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The covid-19 pandemic in relation to built environment design characteristics

A pandemia de covid-19 em relação às características do ambiente construído

Elisa A. D. Muianga
Universidade Estadual de Campinas | Campinas | Brasil | elisa.atalia@gmail.com
Doris C. C. K. Kowaltowski
Universidade Estadual de Campinas | Campinas | Brasil | dkowaltowski@gmail.com
Mariana Rios Castro
Universidade Estadual de Campinas | Campinas | Brasil | m158235@dac.unicamp.br

Abstract

During the Covid-19 pandemic, the built environment impacted the health and safety of the population. In Brazil, the pandemic impacted the ways of life of families, through housing and neighbourhood designs. This research identified built environment design factors that impacted life during the pandemic. A Systematic Literature Review was carried out to evaluate the impacts of the pandemic on the built environment and identify recommendations and actions to reduce those impacts. As a result, we recommend changes to the built environment and especially housing. Improvements are pointed out to ensure the well-being of dwellers, in present and future scenarios.

Keywords: Built Environment. Neighbourhood. Housing. Covid-19. Well-being.

Resumo

Durante a pandemia de Covid-19, o ambiente construído impactou a saúde e a segurança da população. No Brasil, a pandemia impactou o modo de vida de muitas famílias, levantando demandas, principalmente de moradia e vizinhança. Esta pesquisa identificou fatores projetuais do ambiente construído que mais impactaram a vida das pessoas na pandemia de Covid-19. Foi realizada uma Revisão Sistemática da Literatura para avaliar os impactos da pandemia no ambiente construído e identificamos recomendações e ações para a redução desses impactos. Como resultado, recomendamos, alterações no ambiente construído e melhorias para garantir o bem-estar dos moradores, em cenários presente e futuro.

Palavras-chave: Ambiente Construído. Vizinhança. Habitação. Covid-19. Bem-estar.

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INTRODUCTION

The built environment involves all spaces for human use, beyond buildings, in urban or rural areas. The built environment includes physical spaces for the use of people, as well as infrastructure, services such as health clinics, educational institutions and those that support urban mobility for instance [1].

The built environment is a social determinant of health [2], which should contribute to maintaining people's safety. During the Covid-19 pandemic this became evident. The Covid-19 outbreak showed not only devastating health consequences but also revealed shortcomings in the built environment that need to be fully understood. The built environment interacts with the Covid-19 virus transmission through co-factors such as climate, the design of indoor spaces, demographics and densities, pre-existing health conditions, and indirect impacts on the socio-economic status of people [5].

Socio-economic vulnerable populations were the most impacted by the effects of the pandemic and experienced high levels of dissatisfaction and mental health problems related to aspects of the built environment [6][7]. Socio-economic inequalities affected the health mainly of people in their local residential areas. These populations in general, even before the pandemic, lived in conditions with negative impacts on their health. This population suffers a low quality of life throughout their lives due to housing conditions [8].

During the pandemic, the daily life of people was restricted to the indoor spaces of their homes. The conditions of those spaces to support the resident's needs became critical for general health, well-being and satisfaction [6][9]. People with limited access to outdoor environments for their daily physical and leisure activities and social life were impacted to a greater extent [6]. Pre-existing structural issues in the built environment became evident. Space and neighbourhood design standards and services created health inequities [4]. Improvements need to be introduced to prevent further negative impacts [3]. With the potential of new epidemics, the design of buildings and towns should be adjusted to provide adequate living conditions to people globally [4].

Studies demonstrate the association between human behaviour, in terms of perceived stress, and the physical characteristics of their surroundings. Privacy is one of the factors that impacts peoples´ satisfaction with their type of housing and this is related to physical aspects of living conditions. Preferences (layout, spatial organisational, territorial and neighbourhood conditions) exist and are often not met [10]. Physical attributes, spatial layouts, availability of immediate outdoor spaces, safe private gardens or backyards, air quality, natural lighting, and noise control have a direct impact on people of different socioeconomic levels [6]. Small residential unit sizes, with poor daylighting and indoor air quality as well as inadequate thermal comfort conditions, potentially, represent health risks and may negatively affect the well-being of dwellers [9].

