Adapting Smart Street Strategy for Post-Covid Built Environment

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Abstract

The street networks occupy 25% of land use and are the veins of cities. By 2050, more than two-thirds of the world's population will live in urban areas. The urban street infrastructures and systems are expected to serve the public in performing mandatory and social activities on the streets. In addition, walkability and mobility within urban streets are linked with better public health demands. Therefore, there is a need for the public street to adopt smart features to provide better public health towards limiting the spread of covid.The study aims to develop a framework for smart street strategies to facilitate post covid built environment. The study adopts an integrative approach to deduct the smart street features through a robust literature review and workshops that influence post-Covid built environment within the urban design (Infrastructure) and information management. The study objective includes identifying the processes for adapting smart street strategies and healthcare concerns that can be leveraged to support public health in cities. As a result, the strategy can be adopted and applied by policymakers for implementation worldwide. The contributing features of the effort will focus on *tracking, controlling, and preventing analogy*. As a result, the framework will provide a baseline for neighborhoods, communities, and cities to develop and integrate novel strategies for managing public health to have an effective and efficient post-Covid pandemic built environment.

Keywords: Smart street; Post-Covid; Smart city; Pedestrians

1 Introduction

COVID-19 disproportionately impacted different countries worldwide, affected people's way of life, and had tremendous consequences on the world's economy. Gharipour and DeClercq (2021) stated that the pandemic is a social, political and urban phenomena that should be considered to reduce its impact through public, practitioners and interdisciplinary collaboration. Therefore, there is a need to learn from the covid experiences to adapt to post-Covid built environment where measures including tracking, controlling and prevention strategies are adopted to manage future or seasonal pandemics. During epidemics, there is an acute relationship between shared urban public spaces and public health. The study focuses on a smart street intervention that requires urban infrastructure as its core. Furthermore, the streets are public spaces that link people from different communities in the urban fabric. However, the restriction on public movement can facilitate social distancing as one of the vital measures to manage Covid in the public realm. As a result, the streets will play a vital role in supporting the effort to limit the spread of the Covid-19 virus, contributing to making streets safer and healthier. The street is a public domain that allows interaction, communication and transportation of the public. Therefore, several urban interventions can facilitate the impact of pandemics on the street. In addition, urban infrastructure assists in reducing the impact of pandemics from previous knowledge of pandemics. However, the study proposes adopting smart street strategies with required urban infrastructure to mitigate and improve liveability in a post-pandemic built environment. The study adopted the integrative approach as the underpinning theory that supports the creation of new frameworks through a focus group study fostering creative thinking. The smart street framework was developed under five analogies, including infrastructure, smart features, data exchanged, contributions, and healthcare phases. The framework is significant as it provides the basis for interconnection between different devices to support tracking, controlling and prevention in a post-pandemic built environment. It can be adopted worldwide under the guidance of government institutions for implementation.

2 Literature Review

2.1 History of Pandemics

Pandemics spread to the public and caused loss of life and property. There have been several pandemics over the years. As a result, street management can be adopted to minimize the spread, which is not a panacea to the pandemic. Snowden (2019) described that several pandemics took place over the years; in 2008, the research found 335 human diseases between 1960-2004 originated from animals. He quoted virologist Brain Bird stating, “we live in an era now of chronic emergency” pandemic. As a result, the question is not whether but when it occurs and the prevalence of reoccurrence of a societal pandemic. After the Severe Acute Respiratory Syndrome (SARS) experience, the World Health Organisation (WHO) established a preparedness plan to establish country-based guidelines in 2005; they appointed a commission in 2018 that concluded in 2019 ‘*A World at Risk’* that the world and countries are unprepared for long-anticipated pandemics. In addition, funding and comprehensive planning are required to prepare for future pandemics.

2.2 Post-Covid Built Environment

Gillen et al. (2019) described the short and long-term challenges of the post-covid environment. Short-term consequences are becoming fewer, while long-term consequences are unpredictable. There are factors considered beyond the safety measures of social distancing, assigned seating and circulation roles. The post-Covid environment has some threads that include the design for flexibility and adaptability to future proof buildings or public spaces. There is a need to sustainably design spaces (existing and newly built). Hughes and Armstrong (2021) stated that there is a need to rethink and reinvent the order in a post-pandemic environment. Kim and Kim (2022) described the WHO post-pandemic phases when the disease activity is at seasonal levels as described in Figure 1.

