The Impact of the Two Pandemics on Sustainable Urban Housing Development

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Abstract. People had to stay in their homes for long time during the pandemic like SARS or COVID-19. Under this experience, people put forward many opinions and suggestions on the current situation of urban residential architecture design and community planning. The existing deficiencies can be learned form people’s perceptions and the findings is helpful to the sustainable development of cities. Based on the literature survey, the main issues of public dissatisfaction after SARS are summarized and analyzed. An online survey-based households was conducted to explore the updated housing, environmental, and psychological focal points caused by the prolonged COVID-19 pandemic. The main concerns of urban residents on house and community design and planning after the two pandemics are described and reviewed. It is found that there are additional focus on residential buildings and the community environment after the two pandemics. People are still very concerned about elements such as sunlight, natural ventilation, and sewage treatment to prevent the virus transmission. Some deficiency in housing and communities still leave urban residents dissatisfied, and existing urban housing and community designs may still not be ready for the next pandemic. The pandemic has not only renewed awareness of some important basic elements of urban living that cannot be ignored, but has also brought about changes in people's lives.

1. Introduction

In December 2019, the Corona Virus Disease 2019 (COVID-19), as a global threat, rapidly spread to almost all countries[1]. In response to this pandemic, people in affected cities implemented social quarantine measures and adhered to expert guidance by spending more time within their homes. Subsequently, urban residents began expressing common grievances about their living experiences through online platforms or daily discussions. Following this outbreak, many researchers engaged in discussions regarding the correlation between living environments and infectious diseases. The COVID-19 crisis has exposed weaknesses in the ability of buildings to prevent viral transmission, such as deficiencies in sewage systems or ventilation mechanisms. The possible transmission of viruses in wastewater and air has been proven[4,5]. The SARS-CoV-2 may transmit in the drainage system[6], and viruses could be detected in fecal and wastewater samples[7-10]. Tests have confirmed that stack aerosols containing viruses are generated in vertical building drainage pipes[11,12]. Contaminated sewage should be disinfected, and viral loads in sewage, wastewater, and landfill leachate should be monitored regularly[7].

Aerosols with viruses can also be found in poorly ventilated rooms, where infected people spend a lot of time with others[13]. Opening the windows can easily exchange indoor air with the outside, while natural ventilation can be influenced by criteria of thermal energy and comfort level[14]. Indoor air quality greatly affects public health in densely populated high-rise buildings. Vent pipe emissions on the roof can spread communicable respiratory diseases[15].

The significance of incorporating greenery into the built environment and its effects on mental health have garnered attention. Residential greenery was a concern for people during COVID-19, as it has proven functional as a healthy activity place[16]. In the period following the pandemic, people were more likely to engage in physical activity, while at the same time having a heightened and infectious diseases. The COVID-19 crisis has exposed weaknesses in the ability of buildings to prevent viral transmission, such as deficiencies in sewage systems or ventilation mechanisms. The possible transmission of viruses in wastewater and air has been proven[4,5]. The SARS-CoV-2 may transmit in the drainage system[6], and viruses could be detected in fecal and wastewater samples[7-10]. Tests have confirmed that stack aerosols containing viruses are generated in vertical building drainage pipes[11,12]. Contaminated sewage should be disinfected, and viral loads in sewage, wastewater, and landfill leachate should be monitored regularly[7].

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awareness of the importance of public parks[17]. Researchers have observed that prolonged periods of staying at home can lead to significant mental health problems[18]. The online survey revealed that depression and anxiety were significant in all samples[19]. The relationship between the housing environment and mental health was observed by some researchers for an especially long period of time[20,21]. Designing buildings should take into account features like natural light, scenic views, sound control, and spaciousness, which have a significant positive impact on mental health[22].

After the COVID-19 outbreak, urban resilience to pandemics has received considerable academic attention. Housing is a critical spatial element in building urban resilience to pandemics[23]. At the architectural level, current housing design parameters do not adequately meet the evolving needs of residents and are ill-equipped to deal with a pandemic[24]. Technological advances have made it possible for individuals in many professions to work from home (WFH). Implementation of COVID-19 lockdown protocols provided an opportunity for individuals who had not previously worked from home to experiment[25].

