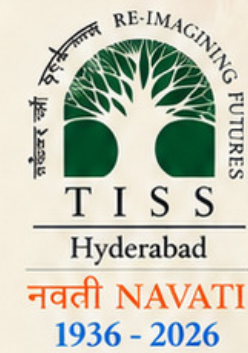


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MAPPING PANDEMIC
GOVERNANCE

*Geospatial Insights from COVID-19
in the Mumbai Metropolitan Region*

Dipak R. Samal

School of Public Policy and Governance, TISS Hyderabad

Working Paper No. 11
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Mapping Pandemic Governance

Geospatial Insights from COVID-19 in the Mumbai Metropolitan Region

Dipak R. Samal^{*}

Abstract

The coronavirus disease 2019 (COVID-19) pandemic tested the efficacy of health infrastructure, as well as the administrative management of urban areas, across the world. This study examines the impact of the COVID-19 pandemic across the nine municipal corporations of the Mumbai Metropolitan Region (MMR), one of the most densely populated regions of the world, with respect to their demography, new cases and deaths. The Kalyan-Dombivli Municipal Corporation (KDMC) recorded the highest incidence of COVID-19 cases, at 11.86 per cent of its population, while the Municipal Corporation of Greater Mumbai (MCGM), also known as the Brihanmumbai Municipal Corporation (BMC) and one of the largest municipal bodies in India, witnessed the lowest occurrence of COVID-19 cases, at 1.36 per cent of its population. This is remarkable, considering that, owing to its large slum population, the BMC is particularly vulnerable to any pandemic. The study therefore focuses on the spread of COVID-19 across the wards of Mumbai, one of the most populous municipal corporation jurisdictions in India, to understand the BMC's management strategies during the pandemic. Using a geographic information system (GIS), the study maps monthly COVID-19 cases and deaths from March 2020 to March 2022 across the municipal corporations of the MMR and the 24 administrative wards of the BMC, and overlays them with ward-level population density and slum population to examine the spatial spread of COVID-19 in the city. The ward-level mapping reveals that, despite relatively larger slum populations in certain wards, both COVID-19 cases and deaths there were relatively low, while some high-rise, high-mobility wards emerged as hotspots. Moreover, no significant correlation is observed between population density and either the number of cases or the number of deaths at the ward level.

Keywords: COVID-19, Mumbai, urban governance, GIS, geospatial analysis, slums

^{*} School of Public Policy and Governance (SPPG), Tata Institute of Social Sciences (TISS), Hyderabad, Telangana.
Email: samaldipak@gmail.com.

1. Introduction

The COVID-19 pandemic was an unprecedented crisis in terms of mortality, devastating many families across the world. It exposed the vulnerabilities of the global health care system and massively disrupted national economies. It brought entire commercial systems and public transport to a halt, challenging the capabilities and capacities of the prevailing systems to deal with the emerging situation.¹ The pandemic disrupted the global economy, and many people lost their lives and livelihoods and faced serious challenges in accessing health care facilities.² Among the hardest-hit countries, the USA, India, Brazil and Russia together accounted for over 50 per cent of all positive cases. The sharp rise in COVID-19 infections, particularly across developing countries, pushed health infrastructure close to breaking point.³ India's first case of COVID-19 was detected on 30 January 2020, and the first phase of the national lockdown was declared on 23 March 2020.⁴ Owing to the increasing number of COVID-19 cases, the Government of India extended the lockdown in a second phase until 3 May 2020, then to 17 May and eventually to 31 May 2020.⁵ The first COVID-19 wave peaked in September 2020. The second wave started in February 2021 and peaked in April 2021; it had a devastating impact, with widespread mortality across India.⁶ By July 2022, more than 42 million people had been infected, of whom 0.05 million (0.12 per cent) succumbed to the virus.

The impact of COVID-19 on a developing economy such as India was unprecedented; several measures initiated by the Government of India were reviewed and revised, and new mechanisms were devised in the light of the pandemic.⁷ India initiated a timely and proactive four-pronged con-

¹ M. Priya, D. R. Samal, and K. V. R. K. Ravi Kumar, "COVID Management Strategies and Techniques Adopted by the Municipal Corporations in the Mumbai Metropolitan Region", in *COVID 19, Containment, Life, Work and Restart: Urban Studies*, ed. T. M. Vinod Kumar (Singapore: Springer, 2022), 123–63, https://doi.org/10.1007/978-981-19-6183-0_3.

² B. Nath et al., "Risk Analysis of COVID-19 Infections in Kolkata Metropolitan City: A GIS-Based Study and Policy Implications", *GeoHealth* 5, no. 4 (2021): e2020GH000368.

³ L. H. Nguyen et al., "Risk of COVID-19 among Front-Line Health-Care Workers and the General Community: A Prospective Cohort Study", *The Lancet Public Health* 5, no. 9 (2020): e475–83, [https://doi.org/10.1016/S2468-2667\(20\)30164-X](https://doi.org/10.1016/S2468-2667(20)30164-X).

⁴ A. Ghosh, S. Nundy, and T. K. Mallick, "How India Is Dealing with COVID-19 Pandemic", *Sensors International* 1 (2020): 100021, <https://doi.org/10.1016/j.sintl.2020.100021>.

