some encouragement and support in policies, and only in this way can the virtuous circle of high-rise housing development be promoted. As can be seen, the political and economic decisions made by the government and the planning philosophy of some housing stakeholders, such as the estate developers, determine the communal space planning of high-rise apartments (Zhu 2015). In terms of management, Sun (2007) and Vasilevska (2013) proposed that local authorities, shared and private sectors, investors, planners and residents are all partners in decision-making negotiation. Policy-makers and those engaged in building standards need to have a deeper understanding of residents' actual needs or involve residents in relevant seminars (Vasilevska 2013). Thus, policy research related to the communal space of high-rise apartments is necessary.

5.2 Research on the building materials used for communal spaces

The green building materials used in communal areas help to create a healthy living environment for residents. At present, few scholars have studied the choice of building materials for communal space. But this subject is crucial to the sustainability of high-rise apartments. In general, materials used in communal space tend to be consistent with building materials. The choice of materials should pose no harm to people's health and safety, and natural materials are encouraged for use because they can save resources and minimise the project's impact on the environment (Larasati, Duijvestein & Fraaij 2007). Additionally, the cost of materials is also a factor to consider when choosing. Again, the aesthetic functions of the materials chosen need to be considered, using the concise design layout and overall aesthetic effect as the criterion (Bagheri & Shahroodi 2015). Kennedy and Buys (2015) suggested the need to study the properties and characteristics of the materials used in both the private and communal spaces of apartment blocks and to make a more active contribution to the liveable and sustainable high-density community. They also suggested, along with Georgi and Sarikou (2005), that in the landscape design of high-rise apartments, natural materials that are environmentally sustainable, economical, easy to maintain and of high aesthetic quality, should be selected.

5.3 Research on information technology and communal space

The shared environment of apartments in the social network is characterised by fast-paced technological changes and the social behaviour of residents (Brignull, Izadi, Fitzpatrick, Rogers & Rodden 2004). The planning and policy-making for shared spaces in high-rise apartments require interdisciplinary communication among the fields of sociology, computer science, architecture and space design (Foth & Sanders 2005). Electronic communication media has changed people's demand for their living environment and has caused some residents to gradually break from face-to-face human interaction (Brignull et al. 2004). But every coin has two sides. The sustainable development of the communal space can make use of the current digital media or information networks. Drucker and Gumpert (1991) advised that the integration of the planning and management of high-rise apartments with the use and development of media has helped to reshape the interaction between residents, for instance, chat group or discussion board. Foth and Sanders (2005) pointed out that the planning of communal space can use modern technology to enhance the privacy, exclusivity, permeability and flexibility of the area in terms of scale, form and functional value. As contemporary public interaction is influenced by the development of media (Lee et al. 2005), how to use existing technologies to promote the sustainable development of communal space is a problem worthy of further research.

6   CONCLUSION

The communal space of high-rise apartments is the area between private and urban public spaces (Smith 2012). Scholars paid attention to the aggregation method of internal and external shared areas of buildings (Huang 2006), the function of communal space (Choa et al. 2018) and the hierarchical division from unit buildings to shared space (Engür 2013). This review has studied the design strategy of communal space, and summarised and analysed the relevant research made by scholars on sustainable development of these spaces. Based on the comprehensive research results, it can be seen that scholars believe that the design of communal space can return to the form of traditional residential shared areas, and can improve on it in combination with current social developments and architectural structure (Malik & Hassan 2019). The main design strategies can be summarised as follows: (1) multiple platform spaces are used in combination with the architectural structure to form a small neighbourhood social circles (Han 2007); (2) with the service space as the core, multiple semi-communal or semi-private spaces are designed on the effective path of residents to form hierarchical spatial divisions, so that residents can have a sense of belonging and security (Lee 2011; Swapan et al. 2018); (3) the space division and public facilities of high-rise apartments should be people-oriented and integrated into the basic concept of general design, taking into account the needs of residents of different age groups (Astuti et al. 2017); (4) security should be considered as an essential design element in the planning of communal space (Xiong 2000); (5)

shared areas should include multi-layer plants according to local natural climate, or reasonably arranged landscape space, such as establishing an aerial platform, roof garden, etc., (Matovnikov et al. 2018; Ghazali & Davis 2014); and, (6) simplicity and innovation in the decoration design of communal spaces should be sought to meet aesthetic requirements (Lum 2011).

Simultaneously, three research gaps have been identified: (1) it is necessary to focus on the development of communal space from the perspective of policy to weigh various interests and provide comprehensive policy support for sustainable development (Bin Abdul Razak & Alias 2015); (2) it is also necessary to increase research on building materials to improve the design of shared spaces (Kennedy & Buys 2015); and, (3) further study is needed to improve the planning and management of communal areas with the help of existing information technology (Foth & Sanders 2005). In conclusion, sustainable development of communal space can be established through understanding and analysing from the perspective of human-oriented requirements, identifying residents' needs for the surrounding environment, absorbing the essence of traditional architecture, and incorporating these into the design process.

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