The perception of crowding (housing density) also represents a negative factor [11]. Crowding is considered a condition when the number of individuals exceeds available

space [5]. Impacts of crowding have been studied in various types of indoor spaces and open areas as well as public transport (leisure, services, amenities, schools, hospitals) [4][11][12][13]. Crowding may affect the propagation of infectious diseases, such as Covid-19 virus [5].

In Brazil, many families in a vulnerable situation, deprived of access to adequate housing conditions, suffered health biases during the Covid-19 outbreak [14]. The pandemic affected the way of life and the habits of families. Indoor, outdoor conditions and crowding induced families to transform or adapt the physical environment to adjust to the new needs of daily life. Transformations that occurred during the pandemic in homes are important to investigate. Also in Brazil, social housing (SH) is based on small units (houses or apartments), and these demonstrated their inadequacy for social distancing. Small homes also generally lack proper functional arrangements for a family to stay at home [12]. The feasibility of transforming typical SH designs to create minimum health conditions, for low-income families, needs to be investigated. Thus, to understand the Covid-19 pandemic impact on the built environment, this research posed the following questions:

1. What are the built environment design factors that contribute to the spread of an airborne virus like Covid-19?
2. How can SH design models be adapted to cope with the Covid-19, with emphasis on Brazil?
3. What are the priority improvements for the built environment to meet the requirements of pandemics caused by airborne viruses such as Covid-19 and/or other contagious diseases?

To respond to these questions, our research identified how the built environment impacted the lives of people during the Covid-19 pandemic. The goals of this study were to collect and evaluate studies published about the pandemic and its impacts on the building and neighbourhood scale. We also aimed to identify recommendations and design factors to improve the built environment to mitigate the impacts of the Covid-19, as well as actions to reduce those impacts with an emphasis given to housing conditions of more vulnerable populations living in SH in countries like Brazil.

With the knowledge that a safe and stable living space can promote positive outcomes in health and well-being of families, it is clear that housing and its surroundings can improve people's quality of life [9][15]. Also, actions to improve post-pandemic housing designs are also needed. Better adapted homes have to meet the needs of dwellers' daily lives and consider basic prevention functions for epidemic outbreaks and the spread of contagious diseases [3]. Dweller needs and transformations of homes and public spaces need research to accumulate knowledge for the conception of future housing designs, to develop places that ensure dwellers' satisfaction, health, security and well-being [25].

METHODOLOGY

A Systematic Literature Review (SLR) was carried to collect relevant studies on the relation of housing and Covid-19 living conditions [16]. Specific terms and variations of these were identified to create strings for our SLR are shown in Table 1.

Table 1: Terms and variations

Main term	Variations	
Covid-19 / (covid*) / (CoV-19)	Pandemic	SARS-CoVs
Impact / Impacts / (impact*)		
Built environment	Housing / (Hous*)	Building
Performance		
Neighbourhood		
Space		
New ways of living	Living / (Liv*)	
Wellbeing	Welfare	
Brazil	Brasil	

Source: The Authors

The research was based on consolidated protocols to identify, select and evaluate articles published between 2020 to 2022 (March) in four databases (Figure 1). Specific search strings composed our screening process. To ensure the literature on Brazilian studies, for each string we added Portuguese terms.

Figure 1: Strings applied to the SLR and search results

	Screening	Scopus	Web of Science	Science Direct	Scielo
String 1	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND neighbourhood AND (liv*)	84	93	-	2
	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND neighbourhood AND (liv*) AND Brazil	1	5	476	1
String 2	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND (built environment OR building OR hous*) AND Performance	7	95	-	0
	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND (built environment OR building OR hous*) AND Performance AND Brazil	0	2	712	0
String 3	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND (built environment OR building OR hous*) AND space AND (welfare OR wellbeing)	4	10	-	0
	(covid* OR pandemic OR SARS-CoVs OR coronavirus) AND (impact*) AND (built environment OR building OR hous*) AND space AND (welfare OR wellbeing) AND Brazil	0	0	170	0
	Total	96	205	1358	3
				First Sample	1662

Source: The Authors

To define the sample, exclusion criteria was applied to select papers. First, we analysed titles and abstracts, as well as duplicity of 1662 studies. Thus, we removed 1549 studies that did not match the issues of: the impact of the Covid-19 on the built environment, neighbourhood performance, and well-being. By reading the full text of the 113 remaining papers, we identified impacts of the Covid-19 on the built environment, however, a further 96 studies were considered irrelevant to the topic after detailed analysis. Thus, 17 studies of interest constituted the final sample. This sample was scrutinised to identify design factors to improve the built environment to mitigate the impacts of the Covid-19.