⁵ J. Saha, B. Barman, and P. Chouhan, "Lockdown for COVID-19 and Its Impact on Community Mobility in India: An Analysis of the COVID-19 Community Mobility Reports, 2020", *Children and Youth Services Review* 116 (2020): 105160, <https://doi.org/10.1016/j.childyouth.2020.105160>; The Lancet, "India under COVID-19 Lockdown", editorial, *The Lancet* 395, no. 10233 (2020): 1315, [https://doi.org/10.1016/S0140-6736\(20\)30938-7](https://doi.org/10.1016/S0140-6736(20)30938-7).

⁶ K. Balasubramani et al., "Spatio-temporal Epidemiology and Associated Indicators of COVID-19 (Wave-I and II) in India", *Scientific Reports* 14 (2024), <https://doi.org/10.1038/s41598-023-50363-2>.

⁷ Priya, Samal, and Ravi Kumar, "COVID Management Strategies".

tainment and management strategy. In addition to imposing a lockdown, concurrent measures were taken to gear up the health care system by boosting the production of protective gear such as masks and of requisite medical equipment such as ventilators. Moreover, large-scale public awareness campaigns and behavioural change with respect to personal and public hygiene were taken up for effective COVID-19 management at the national level.⁸ The Government of India used the Integrated Disease Surveillance Programme (IDSP) to maintain a decentralised, laboratory-based, information technology (IT)-enabled disease surveillance system. It enables the early detection of, and response to, outbreaks through trained Rapid Response Teams (RRTs).⁹

Maharashtra, one of the most urbanised and industrialised states, was the worst-hit state in India, with 18.16 per cent of the total COVID-19 cases and about 28 per cent of the deaths.¹⁰ Mumbai, Pune and Thane were among the most affected metropolitan areas in the state. In early April 2020, the state government recognised that the COVID-19 mortality rate in the state was double that of the rest of the country (7.41 per cent against the national figure of 3.35 per cent at the time). The state government constituted a medical task force to suggest measures to reduce the death rate and to improve the clinical management of critically ill COVID-19 patients, in coordination with the Indian Council of Medical Research (ICMR).¹¹ The mandate of the task force was to recommend suitable drug and patient management protocols to maintain uniformity in the COVID-19 treatment process. Nearly 70 per cent of the deaths in Maharashtra were in Mumbai. Soon thereafter, the Health Department of the Government of Maharashtra set up two committees, one for Mumbai and the other for the rest of Maharashtra, to analyse patient deaths and to reduce the number of fatalities.

The Mumbai Metropolitan Region (MMR) has a population of 23.59 million and is home to the country's busiest seaport and airport. Comprising Mumbai city and its suburban areas, it is one of the most densely populated urban agglomerations in the world. Mumbai is known as the financial capital of India and is also known for its large number of slums and its significant disparities in

⁸ U. Prasad et al., *Mitigation and Management of COVID-19: Practices from India's States and Union Territories* (New Delhi: NITI Aayog, 2020), <https://doi.org/10.7910/DVN/7MHJEM>.

⁹ Prasad et al., *Mitigation and Management of COVID-19*.

¹⁰ Ministry of Health and Family Welfare, Government of India, COVID-19 dashboard (National Informatics Centre), accessed 10 October 2025, <https://www.mohfw.gov.in/>.

¹¹ T. Lahane, "COVID-19: The Battle of Maharashtra", *Indian Journal of Ophthalmology* 69, no. 3 (2021): 477–78, https://doi.org/10.4103/ijo.IJO_100_21.

income, living conditions and access to basic services such as health care and education.¹² It is estimated that 9 million people live in slums,¹³ although unofficial estimates of the slum population are much higher.¹⁴ Slums are densely populated, with inadequate public services and limited access to sanitation and clean water.¹⁵ During the COVID-19 pandemic, slum areas were susceptible to infection, posing not only a significant public health challenge but also demanding innovative and pragmatic approaches to containment.¹⁶ The spread of COVID-19 is influenced not only by population concentration but also by social and living conditions.¹⁷ Specifically, social factors such as housing, the physical environment, food and poverty have been shown to be determinants of COVID-19 infection and mortality.¹⁸ The megacity of Mumbai was one of the worst-hit cities in the world. Despite all the adversities, its COVID-19 management model (“chasing the virus”) was considered a benchmark for other parts of India.¹⁹

The urban local bodies (ULBs) in the MMR performed fairly well in managing COVID-19. Several hotspot zones with very high case numbers were declared and isolated from the rest of the city for a few weeks until the situation improved. The BMC adopted a proactive approach based on the 4Ts (tracing, tracking, testing and treating) rather than waiting for cases to appear. As a result, the number of new cases and deaths declined.²⁰ The challenges in slum areas were enormous during the COVID-19 period, as people lived in small spaces where maintaining COVID-19 protocols was difficult. Additionally, slum inhabitants depended on community toilets, where the chances of infection were also higher. Comprehensive multisectoral planning was therefore launched to facilitate

¹² M. Duvendack and L. Sonne, “Responding to the Multifaceted COVID-19 Crisis: The Case of Mumbai, India”, *Progress in Development Studies* 21, no. 4 (2021): 361–79, <https://doi.org/10.1177/14649934211030449>; S. Bhattacharjee and S. Sattar, “COVID-19 Pandemic and the Poor in the Urban Spaces of India with Special Reference to Mumbai”, *Equality, Diversity and Inclusion: An International Journal* 41, no. 1 (2021): 64–79, <https://doi.org/10.1108/EDI-07-2020-0196>.

