

The resilience of systems-thinking approaches when faced with an evolving crisis: The case of Mumbai

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Submitted: 1 August 2023

Accepted: 4 December 2023

ABSTRACT

Motivation: India has seen severe economic and social impacts from COVID-19, with the most vulnerable people having suffered most. Mumbai's response has been multi-faceted drawing on numerous actors such as local and state government but also businesses and citizens. Disaster management is increasingly common and Mumbai's policy response during COVID-19 wave two provide relevant lessons.

Purpose: We explain Mumbai's policy response to wave two of COVID-19, termed the Mumbai Model, applying) systems thinking approach.

Methods and approach: We adopt a systems thinking approach, applying a framework developed in Duvendack and Sonne (2021) to analyse case study based on secondary data and information on the policy response to COVID-19 in Mumbai.

Findings: The Mumbai Model emerged as a pragmatic policy response. Key actors changed between waves one and two, from a broad set of actors to a narrower set focussed on the unfolding healthcare crisis. This resulted in a reconfiguration of networks and partnerships. Decentralised decision-making further changed the structure of the networks to a hub and spoke model. Communication and feedback loops shifted from primarily top-down to two-way information flows to support decision-making and resource-allocation driven by data. This was enabled by clear leadership and political buy-in.

Policy implications: To tackle a crisis of this magnitude diverse actors collaborating effectively through networks that enable knowledge and information flows is crucial. Governments can use the systems approach for crisis management in large cities which require swift action and efficient flow of information to assess a situation and to prioritise response efforts. Further research is required to better understand how governments can build capacity and policy structures to enable systemic approaches to crisis management in varied contexts.

Keywords: COVID-19, complexity, India ,Mumbai model, systems thinking,

1 Introduction

India was severely affected by COVID-19 (Chatterjee, 2020; Shil et al., 2022). Different Indian cities and regions experienced the crisis differently (Ghosh et al. 2021). For example, in wave one, Gujarat suffered high COVID-19 fatality rates due to poor access to healthcare and a disorganised response to the crisis while Kerala rolled out an extensive testing regime with widespread access to healthcare despite being less of an economic powerhouse than Gujarat (Israelsen & Malji, 2021).

In the first wave of COVID-19, the country suffered a triple crisis: a healthcare, economic and humanitarian crisis. Much of the literature concerned with understanding health aspects of COVID-19 have focussed on the number of deaths (Chatterjee et al, 2020; Chatterjee, 2020), the impact of India's vaccination campaign (Bagcchi, 2021; Potdar et al., 2021), and COVID-19 transmission dynamics (Samui, Mondal & Khajanchi, 2020; Shil et al., 2022; Ghosh et al., 2021). Other recent literature has recognised that during wave one and in its the aftermath, challenges were emerging, some sowing the seeds for long-term damage — for example, women losing their jobs and not returning to work (Azim Premji University, 2021), domestic violence increasing setting back the gender equality agenda for decades (Steinert et al., 2023; Agarwal, 2021), mental health declining (Panda et al., 2023; Narayanan & Sriram, 2023), closures of a large number of micro, small and medium enterprises (Chen et al., 2023), loss of jobs especially among informal sector workers (Kumar & Kumar, 2021; Dev & Sengupta, 2020), among other issues.

By the time wave two gathered strength, the humanitarian crisis had subsided as many migrants remained in their home steads while only a smaller fraction returned to Mumbai to seek work. Wave two, which lasted from approximately late February 2021 to early August 2021, was primarily a healthcare crisis.

This study considers Mumbai's policy response to wave two of COVID-19. We focus on the healthcare crisis while acknowledging that the economic and humanitarian crises had not yet been resolved during this period. Duvendack and Sonne (2021) applied a systems-thinking approach to the case of Mumbai during wave one of the pandemic, finding a web of interconnected actors that had to continuously adapt and innovate to respond to an ever-deepening crisis with the objective to reach the most affected and marginalised individuals in the best possible way. This is the starting point for this paper. We take the Duvendack and Sonne (2021) framework and apply it to Mumbai's policy response to wave two of COVID-19, termed the 'Mumbai Model'. In doing so, we assess policy interventions and responses in Mumbai during wave two of COVID-19, to draw lessons on how governments at different

levels can respond to an unfolding crisis. Wave two saw extremely high infection rates, but in Mumbai there were fewer deaths than in wave one, and there was a markedly different fallout from the crisis as compared to Delhi.

The Mumbai Model is interesting because lessons were learnt during the response to the first wave which meant that Mumbai was better prepared to deal with wave two.

Policymakers were able to create a flexible and adaptive response to the crisis, that brought in a range of actors and relied on decentralised decision-making that took into account that different parts of a large sprawling city like Mumbai needed varied responses. This holds interest for other mega cities around the world grappling with crises. The systems approach is helpful in showing how the response was adaptive, multi-faceted and complex, while also relying on quality leadership and political buy-in. We contribute to the literature on policy responses to COVID-19 in India at the national level (McGowran et al., 2023) and the local level of Dharavi informal settlement in Mumbai (Dighavkar, 2021; Kumar et al., 2024; Kaushal & Mahajan, 2021). Furthermore, the systems approach has a wider application. Disaster management is becoming an increasingly common challenge in large urban cities in the Global South due to climate change, and we build on Chan (2020), Few et al. (2020), Goel et al. (2021) and McGowran, et al. (2023) to suggest that Mumbai's response to COVID-19 in wave two holds lessons for large cities dealing with issues such as flooding and air pollution.

The paper is structured as follows, section 2 provides contextual information followed by section 3 presenting the conceptual framework which draws on a systems-thinking approach before setting out the methodological approach in section 4. Section 5 presents the case study followed by section 6 where the conceptual framework is applied to the Mumbai Model to tease out what we can learn from a systems-thinking perspective in relation to managing a global health crisis. Section 7 concludes and provides recommendations for policy makers and researchers.