RESULTS

The global distribution of articles on the relation between the Covid-19 and built environment design factors are divided according to their emphasis issues. Thus, articles presenting a direct relation to the characteristics of the built environment and the spread of the disease were: 6 in Brazil and 1 international study. Studies which concentrated on the socio-economic status of people affected by the pandemic were: 5 in Brazil and 1 international article. Four international articles gave emphasis on mental and physical health and well-being. The distribution of the 17 articles, by country, were: Brazil-6, USA-3, Canada and China 2 each, and the UK, Italy, Bangladesh and Mexico 1 each.

The methodologies used in the studies were predominantly exploratory approaches (5) and questionnaires (5). Case and experimental studies and narrative approaches numbered two each, and one literature review was found amongst the 17 articles analysed. Information collected and details of each study are presented in the topics below: built environment characteristics, socio-economic status, mental and physical health, and well-being. Design factors to improve the built environment to mitigate the impacts of the Covid-19 and actions to reduce those impacts were identified under each topic.

BUILT ENVIRONMENT CHARACTERISTICS

Built environment characteristics that affected people's lives during the pandemic were described in 7 articles and the factors emphasised are shown in Table 2.

Table 2: Built Environment Characteristic actions

Issues & scale	Actions	Reference and country
Neighbourhood	*Services and equipment:*	
	● access to hospitals (less than 3 km from homes) ● provide local facilities and amenities ● improve local services	[1] China
	Public spaces for socialisation	
	● provide public spaces for leisure, green areas and equipment	[1] China
	Street infrastructure and public transport:	
	● increase mobility fleet, safe walking, cycling, and alternatives ● improve walkability, with secure distances ● provide mobility for people with physical disabilities	[4] Canada

Issues & scale	Actions	Reference and country
	● provide adequate public transport with space for social distances	[5] USA
	Social distance at urban and neighbourhood spaces (avoiding crowding):	
	● provide public spaces designed to facilitate social distancing ● provide diversity of spaces for a variety of uses	[5] USA
	● introduce interaction control/rules ● improve social distancing in public spaces and transportation	[8] Italy
Housing indoor space	*Indoor spaces dimensions*	
	● increase indoor spaces dimensions and individual rooms	[13]Brazil [8] Italy
	● provide at least two bathrooms in a shared house ● provide house which allow at least two metres between residents	[9] Canada
	● increase space variety and adaptability ● provide an isolated master bedroom with private bathroom ● ensure the concept of "smart home" ● create a transition entrance spaces for hygiene	[3] China
	Layout and adaptability	
	● provide adaptable layouts for flexibility in use and increased liveability ● increase spatial variety ● providing outdoor and indoor communal living areas that permit physical distancing for passive and active social interactions. ● Provide shared social spaces to support entertainment, socialising and leisure pursuits	[9] Canada
	● potentiate determine lifestyles, in favour of people's general health ● provide access to green areas ● provide alternative for regular physical exercises	[6] UK
	Design	
	● provide flexible housing design that support self-isolation within shared units ● improve natural lighting conditions for flexible daytime use ● provide bedrooms to support a variety of activities ● provide bedroom windows able to be blacked out for adequate sleep conditions	[9] Canada
	Comfort	
	● improve natural lighting and airflow in compact indoor environments ● improve visual comfort through: natural light, variety of lighting installations ● adaptable floor plans to support new homes functions	[9] Canada
	● increase access to sunlight	[3] China
	● prioritise views with natural elements	[6] UK
	● improve thermal comfort and natural ventilation ● increase openings	
	● improve facade design and high window-to-wall ratios and access to daylight	[9] Canada
	● increase natural ventilation and operable windows as simple passive strategies for healthier environments	
	● improve bathroom and kitchen ventilation	[3] China
	● avoid indoor noise	
	● improve solid waste collection ● increase disinfection of bathrooms and kitchens	
Housing outdoor space	*Layout and adaptability*	
	● provide large balconies to fit a table with chairs for individual family outdoor space, and views with natural elements ● support physical distancing between apartment units	[9] Canada

