



## CASE STUDY

### How the largest slum in India flattened the COVID curve? A Case Study

Monalisha Sahu<sup>1</sup>, Madhumita Dobe<sup>1</sup>

<sup>1</sup> Department of Health Promotion and Education, All India Institute of Hygiene and Public Health, West Bengal, India.

**Corresponding author:** Monalisha Sahu;

Address: 110, Chittaranjan Avenue, Kolkata - 700073, West Bengal, India.

Telephone: +91 9873927966

E-mail: drmonalisha@outlook.com

## Abstract

Mumbai-The economic capital of India, shrivelled with panic as its infamous slum ‘Dharavi’ recorded its first positive case of COVID-19 on 1st April 2020. Dharavi is the largest slum in India and one of the most densely populated areas in the world. Its narrow lanes, teeming with people and chock-a-block with settlements, make physical distancing practically impossible- posing as an excellent breeding ground for the deadly virus. However, with a policy of ‘chasing the virus’ based on strategy of ‘Tracing Tracking Testing and Treating’ Dharavi flattened its epidemic curve within a hundred days. This was achieved through the immediate public health response with strict containment measures, aggressive active and passive surveillance and integration of resources from government and private sectors to provide essential services. In this paper, we have summarized the ongoing measures for successful prevention and control of COVID-19 in Dharavi, which could provide useful learning for other similar settings worldwide.

**Keywords:** containment measures, COVID-19, India, megacity-slum, Mumbai.

**Conflicts of interest:** None declared.

**Acknowledgments:** To the health staff and officers of Brihan Mumbai Corporation.

**Author Contributions:** MS conceptualized the idea and wrote the first draft; MD & MS reviewed and edited the final version. All authors have read and agreed to the published version of the manuscript.

## Background

On the first day of April 2020 when the first case of COVID-19 got diagnosed with subsequent death in Baliga Nagar Dharavi, Mumbai authorities sensed their worst nightmare was about to begin. People feared that the deadly virus may have already possibly taken a firm grip on the overcrowded shanties. What followed next was several deaths one after another as the SARS CoV-2 virus started spreading swiftly even amidst nationwide lockdown with a growth rate of 12% and doubling period of 18 days (1, 2). It took a little over a fortnight for Dharavi to add 100 cases to its tally and by May 3, it crossed the 500 mark. Till May 6, the doubling rate of COVID-19 cases in Dharavi was shortened to six days. Subsequently, Dharavi emerged as one of the most challenging hotspots in India (3).

Multiple strict measures to contain the spread have been implemented since the beginning of the outbreak in Dharavi in April 2020. These measures resulted in the low spread of cases and reduced mortality by June 2020.

This paper aims to focus on documenting the control measures taken to stop the spread of COVID-19 in one of the world's densest slums. The information presented in the paper was obtained through the analysis of recent policies, official press, articles, reports, presentations, and credible data sources. A thematic approach to analysis was used to identify the emerging lessons, which then informed the structure of the reported results. MS excel and Google Maps were used for processing the data and preparing spot maps of the containment zone.

## I. What makes Dharavi such a ticking time bomb?

Located in the G North municipal ward of Mumbai, Dharavi is home to around 1 million people living in a 2.16 square kilometres maze of narrow, haphazard, dirty lanes, in shanties and ramshackle buildings next to open sewers. Its narrow passages, overcrowded houses, miserable, unsafe and unhygienic living conditions offer the perfect breeding ground for pathogens like SARS CoV-2 (4).

**Figure 1. Administrative map of Mumbai with Ward Divisions (4)**



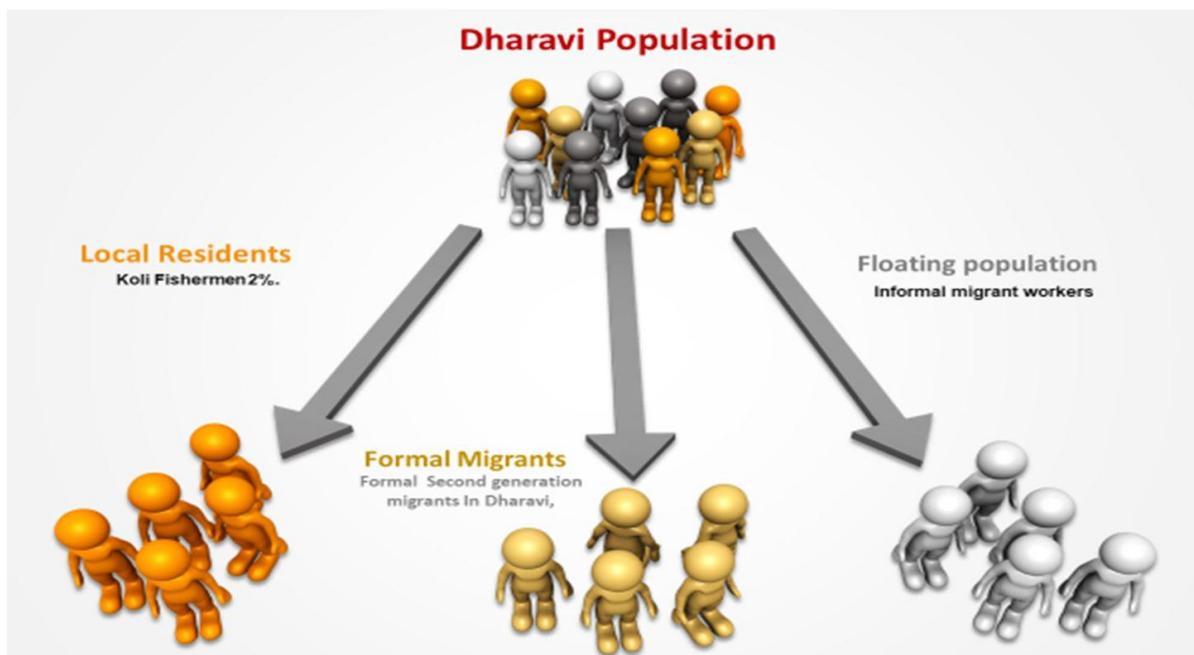
\* Dharavi is located in G North ward of Mumbai with Mahim & Dadar.

