The role of smart cities in managing the COVID-19 outbreak in India

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Abstract

Purpose
The COVID-19 pandemic has affected around 216 countries and territories worldwide and more than 2000 cities in India, alone. The smart cities mission (SCM) in India started in 2015 and 100 smart cities were selected to be initiated with a total project cost of INR 2031.72 billion. Smart city strategies play an important role in implementing the measures adopted by the government such as the issuance of social distancing regulations and other COVID-19 mitigation strategies. However, there is no research reported on the role of smart cities strategies in managing the COVID-19 outbreak in developing countries.

Design/methodology/approach
This paper aims to address the research gap in smart cities, technology, and healthcare management through a review of the literature and primary data collected using semi-structured interviews.

Findings
Each city is unique and has different challenges, the study revealed six key findings on how smart cities in India managed the COVID-19 outbreak. They used: Integrated Command and Control Centres, Artificial Intelligence and Innovative Application-based Solutions, Smart Waste Management Solutions, Smart Healthcare Management, Smart Data Management, and Smart Surveillance.

Originality/value
This paper contributes to informing policymakers of key lessons learnt from the management of COVID-19 in developing countries like India from a smart cities' perspective. This paper draws on the 6 Cs for the implications directed to leaders and decision-makers to rethink and act on COVID-19. The 6 Cs are: Crisis management leadership; Credible communication; Collaboration; Creative governance; Capturing knowledge; and Capacity building.

Keywords: Smart Cities, COVID-19, technology, coronavirus, pandemic, infrastructure

1. Introduction

The world has undergone unprecedented change because of the COVID-19 outbreak. On 31 December, 2019, China informed the World Health Organization (WHO) of a cluster of cases

of pneumonia of an unknown cause in Wuhan City in Hubei province. On 9 January 2020, the WHO issued a statement that Chinese researchers have made the "preliminary determination" of the virus as a novel coronavirus. More than 6.9 million deaths were reported due to COVID-19 around the world as of 6 September 2023. The WHO on 11 March 2020 declared COVID-19 to be a pandemic and that there was a vital need to manage the crisis worldwide.

The WHO (2020) reported that cities and other urban settlements were at risk of COVID-19. With urbanisation increasing around the world, the population has shifted from rural to urban areas for an improved quality of life. Urbanisation being the new trend, the urban population is expected to rise to 5 billion by 2030 (UN, 2018). The United Nation in 2013 addressed that if urbanisation is not controlled with improved infrastructure facilities, people living in slums could lack basic facilities like housing, water, sanitation, electricity, and healthcare. The urban development and city population are developing at a quick pace, causing diverse issues related to the environmental, financial and social maintainability of cities (Shetty et al., 2019; Bhattacharya et al. 2022).

Urban settings face unique dynamics that have a direct impact on the achievement of preparedness for all types of health emergencies, including COVID-19 (WHO, 2020). Many densely populated cities like Mumbai in India have experienced high numbers of COVID-19 carriers and deaths, reflecting the ease of the introduction, and spread of the virus. Other cities such as Delhi, Chennai, Hyderabad, Pune, Bengaluru, and Kanpur had a higher risk of COVID-19 spread due to their high population densities. The first case of COVID-19 reported in India was on 30 January 2020.

India was in nationwide lockdown due to the novel coronavirus pandemic. The first lockdown (Lockdown 1.0) announced was on 24 March 2020 for 21 days with limited access to facilities. This lockdown was then extended until 3 May 2020 (Lockdown 2.0) with moderate access. Thereafter, the country was on Lockdown 3.0 with planned state-wide access with stringent guidelines for containment zones until 16 May 2020 (Gupta et al., 2020). On 17 May 2020, Lockdown 4.0 was extended for two more weeks until 30 May 2020. The lockdown resulted in ban on people stepping out of their houses with all services and shops closed except for emergency and essential services. This was in addition to the closure of: commercial and private establishments, educational institutions, worship places, non-essential public and private transport, and the prohibition of social, political, sports, entertainment, academic, cultural and religious activities. For the economic revival of all states amid the coronavirus lockdown, a committee of ministers and committee of experts were created.

The rate of infection in India was comparatively less compared to other developed countries (Tomar and Gupta, 2020) during the first wave in 2020. The second coronavirus wave was reported in the year 2021. This created a steep rise in cases, reporting more than 400,000 new case, totalling more than 2 million active cases and more than 300,000 deaths as reported by end of May 2021. As of 6 September 2023, the virus spread to all major cities and 44,997,326 total cases were reported with 531,930 deaths and 44,464,793 cured/discharged (MoHFW, 2023).

The variant first described in India (B.1.617), the 'double mutant', is substantially more infectious and contagious compared to the original SARS-CoV2. The WHO (2021) has confirmed the B.1.617 variant to have a higher rate of transmission and potentially slightly

reduced predisposition to neutralisation antibodies. Phase wise lockdown was implemented in different states based on the rise in COIVD-19 cases. The flattening of the curve to a steep increase in the reported cases and deaths perplexed administrators, city planners, the health management system, and citizens in relation to the mismanagement of the situation in the country. A lack of planning and flexibility in the COVID-19 response (Bhuyan, 2021), poor management of healthcare services, and untimely efforts by citizens to proceed to normal life resulted in a surge in cases and reported deaths.

India planned to administer domestically developed vaccines to all citizens of the country. Two vaccines, Covishiled developed by Serum Institute of India and Covaxin developed by Bharat Biotech Ltd, India, where administered under the free vaccination drive which commenced on 16 January 2021. A robust vaccine development program was designed to immunise 30 million people, prioritising healthcare workers, the elderly population over 60, public workers, and those under 50 with comorbidities (Thiagarajan, 2021). The creation of a cost-effective vaccine was fundamental for India to fight the COVID-19 pandemic and help 1.3 billion people with a cost-effective solution (Chakraborty and Agoramoorthy, 2020). The Co-win application, as the digital backbone for the vaccination drive in India, has been linked to existing Universal Immunization Programme (UIP) and was meticulously monitored and followed with immunised individuals (Kumar et al., 2021). An expert committee was formed by the government to overlook the management and advice related to the priorities to do with immunisation nationwide.

Yigitcanlar et al. (2020) noted that the adaption of smart urban technologies offers various opportunities that can enhance the infrastructure's capacity for creating new services, reduce emissions, improved citizen engagement, improved decision-making, and supporting the sustainable development of cities. The Government of India (GoI) decided to develop 100 smart cities in India (Deloitte, 2015). In those cities, citizens are expected to have high speed internet connectivity along with use of internet-enabled devices such as the Internet of Things, sensors, processors, wearables, electronics, software, actuators, vehicles, cell phones and computers, operating at the interface to the real world (Mora et al., 2019).