Issues & scale	Actions	Reference and country
	● provide direct access to green areas	
	● provide multi-functional balconies	[3] China
	● include buffer zones for social distancing in public spaces	[9] Canada
	● provide well ventilated public spaces for social interactions	[3] China

Source: The Authors.

SOCIO-ECONOMIC STATUS

The pandemic affected people's lives in different ways according to their socio-economic status. This was described in 6 articles with implications on the built environment. The factors emphasised are shown in Table 3.

Table 3: Socio-economic status implications

Issues & scale	Actions	Reference and country
Neighbourhood	*Public policies and health - Socio-economic vulnerability*	
	● identify and prioritise health promotion actions, access to basic sanitation and health care ● introduce preventive measures in places of high social vulnerability ● adapt interventions in favour of the well-being of vulnerable populations	[17][18][9] Brazil
	Public policies and social inequalities	
	● develop policies and programs to reduce social inequalities, and high crowding areas ● increase education and job opportunities in low-income areas	[8] Italy [19] Brazil
	Infrastructure	
	● provide social protection and basic services related to public health, water supply and basic sanitation ● provide social isolation and distancing ● provide public transport	[14][17] Brazil

Source: The Authors.

MENTAL AND PHYSICAL HEALTH, WELL-BEING

The pandemic affected people's health, both mental and physical, and their well-being in different ways. These factors and their relation to the built environment were described in 4 international articles. The factors emphasised are shown in Table 4.

Table 4: Mental and physical health, well-being actions

Issues & scale	Actions	Reference and country
Neighbourhood	*Walkability*	
	● increase neighbourhood walkability, pedestrian crossings, sidewalks, and street lighting ● encourage walking and physical outdoor activity, through improved neighbourhood aesthetics.	[2] USA
	Physical features	
	● invest in the improvement of the built environment ● improve physical features in the immediate neighbourhood environment	[2] USA
	Access	
	● increase community investments improving access to the public spaces and transport, neighbourhood infrastructure	[4] Canada
Unit	*Space*	

Issues & scale	Actions	Reference and country
	● increase residential and urban ● reduce risk and improve security. ● Increase the ability to control personal spaces ● improve individual feelings of privacy and security through design ● reduce crowding, provide more house spaces ● ensure human control of private and shared spaces ● reduce contamination and promote clean contact ● apply Public Health Best Practices. ● provide adequate numbers of sinks for handwashing inside homes ● facilitate the cleaning of high touch surfaces ● provide housing facilities (kitchen, toilet, and water supply)	[15] USA [20] Bangladesh
Unit and housing	*Comfort*	
	● increase cross-ventilation, ● increase air exchange rates ● increase humidity control and monitoring. ● provide access to private green spaces with natural elements	[15] USA
	Urban Green Spaces (UGS) ● encourage regular UGS use as an action to improve mental health, and promote Subjective Well-Being (SWB) ● improving the health in single-family homes and work space in covid-19 of crisis	[21] Mexico [15] USA