## II. The Socio-demographic Milieu

Dharavi is home to an estimated one million people with a population density of 270,000 per square kilometre, living mostly in G+1 low rise building, where upper floor act as factories (2). They mostly eke out a living as factory workers in some 5,000 small factories and 15,000 single-room workshops of leather, pottery and textile stitching businesses. Many of its residents' work as helpers and chauffeurs to the financial capital Mumbai's well-heeled residents. Dharavi also serves as the plastic recycling hub of Mumbai.

The original inhabitants of Dharavi were Kolis the fishermen but today their number is less than 2%. Majority of Dharavi population is made of migrants both formal and informal mostly from other districts of Maharashtra, Tamil Nadu, Gujrat, UP and Bihar (5). There has been slight increase of migrants from UP and Bihar over the last few years, and they mostly form the informal floating population of Dharavi. Most of them are informal daily-wage workers who don't cook at home and go out to get their food on daily basis.

**Figure 2. Segmentation of residents living in Dharavi\***



\* Formal Migrants are mostly from states of other parts of Maharashtra, Gujrat and Tamilnadu, whereas floating population is mostly from states of Uttar Pradesh & Bihar.

The situation became worse for the migrant workers when in view of the ongoing COVID-19 pandemic, India went into nationwide lockdown on March 25, 2020, for maintaining adequate social distance to stop spread of the disease (1). Many of the migrant

workers living in Dharavi left for their villages before the lockdown could be strictly implemented, possibly taking the virus far and wide. However, an even bigger number of migrant workers were struck in the slum with no money to buy food or other essential items.

### III. Unsafe Physical Environment

Urban slums of Dharavi constitute one of the most disadvantaged sections of society. Health is a major challenge in the slums of Dharavi, where the struggles to maintain it are faced with multi-layered challenges like:

- a. Overcrowding: In Dharavi eight to 10 people live typically in a cramped 150 sq. ft shanty with no natural light or ventilation and without provision for safe drinking water, sanitation or other basic services.
- b. Poor Sanitation: Most of the (80%) slum households did not have a private toilet facility inside their homes (2). The limited public lavatories they share are filthy, unhygienic and unsafe. Mahim Creek is a local river that is widely used by local residents for open urination and defecation. Also, the open sewers in the city drain to this creek facilitating the spread of contagious diseases.
- c. Unsafe Drinking water: In Dharavi 30% of the residents don't have kitchen in their houses and depend on outside food (6,7). Almost 35% of the residents need to step out of their homes to collect drinking water from public taps, tube wells, and wells stationed throughout the slum (6,7). Insanitary conditions coupled with people crowding around public taps and toilets makes social distancing impossible. Also, hourly restrictions on water availability adds to the challenge of washing hands to keep away from infection.

There is low acceptance for preventive measures amidst other pressing challenges like food, water and shelter. Even simple precautionary measure like regular hand washing and physical distancing are privileges they are unable to afford. They only realize the need for health when it is lost and then

most of them are not in position to afford existing medical services.

In addition, within a densely packed slum like Dharavi many people lack even a postal address, which itself poses unique challenges for health care services.

### IV. The First Few COVID-19 cases and contacts transmission investigation (FFX)

The index case reportedly was a 56-year-old garment unit owner living in a 320 sqm flat in Slum Rehabilitation Authority (SRA) Colony, Baliga Nagar. He initially developed mild cough and fever on 23<sup>rd</sup> April [8]. When his symptoms worsened even after consulting a local doctor, he was referred and admitted to the civic-run Sion Hospital where his throat swab was sent for testing. By the time the reports came positive for COVID-19 he succumbed to the disease.

A five-member team consisting of two medical officers, a sanitary inspector (SI) and two community health volunteers (CHVs) started contact tracing to identify source of infection and plan how to contain it. The team fanned out in the area to inspect the building and the common spaces between closely constructed squad of five buildings. The area had eight buildings comprising of 300 flats and 91 shops (8,9).