Kibria et al. (2018) noted that Artificial Intelligence (AI) is one of the compelling tools emerging as a solution to managing large amounts of data, especially when looking to make predictions and suggestions based on data sets. Machine Learning (ML) and AI are providing new opportunities to operationalise previously untapped and rapidly growing sources of data for patient benefit (Vollmer et al., 2020). Thus, AI data analytics through algorithms identify patterns that may provide opportunities to improve systems without requiring human intervention. Therefore, there is an expectation that adequate technology will be available in these 100 smart cities in India. Henceforth, this paper focuses on the role of smart cities in managing COVID-19 outbreak in India.

There has been very little work done so far that explores the role of smart cities in managing the COVID-19 outbreak in the Indian context. Therefore, this paper aims to facilitate cities in being sustainable and resilient by providing awareness and understanding to various stakeholders (policymakers, business leaders, professionals working in crisis management sector, and academia) on the role of smart cities in managing COVID-19. The paper describes smart cities in India, organisational crisis management, and the COVID-19 outbreak in the first part of the paper then describing the research methods. Furthermore, the results and findings are discussed prior to the conclusion and recommendations.

1.1. Smart Cities in India

The concept of smart cities has garnered increasing attention in recent years (Abdalla et al., 2020). Despite widespread practices worldwide and increasing research centred on smart urbanism, there is no universal definition of 'smart cities' (Prasad and Alizadeh, 2020; Hollands, 2008; Albino et al., 2015). Albino et al. (2015) noted that the concept of smart cities is far from being limited to the application of technology to cities. Caragliu et al. (2011) noted that while the main emphasis of smart cities is on the role of information and communication technologies (ICT) within an infrastructure, much examination has also been carried out regarding the role of human, social and relational capital, and environmental interest as the key drivers of urban growth (Caragliu et al., 2011). Thus, in general, the term "smart city" is increasingly being used to include most of the important technological aspects as well as human capital and physical infrastructure (Chourabi et al. 2012; Hollands, 2008; Nam and Pardo, 2011). Batmetan and Kainde (2022) strength, weakness, opportunities, and threat (SWOT) analysis of the smart city were based on the six dimensions of the smart city. They are smart governance, smart branding, smart economy, smart living, smart society, and smart environment.

According to the Smart Cities Mission (SCM) (2021), the concept of smart cities in India is a little broader. Smart cities in India are defined based on the use of ICT for the enhancement of liveability, workability, and sustainability. They are expected to attract investments, building cities that work well especially for business and developing new technologies for communication. However, the delivered idea of a smart city needs to be localised based on the city. As quoted by the Minister of Urban Development, GoI (2015) "smart leadership and smart people are essential pre-requisites for making cities smart". This statement provides an insight into the development and plans of the Smart Cities Mission (SCM) in India and how it is working to drive economic growth and improve quality of life for people.

The purpose of the SCM is to resolve the urban problems through urban infrastructure developed by advancements in ICT based technology. The mission aims to revitalise structural imbalances, create a sustainable city and a liveable environment with economic prospects. Since the announcement of the SCM Mission Statement and Guidelines in 2015, India has moved a step towards the digital and technological development (see Figure 1). The purpose of the SCM is to drive economic growth and improve the quality of life of citizens by enabling local area development and harnessing technology, especially when it leads to smart outcomes (Smart Cities Mission, 2019). Indian cities need to be developed to provide adequate quality of life and are focusing on retrofitting including city improvement, redevelopment, city renewal, greenfield development, and city extensions and pan-city initiatives with smart solutions. However, the most recent view on smart city development has recognised that the level of technology adoption in urban contexts is no longer able to reflect the real smartness of cities. Technology no longer represents an end but has instead become a component of smart cities (Ardito et al., 2019). The mission aims to revitalise structural imbalances and create a sustainable city and liveable environment with economic prospects.

Figure 1: Smart Cities Mission development in India

The detailed selection process for smart cities was designed by the Government of India (GoI). Initially, the cities were selected by the 36 states based on the urban population and number of statutory towns. The city challenge round for selection of cities required every selected city to provide a smart city proposal. A total of four rounds of selection and one round of fast-track selection were conducted to choose the cities based on the proposals submitted. A total of 100 smart cities have been selected with total project costs of INR 2031.72 billion (SCM, MHUA, GoI, 2018). An urban population of 99,630, 069 people are being impacted by these developments. A total of INR 116.05 billion has been allocated for area-based development projects and INR 22.58 billion for pan-city projects. Projects have been categorised into open space and riverfront development projects, affordable housing projects, application-based solution projects, Public Private Partnerships (PPP) projects, city wise projects and projects of INR 1 billion and above (SCM, MHUA, GoI, 2018). A special purpose vehicle (SPV) has been created in each selected city to monitor progress and evaluate all smart city development projects. A SPV is formally registered with a national authority and is subject to fiscal and legal obligations of the economy. SPV owns and manages the infrastructure asset until the investment cost has been recouped. Implementation of Smart Cities projects are also executed through joint ventures, subsidiaries, PPP, and turnkey contracts. SPVs are working with the Local Governments and citizens. In many cases, the Municipal Commissioner of the Local Government is appointed as the Chief Executive Officer of the SPV.

Indian cities contend with problems of poor physical infrastructure, traffic congestion, pollutions, and lack of municipal service (Tandon et al., 2022). Economic growth and improved quality of life for citizens is the major aim of the program. Competitive and co-operative federalism, leadership and vision for the programme, understanding the new concepts, major investments and utilisation of funds, citizen involvement is among the challenges in the initial stages of the implementation of smart cities.

1.2 Organisational Crisis Management

Lalonde (2007) distinguishes the crisis management approach as using crisis management planning and the analysis of organisational contingencies. Crisis information disclosure and control forms the foundation of crisis management (Shangguan, 2020). According to Taneja et al. (2014), it is essential to study the internal and external factors responsible for crisis situations and to identify organisational strategies for preventing crises as well as effectively and efficiently managing any crises that do occur. Taneja et al. (2014) further noted that crisis management is a leadership imperative involving people within and outside of an organisation. Thus, it is essential and considered to be an element of competition for organisations to be able to cooperate and communicate within teams, within each organisation, with other organisations, with government agencies, with the media, and with other groups.