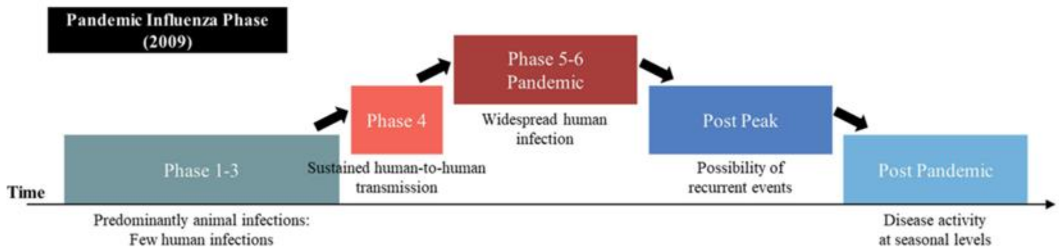


Fig. 1: The WHO (2009) Phases for the pandemic adapted by (Kim and Kim, 2022)

An integral part of the built environment is the street. The streets are destined for density. As the world must adapt and live with pandemics, well-designed and smart streets are needed. A street is a public place that allows the public to communicate, interact and move from one way to another. Street networks occupy 25% of land use and are the veins of cities (Gardner, 2011). By 2050, more than two-thirds of the world’s population will live in urban areas (Ritchie & Roser, 2018). Cities are growth centres of population, consumption and waste generation.

The populations are expected to be serviced by the urban street infrastructures and systems. The public performs mandatory and social activities on the streets (Jung et al., 2009). Walkability and mobility within urban streets are linked with better health and transportation. However, restrictions and movement of people can facilitate social distancing as one of the vital measures to manage Covid in the public realm. The streets are public spaces that link people from different communities in the urban fabric. Therefore, there is a need to manage the spread of Covid smarter. As a result, the streets will play a vital role in supporting the effort to limit the spread of the Covid-19 virus, contributing to making streets safer and healthier. Shawket and El Khateeb (2020) and Lakshmi (2021) indicate the contributing factors for the Covid virus spread in the public realm through physical and air contact with contaminated solids. As a result, neighbourhoods, communities, and cities need to develop new and more innovative strategies for managing the spread to build a post-Covid pandemic-built environment (Klaus, 2020). Urban infrastructure defines the connection between cities and public health; and affects the number of people visiting healthcare services (Gharipour & DeClercq, 2021).

Post-Covid built environment can have an impact on the healthcare phases. Kim and Kim (2022) described the four Korean healthcare phases in Figure 2. The *Concern phases* indicate pre-outbreak while monitoring suspicious pandemic spread; the *Notice Phase* implies the first infection is reported with people in close contact affected and urban spread is initiated. *The Alert phase* describes a confirmed rapid increase in cases leading to an urban emergency. Finally, the *Serious Phase* indicates the rampant spread and disease response reaches its threshold levels. Sharifi et al. (2021) described three main contributions towards limiting the impact of the Covid-19 pandemic. These include tracking, controlling and preventing analogies. Furthermore, they indicated that smart solutions and technologies could facilitate the effort to manage pandemics in a post-Covid built environment.

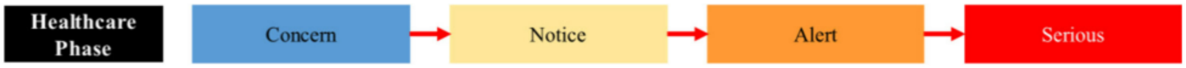


Fig. 2: Healthcare system phase with time series (Kim and Kim, 2022)

2.3 Urban Infrastructure

One of the contributing factors to the spreading of diseases is related to urban mobility. The travels occur within the streets, making them a valuable public realm that would enable mobility and virus spread. Urban infrastructural design and digital data management are vital for smart street interventions. Tešić et al. (2020) believe smart features can facilitate pandemic management. For example, sensors can be used at pedestrian zebra traffic lights to avoid contact with contaminated solids. The cycle lanes' intervention can be achieved by providing shade and using parked vehicles for cyclist safety in narrow streets. Well-designed cycle lanes can reduce the population on sidewalks and public transport use, supporting the challenges of overcrowding, as shown in Fig. 3. Furthermore, the lack of shading can result in pedestrians congesting shaded pathways. As shade is required during summer, which can be achieved through different shading strategies as described by Ahmad et al. (2021).