2 Contextual background

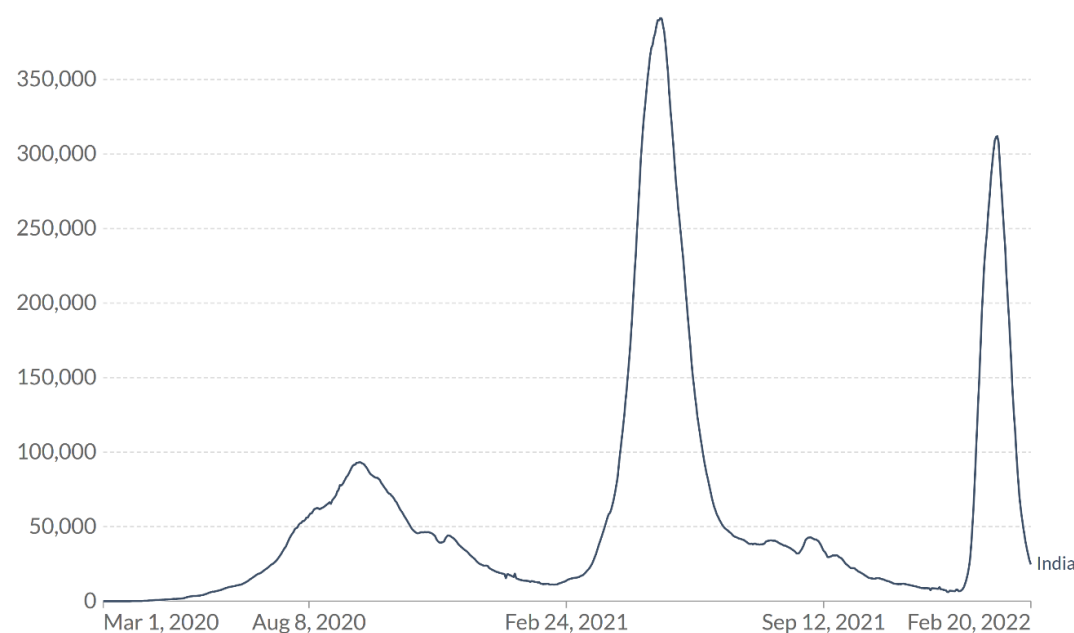
Disasters are often associated with calamitous environmental and, or, climate change related events such as droughts, locusts' infestations, cyclones, earthquakes, volcanic activities and so on (Few et al, 2020). Chan (2020), however, argues that COVID-19 should be treated as a biological disaster rather than a pandemic and thus lessons can be learnt from the disaster management literature, i.e., the disaster management cycle contains four components: mitigation, preparedness, response and recovery. Each of these components involve a range of actors as governments alone may be overwhelmed trying to cope drawing on their own resources and expertise (Chan, 2020). However, what these disasters, including biological ones such as COVID-19, often have in common is their prolonged nature and slow onset resulting in a drawn-out state of emergency leading to multi-faceted impacts on people's

livelihoods, their needs and losses (Few et al, 2020), thus requiring a multi-faceted response over a long period of time.

In the case of Mumbai, we observe a long history of disasters, many drought-related (e.g., the drought of Maharashtra in 1970-1973) but also health-related such as frequent outbreaks of cholera (as early as 1820), the plague (1896-97) and the Spanish Flu (1918-20) disproportionately affecting Mumbai. Historically, the response to these disasters often involved heavy-handed military tactics, which were subsequently endorsed with the establishment of the 'Epidemic Diseases Act' in 1897 (Klein, 1988; Sarkar, 2001). Mumbai has considerable experience at managing these large scale disasters which may partially explain why the city was not as badly affected as some other large Indian cities such as Delhi, during the COVID-19 pandemic waves one and two (The Economist, 2021b; Tirodkar, 2021; Dalal, 2021).

COVID-19 took hold in Mumbai in early March 2020 with the first wave of the pandemic lasting roughly until early September 2020 (see Figure 1 below). This paper focuses on wave two which lasted from approximately late February 2021 to late early August 2021, as can be seen by the steep increase in the seven day rolling average of infection rates between February 24, 2021 and 12 September, 2021 in Figure 1. While it was sharp in terms of extremely high infection rates in Mumbai, it had fewer deaths compared to wave one.

Figure 1: Daily confirmed cases of COVID-19 in India



Notes: Based on seven day rolling average (e.g. average over seven days). Due to limited testing, the number of confirmed cases is lower than the true number of infections.

Source: John Hopkins University CSSE COVID-19 data.

<https://ourworldindata.org/coronavirus/country/india>.

India has three levels of government, all of which were involved in India's response to COVID-19. At the central level, India's national government created an overall COVID-19 response, including took decisions on country-wide lockdowns. Additionally each state has its only state-level government in charge of COVID response for the state, while at the district (county) level in rural areas or city-level in urban areas, the local government took day-to-day implementation decision. Wave one required the local and state governments of Mumbai and Maharashtra to deal with an acute triple crisis: A healthcare, an economic and a humanitarian crisis. Mumbai's healthcare infrastructure started running out of capacity to manage the COVID-19 pandemic early on (Scroll, 2020). The result was an initially high number of fatalities. The local government, Brihanmumbai Municipal Corporation (BMC)¹, reacted to these challenges by upgrading hospitals and classifying some as COVID-19 hospitals. Additionally, private hospitals were required to give up 80% of their beds to be run under the local government, and the state government put in place a pricing list for both COVID-19 and non-COVID-19 healthcare services to avoid predatory pricing (BBC, 2020b; Mint, 2020; Scroll, 2020). Concurrently, quarantine facilities were set up across the city for COVID-19 patients with mild symptoms and for those unable to quarantine at home (Mint, 2020; NDTV, 2020a).

Mumbai responded to wave one by invoking the 'Epidemic Diseases Act' of 1897 in March 2020 which enabled the city to release additional resources to be used for grappling with the pandemic but also to gain additional legislative powers to be able to, e.g., restrict shop opening hours, shut down cinemas, sports centres and malls, mandate social distancing rules and the wearing of face masks, enforce lockdown measures, curfews, working from home measures and so on (Das & Pardeshi, 2020). These measures had of course dire consequences for businesses and the informal sector, further deepening already existing inequalities, but they took the strain off the overwhelmed healthcare sector as infection rates soared to more than 100,000 in a day during the peak of the first wave (see Figure 1). In particular Mumbai's lockdown measures lasting from March to May 2020 put immense pressure on the city's economy with initially temporary supply-chain disruptions causing food