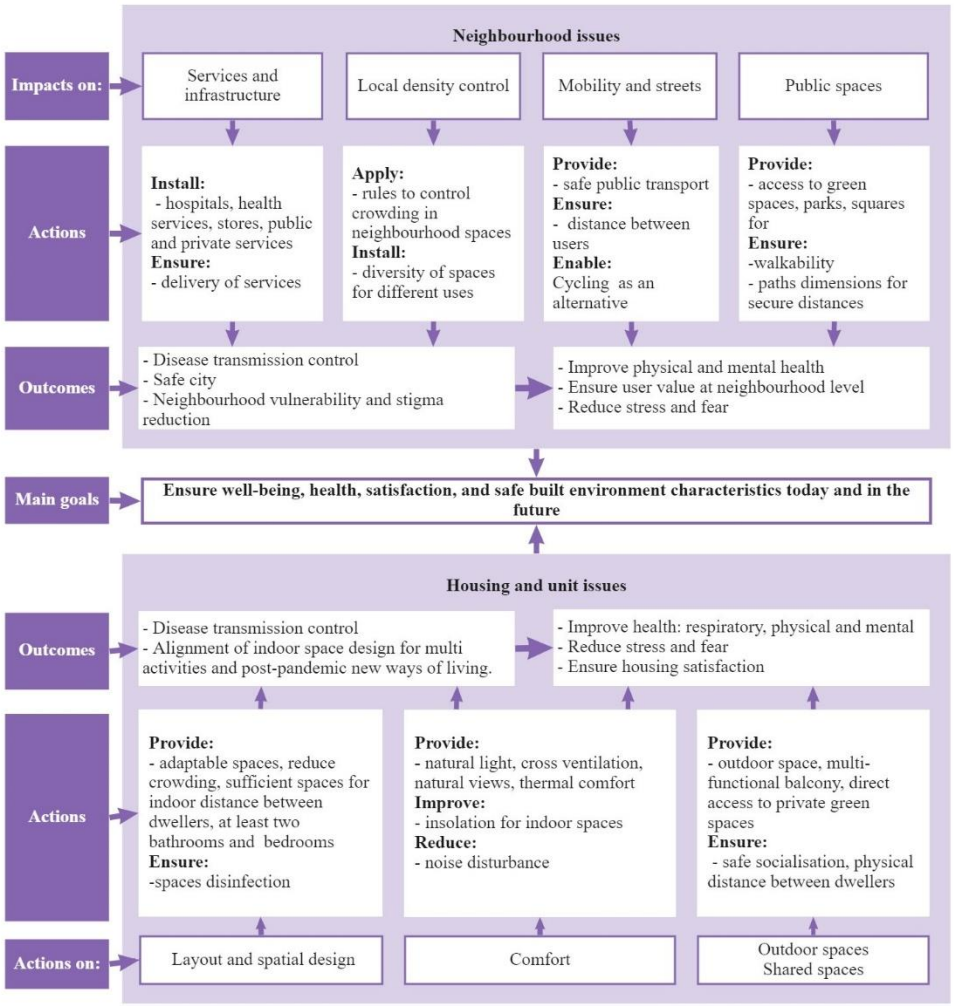
Source: The Authors

DISCUSSION

Despite the fact that many studies were conducted on the impact of the Covid-19, only a few have specifically focused on the built environment. The majority of the studies were conducted in the field of medicine, as the Covid-19 outbreak demanded urgent efforts to control the spread of the disease and protect people. Therefore, our literature review, even with the specific strings and criteria on the built environment, brought forward various studies emphasising medical issues, such as disease transmission rates, testing, social distancing, lockdown, stay-at-home measures, hospital overcrowding, mental health and behaviour impacts due to isolation, preventive measures, among other issues. Concerning directly architecture, engineering, and construction issues, fewer studies related to the impact of the Covid-19 on the built environment and the necessary interventions to improve living conditions under such special circumstances [3].

Only two of the 17 articles, analysed here, addressed built environment issues and actions, and four others contributed with two further topics detailed above: socio-economic status of people and mental and physical health, as well as well-being. Lessons can be learned from these studies to reflect on post-pandemic changes in housing design standards, integrating sustainability and promoting healthy living conditions for dwellers' well-being [9]. Figure 2 presents the summary of the impacts of Covid-19 as presented in Tables 3, 4, and 5.

Figure 2: Impacts of the Covid-19 pandemic on the design of the built environment



Source: The Authors

Figure 2 presents a summary of actions and necessary adaptations that can be applied to reduce the spread of contagious diseases in a built environment, as found in recent studies on the COVID-19 pandemic. Actions in four scales of built environments (urban, neighbourhood, housing and unit) are necessary to be considered in housing projects planning, and also housing upgrading, mainly for SH to improve living conditions and avoid risks of the spread of contagious diseases in the present pandemic and in the future.