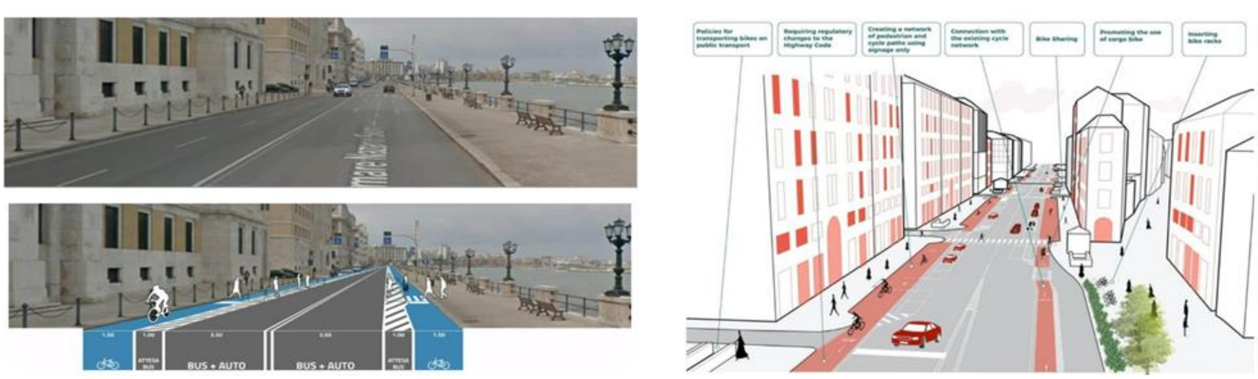


Fig. 3: Urban design (infrastructure) Al-Kindi and (Abbood, 2021)

2.4 Smart Street

Smart Street is defined as a fundamental building block for any smart city architecture. Smart streets have their basis in smart lighting systems (Pribyl & Pribyl, 2015); they include cyber-physical systems and services apart from space, traffic, waste management and environmental monitoring (Ahmed & Rani, 2018). The smart street concepts can be leveraged to support public health in the future. Figure 3highlights the focus on vehicles; however, there is a dire need for pedestrian focus.

Table 1: Principles and elements for the smart street

Principles for Smart Street		**Elements for Smart Street**	
Principles	**Description**	**Elements**	**Description**
People first	Priority-More walkable-pedestrian-cyclist-public transport-public services (goods and services) – Private vehicles	Connectivity corridor	To enable hardware and street furniture for connectivity within the smart street for a variety of direct and indirect socio-economic outcomes
Sense of place	Sense of place-local and cultural integration	Smart street information system	Urban information systems depend on national, regional and local agencies. Ability to collect data on fixed and moving things

From Input to impact	Measuring and communicating the impact of input (technological)	Traffic and transit management	The use of sensors and ability to manage different sections of the street at different times of the day
Connectivity counts	Free public wifi enables economic growth	Accessibility, security and safety	Lack of accessibility and protection of pedestrians
Available and accessible	To enable safe outdoor activities during times such as Covid	Smart street furniture	Items such as benches, transit stops, Covid kiosk to enable dialogue with the public. Lamps, waste management etc.
Flexible programmable public realm	Enable diverse commercial spaces to reduce clusters	Climate protection, environmental monitoring, weather mitigation	Measuring noise, air quality, climate, flood and water levels, weather monitoring and prediction, providing shelter, shade etc
Open not closed	Making government sector information openly available	Environmental sustainability	Reduced carbon emissions by simplifying public transport, bike riding and car-sharing
Evolution not revolution;	Minimize waste and maximize learning with limited budgets	Street activity	Ability to manage street activities through interactive technology.
Complex stakeholder environment	Adopting the bottom-up rather than a top-down focused solely on the achievement of local targets, not international		

Table **1** : Some principles and elements of the smart street. This study tends to deduct the relevant aspects that can be leveraged for public health only. It is noteworthy that the study will integrate smart street strategies to focus on public health.

3 Methodology

The study adopted qualitative data collection and analysis as described in Figure 4. Furthermore, it adopted the integrative research approach as the underpinning theory described in Table 2. Snyder (2019) stated that the integrative approach aims to assess, critique, and synthesize the literature to enable the development of new theoretical frameworks (Torraco, 2005). In addition, the approach allows focusing on newly emerging topics to create conceptual and theoretical models. The study aims to develop a novel and conceptual smart street strategy for a post-covid built environment. The data collection for the integrative approach analyses literature and main ideas in the context of their relationships. MacInnis (2011) stated that the process requires conceptual thinking.

