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City profile

Asia’s largest urban slum-Dharavi: A global model for management of COVID-19

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A B S T R A C T

The Dharavi sector of Mumbai, India is constituted as one of the biggest slums of Asia and the world’s most populated areas. The COVID-19 outburst is at its peak in May and curve gets flattened within next two months. This article focuses on factors responsible for transmission, prevention and in controlling the COVID-19 spread in Dharavi. The COVID-19 data was interpreted in terms of Case Recovery Rate (CRR) and Case Fatality Rate (CFR) for total and closed both. The CFR per closed reached 10.12% nearly to per total 9.82% in Dharavi on 31st July 2020. The CRR per total cases in Dharavi and Mumbai is 87.16 & 76.18% and per closed cases is 89.87 & 93.20% respectively in comparison to the CFR. The calculated CFR and CRR for both Dharavi and Mumbai suggest that the COVID-19 recovery rate is more than the fatality rate. The Dharavi people serve as an important role in controlling the pandemic by adopting 4-T model tracing, tracking, testing, and treating strategy. This article is beneficial for government policy makers and private agencies in controlling the COVID-19 pandemic in densely populated areas and also for nations with high fatality rate.

1. Introduction

The world’s corona virus pandemic (COVID-19) is caused by severe acute respiratory syndrome corona virus 2 (SARS-CoV-2). The COVID-19 declared as a Public Health Emergency of International Concern and global pandemic on 31st January 2020 and 11th March 2020 respectively by the World Health Organization (WHO) (Sohrabi et al., 2020).1 India’s first case of COVID-19 was reported on 30th January 2020 which had originated from Wuhan, China.2 Currently, India has a total number of 16,38,870 confirmed cases, the highest number in Asia and third in the world after the United States and Brazil as on 31st July 2020.3 Although, India has the lowest case fatality rate i.e. 2.41% in the world and the recovery rate stands at 63.18% which continuously increasing day by day according to the Union Health Ministry of India as of 23rd July 2020.4 Six cities of India Mumbai, Delhi, Ahmadabad, Chennai, Pune, and Kolkata reported for half of the cases in the country as of 31st July 2020.5 Mumbai, the capital city of Maharashtra contributed to 66% of the total cases in the state and over 20% of all cases in India.6 Mumbai is the biggest metropolitan city also known as the commercial capital of India, located on the western coast towards the Arabian Sea at coordinates 18.96° North and 72.82° East (Ram-asamy & Sundararajan, 2020). The Mumbai City and suburban areas, collectively known as the Greater Mumbai region occupy only 483 km². Mumbai is recognized as the 4th most populous city of the world and having an estimated population of 20 million presently.6 The migration of people from other Indian regions to Mumbai for Business and employment opportunities leads to a high population in the city. Due to this rapid expansion, a large percentage of residents live in the city’s...
slums. The estimation of people living in slums is over 9 million which means a rate of 41.3% as of Greater Mumbai. Dharavi is recognized as one of the densest slum areas of Asia and the world’s one of the largest slum located in India’s financial capital-Mumbai. Around 8.5 lakh people live in approx. 55,000 dwelling units in Dharavi with a population density of 3.4 lakh per km² and covers around 535 acres of land (Ramasamy & Sundararajan, 2020). Dharavi comprises of nearly 15,000 single-room factories and 5000 businesses (Alam & Matasuyuki, 2020). All over the world, Dharavi is recognized as one of the most densely populated urban agglomerations. Other than ever-increasing population density, the dearth of hygiene and awareness, miniature homes and low income has made living conditions in the Dharavi even worse. In these conditions, social distancing during the COVID-19 pandemic was very difficult. When the COVID-19 cases were reported in early April month in Dharavi, an overpopulated slum area in the heart of India’s financial capital, controlling the spread of the disease is an immense challenge. Despite these conditions, the COVID-19 outbreak can be manageable and not reached at the community level. In this perspective, this research study is conducted to provide insights on understanding the spatial spread of the virus in Mumbai with a special focus on its slum area Dharavi which would be useful in planning and implementing control efforts to prevent COVID-19 spread. This research paper presents the COVID-19 data of Dharavi and evaluates the Case fatality rate and Case recovery rate of the Dharavi in comparison to Mumbai. The various strategies planned to prevent and control the COVID-19 spread in a world’s densely populated area Dharavi slum are discussed here which can be implemented in other places to control the disease.