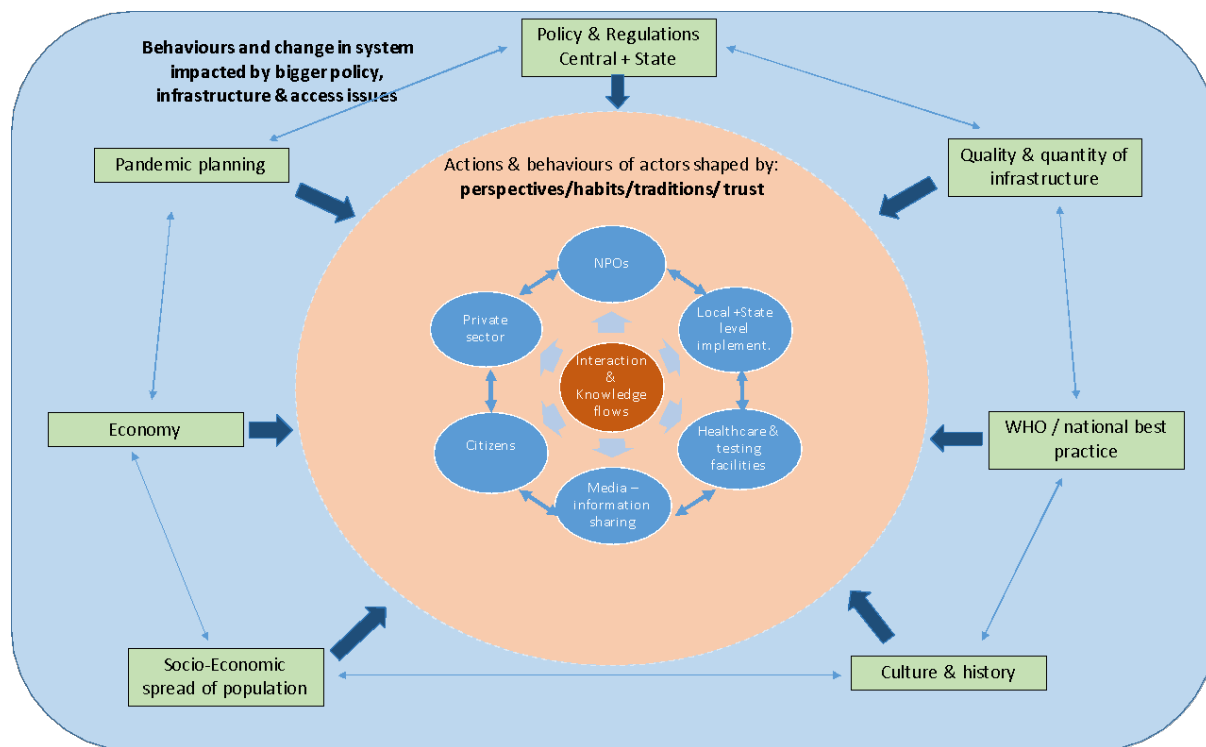
¹ BMC is translated as the Corporation of Greater Mumbai. It should be noted that while we discuss the role of BMC in this paper, Greater Mumbai is part of the larger Mumbai Metropolitan Region (MMR) which incorporates a number of local government bodies for neighbouring areas - including the Municipal Corporations of Thane, The Kalyan-Dombivli, Navi Mumbai, Panvel, Vasai-Virar, Mira-Bhayandar, Bhiwandi-Nizampur, Ulhasnagar.

shortages (BBC News, 2020b; BBC News, 2020a). This led to the involvement of actors that do not always engage in crisis management, such as citizen's initiatives and NPOs helping to alleviate some of these short-term disruptions as they could reach otherwise hard to reach areas, thus filling in for the government.

3 Conceptual framework

As noted in the introduction, we draw on the conceptual framework developed by Duvendack and Sonne (2021), which proved to be useful in capturing the complexities of the pandemic as it unfolded during the first wave of COVID-19 and in visualising the numerous inter-related factors that explain what it takes to successfully manage a crisis of untold magnitude. The framework recognises that a systems-thinking approach enables us to understand the complex nature of the pandemic response, and to tease out the multiple cause and effect relationships that exist between a number of actors typically engaged in crisis management. Systems thinking helps to visualise the interrelatedness and complexity of the world we live in (Ramalingam et al., 2008). Complexity has been conceptualised by a number of authors such as Glouberman and Zimmerman (2002), Kurtz and Snowden (2003) acknowledging that complex situations are unique, presenting challenges for the decision-making process, i.e., previous successes in dealing with complex situations do not guarantee future successes. Patterns of complex situations may only become evident in retrospect and decision-makers are essentially move in the domain of the 'unknowable' (Kurtz & Snowden, 2003). Systems thinking has traditionally been used to help with the decision-making process when faced with complex and non-linear situations (Ramalingam, 2013; Ramalingam et al., 2020). Hence, the starting point to depict the various components and interconnected factors of any complex and adaptive system is presented in Figure 2 which allows us to see the system as a whole but also its parts with the objective to help us understand the relationships and connections that exist between the various actors and processes, which in turn explain the dynamics of the system as a whole (Ramalingam et al., 2008; Ramalingam, 2013; Birney, 2017).

Figure 2: Systems thinking, complexity and COVID-19



Source: Duvendack and Sonne (2021).

In our model, the **system** contains actors, processes, relationships and dynamics that are complex and interrelated. Since the components of the system are interconnected and change over time, the system as a whole is evolutionary in nature, changing shape and structure (Glouberman & Zimmerman, 2002; Kurtz & Snowden, 2003; Ramalingam et al., 2008; Ramalingam, 2013; Barbrook-Johnson, 2020). The system and its actors, processes, dynamics and relationships change in a non-linear, or systemic, manner (Ramalingam et al., 2008; Mytelka, 2000; Ramalingam, 2013; Ramalingam et al. 2020; HM Treasury, 2020; Birney, 2017). Because of the non-linearity and systemic nature, the changes and outcomes of a system can be unpredictable. A well-functioning system therefore needs flexibility in order to evolve to address new challenges and changing needs (Ramalingam, 2013; Duvendack & Sonne, 2021).

A range of **actors** engage and collaborate with each other in unprecedented ways forming new **networks and partnerships** such as, for example, citizens organising themselves online into neighbourhood groups to raise funds and coordinate relief efforts ultimately linking up directly with governments and or private businesses. Or private businesses stepping up to participate in relief work by converting their premises into accommodation for health care and other essential workers and thus supporting the government (NDTV, 2020b;

Mint, 2020). Network density is expected at the core, or centre of the activity such as BMC headquarters, rather than at the periphery, i.e., the outskirts of the network (Ramalingam, 2013; Borgatti & Everett, 2000). This suggests that actors, networks and processes at the core may be more slow to adapt as they may be less flexible.

If we accept that actors are all interconnected, then we will see that **knowledge and information flows** together with feedback loops (presented as arrows in Figure 3), are crucially important to understanding the dynamics and relationships between the various parts in the system, i.e. the actors. The networks of partnerships and feedback loops enable knowledge and information sharing within the system, thus facilitating a learning process to take place between actors allowing them to optimise their responses to the crisis (Mytelka, 2000; Lundvall, 1992; Birney, 2017; Ramalingam, 2008). Learning and feedback loops enable the sharing of new information between actors so that lessons can be learned and new responses formed, and models innovated. However, feedback loops may also reinforce existing behaviours and habits, and lead to false information being shared (Duvendack & Sonne, 2021).