Table 2: Integrative research features- adapted from Synder (2019)

No.	Approach	Integrative research
1	Typical purpose	Critique and synthesize
2	Research question	Narrow or Broad
3	Search strategy	Usually not systematic
4	Sample characteristics	Research articles, books,
5	Analysis and evaluation	Qualitative
6	Examples of contribution	Taxonomy or classification, theoretical model or framework

The literature review analysed smart features adopted in smart public spaces. Smart infrastructure provides the foundation for all the smart features related to a smart city, including smart health and improving city liveability. As a result, infrastructure is vital for the smart street adaptation into post-Covid built environment. The approach defined relevant analogies that include relevant infrastructure facilitating smart street features with their data exchange format and possible contributions towards the WHO healthcare phases. A focus group was further adopted. Morgan and Krueger, (1998) stated that they had between four to six participants, meanwhile, Krueger and Casey (2000) had between six to eight participants. Barbour (2018) stated that focus groups excel in providing a process outcome compared to a defined outcome. The approach's limitation is the unfolding of data in an unsequential manner. Six participants conducted the focus group; there were four architects and two engineers with an average of five years of experience.

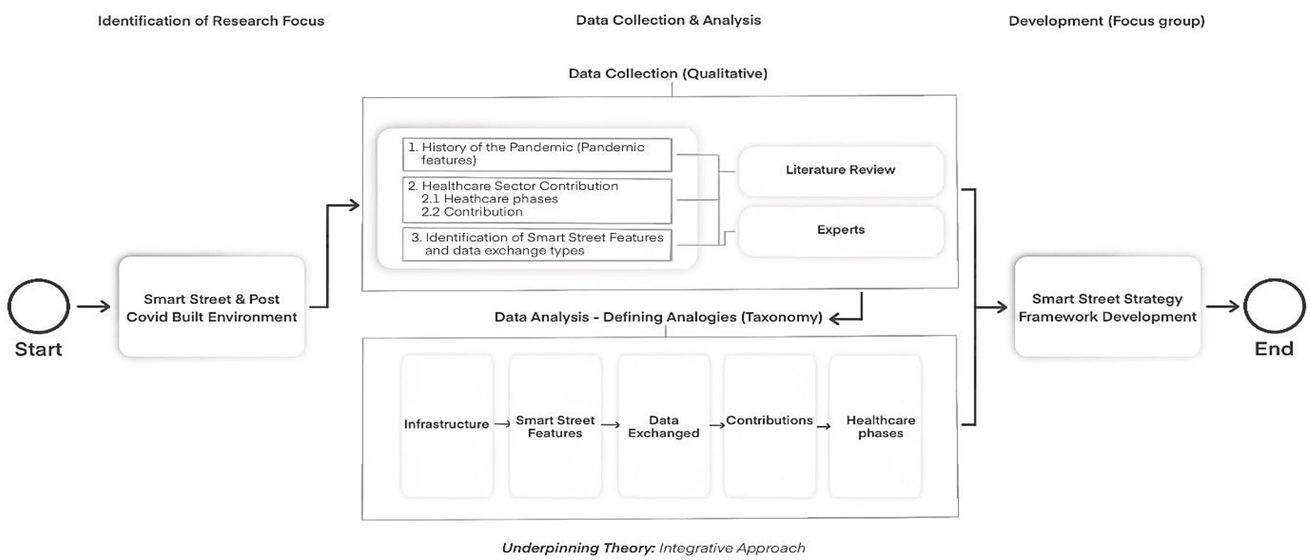


Fig. 4: Smart street framework methodology

The participants attended three sessions that lasted from 45 minutes to one hour. The study adopted a qualitative approach. The focus group questions included highlighting and deducting relevant themes for the smart street with a significance on pandemic tracking, monitoring and prevention. The participants deducted the findings from the literature review, and the framework was developed as a process linking relationships between different analogies.