¹³ Ghosh, Nundy, and Mallick, “How India Is Dealing”.

¹⁴ M. K. Jha, *Pandemic Precarity and the Complicated Case of Maharashtra* (Helsinki: UNU-WIDER, 2022).

¹⁵ V. Tandel et al., “Infrastructure, Enforcement, and COVID-19 in Mumbai Slums: A First Look”, *Journal of Regional Science* 62, no. 3 (2022): 645–69, <https://doi.org/10.1111/jors.12552>.

¹⁶ M. Golechha, “COVID-19 Containment in Asia’s Largest Urban Slum Dharavi-Mumbai, India: Lessons for Policymakers Globally”, *Journal of Urban Health* 97, no. 6 (2020): 796–801.

¹⁷ K. Mukherjee, “COVID-19 and Lockdown: Insights from Mumbai”, *Indian Journal of Public Health* 64, no. 6 (2020): 168–71.

¹⁸ E. M. Abrams and S. J. Szefer, “COVID-19 and the Impact of Social Determinants of Health”, *The Lancet Respiratory Medicine* 8, no. 7 (2020): 659–61, [https://doi.org/10.1016/S2213-2600\(20\)30234-4](https://doi.org/10.1016/S2213-2600(20)30234-4); K. Sasikumar et al., “Impact of Extreme Hot Climate on COVID-19 Outbreak in India”, *GeoHealth* 4, no. 12 (2020): e2020GH000305, <https://doi.org/10.1029/2020GH000305>.

¹⁹ Golechha, “COVID-19 Containment”.

²⁰ Bhattacharjee and Sattar, “COVID-19 Pandemic and the Poor”; S. Alexander and S. Bhatia, “Mapping Mumbai’s Slum Challenge in Coronavirus Battle”, *Mint*, 2020, accessed 11 October 2025.

effective COVID-19 management, engaging people's representatives, non-governmental organisations (NGOs), citizen volunteers, policymakers, civil society and other key stakeholders.²¹ The Mumbai city police were in charge of ensuring compliance by monitoring crowded places through drones and using loudspeakers to spread awareness and warnings about COVID-19.

While several studies have highlighted the COVID-19 scenario in India and Maharashtra, very few have focused on the Mumbai Metropolitan Region. In particular, limited scholarly attention has been given to how Mumbai and its surrounding areas managed the pandemic. The present study therefore examines the situation across the wards of Mumbai, which have diverse demographic characteristics. It examines the COVID-19 management strategies implemented across all ULBs within the MMR, with a particular emphasis on the Brihanmumbai Municipal Corporation (BMC).

2. Study Area

This study covers the MMR, located along the Arabian Sea, which extends over an area of 6,328 km² and covers parts of the Thane, Palghar and Raigad districts of Maharashtra state, India (Figure 1). The MMR, comprising Mumbai city – the financial capital of India – and its suburban areas, is one of the most densely populated urban agglomerations in the world. As per the 2011 census, Mumbai is the largest urban agglomeration in India. The MMR is governed through nine municipal corporations (ULBs for populations of over 1 million), an equal number of municipal councils (ULBs for populations of 0.1–1 million) and more than a thousand nagar panchayats. The municipal corporations are the Brihanmumbai Municipal Corporation (BMC), Thane Municipal Corporation (TMC), Kalyan-Dombivli Municipal Corporation (KDMC), Navi Mumbai Municipal Corporation (NMMC), Mira-Bhayandar Municipal Corporation (MBMC), Vasai-Virar Municipal Corporation (VVMC), Bhiwandi-Nizampur Municipal Corporation (BNMC), Ulhasnagar Municipal Corporation (UMC) and Panvel Municipal Corporation (PMC). Among the nine municipal corporations, Mumbai has the highest population density (26,632 persons per km²) and Vasai-Virar the lowest (6,621 persons per km²).

²¹ Duvendack and Sonne, "Responding to the Multifaceted COVID-19 Crisis"; S. Khaparde et al., "Interventions to Respond to COVID-19 Pandemic in Mumbai and Way Forward", *Indian Journal of Tuberculosis* 69, no. 2 (2022): 234–37, <https://doi.org/10.1016/j.ijtb.2021.04.013>.