A final point worth noting is the role of **hard and soft institutions** in relation to how actors relate to each other within a system (David, 1994; Lundvall, 1992; Ramalingam, 2013). Hard institutions typically include different levels of government that tend to favour rules and regulations which shape their response to a crisis. Soft institutions, e.g., citizens, on the other hand, see their behaviour shaped by habits, traditions and culture possibly eliciting a very different response to a crisis which may be incompatible with that of hard institutions. The type of institution plays an important role in determining how actors behave in relation to each other and how information and knowledge flows within a system (Duvendack & Sonne, 2021).

4 Methods

The methodology uses a case study allowing us to understand the complexities underpinning Mumbai's response to wave two of COVID-19. Especially when faced with a multi-faceted phenomenon as is the case here, a case study is particularly suitable as it permits an in-depth exploration of complex issues (Bryman, 2016). It is also useful in the context of applying a systems-thinking lens to help tease out the numerous connections and relationships between the various actors engaged in the response to COVID-19.

To build and inform this case study, we draw on government reports, newspaper articles, social media posts and any nascent academic literature of relevance. The time of interest is wave two of COVID-19 in India which began in earnest in late February 2021 and lasted

roughly until late early August 2021 (see Figure 2 above). We do not cover wave three which started in late December 2021.

5 Case Study: The Mumbai Model as a response to Wave Two of COVID-19

In this section we provide a case study of the key features of the Mumbai Model. Wave two was primarily a healthcare crisis. The healthcare infrastructure built up by the Mumbai administration in the first wave remained intact, including facilities such as jumbo hospitals and quarantine centres (Mohan, 2021). However, while it helped contain the fallout from wave two, the city still faced challenges at the peak of wave two such as shortage of oxygen and ventilators because of the large number of patients (Dalal, 2021; Tirodkar, 2021).

When wave two hit, Mumbai's leadership had a plan of action, which became known in India as the 'Mumbai Model' (Hindu, 2021; Mohan, 2021; Dalal, 2021). The city government had learnt a great deal — in particular from how the local administration overseeing one of the largest informal settlements in Mumbai, Dharavi, had managed the pandemic in the first wave (Golechha, 2020; Dighavkar, 2021; Kumar et al., 2024; Kaushal & Mahajan, 2021). It was in Dharavi that the BMC first used their strategy of testing, tracing, tracking and treating during wave one, which was then scaled up laying the ground for the emergence of the Mumbai Model (Khaparde et al. (2022). The Mumbai Model has the following key characteristics: clear leadership and political buy-in, decentralised decision-making, a collaborative approach, data-driven decision-making, as summarised in Table 2 below (Mohan, 2021; Dalal, 2021; Hindu, 2021). We discuss these characteristics in more depth.

5.1. Clear leadership and political buy-in

Mumbai's civic body, the BMC, has been in charge of the COVID-19 response since the start of the pandemic. The BMC has 227 elected representatives, or corporators, from the city's 24 administrative wards. The body is headed by a Mayor and Deputy Mayor, who are primarily ceremonial. The administrative wing comprising of civil servants that implement decisions taken by the elected representatives are headed by a Commissioner – an Indian Administrative Service (IAS) Officer supported by additional commissioners and several government departments (Mumbai Mirror, 2010; <https://www.mcgm.gov.in/>).

The Mumbai model is underpinned by clear leadership from Mumbai's civic body and political buy-in at state and local levels. As a result, there was adequate budgeting for infrastructure and equipment which enabled swift implementation of new strategies (Hindu, 2021; Dalal, 2021). The Commissioner and the government departmental leadership set up central disaster control rooms linked to the Mumbai Police as well as local control rooms in each of the city's wards (Hindu, 2021; Mahale, 2021). These ward level control rooms

became known as ward war rooms which we discuss in later sections. BMC leadership redeployed staff and repurposed resources. For example, when Mumbai was short of ambulances, 800 SUVs usually used for election functions and 50 minibuses were repurposed as ambulances that could fit stretchers (Hindu, 2021; Pandya & Sanjai, 2021).

Furthermore, there are several examples of political buy-in and adequate budgeting that enabled the administrative arm of the civic body to put in place appropriate infrastructure. For example, as part of its relief efforts, “the BMC approved the setting up of 16 liquid medical oxygen plants at 12 locations with a cumulative capacity of 45 metric tonnes per day” (Lewis, 2021:1), and built new facilities within Mumbai’s public (state-run) hospitals, such as Kasturba, Cooper Hospital and Bhabha Hospital, to generate additional oxygen (Lewis, 2021; Indian Express; 2021). In addition, the BMC set up five jumbo centres — huge healthcare facilities — for COVID-19 testing, COVID-19-related hospitalisation and later for COVID-19 vaccination (Lewis, 2021).

5.2. Decentralised hub-and-spoke structure centred around ward war rooms

The BMC adopted a strategy of a decentralised hub-and-spoke structure (Mohan, 2021). Mumbai’s 24 wards each got their own pandemic management control room, called ‘ward war rooms’. The central BMC control room became the hub to which each of the 24 wards reported back (Dalal, 2021). Each ward war room contained computers with a dashboard, mobile phones and a team of medical and non-medical staff.

This decentralised approach was put in place to collect, analyse and share data for decision-making, be able to quickly respond locally, and implement local level decisions. Based on lessons from wave one, each ward war room had a separate 24-hour helpline, instead of one central helpline:

“[T]he central control room (number 1916) buckled under the pressure of calls during the first wave of COVID-19. As 75% of the staff tested positive, there were very few people to take the calls, let alone address the queries of those desperate people who were calling” (Hindu, 2021).

The medical staff as well as BMC employees would work in three shifts to ensure a 24-hour operation (Hindu, 2021). The helpline operators took calls from residents about everything from suspected COVID-19 cases, and requirements for hospitalisation, to food shortages related to lockdown and quarantine zones (Mariwala & Shah, 2021; Nair, 2021). The phone lines were manned primarily by schoolteachers on special duty. Teachers would also make calls to COVID-19 positive residents to monitor their situation and decide on whether home quarantine is sufficient, or a hospital bed is required (Nair, 2021). The ward war room had in-house medical personnel and ambulances at their disposal (Mariwala & Shah, 2021; Nair,

2021). Each ward war room was connected to their own network or spokes, including local hospitals and quarantine centres, local hotels, and citizen representatives.

To place medical personnel in the ward war rooms and emergency teams, the BMC employed 900 doctors and 600 nurses:

*“BMC invited doctors and medical support staff specifically to handle the war rooms (especially fresh graduates from **medical** colleges and nursing schools across the state), provided them with a stipend (Rs. 50,000 per month) and hotel accommodation at walking distance within the ward”*
(Dalal 2021).