Even with established business continuous capabilities, organisations are under pressure to respond to crises. Crisis management is employed to minimise the impacts of a crisis and, if done well, it can quickly restore functionality to organisations suffering from the effects of disrupted or weakened systems (Kuckertz, 2020). Research has identified the positive implications of crises for stakeholders as they can stimulate the innovation approaches for companies and identify new markets (Kraus, 2020).

The situation of the COVID-19 pandemic put organisations into a more volatile and riskier environment than expected. The unprecedented crisis posed a significant setback related to socio-economic development outcomes. Organisations globally were required to prepare and respond to reduce the significant impacts that the pandemic caused on businesses and the economy. Organisations prepared for, responded to and recovered from a full range of disruptive events. To navigate through the COVID-19 related challenges, organisations needed to focus on the changes to the workforce, the deployment and enforcement of business resumption protocols, mental health considerations, threat assessment and management, information, technology, and cyber risk mitigation. The organisational response to COVID-19 crisis sheds a light on the distinctive characteristics of bureaucracy, the relationship between the central and state governments, and the larger issues about governance (Zhou, 2020). The development of smart cities and crisis management in this field can be challenging. Smart cities were at the forefront of tackling the pandemic using technology and digital transformation. This required an assessment of the robustness and sustainability of crisis management to develop a crisis response program. Almeida et al. (2020) noted that the repercussions and pace of technological disruption in organisations increased, accelerated by COVID-19. Organisations need to be prepared for technological challenges. There is an urgent need for a greater understanding of what roles information systems, technology, and researchers played in the global pandemic (He et al., 2021).

1.3 Research Gap

The prospective benefits of technologies in cities have been variedly discussed in literature in the context of smart cities, enabled by community, technology, and policy to deliver productivity, innovation, liveability, wellbeing, sustainability, accessibility, as well as good governance and planning (Giffinger et al., 2007; Caragliu et al., 2011; Nam and Pardo, 2011; Letaifa, 2015; Yigitcanlar et al., 2018; Yigitcanlar et al., 2020). Smart healthcare, smart safety, smart education, and smart surveillance are different attributes important for strategising in smart cities (Giffinger et al., 2007; Yigitcanlar et al., 2018; Yigitcanlar et al., 2020). Costa and Peixoto (2020) study discuss potential solutions and review recent approaches that can be exploited in complex scenario, describing feasible and promising development trends for the construction of the new expected health-centric smart cities. Participatory governance by involving various stakeholders is important for the development of smart cities. Political stability, strong administrative commitment and collaboration between the local and national governments could impact the development of smart cities in a democratic nation like India. Conceptualising and implementing engineering and technological solutions for the betterment of a community through an umbrella approach is the main pillar of a developmental institution. However, the challenges faced by smart cities in India include poor infrastructure planning and management, population pressure, financial investments, technology dependence, inefficient local governance, citizen perspective and social divergence (Shetty et al., 2019). Providing viable solutions through the implementation of innovative technology would provide the right pathway for the development of smart cities to deal with the COVID-19 pandemic and other future crises. Smart cities worked on varied technological and implementation-based solutions to combat the virus.

Kummitha (2020) noted that most COVID-19 affected countries in the Western context are the most advanced smart cities in the world. Smart cities strategies had the potential to play an integral role in flattening the curve, limiting the spread of the COVID-19 and assisting in the treatment of infected individuals. Smart cities provide various solutions to manage and

prepare for future crises. Smart cities strategies also play an important role in implementing the measures adopted by the central and state governments such as the issuance of work-from-home policies, social distancing norms, stay-at-home notices, and other COVID-19 mitigation strategies. However, there is no research reported, to the author's knowledge, on the role that smart cities strategies have played in managing the COVID-19 outbreak in developing countries, particularly India. Therefore, this paper aimed to address the research gap in the subject of smart cities, technology, and healthcare management.

2. Research Methods

A systematic literature review was performed to synthesise the research findings in a systematic, transparent and reproducible way (Snyder, 2019, Jesson et al., 2011) to review the documents related to COVID-19 and smart cities. The review presents practical implications and describes avenues for further research. The search systematisation began with the identification of search strings drawn from the scope of the study and discussions with the group involved with the review (Tranfield et al., 2003). Strings of words were used to retrieve the documents for study. "Smart city", "COVID-19", "smart city mission India", "Coronavirus", "smart city and COVID-19" were the different search string words used to collate the relevant documents for the research analysis. The systematic review searched for peer-reviewed articles in three databases: Science Direct, Scopus and Google Scholar. The initial search resulted in 183 papers. The inclusion and exclusion criteria were applied to find relevant papers in the right field of study. A review of the inclusion and exclusion criteria was conducted with academics experienced in the field of study. Criteria like date, location, language and subject were considered to filter the papers further (see Figure 2). The inclusion criteria for the study where papers between the year 2015 and 2020 and the location for the study was selected as India as the paper focuses on challenges in the Indian context. Papers published in English were opted for inclusion in the review. The year range was chosen because smart cities in India were active from the year 2015. Three databases were searched using the subject inclusion criteria, the topics were spread differently. In total, 11 papers were selected with relevant research ideas on smart cities and COVID-19.
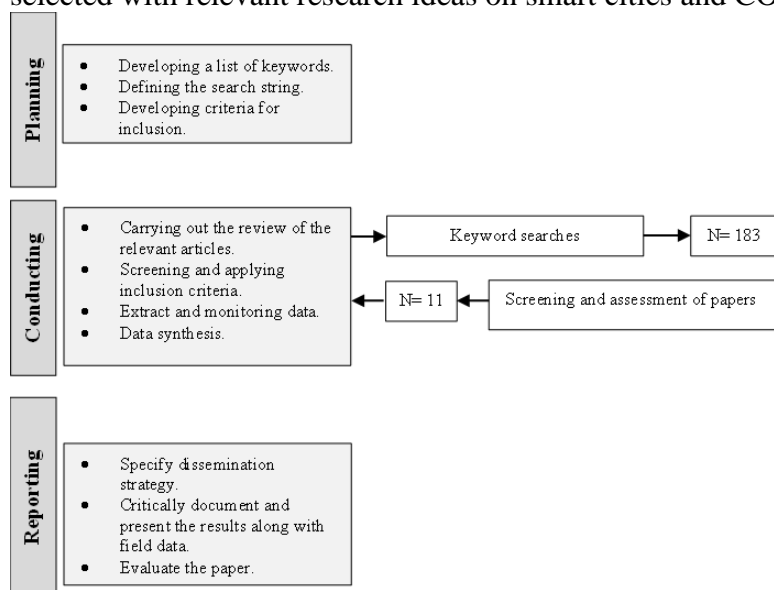