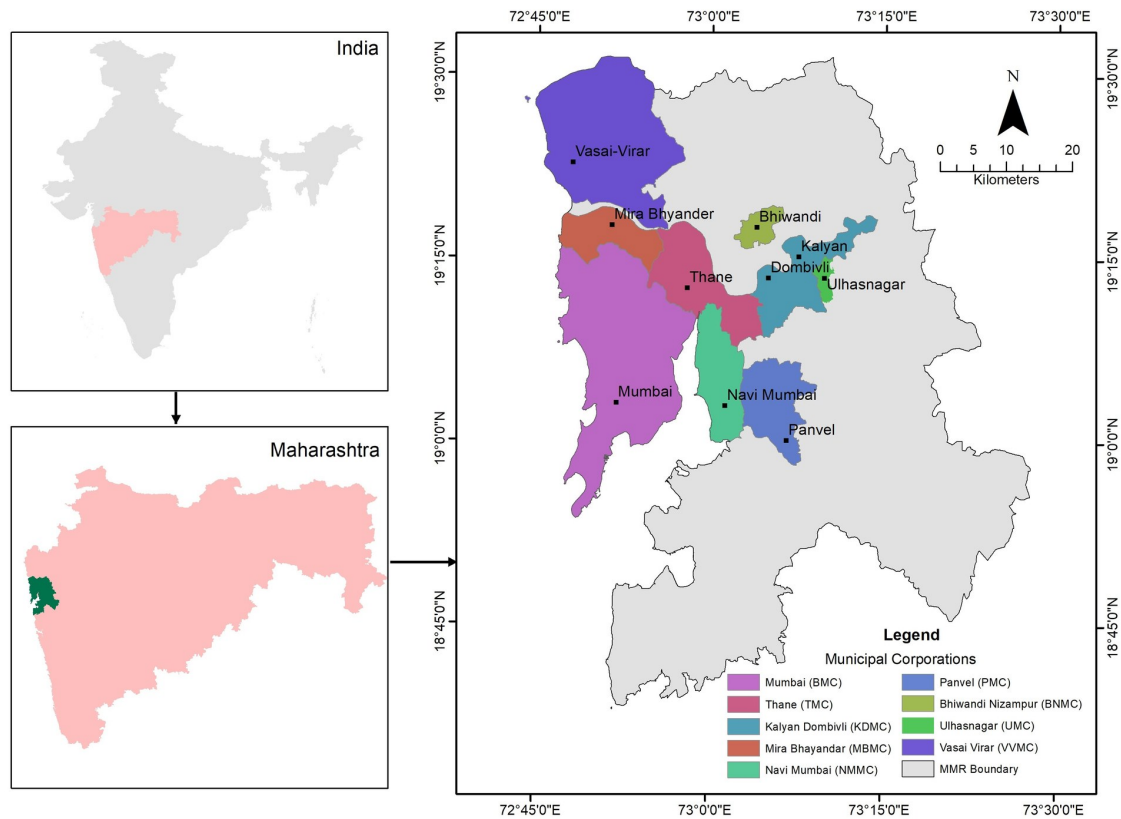


Figure 1: Study area: Mumbai Metropolitan Region (MMR)

3. Data, Materials and Methods

The study was conducted in two phases. In the first phase, COVID-19-related datasets, including daily new cases and deaths from March 2020 to March 2022, were collected and compiled for all the municipalities in the MMR. In the second phase, a thematic database was developed to analyse and visualise the severity of the COVID-19 impact within the BMC and other ULBs. In addition, data on the total population and slum population of the BMC were added to investigate the underlying relationship between demographic structure and COVID-19 cases. For Mumbai, every ward was mapped for COVID-19 cases and other population attributes.

Data on daily reported COVID-19 cases and deaths were collected from the respective municipal corporations for March 2020 to March 2022, covering the first, second and third waves of the pandemic. In addition, ward-wise data on the total and slum populations of the BMC were compiled, along with new COVID-19 cases and reported deaths. The datasets were aggregated and analysed on a monthly basis. Missing values during the study period were addressed by imputing averages from adjacent days. GIS techniques were employed to visualise and analyse the COVID-19 scenario both at the municipal corporation level and across individual wards within the BMC. To

complement the quantitative data, officials involved in COVID-19 management were contacted to understand the ground realities during the pandemic. Furthermore, local and national newspapers were systematically reviewed to corroborate the trends observed in the datasets. Statistical techniques were employed to examine the relationship between slum population and the incidence of COVID-19 cases and deaths within the BMC.

4. Results and Discussion

The total number of COVID-19 cases across all the ULBs reveals that the highest percentage of the population (11.86 per cent) was infected in the area under the jurisdiction of the KDMC, followed by the PMC (9.93 per cent) and the BMC (8.52 per cent) (Figure 2). The BNMC was the least affected, with only 1.36 per cent of its population infected. Despite having the highest population density, the BMC reported only 8.52 per cent of its population affected, while the remaining ULBs reported cases among less than 5 per cent of their populations. The differential spread of infection reflects the diversity among ULBs in terms of demographic composition, population density and COVID-19 management strategies. The highest number of cases, in the KDMC, is attributed to violations of COVID-19 norms and public negligence of social distancing and mask-wearing in public places. In addition, more cases were reported from housing complexes than from slum areas.²² In contrast, the BMC was credited for its preparedness through decentralised planning, real-time monitoring and the optimal use of medical resources to contain the spread of COVID-19 in a highly dense region of India.²³ The lower number of cases is also attributed to the “chasing the virus” model adopted by the BMC,²⁴ which involved tracing, testing, tracking and treating (the 4Ts) positive cases before the situation worsened.