3. Research methods

More than a decade has passed since the first pandemic, and it is unlikely that people feel very strongly about it. Therefore, for the perception focus after the first pandemic, the method of summarizing the literature retrospective research was mainly adopted. While people remember the second pandemic particularly well, therefore, literature research was adopted to summarize the main concerns initially, and then a questionnaire survey was conducted, which can be more in line with the objective situation to understand people's actual needs. A literature retrospective on the aftermath of the SARS outbreak helps to understand the perceptions of housing issues at the time. Some of the ideas are derived from the centralized opinions of industry experts at the seminars, while others are derived from experts' personal opinions. The analysis of the advancements in focal points subsequent to the first pandemic is reviewed from a historical perspective. A questionnaire survey was conducted to investigate the perspectives of urban residents on their housing needs after the outbreak of COVID-19. This study provides valuable information and insights to practitioners in the fields of urban planning, architectural design, revitalization of historic areas, the smart home technology industry, and other related sectors.

4. The focal points after SARS

In the midst of the profound shock and anxiety caused by the SARS pandemic, many people reflected on their housing and living conditions and tried to understand why the virus spread so quickly. They sought to comprehend why the SARS virus propagated with such alarming speed, while concurrently considering strategies for healthy housing and living. Nowadays it is impossible to ask people who lived through the pandemic to recall their feelings. Fortunately, the pandemic shook the whole society so strongly that the various media of the time, such as journals, magazines, newspapers, etc., were involved in in-depth discussions, and some seminars, in particular, left important records. From these articles or records of discussions, it is possible to distill the main ideas of the time. The social discussion received positive feedback from experts, who acknowledged certain deficiencies in current architectural planning, design, facilities, and environment. Within these warned societal discussions, experts and researchers shared their thoughts[3,26-35]. Some expert seminars for the construction industry had also been held. For example, on 2 June 2003, a seminar on SARS and construction was organized by the China Building Decoration Association, the China Academy of Architectural Design and Tsinghua University[3]. Based on expert opinions, the major defects are listed below.

(1) Architectural planning and design
The building plot ratio is too high, which affects the comfort of community life. The building plan type of tower high-rise buildings lead to high population density.

The dominant wind direction was ignored in some communities’ planning, adverse to the rooms’ natural ventilation. Some real estate placed too much emphasis on the selling point of “landscape” and used floor-to-ceiling windows, but the opening area of the windows was too small, and the indoor air could not be effectively exchanged. The glass curtain walls in some office buildings did not have openable windows. The sunshine spacing between buildings in some communities is too small, resulting in insufficient sunshine exposure, even no sunshine all year round in some extreme cases. Some units do not have balconies, and residents cannot take advantage of sunlight disinfection.

(2) Decoration materials
Indoor air pollution caused by unqualified decoration materials was serious. Even if each decoration material met the standard, indoor air quality still did not meet the standard after multiple decoration materials were installed in a room.

(3) Drainage system
There are sanitation risks in indoor and outdoor wastewater system facilities like the Amoy Gardens case.

(4) Community support and environment
Improper garbage disposal led to environmental pollution and disease transmission dangers. Lack of public supporting facilities, such as health care facilities and public activity places. Traffic noise nuisance caused by the neighborhood plan's proximity to the road.

5. A questionnaire survey after COVID-19

To investigate the evolving needs of urban residents post-COVID-19, an online survey was conducted during the first half of 2023. The survey content design is based on the results of literature research, internet discussion hotspots and small discussions done beforehand. The questionnaire encompassed aspects related to indoor
space configuration, ventilation and sunshine, and indoor facilities, etc. The survey particularly examined the spiritual experiences of individuals in relation to their living surroundings, which were influenced by the long periods of social isolation during the pandemic. The questionnaire was based on household responses, and a total of 117 valid responses were received. Respondents' households are from different municipalities, and the administrative area of the household address ensures that the respondent lives in the urban area.

To prevent the spread of the virus, local governments took measures to restrict social activities and maintain social distance. In order to understand the citizens' opinions on the indoor living experience, we conducted a survey on indoor space configuration in the questionnaire. The findings (Figure 1) revealed some major opinions such as "Lack of independent study room," "Dissatisfaction with the number or size of bedrooms," "Lack of versatility in the living room," and "Insufficient toilets." As families spent more time at home, inconveniences or conflicts arose due to limited in-room functionality. This situation was particularly unique during the pandemic. Certainly, after the pandemic is over, more people will have jobs outside the home and less opinion about these conflicts. However, the pandemic has prompted residents to reconsider the configuration of their indoor spaces. Specifically, there is a growing emphasis on creating areas for home-based learning and fitness activities. Figure 2 shows that 76.92% of the respondents said that they needed spaces for fitness activities at home.

Approximately 38.46% of families agree on the necessity of establishing a designated isolation room, while the remaining participants either deem them unnecessary or dispensable (Figure 3). This proves that most households do not think the pandemic will affect their lives in the long term.