During contact tracing it was found that the index case had possibly hosted some people who had attended a religious congregation in Nizamuddin Delhi in March, which was India's first big cluster of COVID-19 cases (10). Based on contact tracing, a list of 15 immediate high-risk contacts including the deceased's wife, his four sons, two daughters, immediate neighbours, the local doctor the man had visited and two of the staff at the doctor's clinic were identified and tested. The family's acquaintances were categorized as low risk and alerted. With the help of pest control officers (PCO) the entire building

was disinfected and sealed. The Sion Hospital OPD, was shifted outdoors while the building was sanitized.

The entire Baliga Nagar Housing Society was sealed and declared containment zone with about 2,500 residents stamped for quarantine. Parallely, a nearby sports complex was converted into a 300-bed facility for isolation. A team of police was stationed outside the colony to ensure the quarantine is not violated. A containment officer (CO) was deployed at the site to coordinate with the police, the BMC and the residents to ensure the residents get essential supplies like food, milk, water and medicines every day. In addition, six volunteers were identified who could step out for essentials on rotation basis. Elderly people with co-morbidities like hypertension, asthma and diabetes were screened and nine particularly vulnerable people with respiratory illness were tested. Apart from it, 75 people who came in contact of the visitors from Delhi were isolated, in an attempt to break the chain of infection.

Second case was reported within 24 hrs as a 52-year-old conservancy worker from Worli who was on duty in Dharavi. Third case was of a surgeon resident of Vaibhav Apartment

Within a span of one month, around four lakh residents in Dharavi were screened for the symptoms of Covid-19 by teams of 24 health practitioners. Around 47,500 people were screened in high-risk zones by door-to-door visits by doctors and private clinics, about 14,970 people were screened with the help of Mobile Vans, and rest were surveyed by BMC health workers. Out of these, 2,000 were suspect cases and 600 were subjected to tests. Following the screening, about 5,857 were put in institutional quarantine and 31,725 residents were directed to remain under home quarantine. Also, around 8246 Senior Citizens were surveyed and as part of its

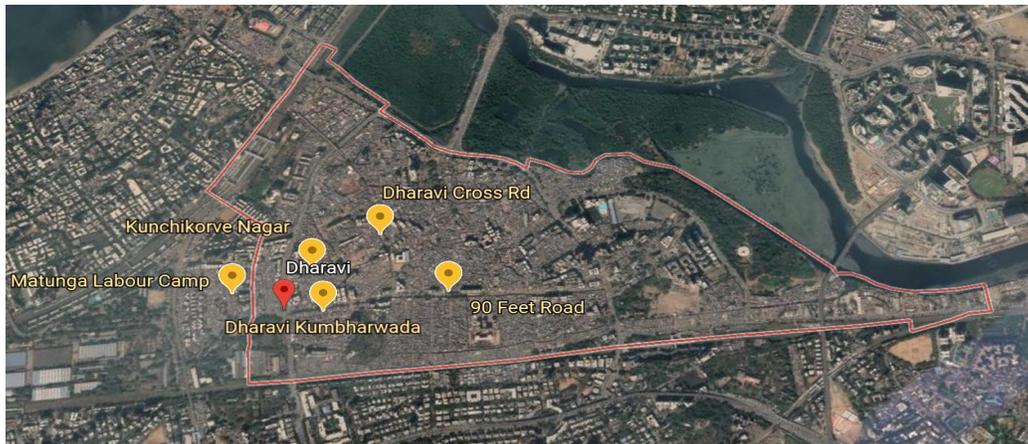
in Dharavi, who was working with one private Hospital, which had earlier reported many infections among its healthcare workers. The doctor's wife also tested positive later. So, all these cases had different source of exposure and were in building setup. The real alarm was set off on 4<sup>th</sup> April when a positive case was reported from a slum shanty of Mukund Nagar, where a 48-year-old-man living with his 11 family members in a two-room house (100 sq. ft) came positive.

Due to emerging of multiple cases from multiple parts of Dharavi, medical camps were started to screen people in areas with multiple cases. Gauging the increasing spread Maharashtra Medical Council officials in collaboration with BMC started active surveillance of cases by door-to-door screening. By 25<sup>th</sup> April total 214 active cases and 13 deaths were recorded mostly from the areas of Mukund Nagar, Azad Nagar, Dharavi Cross Road, Matunga Labour Camp and Indira Nagar. Individual slum pockets were grouped together to form high risk zones based on the case load. Five such slum pockets in Dharavi were identified as hot spots and marked as high risk/red zones (11).

policy of 'Timely Separation' from the other community to effectively limit the transmission (2).