The month-wise COVID-19 positive cases across all the ULBs reflect the severity of the second wave in the MMR (Figure 3). All ULBs experienced a relatively higher number of cases during the second wave. The KDMC had the highest number of cases during both the first and the second waves. In the third wave, the BMC showed a significant rise in the number of cases in comparison with other ULBs. In January 2022 in particular, the numbers were very high, which is attributed to the

²² S. Nambiar, “Kalyan Leads with Highest Progressive COVID-19 Cases in MMR”, *Hindustan Times*, 2021, <https://www.hindustantimes.com/cities/mumbai-news/kalyan-leads-with-highest-progressive-covid-19-cases-in-mmr-101618256677994.html>.

²³ World Health Organization (WHO), “Decentralisation and Planning Helped Mumbai Fight the Second COVID-19 Surge”, feature story, 2021, <https://www.who.int/india/news-room/feature-stories/detail/decentralisation-and-planning-helped-mumbai-fight-the-second-covid-19-surge>.

²⁴ Golechha, “COVID-19 Containment”.

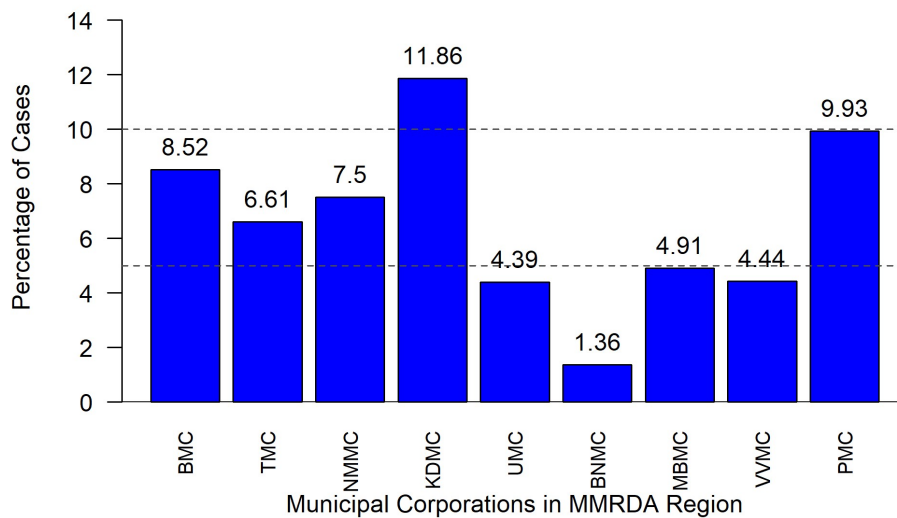


Figure 2: Proportion of COVID-19 cases in the urban local bodies (ULBs) of the MMR

changing nature of the virus. As a result, new COVID-19 restrictions were introduced to contain the rise in cases in the BMC. The local government imposed a night curfew and shut public places such as swimming pools, gyms, spas, parks, zoos, museums and forts.²⁵ In January 2022, the BMC reported an unprecedented 15,000 cases in a single day. Unlike the second wave, the third wave was not very fatal, and most of the cases were asymptomatic.²⁶ Most of the cases were from high-rise buildings, while fewer cases were observed in slum areas, although it had been presumed during the pandemic that slum areas would be the worst hit owing to their dense populations and unhealthy living conditions. The data and observations obtained from the ground, however, proved this presumption wrong: despite the large slum clusters in Mumbai, most of the cases were confined to high-rise buildings.

The study then examined the COVID-19 scenario in the Mumbai city area, which has a total population of nearly 12.8 million and is divided into 24 wards for administration. It is the most densely populated urban settlement in the country and falls under the administrative jurisdiction of the

²⁵ “Maharashtra Government Announces New COVID Restrictions”, *Indian Express*, 2022, <https://indianexpress.com/article/cities/mumbai/mumbai-news-live-bmc-rt-pcr-test-airport-covid-omicron-7706853/>; P. Upadhyay, “Amid COVID-19 Surge, Private Hospitals in Mumbai See Increased Bed Occupancy”, *India Today*, 8 January 2022, <https://www.indiatoday.in/coronavirus-outbreak/story/mumbai-covid-19-private-hospitals-increased-bed-occupancy-omicron-1897535-2022-01-08>.

²⁶ S. R. Choudhury, “Mumbai Is ‘Prepared for the Worst’ as Third COVID Wave Sweeps India, City’s Municipal Commissioner Says”, *CNBC*, 6 January 2022, <https://www.cnbc.com/2022/01/06/india-covid-commissioner-on-omicron-cases-impact-on-mumbai-hospitals.html>.