4 Data Analysis and Discussion

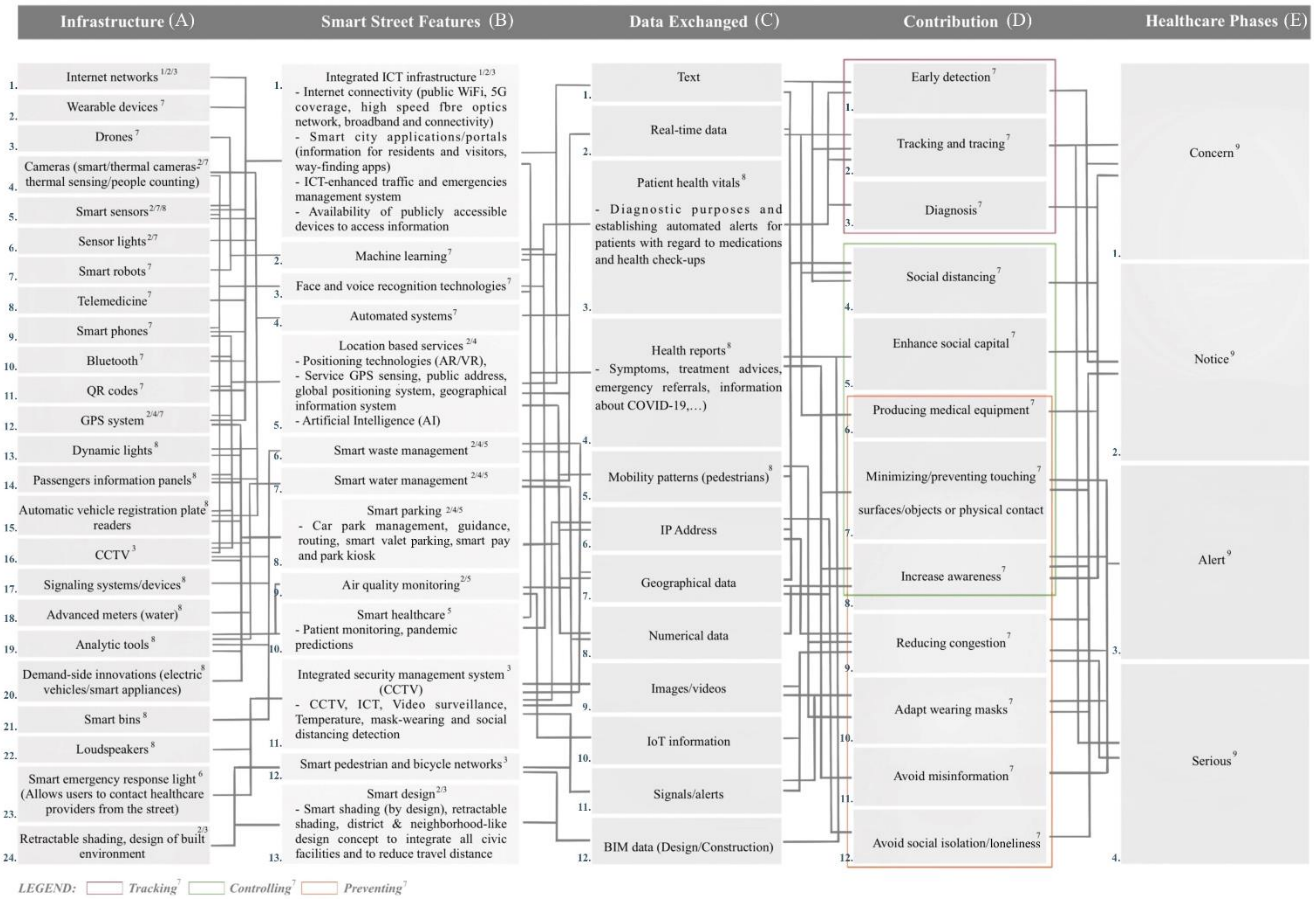
The study adopted an integrative research approach that facilitated deductions from secondary data leading to the development of the smart street framework. Smart infrastructure provides the core characteristic that underpins most of the smart components to connect and generate data, which may be used intelligently to ensure the optimal use of resources and improve the performance of the street. This section introduced some critical components of smart city infrastructure as described in Table 3.