Even with all ongoing activities, a whopping 1,400 COVID-19 patients were added to the tally by mid-May, a figure almost 380 percent higher than the April figures. With a rise in containment zones to 202 from a mere 49 such zones at the end of April, the hotspots or high-risk zones increased to 10 from five with Matunga Labour Camp, 90 ft road, Dharavi Cross Road, Kunchi Korve Nagar being the particular focus areas due to rising cases (12)

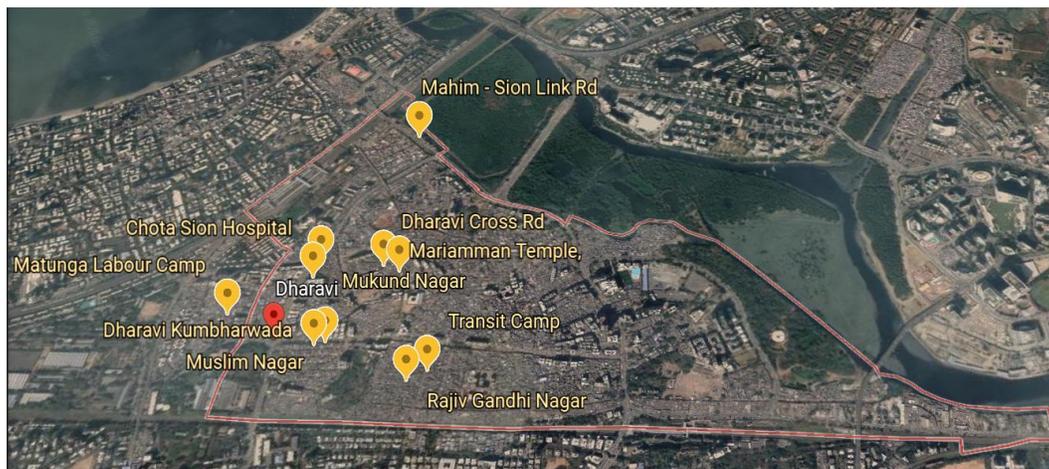
**Figure 3. Spatial distribution of five high-risk zones for COVID-19 outbreak in Dharavi as on 25<sup>th</sup> April 2020**



**Legend:**

-  Dharavi
-  Borders of Dharavi
-  5 Hot Spots of COVID-19 (Dharavi Kumbharwada, Dharavi Cross Road, Matunga Labour camp, KunchiKorve Nagar, 90 Feet Road).

**Figure 4. Spatial distribution of high-risk zones of Dharavi as on 23<sup>rd</sup> May 2020**



**Legend:**

-  Dharavi
-  Borders of Dharavi
-  10 Hot Spots of COVID-19 (Mahim Sion Link road, Rajiv Gandhi Nagar, Mukund Nagar, Marlyamma temple, Muslim Nagar, Transit Camp, Kumbharwada, Matunga Labour Camp, Chota Sion Hospital and Dharavi Cross Road).

The maximum number of cases in Dharavi were reported from the Matunga Labour Camp (55 cases), followed by Mukund Nagar (49 cases), Kumbharwada (45 cases) and Dharavi Cross Road (38 cases). Majority of cases in Dharavi (75%) were reported in people aged 21 to 60 years. Almost 35% of the cases had contracted infection within their families. Dharavi also reported increased mortality due to Covid10 in May (70 deaths) in comparison with April (18 deaths).

## V. Specific processes and activities in implementation of ‘Mission Dharavi’

Under the clear leadership of Brihan Mumbai Corporation (BMC) - the local civic body which is Asia’s richest municipality, **Mission Dharavi** was launched with a slew of proactive steps to contain the virus (13). At the heart of Mission Dharavi, the motto was to chase the Virus by Tracing Tracking Testing & Treating. ‘Corona war room’ was launched in the disaster control unit for various activities like planning, prevention and management of the pandemic 24/7 functional. Early diagnosis and early treatment were key measures to reduce the new infection and mortality rates. The major activities conducted under ‘Mission Dharavi’ are as follows:

**1. Focussed High risk areas with Watertight Containment zones:** BMC’s COVID containment strategy included identification of maximum possible containment zones, these are places where positives have been detected and those surrounding areas have been sealed to protect everyone inside and outside from further spread (13). The containment zones were further classified into the following for the purpose of triaging and focussed efforts (14):

- a. Red which are congested areas;
- b. Orange which are congested, but still more manageable than red;

c. Blue which are the buildings.

The state government chalked out a three-fold strategy of an effective containment, conducting comprehensive testing and ensuring uninterrupted supply of goods and essential supplies to the community. To make sure the harsh containment worked, officials partnered with non-profits to provide free meals rations and medicine to the residents and migrant workers left jobless by a weeks-long nationwide lockdown. Community kitchen were opened to provide food packets (2). The G-north ward also launched a 12-hour helpline number to help people contact BMC for food, grocery, transportation and stay. Social media platforms were used to inform residents about relief efforts.

**2. Perimeter control:** To maintain the perimeter control, police were deputed. Considering the overcrowding, BMC started monitoring movements within the red zones by drones which alerted police if residents attempted to leave their homes and a fine was imposed. Local leaders and youth of the area were identified as volunteers named “Corona Yodhdhas” (Corona warriors) to help the community with procurement of essential commodities. Free meals and food rations were provided to residents trapped at home without work and income.