5.3. Collaboration with a variety of actors

The decentralised hub-and-spoke structure was greatly helped by the emphasis on collaborative approaches (Mohan, 2021). As noted in the previous section, BMC and the ward war rooms worked closely with public and private hospitals, quarantine centres, pathology labs, and building society secretaries as well as community leaders. In addition, crematoriums, the police, universities, research centres, private sector entities and non-profit organisations were also active collaborators (Hindu, 2021). Table 1 offers an overview of the key collaborators within the de-centralised hub-and-spoke structure as well as their roles. We covered BMC and ward war rooms in previous sections but will provide further detail of the other actors below.

Table 1: Key actors in the Mumbai Model of COVID-19 management

Actor	Role
BMC HQ	Overall coordination of relief efforts across the city.
Ward war rooms	Coordination of relief effort in ward; main port of call.
Building society secretaries	Ensure BMC sanitises and seals buildings; reports to ward war rooms.
Community leaders	Ensure BMC contractors undertake work; encourage residents to get tested; contact point for BMC in local community.
Hospitals & quarantine centres	80% of beds in hospitals for COVID patients; less severe cases sent to quarantine centres, including hotels.
Pathology labs (public & private)	Contacted by citizens for tests; results sent to BMC.

Source: Authors own representation, drawing on Samuel and Panchal, ICMA, 2021: <https://icma.org/articles/pm-magazine/leadership-crisis-mumbai-model>.

Building society secretaries and community leaders. The ward war rooms relied on two types of leaders at the grassroots level. These include the elected leaders (called society secretaries) of apartment buildings (called housing societies), and community leaders - men and women of standing who may or may not be elected, in informal housing settlements. These leaders have a duty to ensure that residents complied with regulations, to report on any new COVID-19 cases and to ensure that work to be done by BMC employees and contractors was carried out satisfactorily. The secretary of each housing society was connected to the ward war rooms in order to coordinate COVID-19 related actions including sealing buildings in case of more than five infections and ensuring that residents were not in breach of regulations (Hindu, 2021). Building society secretaries were expected, by BMC, to ensure that buildings or flats remained in quarantine for the required duration, and to liaise with BMC about new patients.

“The numbers of secretaries of all societies are registered with ward offices. So, if any society finds a new patient, they inform the ward office or vice versa [...] This helps in creating containment zones, in sanitising the area as well as making people conscious about their movements. This also helps the BMC to keep a record of area-wise patients” (Tirodkar, 2021).

Community leaders played a particularly important role in ensuring frequent checks in informal housing settlements. These leaders were provided with a mobile phone and stayed in regular contact with the ward war rooms (Hindu, 2021). Community leaders would check that door-to-door testing was conducted properly and followed through, that public toilets were sanitised as per schedule, that food packets distributed by BMC were of sufficient quality and they would also keep an eye on whether local residents would develop symptoms.

Hospitals and quarantine centres. Both directly, and through its ward war rooms, the BMC worked closely with public and private hospitals (Hindu, 2021). Staff in the ward war rooms would liaise

“with hospitals and COVID-19 facilities within their ward. In case of bed unavailability in the ward, the doctors contact other ward war rooms using the information displayed on the dashboard. Ambulances are then dispatched to move the patients for whom the doctors have recommended hospital admission” (Nair, 2021).

Hospitals in the city agreed to not admit patients directly, but to collaborate with the BMC so that admissions could happen in an organised manner based on triage, and with dashboards in the ward war rooms being updated with the latest availability of beds.

“The chief operating officers of 35 private hospitals including Breach Candy Hospital, Lilavati Hospital, Nanavati Hospital, Wockhardt Hospitals and Hiranandani were brought in. A BMC order stated that 80% of the total beds and 100% of intensive care unit (ICU) beds in private hospitals shall be kept reserved only for COVID19 patients referred by ward war rooms” (Hindu, 2021).

Furthermore, hotels were repurposed as quarantine centres for travellers or those with mild COVID-19 symptoms. They were also used as hostels for medical staff who struggled to reach home when the public transport system was only partially functioning, and housing societies did not allow medical staff to come home for fear of spread of the virus (Lewis, 2021).

Pathology Labs. Private and public pathology labs were required to submit test results to BMC rather than directly to individual citizens, as is the norm. This allowed BMC to first review the tests and take action accordingly (Dalal, 2021). In crowded informal settlements such as Dharavi, the BMC emphasised the need for rapid testing and set up temporary clinics. The local testing centres and the mobile units responsible for test and trace, were especially important to collect data in informal settlements.

“Not all patient information can be gathered by making calls from the war room. [...] those living [in informal settlements] are unlikely to have access to thermometers, let alone pulse oximeters. The health posts are assigned to record vital parameters like oxygen saturation levels and temperature of the suspect and confirmed Covid-19 cases in these areas” (Nair, 2021). In more affluent parts of the city, residents often went to private labs to take COVID-19 tests (Tirodkar, 2021).

5.4. Data-driven decision-making

The BMC made data-driven decision-making a key feature of its fight against COVID-19. This emphasis on data-driven decision-making, created a need for regular reporting of data, as well as dashboards that update data as they come in. This in turn resulted in continuous feedback loops between different actors in the system. The Mumbai Model put in place an emphasis on collecting high quality data and putting in place processes for both daily updates as well as real-time data capture.

There were two sets of data of particular importance – data on residents with suspected or confirmed COVID-19 infections; and data on resources at hand – including available hospital beds and quarantine facilities. With respect to the first type of data, on residents, the BMC would receive a list of COVID-19 positive patients and send it on to the ward war rooms:

“Every day, all 24 war rooms receive the list of Covid-19 positive people in their respective wards [...]. They also receive calls from people who have Covid-19 symptoms and are still awaiting confirmatory tests or test reports. Health workers doing contact tracing on the ground also feed in data about those showing symptoms” (Nair, 2021).

A crucial part of the ward war room level data-driven decision-making approach was to adopt a process of triage to assess how to prioritise among patients. This was a lesson from wave one:

“One of the key learnings from the early months of the pandemic for the city’s civic body, BMC, has been that strict triaging of patients is essential to ensure the best use of resources” (Nair, 2021).

The staff that worked the helpline phones had been trained in how to prioritise cases based on a set of questions including “oxygen saturation levels, symptoms, comorbidities, vaccine status, and the type of house they live in” (Nair, 2021).

This way, the ward war rooms were able to prioritise who would need a hospital bed – and what kind of bed, and who could make do with home quarantine.

The data was fed into the dashboard every evening to ensure that the latest data was available in real time to BMC headquarters and the ward war rooms (Hindu, 2021).