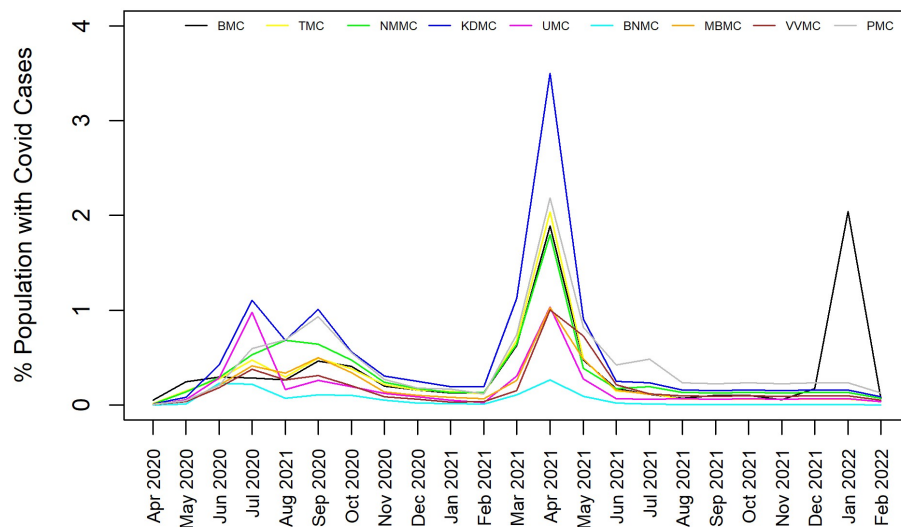


Figure 3: Month-wise distribution of COVID-19 cases in the MMR

BMC, the richest urban local body in India. Population densities at the ward level range from less than 10,000 to more than 50,000 per km². Nearly 40 per cent of the population lives in slums,²⁷ where the chances of the spread of COVID-19 were extremely high. The number of COVID-19 cases and deaths and the total and slum populations were therefore considered for further analysis. The data exhibit a strong positive correlation between the number of positive cases and deaths reported across the wards of the BMC (Figure 4). The ward population density ranges from less than 10,000 to more than 50,000 per km² (Figure 6a). The scatter plot reflects a weak correlation between density and the number of cases (Figure 7a). In fact, a few wards with relatively higher population densities have fewer COVID-19 cases. Population density also has no significant relationship with the number of COVID-19 deaths (Figure 7b). Despite large slum populations in a few wards, the number of COVID-19 cases has not been very high (Figure 8a). Similarly, the number of deaths in relation to slum population does not show a clear trend across the BMC (Figure 8b). A few wards with significant slum populations recorded very few COVID-19 cases and deaths. This defies the notion that slums would be severely affected by COVID-19. It is important to highlight that the wards of the BMC are very porous in terms of the movement of people for jobs and livelihoods.²⁸ The ward-wise COVID-19 cases indicate a diverse scenario, with cases ranging from

²⁷ N. Chatterjee, R. Singh, and M. Venkaiah Naidu, *Slums in India: A Statistical Compendium* (New Delhi: National Buildings Organisation, Ministry of Housing and Urban Poverty Alleviation, Government of India, 2015).

²⁸ Mukherjee, "COVID-19 and Lockdown".

less than 10,000 to nearly 100,000 (Figure 5a). The highest number of cases was recorded in K/W ward (Juhu, Andheri West), followed by K/E ward (Airport, Andheri East) and R/C ward (Borivali, Gorai). K/W ward has a higher population density than many other wards and is close to the airport; as a result, its number of cases is higher than in other wards.²⁹ In contrast, the fewest cases were recorded in ward B, followed by wards C and A. In terms of deaths, K/E ward recorded the highest number, followed by S and R/C wards. As with COVID-19 cases, the number of deaths was lowest in ward A, followed by wards B and C. These wards consistently reported lower numbers of both COVID-19 cases and deaths. Other research likewise argues that placing too much blame on urban density is a mistake,³⁰ and previous studies have contradicted the view that denser cities are more vulnerable to pandemics.³¹ The findings reveal that the COVID-19 pandemic had a varied impact across the wards of Mumbai, associated with the unequal socio-economic conditions that prevail across the city.³²

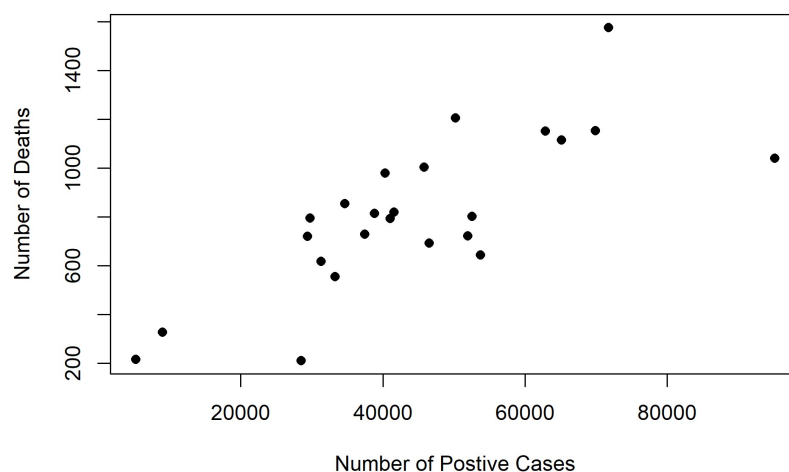


Figure 4: Relationship between COVID-19 cases and deaths in the BMC

²⁹ P. Acharya, “Mumbai Logs 119 COVID-19 Infections; Andheri, Juhu Areas Have Most Active Cases”, *Hindustan Times*, 2022, <https://www.hindustantimes.com/cities/mumbai-news/mumbai-logs-119-covid-19-infections-andheri-juhu-areas-have-most-active-cases-101645722912069.html>.