**3. Early Diagnosis:** Early detection and treatment are of utmost importance for favourable outcomes and reducing the mortality rates (Figure 4). Dharavi was not only dealing with an increased number of cases but also increased mortality. It was seen that those who were brought late to the facility had higher mortality rates. To ensure early detection of disease targeted testing approach was tried. **a. Aggressive active surveillance:** Screening effort involving door to door active surveillance, taking help of private clin-

ics/doctors, were conducted. Teams comprising of Community health volunteers (CHVs) and local COVID volunteers under the leadership of the Medical officer conducted door to door active surveillance for cases. Each team in personal protective gear on an average visited 100-150 households of high risk and low risk contacts and screened them for fever and oxygen concentration with the help of thermal guns and pulse oximetry. Altogether 47,500 people from the high-risk zones and 1.25 lakh residents of containment zones of Dharavi were screened (2). This became a game changer. **b. Passive surveillance at Fever Camps:** Fever camps were conducted at regular intervals in strategic locations of the slum. At each camp about 80-100 residents were screened every day by Medical officer with the help of health workers for fever and blood oxygen levels using infrared thermometers and pulse oximeters. The local private practitioners were also instructed to report and refer all the patients with fever or /and respiratory symptoms like cough, sore throat and shortness of breath to the fever clinics for further testing. Those who tested positive were moved to local institutional quarantine facilities with the guidance of health workers.

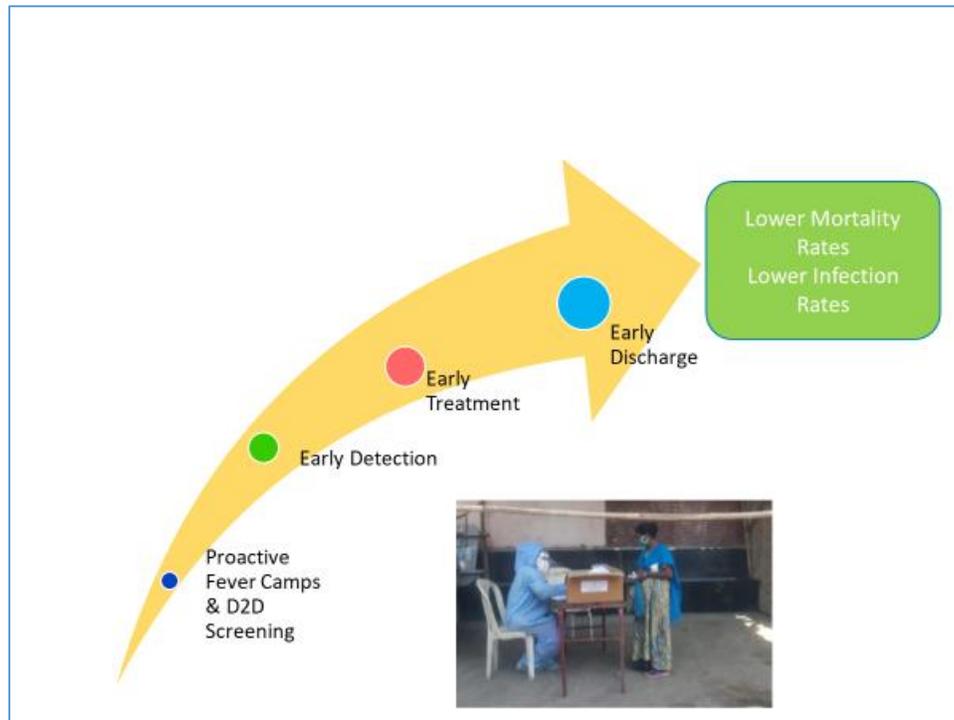
**4. Early Treatment with Triage of Facilities:** To ensure proper utilization of limited

resources medical care centres for COVID 19 were divided in four categories (13):

- a. Corona Care Centre Type 1 (CCC1): These facilities were meant for high-risk contacts and those awaiting reports and were arranged in hotels, lodges, halls or newly constructed buildings, and they don't have round-the clock medical staff;
- b. Corona Care Centre Type 2 (CCC2) facilities for asymptomatic to mild positive patients. They have round-the clock medical staff and oxygen facilities. Food, multi-vitamins and medicines are supplied free of cost to the people admitted;
- c. Dedicated COVID health centre (DCHC) for moderate to critical patients;
- d. Dedicated COVID Hospital (DCH) for critical patients. There are five covid-19 dedicated hospitals, Sai Hospital, Ayush Hospital, Life Case Hospital, Family Care Hospital and Prabhat Nursing Home, for residents of Dharavi.

The triaging helped in judicious utilization of resources and only critical patients were shifted for admission to hospitals and ICUs. Centralized toll-free number for live availability of ICU beds was generated for the community. Ambulances and mobile vans with oxygen facility to transfer patients from CCC1/CCC2 to DCH as and when required were made available.

**Figure 5. Strategy for reducing the new infection rates and mortality due to COVID-19**



Because of these proactive steps, even with limited resources the virus was detected early and promptly treated, increasing the recovery rates and lowering the mortality rates. Dharavi reported recovery rate of about 51% as compared to 41% in the rest of Mumbai, where most patients reached hospitals late. Also, almost 90% of the patients were treated inside Dharavi itself (2).