Table 3: Smart digital layers, Adapted from United Nations (2016)

Smart Digit Layer	Description	Healthcare Contribution
Urban	They include physical and digital infrastructures. For example–smart buildings, mobility, and waste management systems.	Smart parking reduces congestion. Smart waste reducing physical contact
Sensors	They include smart devices that measure and monitor different parameters.	Smart sensors reduce physical contact and detect masking and social distancing.
Connectivity	They include data and information from the sensor level to storage and for further analysis	Smart data facilitate pandemic control identifying areas of concern for public
Data Analytics	They include the analysis of data collected by different smart infrastructure systems to help predict some events (such as traffic congestion)	Predictions can reduce congestion and prevent the spread of the virus
Automation	They include a digital enabling interface layer that enables automation and scalability for a large number of devices across multiple domains	To report/ update the public with timely data, the interface connected to several devices is vital to prevent the spread

The framework described in Figure 5 is developed based on analogies from the literature review. The focus group findings played a vital role towards developing the concepts and relationships between the different thematic analogies deducted from existing studies. The framework adopted five themes. These include Infrastructure, Data exchange, Smart features, Contributions and the Healthcare phases. The Infrastructure provides a platform for the smart function to take place. The Data exchanged format is vital to understand the nature of the information interoperable within an interface. The Smart features are non-exhaustive; there will be novel Smart features over time as technological advancement is imperative. The Contributions are towards healthcare management of covid. The Healthcare phases highlight relationship between healthcare contributions. For example, Smart camera can highlight the rise in public temperature, highlighting early detection and indicating concern as Healthcare phase.

The framework is the outcome of the focus group. It focuses on achieving the framework rather than the framework outcome. The study provides a platform for smart street features that facilitate the development of post-Covid built environment. Future research can highlight novel smart street features and adopt their contribution towards public health. For example, sensor on a zebra crossing to prevent the spread of the virus through physical contact. The practicality of the framework can be realised with government support and guidance due to the nature of the study, which centres on public spaces and public health. In addition, the framework can be adopted in the short term by retrofitting existing infrastructure. For example, CCTV cameras can be replaced with Smart cameras that allow temperature and masking detection to control and prevent the virus's spread. While on the long term, an established Central Command Centre is required to be developed to manage the interconnected Smart features effectively and efficiently.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A	B1	B1	B2	B3, B4	B1, B2, B3, B4	B4	B2	B1	B1, B3, B5	B1, B5	B1, B5	B1, B5, B8	B4, B8	B4, B5, B8	B4, B5, B8	B3, B5, B7	B9	B7	B6, B7, B8, B9, B10	B8	B6	B11	B11	B12, B13
B	C1, C4	C1, C3, C4	C3, C4	C2	C1, C2, C5, C6, C7, C8	C2, C7	C2, C8	C5, C6, C7, C8	C8, C10	C3, C4	C6, C7, C8, C9, C11	C11, C12	C12											
C	D1, D4	D2, D4	D1, D2, D3	D5, D7, D8, D11	D4, D9, D10	D4, D9, D12	D4, D8, D12	D8	D9, D10	D9	D9, D10	D5												
D	E1, E2	E1, E4	E1	E1	E1	E1	E2, E3	E1, E2, E3	E2, E3, E4	E2, E3	E3													

LEGEND: A: Infrastructure - B: Smart Street Features - C: Data Exchanged - D: Contribution - E: Healthcare Phases

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Fig. 5: Smart Street Framework for post-Covid built environment. (Non-exhaustive list)

5 Conclusion and Recommendation

Most of the country’s population will go more into the urban areas. As a result, the street network is taking up a large part of the urban land. Streets are a cornerstone to communication, interaction and transportation of the public. Smart streets are developed from the idea of smart lights that contribute towards developing more smart city features. Therefore, smart strategy initiatives are required to manage the communities and cities for resilient post-Covid built environments. The study aimed to develop a Smart street framework strategy towards the post-pandemic built environment. It is expected to be resilient towards Covid spread at seasonal levels by providing preventive and controlling inputs into the public streets. The integrative approach allows focusing on newly emerging areas of study to create conceptual and theoretical models. Smart features from secondary data were analysed and deducted to develop the smart street framework; it targets smart city and public health researchers to contribute towards tracking, controlling and preventing the spread of Covid within the built environment. The smart street can be applied in densely populated areas in the short-term and to other streets in the long-term. Future research recommendation for the study suggests exploring the interoperability of the data exchanged between the muti-facet and disciplinary applications to enable efficient and effective information management of the spread in the communities and cities.

Limitation

The study highlights a conceptual framework that provides a basis for future Smart street strategies towards post-Covid built environment. However, the framework only provides an exhaustive list of all relevant Smart features identified from literature review sources. As a result, it is non-exhaustive. Furthermore, this study does not consider the cost implication of adopting the framework.

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