“The dashboard gives information on the number of positive cases, active cases (symptomatic and asymptomatic) and number of patients discharged” (Hindu, 2021).

With respect to the second type of data, on hospital bed availability,

“in all the dedicated COVID-19 hospitals, healthcare centres and ‘jumbo’ COVID-19 facilities, a nodal officer has been appointed to update the data at regular intervals. The same information is available to the disaster management cell as well as the ‘war rooms’ and the administrators of each ward” (Hindu, 2021).

Thus, the dashboards at the ward war rooms could track available hospital beds in private and public hospitals and jumbo centres in the city in real time. The data on availability of hospital beds together with the status of COVID-19 positive residents allowed decentralised BMC teams to quickly take decisions on who needed hospitalisation or access to quarantine facilities (Mohan, 2021). The BMC had in essence set up a data management system that

could track the number of COVID-19 positive patients as well as the types of hospital beds available (regular, with oxygen, or ventilator) and their locality. It also managed information to coordinate ambulances for patients, it managed outreach teams from ward war rooms, and managed the monitoring of self-isolating patients, as well as coordinated timelines for crematoriums (Mohan, 2021).

Table 2: Key features of the Mumbai Model

Feature	Explanation
Clear leadership & political buy-in	Political buy-in and available budget together with clear leadership enabling a decentralised data-driven decision-making approach.
Decentralised decision-making via ward war rooms	BMC* delegates to ward war rooms. Ward war rooms - local level control rooms - provide helpline for residents, monitor number of cases and coordinate hospital & quarantine beds; enforce isolation measures. Ward war rooms rely on local community leaders and secretaries to implement restrictions & ensure task completion.
Collaboration with variety of actors	Hospitals agree with BMC to have a centralised admissions system. IITB** and Uber use smart digital technology to track crematoria, dialysis, and ambulances on different interfaces. Community leaders, housing society secretaries ensure compliance.
Data-driven decision-making	Testing to facilitate quick action. Triaging to prioritise cases. Monitoring and coordination of resources.

Notes: *BMC = Brihanmumbai Municipal Corporation; **IITB = Indian Institute of Technology-Bombay.

Sources: Authors' own drawing on Hindu, 2021; Mahale, 2021.

6 Discussion – Mumbai Model as a response to a complex healthcare crisis

To understand how the key features of the Mumbai Model (Table 2) were able to respond efficiently to a complex health crisis, we apply the systems-thinking framework presented in section 3. As such, we start by discussing the actors involved in the response, before considering the networks and partnerships that emerged. We then consider knowledge and

information flows including the resultant feedback loops, before finishing with the hard and soft institutions that underpin the way the system responds. The changes that occurred between wave one and wave two in relation to the Mumbai Model, and implications for theory are summarised in Table 3 at the end of the section.

6.1. Actors

As noted in our framework, the range and type of actors that engage in a system matters for the kind of partnerships, networks and knowledge flows that emerge which in turn affect the response to challenges and changes. For example, in the first wave, the government was managing multiple and sudden crises with competing priorities during the first wave, a wide variety of other actors, including NPOs, individual citizens and enterprises, played significant roles.

The focus of the Mumbai Model of wave two was on healthcare provision, and later on vaccinations as well. This is a significant shift. The Mumbai Model therefore had a smaller range of actors in key roles. Given the core focus on testing and healthcare provision, the core actors that were part of the Mumbai Model were closely linked to either testing or treatment facilities. These include, the BMC headquarters, the decentralised BMC ward war rooms; the pathology labs; the hospitals and other care facilities, quarantine centres including hotels; crematoriums; and community leaders and building society secretaries who engaged closely with citizens. In line with the framework, therefore, there were a range of actors bringing different expertise and knowledge to the Mumbai Model, though not as diverse as during wave one.

Furthermore, Mumbai's experience during the COVID-19 pandemic highlights the importance of political buy-in between bureaucrats and politicians as well as between politicians at the local and state levels. For example, the civic body in Mumbai was able to respond quickly to the unfolding crisis of wave one in part at least, due to political buy-in and open communication lines between the local city-level government (BMC) and the state-level government. Both were at the time run by or in partnership with the same leading party - the Shiv Sena. This made it easier to take swift decisions, especially those that entailed permissions at the state-level, it enabled adequate budgeting for improving and upscaling health infrastructure, and likely contributed to the decision on the part of the Chief Minister of the state government, and party president of Shiv Sena, to allow the city-level bureaucrats and politicians to run the COVID-19 response in Mumbai even after invoking the 'Epidemic Diseases Act' of 1897 in March, 2020, which provided scope for the Chief Minister to take over the running of the city and the emergency response.

In wave two, the political buy-in between local and state governments continued with open communication and an adequate budget allocation to improve and scale up infrastructure (Dalal, 2021). Likewise, local party members were called in at the grassroots level to ensure

that efforts were made at the ward level to efficiently manage the pandemic. Since ward level members of the local assembly (MLA) were members of the party, again there was clear communication lines between ward level and BMC HQ level as well as between political representatives and bureaucrats both at the ward level and city level.

Political buy-in was previously not discussed in detail in the framework itself. The idea that multiple actors played important roles during the pandemic is supported by our systems-thinking framework. However, we note that the type of key actors have changed between the two COVID-19 waves, and as the focus moved onto healthcare provision, the range of actors narrowed. Actors with key roles would bring distinct expertise and abilities to the COVID-19 response and the Mumbai Model was able to harness this. The Mumbai Model suggests that a robust response to a growing crisis needs to ensure that the type of key actors that are engaged in the response can evolve as the crisis unfolds.

6.2. Networks and partnerships

Strong networks and partnerships are important for knowledge and information to flow smoothly between actors according to our framework. During wave one newly constructed and fluid networks and partnerships between government, private sector enterprises, NPOs and citizens were formed to deal with the sudden emergence of a triple crisis. The framework suggests that actors at the periphery, such as NPOs, were able to act faster than actors at the core (e.g. Government) since they were less constrained by rules and habits regulating institutional behaviour. However, these networks did not feature prominently in wave two. The Mumbai Model instead focused on a smaller range of actors which allowed networks and partnerships to appear more solidified, as they were working on specific issues with defined ways of operating and dealing with them.

The second noticeable change between wave one and wave two is the central node of networks. Previously, networks were centred around the centralised BMC headquarters as the main hub and central node. However, in wave two, BMC decentralised decision-making to the ward war rooms. Therefore, while the BMC headquarters oversaw the work of all ward war rooms, and coordinated city-level efforts, the ward war rooms became central nodes for their individual networks as they became focal points of the relief efforts, and thus could be considered hubs within their own networks. Creating network hubs at the decentralised ward level allowed for individual connections to be formed, and for pre-existing connections with individual representatives of communities and healthcare facilities at the local level to be used. It is very likely that this facilitated a more efficient implementation of the crisis response locally than a more centralised and formalised structure.