Figure 2: The systematic literature review process

The second phase of the research methodology involved a qualitative research approach (Amaratunga, *et al.*, 2002). Qualitative research methods focus on discovering and understanding the experiences, perspectives, and thoughts of participants. Qualitative research explores meaning, purpose, or reality (Creswell and Creswell, 2018). Professionals working in the fields of smart cities and COVID-19 were interviewed to understand the management and challenges faced when combating COVID-19 in India. The research followed a purposive sampling method, which involves identifying and selecting individuals or groups of individuals that are especially knowledgeable about or experienced with the phenomenon of interest. Over 100 experts were invited via email to participate in this study, and 20 agreed. The interview was guided using semi-structured questions (Bolderston, 2012). A total of 20 interviews were conducted virtually with professionals from both the public sector and private sector working as a part of the SCM and the management of COVID-19 in India nationally and regionally. The selected personnel were interviewed for their expertise, knowledge and hands-on work on smart cities and the work being conducted during the pandemic in India. Participants were sent an invitation letter that provided information about the research, the ethical aspects of conducting online interviews, and the benefits of participating. Interviewees have had 10 to 30 years of experience and are professionally qualified. Their job descriptions include directors, advisors, managers, and city coordinators. University's ethical approval was obtained for this research. The interviews were audio recorded and transcribed verbatim. Thematic analysis was conducted. The results of the study revealed six themes. They are integrated command and control centres, artificial intelligence and innovative application-based solutions, smart waste management solutions, smart health care management, smart data management and smart surveillance played an important role in managing COVID-19 in Indian smart cities. Details of each theme are discussed below with the support of literature review conducted in the first phase.

3. Findings

Indian smart cities worked at the forefront of managing the COVID-19 outbreak. The Ministry of Housing and Urban Affairs (MoHUA) reports indicates that the smart city infrastructure became an important tool for combat against coronavirus. The easiest and most imperative way to contain the spread of the disease was through surveillance and shutdowns which were the key to COVID-19 containment and Indian states have approached it with a collaborative spirit. However, Kummitha (2020) criticised the smart cities techno-driven approach was also adopted by the Chinese government for tackling COVID-19 outbreak, with a reliance on sophisticated technologies and stringent surveillance imposed across cities to keep transmission under control. On the other hand, Western democracies, such as the UK, opted for a more human-driven approach. Technologies were developed to monitor affected areas and maintain closure on its further spread. The slowdown in cases with heavy resilience was related to India's data infrastructures. The smart cities mission remains critical in the decision-making process and providing real time data. For example, ICT played an important role in enabling the swift gathering and disseminating of data through public health communication on infections, addressing issues related to testing and contact tracing, and raising the public awareness of the necessary measures to prevent the spread of the coronavirus (Abdalla et al., 2023; Choi et al., 2021).

With an economy focus, the Indian government released guidelines on reopening in a phased manner, such as 'Unlock 1.0' from 1 June 2020 to 30 June 2020 with night curfew restrictions and ban on large gatherings. The country was then on 'Unlock 2.0' until 30 July 2020 with state governments that were allowed to put suitable restrictions on activities. The

country gradually returned to normal with relatively less COVID-19 cases being reported until a sudden surge in cases was report in February 2021. State-wide lockdown was implemented in most states based on the rise in the cases. Amid the rising cases, a 14-day lockdown was imposed in most states from 5 May 2021 until 19 May 2021. The lockdown was extended until 7 June 2021 in some states. The country progressed with better measures and health facilities to contain the spread of the virus. India has vaccinated more than 1,303,932,286 people as of 8 December 2021.

The findings were categorised under six groups. These groups were based on the main themes of the 20 interviews' findings and the reviewed articles based on the key aspects of the role of smart cities in managing the COVID-19 outbreak.

3.1.   Integrated Command and Control Centres

Indian smart cities have operational integrated command and control centres (ICCCs) set up under the smart cities mission which act as 24/7 nerve centres for city managers, creating situational awareness and the real-time coordination of emergency response services (MoHUA, 2018). In total, 45 command and control centres were constructed under the smart city mission. They were used for various municipal functions including 24-hour water supply projects, property tax collection, traffic management, street lighting, monitoring bus movement and CCTV for security. However, these ICCCs were also used to manage the COVID-19 outbreak. For instance, one of the interviewees proclaimed that:

> *"Cities like Bengaluru were able to create 24/7 war rooms overnight. A war room, comprising representatives of the health department, the local administration, and the police, was set up to coordinate the COVID-19 containment efforts".*

The 24x7 centres helped to map each COVID-19 positive case using the Geographic Information System (GIS), tracking healthcare workers, and drawing up a containment plan using heat mapping technologies. Some cities like Tirupati used their command centre to deliver essential groceries to citizens. Ujjain Smart City Limited (USCL) created an app to ensure public awareness and monitor containment zones. The app marks COVID-19 positive cases and containment areas so then citizens could avoid travel to those areas of the city (Smart City Mission, 2020).

Smart cities like Mangalore have different departments working with integration at the command-and-control centres. The COVID-19 control room managed the tracking of coronavirus patients, lockdown violations, supply of essential items and health supplies. The primary objective of establishing a 24X7 control room was to ensure the safety and security of service providers and to monitor the quarantined. This was achieved by installing CCTV cameras at specific locations. Drone aerial surveillance was also done to ensure that the rules were being followed and all violators were penalised as per the law (MHUA GoI, 2020).

Dehradun city utilised the ICCC for monitoring and surveillance activities in the fight against COVID-19. The primary objective of the ICCC was providing 24×7 security using a CCTV surveillance system and a video feed paired with AI-based Face Recognition at isolation/quarantine locations. Eck and Hatz (2020) noted that much of the research on surveillance has come to focus on its application by authoritarian regimes and as a tool to counter domestic political threats as surveillance allows for the detection of dissent and the extraction of intelligence, enabling the targeted application of repression.

Dehradun city also used the smart cities infrastructure to spread awareness regarding lockdown and the services that have been provided by municipal corporations and all other government services. The city educated people through Facebook, Instagram, Twitter and WhatsApp groups and Variable Messaging Displays (VMDs) placed at critical junctions of the city. Emergency numbers – police, health and other important departments displayed on VMDs. This demonstrates how ICCCs have enabled cities to have a seamless linkage including input and output integration through real-time efforts.