After spending more time at home, residents experienced and rethought more about their living environment. As shown in Figure 4, more than 80% of households value indoor sun disinfection and natural air circulation, highlighting the importance of sunlight exposure and ventilation in the community plan and design. Especially for high-rise residential buildings, it is crucial to utilize natural conditions and try to avoid awful designs, such as balconies or dark rooms without sunlight.

The questionnaire investigated residents how they felt during this special period. According to the results (Figure 5), almost half (45.3%) selections are feeling stressed with staying at home for a long time. Other relatively high answers include being unable to go out for sports or social activities (22.22%), disruptions to their daily routines (15.38%), and conflicts over indoor space (12.82%). However, most people are not concerned about indoor disease infection (4.27%). This is in stark contrast to the strong reaction during the SARS outbreak in 2003. The majority of respondents have confirmed that balcony played a significant role in soothing negative emotions during the pandemic (Figure 6).
The questionnaire investigated the dissatisfaction issues of urban residents in their daily life experience. The results (Figure 7) reveal that 63.25 percent of respondents express their highest dissatisfaction with noise, including road noise and noise from neighbors within their buildings. Road noise is an inherent challenge to the development of urban areas and is intricately linked to the overall planning of cities and urban districts. Neighborhood noises include typical decoration sounds, floor vibrations caused by children running and jumping, and family gatherings. Kitchen fumes (43.59%), rat and roach infestations (40.17%), poor ventilation or sunlight (38.46%), and toilet odors (35.04%) are other concerns raised by the residents. Conversely, dissatisfaction with sewage leakage is selected at the lowest rate of 18.8%.

The previous poll shows that residents have a relatively low dissatisfaction rate with sewage leaks, reflecting confidence in the quality of the current facilities. However, when addressing residents' concerns about possible living safety, water leakage resulting from housing waterproof failure and pipeline rupture ranks their worries at a rate of 56% (Figure 8). The reason behind this is the serious apprehension of residents regarding the future aging deterioration of facilities. The top-ranked concern, chosen by 58.97% of participants, is burglary. Structural damage and fire are also significant concerns at rates of 55.56% and 52.14%, respectively; these aspects are frequently highlighted in news reports as well. The subsequent risks include the potential for electric shock and the hazard of falling objects from tall structures, with respective proportions of 44.44% and 35.90%.

With the advancement of 5G and IoT technologies, intelligent products such as internet-connected smart lights, smart refrigerators, motion-sensing televisions, and automated temperature and humidity control systems are increasingly integrated into people's daily life. A growing number of households are embracing innovative smart features, leading to more user-friendly living spaces. The survey findings indicate a strong user interest in intelligent amenities (Figure 9). Respondents have showed great enthusiasm for smart vacuum cleaners, remote control of household appliances, intelligent fire detection systems, voice-activated speakers, and advanced lighting solutions. For example, the demand for sweeping robots in respondents' homes is as high as 70.94%, and smart kitchen appliances are chosen by 65.81%. This shows that people want smart devices to free them from the drudgery of household chores. People place a high value on life safety facilities, such as intelligent fire alarm device, with a selection percentage of 63.25%. Other smart devices, such as smart audio, smart lamp, and intelligent control curtain, which can make people's lives more comfortable, have also become highly desired options, with selection ratios exceeding 50%.
6. Results and discussion

6.1. Issues less urgent than in the past

6.1.1 Community building planning

The deficiencies in community planning and design became hot issues following the SARS outbreak, such as building plot ratio, building plan type, natural ventilation, and sunshine. In the early 21st century, residents encountered many planning problems in their living experiences during the initial stage of the development of China's housing industry. In the last twenty years, significant advances have been achieved in the field of community planning, mostly through continual improvements in standards. For example, the Standard for Urban Residential Area Planning and Design,[36], serves as a guiding framework for communities. It was published since 1993 and updated with new versions released in 2002, 2016, and 2018. The standard specifies parameters such as plot ratio, building density, green land ratio, building height, and per capita residential area, providing a clear and concise framework for urban residential area planning and design. Related provisions are described as mandatory standard guidelines.

6.1.2 Building type

The social controversy about tower buildings was primarily influenced by the Amoy Garden case. Sometimes, it is difficult to completely avoid the tower building plan due to the special lot shape. From personal living experiences and observations, it is evident that tower buildings still exist in the real estate market. Of course, despite good seismic performance, these building products are not considered as the best building products in China. From the utilization of sunshine and ventilation, slab buildings are naturally welcomed by the consumers.