Third, the BMC expanded its network in new ways, e.g., by working collaboratively with external actors to outsource activities that could be more efficiently run by them. Private pathology labs were contracted to run large scale testing. Consulting agencies analysed data

and trends. Likewise, to manage the ambulances, BMC turned to UBER to use their software to track ambulance movements in the city (Dalal, 2021). With the help of IIT-Bombay, crematoriums in the city were connected via an app so that information could be shared on where there was availability, and slots could be booked online, to ensure minimal queuing, and some degree of privacy and dignity (Hindu, 2021). The above two points are examples of how networks and partnerships need to evolve and adapt over time, as highlighted by the systems-based approach and our framework.

Fourth, we note that in both waves one and two, collaboration and communication between the state and local level governments appeared to have worked well. This is likely due to the fact that both governments are from the same party (Shiv Sena) – again, as noted in section 5, and that the headquarters of the Maharashtra government as well as the party headquarters are in Mumbai. This is likely to have created formal and informal channels of communication; and provided incentive structures to work for the common good as local and state level politicians were from the same party.

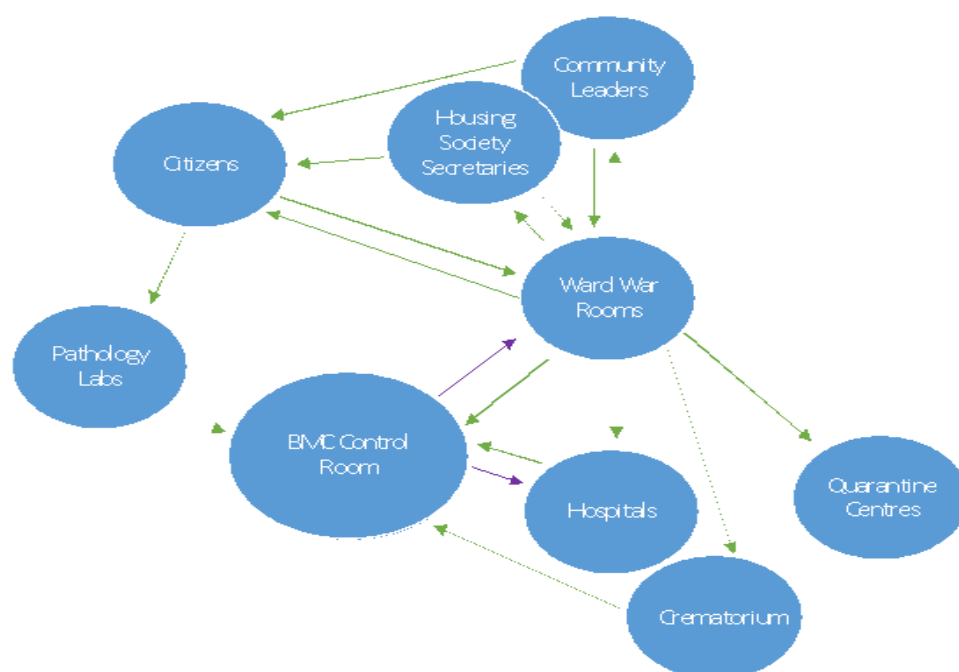
Overall, we find reconfiguration of networks and changes in network strengths from wave one to wave two, allowing for information to flow more efficiently (discussed in more detail in the next section), and for decisions to be taken based on up-to-date information in an efficient manner. In line with the framework, it is likely that Mumbai's robust response to wave two is in part because it was able to adapt and reconfigure its networks to better suit their adapted response to the evolving crisis.

6.3. Knowledge and information sharing

To react to new challenges, and learn from experience, efficient knowledge and information sharing needs to be in place according to the framework. During wave one, the information flow was primarily one-way as the government shared information with citizens, private enterprises and NPOs, including daily status updates, regular video addresses by the Chief Minister via social media and TV, and frequent press release.

In wave two, while the government continued to share frequent updates with residents, the knowledge sharing within the Mumbai Model became a two-way information flow. The BMC formalised the collection of information and built a dashboard showcasing information and data collected. The knowledge flows are highlighted with arrows in the Figure 3 and discussed in detail further below.

Figure 3: Information Flows within the Mumbai Model



Source: Authors own representation, drawing on Samuel and Panchal (2021).

As can be seen in Figure 4, ward war rooms were the first port of call for residents who suspected they had COVID-19. Citizens would then either get tested via government-provided facilities, or via private pathology labs. The test results from the pathology labs, were sent to the BMC headquarters and the concerned ward war rooms, in order to track the spread of COVID-19, to be able to prioritise the caseload, and to take quick action such as dispatch ambulances or activate BMC teams to seal flats (Tirodkar, 2021; Mohan, 2021; Hindu, 2021). Ward war room staff were central to these knowledge flows as they ran de facto call centres, taking calls from concerned residents and contacting them to verify whether they were able to isolate at home, needed to go to a quarantine centre or indeed to a hospital.

Another example of two-way knowledge flows relates to building society secretaries and community leaders in informal settlements, who would ensure that information from the BMC was provided locally to citizens and likewise they informed BMC ward war rooms of new cases and issues related to quarantine in the localities they operated in. These two-way knowledge flows resulted in continuous feedback loops between different actors in the system. These feedback loops, for example, led to efficient coordination and allocation of hospital beds within wards and across the city. Thus, the decentralised system with continuous data collections and knowledge sharing, allowed for city-wide coordination so

that resources could be put to use where they were most urgently required (Mariwala & Shah, 2021).

In sum, as noted in the framework, and detailed above, when information flows efficiently through the system creating feedback loops, it allows actors to sensibly allocate resources and swiftly act upon decisions. We find that the information flows evolved between waves one and two, from top-down during wave one to a two-way flow during wave two with additional feedback loops in place allowing more organised and continuous collection of data. At the same time, actor and network configurations became more formalised. Thus, in line with the framework, the evolution of knowledge flows and feedback loops in this way are likely central to the success of the Mumbai Model.

6.4. Hard and soft Institutions

Finally, the framework highlights that the role of hard institutions (rules and regulations) and soft institutions (behaviour, habits and practices) is worth noting as they govern the way actors engage with, and relate to, each other within a system, and thus influence the kind of partnerships that form, the configuration of networks, and the way knowledge and information flows.