3.2.   Artificial Intelligence and Innovative Application-based Solutions

Indian smart cities have been widely using technology to combat the COVID-19 outbreak. For instance, Nagpur Municipal Corporation launched a coronavirus mobile application for the benefit of citizens. Users enter their symptoms into a mobile app, which then detects whether they are likely to have contracted COVID-19 or not. In the case of identified symptoms, the app informs a team of municipal doctors for further action. This mobile app goes a long way in terms of not just relieving people's tensions but also screening them and reducing the load on health workers. The city's municipal corporation also lists every grocery store in the city so residents can place orders by phone. Similarly, Dehradun city has deployed a mobile app named 'Essential Service Lockdown Pass'. If any citizen needs any of the emergency services during lockdown, they can apply for the pass, get it approved and then leave their home and use the district level/City Level emergency and essential services including services for senior citizens, funeral, medical services, food supply and grocery services, home delivery, and telecom services.

Bhagalpur city had launched the mobile app 'Mera Bhagalpur' and used it to create awareness, provide important information at a single point and engage people to keep their morale high during the COVID-19 outbreak. This mobile app has the following features: daily city updates regarding COVID-19, 'do's and don'ts' to fight COVID-19, important announcements by government departments, list of doctors, emergency numbers of all government departments, list of volunteers, and quick contact.

The Ministry of Electronics and Information Technology (MeiTY) has officially launched the new tracking mobile application 'Aarogya Setu' that aims to alert people in close contact with someone infected with COVID-19. This has been designed to help the government take all necessary and timely steps for assessing the risk of the spread of infection and ensuring isolation where required. With the landscape of cities changing rapidly, data and technology is also seeing new inventions. For instance, one of the interviewees stated that:

> *"Around 75 million people have already downloaded 'Aarogya Setu' mobile App on their mobile phones. This App is one of the most important tools in fighting COVID-19 and one of the lifelines for common people during this global pandemic. Officials are asked to make all efforts to encourage citizens to use this App".*

Elavarasan et al*., (2020) noted that technologies have been developing consistently day-by-day but during an unexpected circumstance such as the COVID-19 pandemic, the role of these technologies to support humanity in various means is substantial. Technologies have been helpful in supporting the government and public in dealing with COVID-19. Netizens are working towards positive attitudes towards using the government-based solutions, as well

as working on spreading positivity. Positive thoughts, innovative solutions, ideas, and dedicated education can contribute towards eradicating coronavirus.

Kanpur Smart City (KSCL) has established an artificial intelligence tool for administration work to be carried out during the ongoing nationwide lockdown. Medical staffs in Chennai hospitals work with the interactive robot 'Zafi' that was deployed in COVID-19 isolation wards. Smart healthcare is not just about curing an ailment but also preventing it through early detection and prediction. This is where smart technologies such as Artificial Intelligence (AI) and Internet of Things (IoT) play a role (Financial Express, 2018). AI, with its technology, algorithms, and learning capabilities, can equip decision-makers with better data analytics and prediction models that work in more efficient and effective ways. It can be a useful vehicle for automating the problem solving and decision-making processes, as well as supporting the development of smarter cities (Yigitcanlar et al., 2020). Organisations are using AI-driven algorithms to predict the spread of diseases through searching news reports and airline ticketing data (Allam et al., 2020).

For instance, in the city of Bhagalpur, smart city strategies have been supporting the city administration in combating COVID-19. The key initiatives taken up by the city of Bhagalpur include the use of technology for spreading awareness, innovative measures for sharing experience during lockdown periods, the establishment of shelters for vulnerable populations, and the distribution of supplies and food and other protection measures such as sanitiser preparation and distribution, mask and gloves distribution, and disinfection tunnels. Also, Bhagalpur city has effectively leveraged the power of radio channels to reach out to citizens and ensure that the right messages are disseminated.

3.3.   Smart Waste Management Solutions

The COVID-19 pandemic continues to spread and its impact upon human health and the economy is intensifying. Government and citizens are urged to segregate and dispose of solid waste, hazardous waste, and biomedical waste with utmost care. Onoda (2020) noted that the COVID-19 crisis has implications for waste (the need for cautious handling of infectious waste). Further increases in the demand for disposable masks and testing kits will also increase the infectious waste plastics discarded. Cities are acting and working on best practices during this crisis. For instance, in Bhopal City, a microcontroller based Smart Restroom Monitoring System (SRMS) was deployed to monitor public washrooms to ensure cleanliness, hygiene and social distancing amidst the COVID-19 pandemic. The SRMS system not only monitors hygiene parameters but also regulates the cleanliness maintenance operations. The device monitors the cleanliness level in real time through being Internet of Things (IoT) enabled and keeps a log of the daily tasks at the command centre. Institutes like the Indian Institute of Technology at Madras are working on an IoT-enabled smart bin system to prevent the spread of COVID-19 through the waste generated at vulnerable contagion points such as hospitals, clinics, public bins, and quarantine hotspots. As quoted by one of the interviewees:

> *"Waste management processes will play a key role in containing the contagion at public or private spaces. From waste collection, transport, segregation, and disposal to recycling, every process needs to be overhauled quickly. Technology will play a vital role in this transformation. Timely cleaning of bins will be a key priority while faced with shortage of labour."*

The planned management and disposal of waste is the need to avoid infections and other effects on human health and the environment. Proper waste management is part of the essential services in our society. Other than digital methods to solve these problems, citizens, sanitary staff mangers and treatment facility operators need to take on the Central Pollution Control Board (CPCB) guidelines, measures, and advice to contain the spread of the disease through waste. Therefore, it should be a top priority to make sure that collection workers increase their protection from infection. This means that besides the measures that are taken for the whole population, smart waste management should be at the core of driving awareness and action to contain the deadly virus.

3.4. Smart Healthcare Management

Smart healthcare plays a vital role in smart city technology by reducing the COVID risk. Gandhinagar - a team of medical experts - hold regular video conferences with people in quarantine and suspected patients. Kota smart city uses remote digital medical consultations. Chennai, a team of 25 doctors, are engaged in the Integrated Command and Control Centre (ICCC) and each doctor was 250 quarantined people to handle. The doctors reached out to patients with moral and psychological support. In Vellore, 118 suspected patients were mapped and matched individual health experts for advice. Smart city grids were used to provide telemedicine and counselling and for coordinating daily patient requirements (Jaiswal et al., 2020). Cities like Pune initiated the healthcare and patient tracking dashboard at the Pimpri-Chinchwad Municipal Corporation (PCMC) which provided real-time information on COVID-19 related cases, as well as testing and healthcare arrangements. Discussing the healthcare facilities, workers, and their preparedness in combating the viral pandemic, one of interviewee said:

> *"We categorised the hospitals into three categories. One for quarantine purposes, second for testing and third for isolation of those found positive and their proper treatment. The hospitals are equipped with necessary facilities like ventilators, PPEs, bio-medical waste management, ventilator management and more. We are strictly following the guidelines issued by the Indian Council of Medical Research (ICMR)"*

The healthcare sector is rapidly emerging as one of the backbones of Indian economic growth. This growth is likely to be driven by various government programs that are focusing on the provision of affordable healthcare services to the billion plus population (Swedish Trade Council, 2012). The COVID-19 crisis is demonstrating the potential of digital health technology to manage some of the greatest public health challenges. Governments and medical professional bodies must pay attention to the ongoing structural changes in the private healthcare sector, the growth of corporate ways of working, and the implications for medical practices and standards (Marathe et al., 2020). The government is working on enhancing its collaboration with the public, private and research sectors, improving health technology and increasing the efficiency of healthcare delivery by sharing best practices.