**5. Institutional Quarantine facilities:** Instead of putting people in home quarantine, the government decided to put high-risk people from Dharavi in institutional quarantine because at home they were still sharing the public toilet. In order to increase the capacity of Quarantine Centres, makeshift shelters and transit camps were erected. Schools, colleges, hotels, lodges, marriage halls, sports complexes were transformed into quarantine centres, equipped with facilities like lights, fans, charging points & daily usable. The G

North ward prepared a capacity of about 3,000 quarantine beds in facilities like Rajiv Gandhi Sports Complex, Dharavi Municipal School, Manohar Joshi Vidyalaya, D'silva High School, Ruparel College Hostel, Scout & Guide Hall, Mahim Nature Park, and various other hotels and lodges in the ward. The ratio of Positive to institutional quarantined ratio increased to 1:5.45 in May from 1:3.381 in April (15). Every person in the isolation centres received three meals and round-the-clock medical supervision free of cost. Taking care of the religious sentiments during Ramadan -- the Muslim holy month, authorities ensured they got fruits and dates and distributed proper meals at appropriate times for breaking their religious fasts at sunset. Such activities increased the acceptance of institutional quarantine in the community. Also, mental health aspect of quarantine inmates

was taken care of with the help of dedicated counsellors, yoga and meditation sessions.

**6. Improved Sanitation:** Poor sanitation in community toilets in Dharavi have been the key source of spread of infectious diseases like COVID. In order to improve sanitation, the 225 public toilets were disinfected and fumigated twice daily. The G North Ward also installed foot operated devices for using washbasins, toilet flush, and so on. Public awareness campaigns about sanitising hands and washrooms were regularly conducted (16).

**7. Social mobilization processes** were undertaken, exploring opportunities and innovative means to bring together all societal influences to raise awareness, like local leaders and Bollywood stars to assist in the delivery of services and resources. It included:

a. **Community Engagement:** Community engagement is central to any public health intervention even more so during public health emergencies. It involves those affected in understanding the vulnerabilities they face, and involves them in response actions. The Dharavi model adopted the process of working collaboratively with and through groups of people in the affected community to address issues to bring about environmental and behavioural changes that will improve the health of the community members. This involved recruitment of local volunteers to influence and serve as catalysts for changing practices, reaching out to and informing the community of policy directions of the government and build community awareness and understanding. Frontline health workers played critical roles in the prevention by providing health education on preventive measures for all people in the containment zones. The transparency of updated

information and clear communication messages on COVID-19 through official and social media were important contributors to changing community behaviours towards wearing masks, hand washing, and social distancing, from February 2020.

b. **Public Private Partnership (PPP):** Even when COVID Care facilities were ready, arrangement of manpower to run them was a real challenge. To tackle the issue of trained health workforce strategic public private partnerships were forged and all available ‘private’ practitioners from the nine Dispensaries and 350 private clinics located in Dharavi were roped in. All practitioners were encouraged and supported with resources to open their clinics to attend to the patients and communicate to BMC in case any COVID-19 suspects were found. The added advantage of including the private practitioners was that they had the trust and confidence of the residents who will approach them even for slight fever, or any other symptoms making it easy for screen and test.

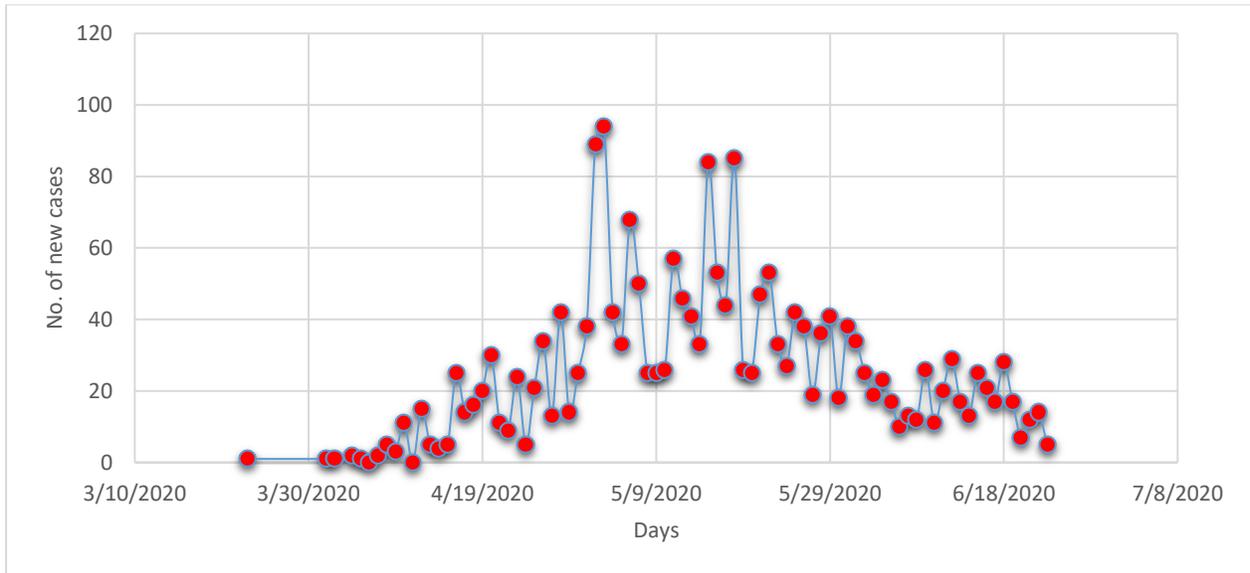
**8. Exodus of Migrants:** Apart from the above initiatives, reverse migration of thousands of migrant workers residing in Dharavi, towards their homes in other states also contributed directly and indirectly towards decreasing the case load in Dharavi.