6.1.3 Solid waste classification

In the past, Chinese urban residents often expressed their dissatisfaction with waste management. After years of advocacy and preparation, the trial implementation of Chinese urban garbage classification was initiated in several cities in 2017. Two years later, the policy was officially expanded to encompass all other cities. The measures of centralized collection, transportation, and treatment would significantly mitigate the risk of environmental pollution and virus transmission in communities.

6.2. Issues that remain of high concerns

6.2.1 Natural ventilation and sunshine

Aerosols with viruses can also be found in poorly ventilated rooms, where infected people spend a lot of time with others.[32]. Opening the windows can easily exchange indoor air with the outside, while natural ventilation can be influenced by criteria of thermal energy and comfort level. Indoor air quality greatly affects public health in densely populated high-rise buildings. Vent pipe emissions on the roof can spread communicable respiratory diseases.[13].

In China, a sort of traditional residential culture has been faithfully upheld for thousands of years. Some unwritten rules in residence that obey the principles of "Back to north and face to the south" and "cross-ventilation" are typically regarded as some sort of auspicious faiths by Chinese people. These rules reflect natural practices of people in the Northern Hemisphere, such as natural sunlight, ventilation, disinfection, energy conservation. Under the influence of these traditional concepts, slab buildings with these characteristics are naturally popular in Chinese real estate market.

6.2.2 Indoor pollution by decoration materials

Most residents are concerned about the problem of indoor air pollution caused by decorative materials. Emissions of hazardous gases, including formaldehyde, toluene, xylene (FTX), and volatile organic compounds (VOCs), may be detected from substandard materials.[19]. In response to increasing environmental protection requirements, more and more environmentally friendly decoration materials have been introduced to the market. However, as a result of technological constraints, certain products may still use formaldehyde-containing chemical raw materials during manufacturing. It has been observed that even if each decoration material product meets environmental protection standards, the integration of several "qualified" products in a room can still result in excessive levels of formaldehyde in the air. From May 2013 to March 2018, researchers conducted 1,278 measurements at 472 indoor sites in Harbin, a major city in China. The results revealed that the average concentration of formaldehyde exceeded the national standard indoor limit of 0.1 mg/m$^{3}$ (reaching 0.171±0.084 mg/m$^{3}$) across various types of rooms including living rooms, bedrooms, and study rooms. Moreover, the predicted carcinogenic risk associated with formaldehyde surpasses the threshold value of 1×10$^{-6}$.[37]. These investigation results indicate that indoor air pollution is still a potential hazard to residents.

6.2.3 The risk of virus transmission in the aging drainage system

The broken sewerage system in Amoy Garden drew considerable attention to the sewerage system, making it a prominent public concern after the SARS outbreak. Before SARS, residents frequently reported unpleasant experiences such as foul odors, sewage leaks, and pipe blockages.[5]. In the last twenty years, significant progress has been made in the field of drainage technology and the improvement of facility quality. However, the aging risk should still be taken seriously as the service time of the drainage system increases. Recent studies have provided evidence supporting the role of sewage overflow and contamination aerosols in facilitating the
transmission of COVID-19 within communities, thus highlighting the potential for virus dissemination through sewage systems as a route for human infectious diseases[21,38]. The findings demonstrate the importance of improving facility maintenance and management in preparation against future possible pandemics.

The COVID-19 crisis has exposed weaknesses in the ability of buildings to prevent viral transmission, such as deficiencies in sewage systems or ventilation mechanisms. The possible transmission of viruses in wastewater and air has been proven. The SARS-CoV-2 may transmit in the drainage system, and viruses could be detected in fecal and wastewater samples. Tests have confirmed that stack aerosols containing viruses are generated in vertical building drainage pipes. Contaminated sewage should be disinfected, and viral loads in sewage, wastewater, and landfill leachate should be monitored regularly.

6.2.4 Community public support

Due to the growing population, the significance of incorporating greenery into the built environment and its effects on mental health have garnered more attention. Residential greenery was a concern for people during COVID-19, as it has proven functional as a healthy activity place. In the period following the pandemic, people were more likely to engage in physical activity, while at the same time having a heightened awareness of the importance of public parks[17]. Researchers have observed that prolonged periods of staying at home can lead to significant mental health problems. The online survey revealed that depression and anxiety were significant in all samples. The relationship between the housing environment and mental health was observed by some researchers for an especially long period of time. Designing buildings should take into account features like natural light, scenic views, sound control, and spaciousness, which have a significant positive impact on mental health[38].