Robotics and telemedicine have shone during the virus spread as doctors in facilities around the world resorted to using robots in isolation units for the treatment of COVID-19 cases. With social distancing as a key measure to fight this contagion, telemedicine has emerged as an important technology (MUAH, 2020). The Smart Clinic initiative by Pune Smart City provides primary health check-up and diagnosis, free sample collection and lab services, and free medicines for common ailments to citizens. Initiatives and strategies planned by smart cities have helped fight the COVID-19 outbreak in major densely populated cities in India.

Cities are developing predictive analytics using heat maps and working on monitoring movements using geo-fencing, as well as periodic health status updates for suspected cases.

The strategy of smart health is based on providing cheaper doctor consultations, reasonably priced medicines, and affordable diagnostics. This can be done by converging different schemes. Establishing a round-the-clock doctor consultation, a unique version of telemedicine, can be designed by establishing an IT platform to match patients and doctors, bringing convenience to the patient's doorstep. Smart cities could work on delivering applications on IT platforms to link general physicians and specialists in hospitals to patients in slum localities for online consultation. Providing these affordable services to citizens provides an improved quality of life, safety, and security. Providing these prevalent technologies and affordable services to citizens are among the major goals of delivering smart cities in developing countries.

The COVID-19 crisis generated stress throughout the world population. On the 18March 2020, the WHO's Department of Mental Health and Substance Use issued several considerations presented in a document titled 'Mental health and psychosocial considerations during the COVID-19 outbreak'. The World Health Organization (WHO) has provided guidelines on the common responses of people who are affected either directly or indirectly by such epidemics. These include a fear of falling ill and dying; avoid approaching health facilities due to fear of becoming infected while in care; fear of losing their livelihood and of being dismissed from work; feeling powerless to protect loved ones and fear of losing loved ones; and refusal to care for unaccompanied or separated minors, people with disabilities or the elderly due to fear of infection because their parents or caregivers have been taken into quarantine.

During times of fear and uncertainty, the very best elements of human nature can prevail as is the case in COVID-19-related good news stories. For instance, Bhagalpur city implemented an innovative storytelling initiative called 'Lockdown Ke Panney'. This initiative aimed to share a series of news stories based on experiences in the lockdown period. Every story had a positive message such as helping citizens keep their mental health and moral high, introspection and explore his/her hidden talents, the appreciation of the sacrifices made by homemakers/housewives for family motivating them to connect with nature and improving the bonding with family and their understanding of Indian culture.

Different smart city products should be fashioned to support the standardised protocols for improvements in the healthcare sector and to ensure the upholding of data integrity and safety during communication and transmission (Weber and Žarko, 2019). Allam (2020) explained the use of smart city products as solutions only understood by service providers, often resulting in the unnecessary disintegration of information, and interpreting only a partial combined view. The miscommunication and mismanagement of data hinders the effectiveness of making decisions to contain global pandemics and acting in response to them with social and economic integrity.

3.5. Smart Data Management

Triguero et al. (2019) noted that smart data refers to the development of tools capable of dealing with massive and unstructured data to reveal its value. Data can be a powerful tool to manage disease outbreaks and pandemics, and smart city platforms and technologies can effectively leverage data to reduce the spread of COVID-19. Smart city platforms provide the

solution for managing data from a variety of sources in city operating systems in a single environment using common visualisations and ways to turn the data into useful information to make informed decisions (ARC Advisory Group, 2020). Lewis (2020) noted that smart data management systems can ease the workload of contacttracers and help countries get by with fewer disease detectives. Many nations, including South Korea, Vietnam, and Germany, developed their own. State governments in Australia and the United States adopted a commercial system. The real time availability of data helps decision-making. One of the interviewees mentioned the importance of data and said:

> *"As the implementation protocol is changing on a daily basis, it becomes important that the data is regularly collected and managed. We have deployed a team of 30 officials to take care of the data management."*

Smart cities in India are finding it challenging to collate real time data. City governments deal with many complex issues that require integrated approaches to resolve. To tackle these challenges, the government, citizens, academia, and industry are working together to play a significant role in the functioning of cities. These organisations are the custodians of different types of datasets that hold a part of the solution to urban challenges. To leverage the data generated by the systems and processes deployed in cities, the Ministry, through its Smart Cities Mission, proposed the DataSmart Cities Strategy which lays down the basic premise, foundational pillars and suggested roadmap for cities to improve their readiness for the intelligent use of data to address complex urban challenges.

3.6. Smart Surveillance

Regarding the COVID-19 pandemic, containing and fighting the disease was only possible with reliable information about the prevalence of the infection and its spread. State governments and large municipalities came up with strict surveillance mechanisms to ensure that those quarantined adhere to the norms and stayed at home. Ibrahim (2020) noted that many countries utilised smart or digital surveillance including apps, location data and electronic tags during the COVID-19 pandemic. Pervaiz et al. (2021) proposed a hybrid approach for people detection and people tracking in surveillance videos using gaussian filter. The proposed approach involves five main steps including pre-processing, object detection, human verification, people counting and body tracking.

Ponnaiah et al. (2021) noted that the Indian Council of Medical Research (ICMR) set up a pan-national laboratory network to diagnose and monitor the COVID-19 outbreak. To monitor the evolution and spread of the pandemic in real-time, 2294 laboratories (as of January 2021) and testing centres were required to enter their records via a web application designed specifically for this purpose. All reporting units in the network entered their data (e.g., personal characteristics) daily from every district. The key public health strategy towards reducing the transmission of COVID-19 was testing suspected and high-risk individuals followed by tracking and contact tracing. This strategy relied mainly on the laboratory confirmation of COVID-19 using real-time reverse transcription-polymerase chain reaction (RT-PCR) among suspected and at-risk groups.