## **VI. Temporal Variation of cases and the epidemic curve**

With the strategy of actively ‘chasing the virus’, the epidemic curve of Dharavi displayed signs of flattening by late May (Figure 3). A steady decline in the number of COVID-19 cases was observed in late May which continued in June when daily reported new infections dropped to 5 cases in third week of June

from a high of 94 cases a day in early May (13).

**Figure. 6. Temporal variation in number of new COVID-19 cases in Dharavi**

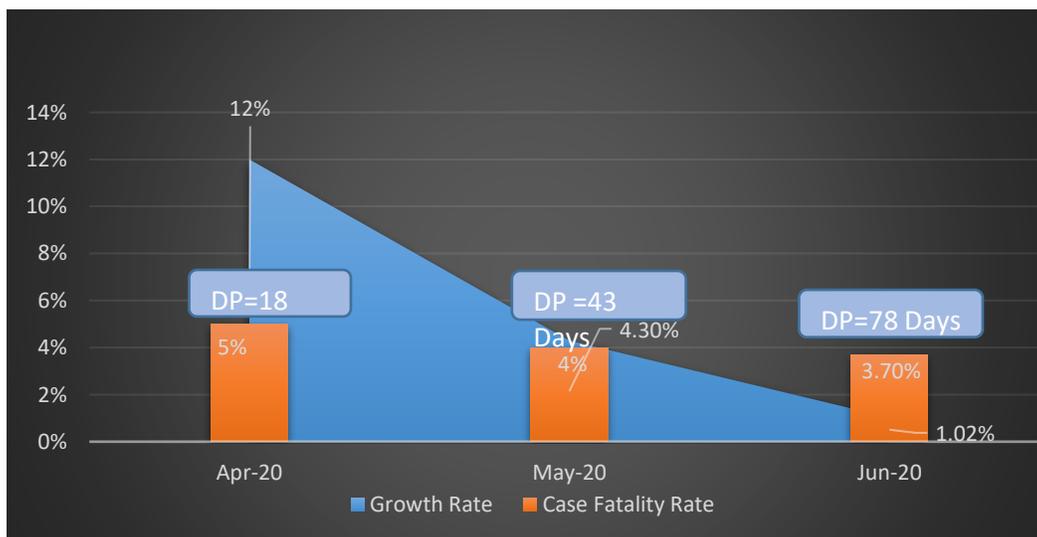


**Legends:** — No. of cases

The drop in the new cases in Dharavi was also associated with a steep rise in the doubling time of 18 days in the last week of April

to 78 days as of June 19. The growth rate declined to 1.02% and the case fatality rate dipped to 3.7% by the month of June (2,13).

**Figure 7. Comparative analysis of COVID 19 Growth rate and Doubling time for Dharavi**



The Ministry of Health and Family Welfare (MoHFW) also mobilized provision of medical equipment and organized several site visits for central inter-ministerial and public health teams to support local health facilities to prepare for combating COVID-19.

## VII. Challenges

Dharavi's war against the virus is still far from over. The severe lockdown measures can't continue forever. Though relief efforts for providing food and ration are continued in the area, many are still not able to procure them and are forced to step out of their home to arrange meals. Upcoming monsoon with waterlogging can pose a serious threat on the makeshift quarantine facilities. Also, monsoon will increase the burden of other communicable diseases like Dengue and Malaria, which will further overburden the health system. With the unlock and start of local trains, buses and other modes of transportation the virus can easily make its way back to the slum. The community still lack awareness, and many are ignorant to preventive measures like wearing masks properly and maintaining physical distance. Hence, the chances of a second wave in near future cannot be denied. Arranging trained health workforce and ICU beds can be difficult with the

already overburdened health workers and health system. Therefore, there should be continued administrative measures and screening at all points of entry till the virus is chased out from the state and the country which is again a challenge.

## Conclusion

Almost a hundred days after Dharavi began its fight against Covid-19, Asia's largest slum seems to have flattened the curve. The Dharavi model is based on the dogged approach to "chase the virus" by screening, contact-tracing and isolating infected patients along with multi-sectoral approach, social mobilization and community engagement. However, for sustaining the 'Mission Dharavi win', it is important to resolve the environment and sanitation issues on a long-term basis.

This chase the virus approach could also be used as an example in similar settings like slums in Pakistan, Bangladesh, favelas of Brazil or shanty towns in South Africa. However, the wider applicability of these experiences is subject to differences in socio-political environments and further remodelling of this strategy can be done to fit the context-specific needs of the affected communities.