2. Method

2.1. Study design

This research is based on an observational investigation of COVID-19 in the Dharavi sector in Mumbai, India as of the end of 31st July 2020. Fig. 1 shows the geographical location of Mumbai in India and a satellite image of the Dharavi sector. The Brihanmumbai Municipal Corporation (BMC) is Municipal Corporation of Greater Mumbai which is a local governing body. The BMC is monitoring and responsible for the implementation of the public health and economic activities in the wards. During the COVID-19 outbreak in this region, BMC is closely monitoring the situation and plans and executes the policies to control the spread of disease. The information about COVID-19 cases updated and informed to the ‘corona war room’ in the control unit through the BMC’s Health Department team. The data for analysis of COVID-19 cases is extracted from the official portal of BMC.7 The BMC publicized its data for public use on its website. The nationwide data for COVID-19 is extracted from the Ministry of Health and Family Welfare (MoHW), India.8 The United Nation Population Report is used to extract the population data.9

2.2. Data analysis

The descriptive statistics of confirmed cases in Mumbai were compiled to study the epidemiological characteristics of COVID-19 spread. This analysis involves the calculation of Case Fatality Rate (CFR) and Case Recovery Rate (CRR) for confirmed cases of COVID-19 diagnosis in Mumbai till 31st July 2020 and calculated as per equations given below (Ghani et al., 2005; Kim & Goel, 2020; Mahajan & Kaushal, 2020; Szychalski et al., 2020):

\[
\text{CFR} = \frac{\text{Total number of Deaths}}{\text{Total number of cases Confirmed}} \times 100
\]

\[
\text{CFR} = \frac{\text{Total number of Deaths}}{\sum \text{Total number of Death + Recovered}} \times 100
\]

\[
\text{CRR} = \frac{\text{Total number of Recovered Cases}}{\text{Total number of cases Confirmed}} \times 100
\]

\[
\text{CRR} = \frac{\text{Total Number of Recovered}}{\sum \text{Total number of Death + Recovered cases}} \times 100
\]

3. Result

In India, a total of 1,693,274 COVID-19 confirmed cases along with 36,513 deaths have been reported in as of 31st July 2020, 08:00 GMT+ 5:30 according to the MoHFW. Maharashtra is in first place with 422,118 COVID-19 cases followed by Tamil Nadu, Andhra Pradesh, Delhi, and Karnataka the top five states with the number of cases more than one lakh.9 The case fatality rate of Maharashtra is nearly 4.3% that is significantly higher than other Indian states with large numbers of cases however it is lower than the global average rate as of 31st July 2020.

Mumbai, the financial capital of India is the worst affected city with about 115,346 cases with 6395 deaths as of 31st July 2020.9 Fig. 2 represents the timeline of the confirmed, recovered, and death counts of the COVID-19 pandemic in Mumbai from 21st March to 31st July 2020. This pattern indicates the incomparable disaster that is happening in the commercial capital of India. In India, only Delhi as a metropolitan city and capital of India is somewhat closer to Mumbai city with 136,716 confirmed cases and 3963 deaths.9 Otherwise, no other cities are near to Mumbai city in terms of COVID-19 cases. Though Mumbai is affected severely in India, the numbers of confirmed cases are less as compared to other cities of global importance. Around 2% of the population is affected in New-York city with 387,272 cases while Mumbai stands with 0.32% cases for its population of 20,411,274 (Desai, 2020).11 The population density of Mumbai is more than double of New York City, which is currently the epicenter of the COVID-19 pandemic in the USA.12 However, it is affected six times worse than Mumbai. Lombardy (Italy), Moscow (Russia), Sao Paulo (Brazil), Lima (Peru) etc. are greatly affected by COVID-19 and having confirmed cases in thousands with high number of causalities in comparison to Mumbai (Ramasamy & Sundararajan, 2020). Mumbai’s 60% populations live in Dharavi and they occupy only 6% of the total land area of the city.13 However, the confirmed number of COVID-19 cases reported in Dharavi is only 2.2% in comparison to Mumbai. The total confirmed patients, recovered and deaths from the COVID-19 timeline of the Dharavi sector up to 31st July 2020 have been shown in Fig. 3.