Ummer et al. (2021) noted that cities in Kerala deployed digital technology in the contact tracing of COVID-19 patients involving virus detectives, surveillance, and tracing the movements of positive patients. However, there have been privacy breaches, as well as

accusations of government over-reach in relation to Kerala's use of digital tools to manage COVID-19. Privacy breaches have included leaks of COVID-19 patient-level data from hospitals (both private and public) and leaks of Google map links that exposed identifiable information about people who underwent contact tracing. Following various protests and legal arguments, the government of Kerala made all tracking applications voluntary with the exception of infection reporting and set a limit of 14 days for the retention of call records and other individual data. However, the debate continues on the appropriate balance between disease surveillance and individual rights (Ummer et al., 2021).

Smart Cities like Bengaluru deployed technology, including smartphone apps with geotagging features, to ensure the strict observance of home quarantine. In cities like Vadodara, the district administration installed a helium balloon with two cameras attached and a public address system for the surveillance of lockdown violators. The administration divided the city into four zones, red, orange, yellow, and green, as part of a strategy to deal with the coronavirus pandemic. The key to success was contact tracing and the identification of infected individuals, including who they contacted and to whom they risked spreading the disease. The contract tracers were immediately interviewed and warned about their exposure, symptoms and risks, and the available testing and care facilities (Public and Practice, 2020).

The scale of the COVID-19 outbreak demanded a lot of contact tracers and dealing with this disease was especially challenging because it spreads quickly. There can be a two-week delay between acquiring the virus and getting sick. One of the interviewees mentioned the importance of contact tracing in cities:

> "We conducted door-to-door surveys to identify people who have symptoms or have travel history who is suspected to be infected. Moreover, the survey also aimed at tracing of those who came in contact with the infected people".

Deploying thermal cameras at locations like transit hubs and at facilities with large gatherings can be used to identify people with fevers and closed-circuit TV (CCTV) networks can be used to follow and trace the paths of these individuals. Applications on phones can identify when infected individuals are proximate, alerting the owner to potential infection. Smart or wearable fitness devices could help track people with symptoms. Technology can help overcome human shortcomings. Technology can provide quicker, more accurate information about exposure and can be used to create a database that offers greater insight into infection and exposure. He et al. (2021) noted that technologies can be useful for reducing the severity of the coronavirus pandemic's impact on people, organisations, and society. However, the use of technologies to combat the pandemic raises challenges such as security, privacy, biases, ethics, and the digital divide.

4. Discussion

The results shows that the current pandemic of COVID-19 is unprecedented. Although some good progress has been made in preparedness following previous outbreaks (Ebola and SARs) over the last decade, there are still clear and significant challenges (WHO, 2020). The biggest challenge has been the roll out and availability of vaccines and there are currently no proven therapeutics or rapid point of care diagnostic tests for COVID-19. Globally, the

coronavirus pandemic has caused a radical slowing of economic activity. India has seen significant impacts on the economy with industries scaling back on production, more employees working from home, and communities on lockdown (McKinsey, 2020). The lockdown measures and other COVID-19 combating measures have short-term, medium term and long-term impacts. The measures taken by the government in 2020 to combat the virus were commendable and India as a country fought through the pandemic. Nonetheless, the above measures and actions could not reduce the cases that surged in 2021. The work started on smart cities in 2015 helped to prepare a foundation to implement digital technologies as a foundation for managing the COVID-19 pandemic.

A cities' pandemic disaster resilience is majorly exemplified by their agglomeration characteristics, healthcare resource adequacy and inflow risk pressure related to the COVID-19 virus (Chen et al., 2021). Urban sectors and factors like socio-economic and environmental factors, management and governance, and transportation and urban design could be impacted by the dynamics of the pandemic (Sharifi and Khavarian-Garmsir, 2021). Different cities and regions have responded differently, and the response mechanisms diverge from one context to the other. A one-size-fits-all solution cannot be provided at the city level and city planners and administrators are required to develop context-specific integrated approaches for developing cities.

Maturana, et al., (2021) work based on reviewing work done in 12 countries reveal three areas: (a) the pandemic condition as it relates to the built environment, (b) analytical reflections on the emerging themes and (c) the diversity and complexity embedded in these themes. Salama (2020) provides two conceptual frameworks where one focuses on addressing urban and socio-spatial implications of COVID-19 measures while the other on post pandemic urban and socio-spatial implications. Abusaada and Elshater (2022), developed three-pillar guidelines. These pillars include recommendations for the trinity of heterogeneity for metamorphosis in urban form; changes in public life; and digital transformation in a time of uncertainty on how to confront (un)seen boredom in public spaces. Diker and Demirkan (2022), highlighted the need for a rethinking of interior design approaches regarding the design for isolated and confined environments. Singh and Parma, (2022) note that a city needs to be resilient and sustainable. The urbanisation trends of medium-sized cities of India need to develop a typology of urban resilience. They work focuses on historic second-tier cities like Nashik, Bhopal, Kolkata and Agra, which are laboratories of smart experiments and are subject to technological ubiquity, with rampant deployment of smart technologies and dashboard governance.

Disease outbreak response management solutions provide real-time details about the outbreak. Smart cities could plan their resources better when the lockdown solutions are integrated with other solutions such as smart data management, smart surveillance, smart waste management and smart healthcare (see Figure 3). Similar solutions could be developed by other cities and other developing countries to overcome the current COVID-19 challenges.

Figure 3: Smart City applications for fighting COVID-19

The following 6Cs are the resulting implications for city leaders and decision-makers to encourage them to rethink and act on COVID-19:

(1) Crisis management leadership: The world is facing an unprecedented crisis right now; the outbreak of COVID-19 has widely affected people all over the world and radically changed the routine functions of humanity. The COVID-19 crisis involved shipwrecks and glaciers that leaders throughout the world are still navigating in the form of unprecedented challenges (Simkin, 2020). Leadership requires conscientious flexibility but it also requires consistency and commitment to the greatest issues of our time. Therefore, strong leaders define their mission, frame the stakes, and pivot as the situation requires. They also pay close attention to their teams, managing their energy and morale in order to build determination, solidarity, and a shared sense of purpose. Tackling this unprecedented challenge requires a systems approach and the mobilisation of all stakeholders to respond (WEF, 2020). Therefore, - leadership plays a crucial role and leadership can be a key to overcoming negativity during crisis management. Indian smart cities such as Bengaluru, Nagpur, Kanpur, and Gandhinagar have shown that strong national and state-level leadership with a broad vision is an important success factor in managing the COVID-19 outbreak.