6.3. Some new trends after the second pandemic

Technological advances have made it possible for individuals in many professions to work from home (WFH). The COVID-19 lockdown provided an opportunity for individuals to try working from home[25]. The demands of home study and exercise have also led to a rethinking of the allocation and utilization of indoor space. As a result of the lived experience in the COVID-19, people are finding that the living room is increasingly losing its previous function as a "meeting spot". Recently, many Chinese families are transforming their traditional living rooms into fitness places or workplaces, which is known as the "removing the living room" movement. They have removed sofas and coffee tables from the living room and replaced them with conference tables or workbenches; or put in fitness mats for at-home exercise.

Another notable phenomenon stems from the advancement of technology. People are highly receptive and enthusiastic about trying out smart home products. The respondents have shown positive willingness for all types of smart home products. Especially those products that can free people from tedious housework, such as sweeping robots and kitchen dishwashers. In addition, personal hygiene care products and home safety products are also widely embraced.

7. Conclusions

People's home is closely related to human survival and health, as it serves as a crucial sanctuary against unknown diseases. When faced with an unfamiliar virus, it may be hard to promptly find suitable medicines and treatments. Drawing upon thousands of years of experiences in combating diseases, there is a strong belief in the correlation between living environments and disease resistance. After the COVID-19 outbreak, urban resilience to pandemics has received considerable academic attention. Housing is a critical spatial element in building urban resilience to pandemics. At the architectural level, current housing design parameters are not prepared for facing another future pandemic. Hence, it is imperative for urban planners and architects to take into account valuable insights from previous pandemics when addressing what's needed for disease resistance. The two pandemics have presented a chance for housing market participants to think deeply about the relationship between living health and infectious diseases.

After the outbreak of SARS, people expressed many focal points of residential needs including building type, sewage system, sunshine, natural ventilation, decoration material pollution, and waste disposal, magnified with the influence of the Amoy Garden case. After the COVID-19 outbreak, people pay more attention on personalized requirements also. There is still an emphasis on elements such as sunlight, natural ventilation, and air circulation. Meanwhile, many appeals are voiced with significant emphasis on the psychological needs of living and environment.

Due to the iterative updating of norms and standards, the planning problems existing in the SARS era, such as community plot ratio, building spacing, and building type, have now been greatly improved. Furthermore, the solid waste classification policy and its implementation have also been a significant advancement in recent years.

The utilization of sunlight and natural ventilation as a crucial strategy against unknown viruses is still imperative. Due to the technological advance of indoor lighting and fresh air systems, there is a view that it is not indispensable for utilizing natural sunlight and ventilation now. However, the facts after two pandemics have demonstrated that these functions remain essential elements for building designs.

After the Amoy Garden case during the SARS outbreak, residents were particularly concerned about the risk of transmission of the viruses from the sewage system. Following COVID-19, more concerns came from the risks posed by future pipeline aging. The distinction between the two is that one is concerned with the present while the other is focused on the future. Effective
property management and prompt maintenance of facilities have emerged as new priorities for residents.

There was significant public response to the pollution issue caused by decoration materials. Over the past two decades, with the advancements in green building materials technology, indoor air pollution has become less prominent compared to the SARS era. However, it is still a cautious problem that the integration of multiple decoration materials may lead to excessive air pollution.

After the outbreak of COVID-19, the prolonged period of staying at home has heightened the conflict in room space utilization. There is an increasing demand for learning, work, and fitness at home. The traditional function of the living room as a space for meetings has become almost redundant during the pandemic. Constrained by limited rooms, more residents have started reforming their living rooms into fitness or work and study spots. This phenomenon is commonly noted as “removing the living room”.

With the rapid advancement of science and technology, urban residents have shown a clear interest and high anticipation in smart home facilities. A household-based questionnaire survey displayed that individuals were eager to try to use various smart facilities. However, the current adoption rate of smart home facilities remains relatively low. This finding highlights the immense potential for future development and widespread integration of smart home facilities.

Urban communities, as places of intensive human habitation, can give us important insights into the existing deficiencies exposed by pandemic disasters. This paper focuses on the various claims and opinions in the aftermath of two pandemics, which may be scattered in various types of media, such as journals, newspapers, and the Internet, or present in people's discussions and reflections. Bringing together these diverse and complex perceptions into a major focus is an important guide to understanding the design, planning and construction of urban residential buildings and communities. It helps to understand the shortcomings of existing urban development, the actual needs of people, and the future direction of development.

References

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