³⁰ J. Barr and T. Tassier, “Are Crowded Cities the Reason for the COVID-19 Pandemic?” *Scientific American* (blog), 2020, accessed 15 October 2025, <https://www.scientificamerican.com/blog/observations/are-crowded-cities-the-reason-for-the-covid-19-pandemic/>.

³¹ S. Panda and S. Ray, “Exploring Urban Dynamics of Crowding with COVID-19 Incidence: A Case Study of Mumbai and Bengaluru City in India”, *Journal of Urban Management* 10, no. 4 (2021): 345–56.

³² S. Bhattacharjee and S. Sattar, “Pandemic and Urban Sustainability: Analyzing the COVID-19 Scenario in Mumbai, India”, *Geography, Environment, Sustainability* 14, no. 1 (2021): 17–24.

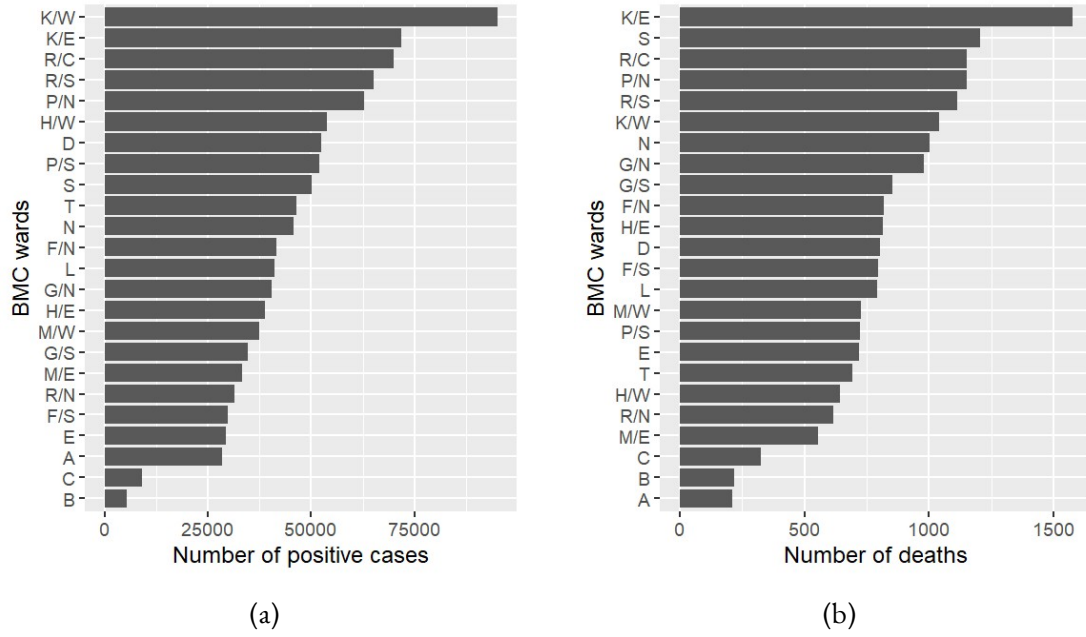


Figure 5: Number of COVID-19 (a) cases and (b) deaths in the BMC

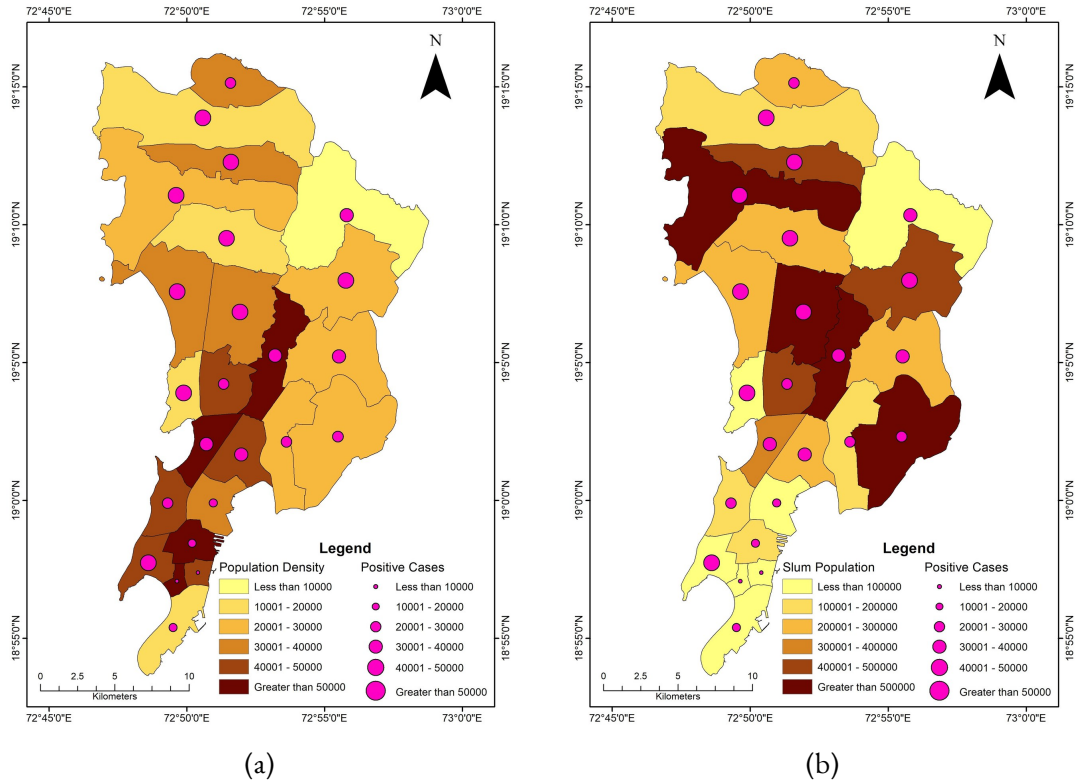
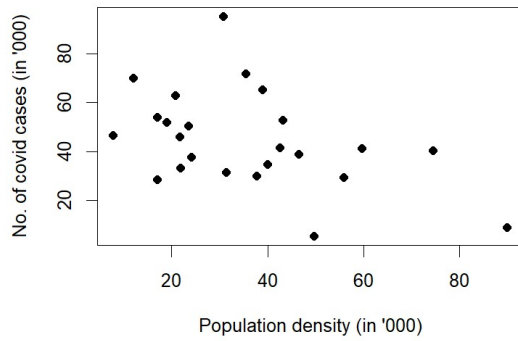
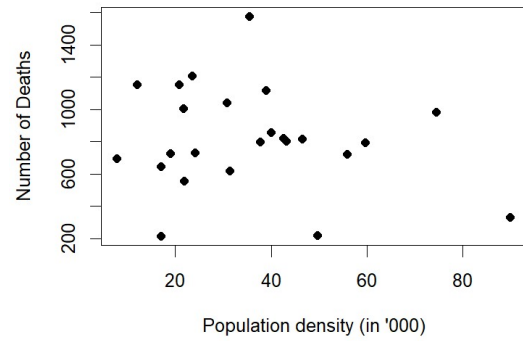


Figure 6: Distribution of COVID-19 cases with respect to (a) population density and (b) positive cases in the BMC

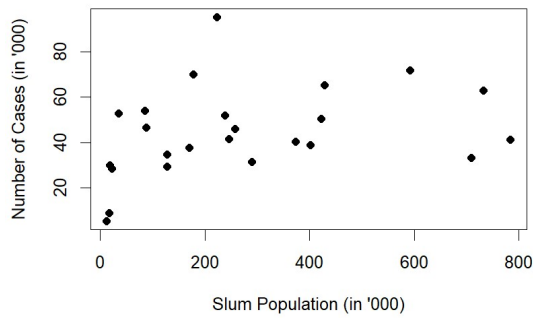


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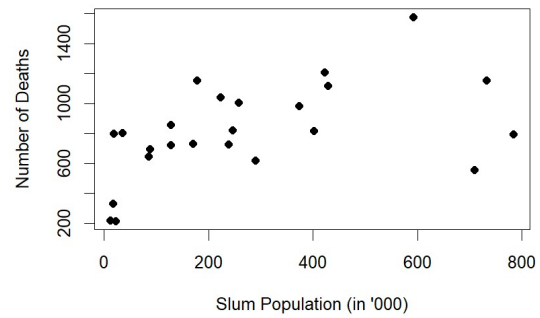


(b)

Figure 7: Relationship between population density and COVID-19 (a) cases and (b) deaths in the BMC



(a)



(b)

Figure 8: Relationship between slum population and (a) positive cases and (b) deaths in the BMC

5. Conclusions

The present study demonstrates a data-driven approach to assessing the COVID-19 pandemic situation in the Mumbai Metropolitan Region. The analysis of the spread of COVID-19 across the ULBs of the MMR and within the wards of the BMC underscores that infection rates were shaped less by sheer population density or slum concentration and more by socio-economic diversity, governance strategies and the behavioural responses of communities. While the KDMC recorded the highest infection rates owing to negligence and violations of norms, the BMC demonstrated the effectiveness of decentralised planning, real-time monitoring and the “chasing the virus” model in containing the spread despite extreme density. The ward-level data further reveal that slum clusters did not experience the anticipated severity, with high-rise complexes emerging as hotspots, and that deaths correlated more strongly with case numbers than with density or slum population. Some BMC wards, such as A, B and C, consistently reported fewer cases and deaths, probably owing to lower mobility, smaller populations and relatively better compliance with restrictions. These findings challenge the conventional assumption that urban density alone drives pandemic vulnerability, highlighting instead the critical role of socio-economic inequalities, preparedness and adaptive governance in shaping the trajectory of COVID-19 across the MMR and Mumbai.

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