(2) Credible communication: The COVID-19 pandemic is a complex event that has affected every citizen and business in the country (PWC, 2020). Therefore, a communication strategy is critical, and the three basic principles of communication

include transparency, compassion, and ownership. National/state governments and city mayors must continue to ensure constant, consistent, and credible communication to provide any necessary COVID-19 related guidance and to calm the fears and panic among citizens.

(3) Collaboration: The COVID-19 outbreak demonstrates that the problems that emerge in distant places can quickly become a local catastrophe. Therefore, international, national, state government, and city collaborations are particularly important considering the gaps in information and capabilities when combating the COVID-19 outbreak. Different stakeholders including policymakers, religious leaders, doctors, researchers, engineers, and scientists from all fields of society need to work together to confront the COVID-19 outbreak with an unprecedented spirit of collaboration (WEF, 2020). The focus of developing smart cities has moved from people and their capabilities to technology (Kummitha and Crutzen, 2017). Smart cities strategies would help to improve the collaboration among different stakeholders. However, the lack of readiness of people, the lack of knowledge and the lack of access to information in the COVID-19 domain could be alarming to the citizens. Enhancing the human capital and skill development are the most important factors that need to be worked on for cities in India.

(4) Creative governance: Governance plays a prominent role in the management of the COVID-19 outbreak. People involved in decision-making need to be transparent and cooperate and coordinate with the city networks to bring out the best results. Indian cities follow peri urban structures which are governed by rural councils (Butsch et al., 2017). Trust needs to be built between the governed and the government to provide the better management of the COVID-19 outbreak. Participatory governance by involving various stakeholders is important for the management of a pandemic in cities. Political stability and strong administrative commitment and collaboration between the local and national government could impact positively on the management of COVID-19 outbreak in a democratic nation like India.

(5) Capturing knowledge: Smart cities must promote digital transformation and an open innovation culture that facilitates the effort to manage a COVID-19-like crisis. During a crisis, which is ruled by unfamiliarity and uncertainty, effective responses are largely improvised. All knowledge needs to be managed effectively. Organisations implementing smart cities projects need to build a knowledge sharing culture. Therefore, they should transform, develop, and nurture systems and processes to ensure knowledge creation, storing, codification and sharing in a meaningful way to expand all tacit knowledge into explicit knowledge which can in turn be used to continue learning and enhance any competitive advantage.

(6) Capacity building: Although major cities are known to prepare themselves for potential outbreaks, their health policies and protocols are observed to diverge from one another. Without a global collaborative approach, progress towards working for a cure and a universally acceptable policy approach can take longer. Research provides further opportunities to work on protocols and policies and for the government to engage in better preparedness during disasters. Information, two-way communication, management, and preparedness at both rural and urban levels helps nations to build better cities and combat the virus outbreak. At the urban local body (ULB) level, the expertise and exposure are limited to undertaking challenges. Capacity building for people working in the health sector is required to be efficient to tackle virus outbreaks, as well as identifying strengths and coming together to work for the betterment of all citizens. Strengthening the local health preparedness, granular, dynamic and locally driven lockdown, restarting management capabilities, increasing

implementation strategies, operationalising safe passage along key labour corridors, strengthening coordination and communication, and looking ahead and planning for contingencies are measures to be considered when sustainably championing the health and safety of citizens. While effective protocols in regard to the sharing of health data are emphasised, urban data, on the other hand, specifically relating to urban health and safe city concepts, is still viewed from a national perspective as solely benefiting a nation's economy and its economic and political influence.

5. Conclusion

India as a nation is looking at establishing a collaborative effort between the state, enterprises, academia, the entrepreneur ecosystem, and citizens to not just combat the novel coronavirus but to continue to facilitate life after lockdown. With India working on new projects like start-up India and digital India, the future of working on managing and combating outbreaks could be promising. Protocols, systems, and procedures need to be put in place to make people ready for the same to happen again. This paper explored the role of smart cities in dealing with the COVID-19 outbreak in India through a review of the literature and primary data collected from semi-structured interviews. It discussed the smart cities mission in India and outlines the COVID-19 situation in the country. The Indian smart city strategies have supported the city administration in combating the COVID-19 outbreak. Furthermore, the findings reveal the importance of Integrated Command and Control Centre, artificial intelligence and innovative application-based solutions, smart healthcare, smart data, waste management and smart surveillance as a convergence to allow smart cities to manage the COVID-19 outbreak.

There are 1.4 billion citizens in India and healthcare sector has been neglected for a long time. The COVID-19 pandemic has accelerated the pace of digitalisation of some aspects of healthcare in India. Increasing numbers of citizens across India are no longer prepared to be passive recipients of care, instead they expect to have access to care quickly and easily when it suits them, and to have choices based on trusted advice and reliable information. The Centres for Disease Control and Prevention has recognised that technology and surveillance can play an important part in supporting the public health response to outbreaks. Technology has played a prominent role in information, prevention, and treatment. Digital technologies can integrate healthcare by identifying and reducing risks also predicting and helping to manage the population healthcare needs and improving the quality of data flow to deliver timely, efficient, and safe healthcare. Data management, health management, waste management and safety converging with technology provides a future approach to combat outbreaks. Cities are moving towards collective knowledge management to enable smarter approaches to COVID-19. A coordinated national response, effective governance and leadership, a multi-sectoral approach, community involvement, effective surveillance systems, healthcare provision, health infrastructure, tested protocols, proper education for health providers, and close collaboration and planning are required for the survival of a system and future generations. This study emphasises relevance of preparedness for bureaucrats, city planners and decision-makers to enable them to implement and embed radical innovative solutions to make the cities smart and resilient.

In conclusion, humanity is still dealing with and fighting in the aftermath of the pandemic. The pandemic is exposing the quality of governance and scale of inequalities in our cities. It is also providing an opportunity for urban planners and entrepreneurs to build back better.

Some of them are exploring ways to upgrade their zoning and procurement policies to promote smart density and greener investment. Cities are the perfect test beds for new innovations. This study helps to identify the current and potential role that smart cities play in managing COVID-19 in India but also disaster management in the future.

Despite the novel insights provided by this study, it has some limitations. Given that the research reported in this paper is a preliminary study and exploratory by nature, the results presented are only tentative and of limited value for the purpose of generalisability. Additional research with a more elaborate and better articulated design is called for to further explore the complex issues of managing a COVID-19 outbreak. Furthermore, the findings of this paper are limited to India only. As such, the level of generalisability outside of this context may be very limited. However, we argue that the results obtained are useful for similar developing countries.

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