The design factors that contribute to the spread of the Covid-19 disease are essentially related to maintaining a minimum distance between people to reduce person-to-person contamination and providing adequate ventilation conditions to reduce the concentration of the virus in a specific volume of a confined space. This became clear when investigations demonstrated the disease to be primarily airborne. Square metres per person and the number of air changes per hour for functional dimensions of spaces are of major importance [9]. Most research with this focus was concerned with assembly-type of environments like auditoriums, classrooms, and also office buildings [23].

For residential areas, it became clear that crowding in low-income neighbourhoods accelerated the spread of the disease. SH, based on small rooms and often on high-

density designs, therefore needs to revise a minimum requirements to avoid major health consequences and its costs on human suffering. Social impacts that trigger social costs increased during the pandemic, burdening the social assistance systems with extreme needs for hospital care [14]. As well as these consequences, long-term therapies became apparent, demanding new investments. Social cost are costs incurred on society and the public sector by built environment impacts [11].

To better cope with an air-born virus epidemic, SH design needs to revise and provide cross-ventilation possibilities for all residential units [9][24]. For tropical climates, as found in countries like Brazil, this also improves thermal comfort conditions as a whole.

The possibility to isolate a contaminated person from other people is important. This aspect can be addressed by providing two bathrooms and two bedrooms for each residential unit [3]. The typical architectural program for SH in Brazil is already based on two bedrooms, but convincing justifications to change public policies to increase the number of bathrooms need detailed scientific studies [22]. Similar data is also necessary to increase room and unit sizes for SH.

On the whole, the pandemic has reinforced the need for public spending on SH. Essential is the reduction of the housing deficit through quality design models that do not need upgrading as soon as they are occupied and families express their dissatisfaction. Also, refurbishment of the old SH stock is critical to adjust conditions to new ways of living and standards based on up to date scientific research, especially in relation to health and environmental comfort conditions [11].

For residential spaces, studies demonstrated other subjective concerns, relating to the negative effects of long-term social distancing, as a consequence of lockdowns. Thus, mental health was addressed and studies recommended better access to green areas, balconies and views with natural elements. These types of changes are feasible through investments, even in the existing SH stock, through better landscaping and adding balconies to apartment blocks, a common practice in developed countries with a large volume of older housing developments [3][9].

During the pandemic, many people on their own introduced changes to their living conditions. First, to improve hygiene, entrances gained a transition space to change outdoor to clean indoor clothing [3]. In Brazil, many residential design models have a social and a service entrance. This facilitated the concern for hygiene. In SH models two entrances are not the norm and people had to adapt layouts to cope.

Other transformations of houses and apartments had to do with providing adequate areas for work and study at home. The home office became a major new introduction to the residential architectural programme [6][9]. Many families also made efforts to provide play areas for small children and introduced natural elements, such as flowers and plants, a in vases into the home. However, again these changes occurred where space was available and financial resources were not drastically reduced during the pandemic.

For low-income families, most transformations were not in the form of physical changes to their homes as incomes decreased during the pandemic. Adults, needing

to continue working outside the home, were exposed to crowded contaminating conditions in public transportation systems. Thus, priority improvements to meet the requirements of a pandemic caused by airborne viruses such as Covid-19 and/or other contagious diseases need to include investments for better urban mobility and improving the quality of public transportation [5][8][17].

FINAL REMARKS

This article presented results of a SLR on studies of SH under Covid-19 pandemic conditions. The built environment design factors that contribute to the spread of an airborne virus like Covid-19 were identified, such as space dimensions, access to services, parks and conditions of urban mobility. Necessary SH adaptations to cope with the Covid-19, with emphasis on Brazil were for the units the availability of a second bathroom, an increase in room dimensions and access to a private outdoor space. These factors are specifically important for social distancing and for improving peoples´ mental health during lockdown. Other priority improvements at the neighbourhood-scale to meet the requirements of pandemics caused by airborne viruses such as Covid-19 and/or other contagious diseases included better distribution of green areas and better pedestrian sidewalks.

This study thus presents relevant contributions to the discussion of SH under an airborne virus pandemic condition. Housing as well as neighbourhood design quality needs new proposals to face such challenges imposed by Covid -19. We also stress that the feasibility of the recommended actions to improve SH need further studies and evaluations of actual improvements and to assess user satisfaction rates.

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