During wave one, new behaviours were created through new enforced rules, such as staying at home for long periods of time during lockdown, wearing of masks outside of the home; and requests to the public to adhere to new best practices, including frequent and careful washing and sanitising of hands, and social distancing. By the time wave two arrived, these rules and best practices had become habits for the majority of residents. However, wave two saw new challenges in the form of maintaining social distancing discipline, maintaining the wearing of masks in public places, as well as maintaining quarantine for those at risk of infection of COVID-19. To ensure that these norms were followed, the BMC gave its staff the task to patrol public places and fine people for not wearing masks. Relating this back to the framework, hard institutions enforcing rules, were therefore used to ensure that soft institutions – the newly formed behaviours and habits of mask wearing and social distancing – were maintained, to slow the pace of the spread of COVID-19.

We find that hard institutions remained similar between waves one and two and in accordance with our framework. However, aspects of soft institutions changed, e.g., what were considered new behaviours in the wave one, had become regular habits by the time wave two hit. This change in soft institutions had not previously been considered in the framework.

Table 3: Systems perspective on evolution of COVID-19 response

Component	Wave one (03/2020-09/2020)	Wave two (02/2021-08/2021)	Implications for theory
Actors	Government helped by other actors like citizens, NPOs, enterprises in response to new and multiple crises.	Government primary actor; was prepared and managed healthcare crisis. BMC changed roles and created decentralised ward war rooms that adopted major implementation responsibility. Other actors less prominent.	Actors and their roles change over time. Non-government actors quick to respond but over time government is the primary first responder as system matures.
Networks	Government centre of network but multiple peripheral networks undertook work to ease triple crises. New partnerships formed to manage crisis and networks therefore evolved rapidly.	Government at centre of network thus bringing about stability with limited types of actors involved. Network structure decentralised with ward war rooms as hubs and main nodes for local action.	Structure and character of network change over time. Key nodes change as do key partnerships. Network appears fluid and ad hoc at first but matures over time to be organised as hubs and spoke.
Knowledge flows	Top-down information flows from government to citizen. Informal and often online citizen-citizen information sharing. Information sharing ad hoc and to firefight.	Top-down information from government remained. Organised, systematic and continuous data collection from bottom-up, top-down and laterally. Ward war room call centres a two-way channel between government and residents.	Knowledge flows change over time and formalise. Data collection and sharing processes enable consistent and continuous information sharing. Build capacity to analyse data and act on it.
Institutions	Learn new rules – wear mask, stay at home, limited travel; and recommended new behaviour such as hand washing, social distancing. Large number of policy and security to enforce new rules.	Learnt new behaviour such as staying at home, social distancing, mask wearing, and hand washing have become new habits. The way we live has changed with infrastructure set up for not leaving the house, i.e., working from home.	Over time new hard institutions such as rules about staying at home or washing hands or wearing face masks became newly learnt habits which in turn saw the development of new infrastructure.

Source: Authors' own, based on Duvendack & Sonne (2021).

7 Conclusion and recommendations

This paper applies the framework developed by Duvendack and Sonne (2021) to help us understand the systemic approach of the Mumbai Model, Mumbai's policy response to wave two of COVID-19.

We build on Chan (2020) and Few et al. (2020) and find that the Mumbai Model emerged as a pragmatic policy response enabling the local government to address a severe crisis making the most of scarce resources in a rapidly evolving context. We learn some important lessons from the case study of the Mumbai Model which may be useful for a wider policy and research audience. For example, governments cannot tackle a crisis of this magnitude by themselves, instead, a variety of diverse actors that collaborate effectively through a wide range of channels is crucial allowing information and knowledge to flow at all levels as outlined in Figure 4. Furthermore, decentralised and data-driven approaches to decision-making are crucial as is clear leadership as demonstrated by our case study. In addition, the Mumbai Model highlights the importance of political buy-in between bureaucrats and politicians as well as between politicians at the local and state levels. The civic body in Mumbai was able to respond quickly to the unfolding crisis of waves one and two in part due to political buy-in and open communication lines between the local city-level government and the state-level government.

We believe the combination of a decentralised and data-driven approach that Mumbai took, set it apart from other parts of India, such as in Gujarat (Israelsen & Malji, 2021) and in Delhi.

A system-thinking framework helps break down the complexities of crisis situations emphasising aspects of importance such as the role of actors, how they are linked via networks and partnerships, their function as bearers of knowledge and information sharers as well as the underpinning role of hard and soft institutions within these actors operate.

Overall, we find that our framework illustrates how using a systemic approach has helped the Mumbai Model to succeed. We find that changes have occurred between waves one and two as the policy response to the pandemic evolved and matured. We find that the key actors changed between waves one and two, from a broad set of actors to deal with multiple crises, to a narrower set of actors that focussed on the unfolding healthcare crisis. This resulted in a reconfiguration of networks and partnerships as BMC focussed on healthcare issues rather than on a wider range of different emergency responses as required by the first wave.

The decentralisation of decision-making further changed the structure of the networks to a hub and spoke model where ward level war rooms were crucial response centres within each ward. Ward war rooms therefore emerged in wave two as a new and key actor within the Mumbai Model. The stronger networks and more focussed area of work on healthcare emergencies, allowed for communication and feedback loops to work well, and

communication shifted from primarily top-down to two-way information flows aiming to support decision-making and resource-allocation through a data-driven approach.

The emphasis on data collection and analysis for decision-making was something our framework had hinted at. In wave two we saw how the focus on data collection and analysis as well as data driven decision-making enabled an efficient decentralised response. It is likely that this emphasis on data ensured that the decentralised decision-making and implementation structure was a success since it enabled two-way knowledge flows and rapid dissemination of information and knowledge. Without it, it might have been more difficult to take decisions in decentralised hubs and the structure may have relied more on direction and information from the central node, in this case the BMC HQ. Finally, we note that the evolutionary nature and systemic aspects of the Mumbai Model are clear to see throughout our case study. We find that the 'system' of the Mumbai Model as a whole changed between waves one and two.

While our research focused on wave two of COVID-19, this systems approach has wider applications, for example to climate change related crises such as flooding of a vast complex city such as Mumbai, which would require swift action and a two-way flow of information to assess the gravity of the situation and be able to prioritise response efforts. Likewise, using a similar approach to the Mumbai Model could be useful to tackle air pollution, which many Asian cities now face. Data collection points would enable local government to keep track of pollution levels while decentralised nodes could be put in charge of ensuring that anti-pollution measures are implemented and adhered to. Further research is required to better understand how national and local governments can build capacity and policy structures to enable systemic approaches to crisis management in a variety of contexts.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

ETHICS STATEMENT

This paper reports analysis of secondary sources.

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