## References

1. Government of India. Press Information Bureau, Delhi. Government of India issues Orders prescribing lockdown for containment of COVID19 Epidemic in the country. New Delhi, March 24, 2020. Available from: [https://www.mha.gov.in/sites/default/files/PR\\_NationalLockdown\\_26032020\\_0.pdf](https://www.mha.gov.in/sites/default/files/PR_NationalLockdown_26032020_0.pdf)
2. Press Information Bureau, Delhi. COVID-19 UPDATES. "Chasing the Virus" in Dharavi, and ensuring a steep decline of daily cases from an average 43 in May to 19 in third week of June. June 21, 2020. Available from: <https://pib.gov.in/PressReleasePage.aspx?PRID=1633177> (accessed: July 2, 2020).

3. The Economic Times. Dharavi's journey to becoming Mumbai's COVID-19 hotspot. May 14, 2020. Available from: [https://economictimes.indiatimes.com/news/politics-and-nation/dharavis-journey-to-becoming-mumbai-s-covid-19-hotspot/articleshow/75737341.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](https://economictimes.indiatimes.com/news/politics-and-nation/dharavis-journey-to-becoming-mumbai-s-covid-19-hotspot/articleshow/75737341.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst) (accessed: July 2, 2020).
4. Modi S. Understanding Mumbai's Social Indicators Through Ward Maps. Available from: <https://medium.com/econinthebar/mumbai-with-the-size-of-its-economy-and-population-makes-for-a-compelling-case-in-being-a-5ade2b75e7b5> (accessed: July 2, 2020).
5. Zhang Y. Building a slum-free Mumbai. Wilson Center; 2016. Available from: <https://www.wilsoncenter.org/article/building-slum-free-mumbai> (accessed: July 2, 2020).
6. Directorate of Census operations. Census of India 2011, Maharashtra. Available from: [https://censusindia.gov.in/2011census/dchb/DCHB\\_A/27/2723\\_PART\\_A\\_DCHB\\_MUMBAI.pdf](https://censusindia.gov.in/2011census/dchb/DCHB_A/27/2723_PART_A_DCHB_MUMBAI.pdf) (accessed: July 2, 2020)
7. Nutkiewicz A, Jain RK, Bardhan R. Energy modeling of urban informal settlement redevelopment: exploring design parameters for optimal thermal comfort in Dharavi, Mumbai, India. Appl Energy 2018;231:433-45.
8. The Economic Times. Asia's largest slum Dharavi reports first Covid-19 casualty. April 02, 2020. Available from: [https://economictimes.indiatimes.com/news/politics-and-nation/asias-largest-slum-dharavi-reports-first-case-of-coronavirus/articleshow/74937159.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](https://economictimes.indiatimes.com/news/politics-and-nation/asias-largest-slum-dharavi-reports-first-case-of-coronavirus/articleshow/74937159.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst) (accessed: July 2, 2020).
9. Deshpande T. Dharavi emerges as COVID-19 hotspot. The Hindu. April 2, 2020. Available from: <https://www.thehindu.com/news/cities/mumbai/coronavirus-bmc-sweeper-is-second-positive-case-in-dharavi/article31234805.ece> (accessed: July 2, 2020).
10. Deshpande T. Dharavi victim likely met Jamaat members. The Hindu. April 2, 2020. Available from: <https://www.thehindu.com/news/national/coronavirus-dharavi-victim-likely-met-jamaat-members/article31251972.ece> (accessed: July 2, 2020).
11. Bhalerao S. BMC de-seals Dharavi's first containment zone after no new cases since April 7. The Indian Express. May 16, 2020. Available from: <https://indianexpress.com/article/cities/mumbai/bmc-de-seals-dharavis-first-containment-zone-after-no-new-cases-since-april-7-6412079/> (accessed: July 2, 2020).
12. Saxena R. Covid-19: First area in Dharavi freed of containment, more will follow suit. Livemint. May 8, 2020. Available from: <https://www.livemint.com/news/india/dharavi-s-first-covid-19-hotspot-dr-baliga-nagar-de-contained-more-to-follow-11588856754467.html> (accessed: July 2, 2020).

13. Brihan Mumbai Municipal Corporation. Department of Health. Stop Corona in Mumbai. Available from: <https://stopcorona-virus.mcgm.gov.in/ToM-treatment-facilities> (accessed: July 2, 2020).
14. Mumbai LIVE. Mumbai's Containment Areas To Be Classified Into Red, Orange, And Blue Zones Based On The Severity Of Cases. May 2, 2020. Available from: <https://www.mumbai-live.com/en/infrastructure/mumbai's-containment-areas-to-be-classified-into-red-orange-and-blue-zones-based-on-the-severity-of-cases-48568> (accessed: July 2, 2020).
15. Daily Hunt. BMC has quarantined over 6,500 at its facility in Dharavi so far. May 18, 2020. Available from: <https://m.dailyhunt.in/news/india/english/mumbai+live+english-epaper-mliveng/bmc+has+quarantined+over+6+500+at+its+facility+in+dhara+vi+so+far-newsid-n185467382> (accessed: July 2, 2020).
16. BMC. Embracing Innovation To Take On The Virus! June 23, 2020. Available from: <https://twitter.com/mybmc/status/1275386375945154562> (accessed: July 2, 2020).

---

© 2020 Sahu et al; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.