The first COVID-19 case and causality from Dharavi were accounted for on 1st April 2020 after three weeks of the Mumbai’s first case. In the
April month, the COVID-19 cases in Dharavi shot up severely to 491 cases with a 12% growth rate and 18 days doubling period. The month of May, an average of 48 cases per day reported in Dharavi with highest record of 94 cases on May 3. Thereafter, the practical measures are taken by the BMC and other agencies to control the disease, and the growth rate declined to 4.3% at the end of May. In June, Dharavi appears to have changed the scenario and cases are increasing only by 18 per day. It has been also observed that the doubling time increased from 18 days in April to 43 days in May, 78 days in June spelling, and slowed down 430 days in July. Indeed, only 5 cases have been reported on 23 June 2020, the lowest since 5th April 2020 and BMC forced to shut down its two COVID Care Centers (CCC). As per 31st July 2020, Dharavi has only 77 active cases and 2479 patients have recovered and discharged.

The CFR and CRR for Dharavi in comparison to Mumbai from April to July 2020 summarized in Figs. 4 and 5 respectively. The early stage of the outbreak in Dharavi started in the third week of April. As shown in Fig. 4, the maximum peak value of CFR per closed for Dharavi is found at 37.50% whereas for Mumbai it is only 26.88% on 21st April 2020. The CFR per closed value dropped to 4.55% for Dharavi and 9.36% for Mumbai as of 1st July 2020. This difference suggests that the outbreak of

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14 The Hindu https://www.thehindu.com/news/national/other-states/steep-decline-of-daily-covid-19-cases-in-dharavi-says-union-health-ministry/article31883369.ece.
the COVID-19 pandemic is a downturn stage in the June. This sharp decrease in COVID-19 cases in Dharavi recognized by the Union ministry of health and family welfare of India and it issued a release soliciting the Dharavi model on June 21. The CFR per closed (10.12%) reaches nearly to per total (9.82%) in Dharavi with only 77 active cases as per 31st July 2020. As shown in Fig. 4, CRR per total cases in Dharavi and Mumbai is 87.16% & 76.18% and per closed cases is 89.87% and 93.20% respectively in comparison to the CFR. These findings suggest that the COVID-19 recovery rate is more than the fatality rate for both Dharavi & Mumbai. But, still Mumbai has 20,863 active cases to be recovered. In Dharavi, 87.16% of COVID-19 patients have been recovered so far with only 77 active cases.

4. Discussion

The WHO confirmed the pandemic outbreak of COVID-19 on March 11, 2020 and announced the guidelines to limit the transmission of the virus which focused on lockdown, social distancing, and use of facial masks for the general public. As COVID-19 infection is supposed to be highly susceptible to densely populated areas such as slums and informal settlements in cities, the situation become worst when these slums emerged as hotspots of COVID-19 virus. The developed nations like USA, China, UK, Brazil, Russia, Italy etc. with well-equipped health systems have struggled on war foot to tackle the situation. In comparison to these nations, the challenges in these slums are much more and required more innovative solutions to curb the spread of disease. Dharavi, a most populated an urban slum of Mumbai City emerged as such hotspot of the COVID-19 pandemic. The challenges in Dharavi were enormous to control the COVID-19 spread as shown in Fig. 6.

Dharavi is basically a complete city within Mumbai city, with a non-spacious endless stretch of lanes with open sewers and overcrowded huts. Approximately 850,000 people reside with an inordinate population density of 277,136 per km$^2$ in the Dharavi sector which has the only area of 2.5 km$^2$. On average, 10–12 people live in minuscule homes of $10 \times 10$ ft size situated in narrow lanes. The common toilets and water taps are used by thousands of people daily. In addition, several legal and non–legal small-scale manufacturing units are located in Dharavi. About 15,000 single-room factories and 5000 registered companies
having the capacity of international export with an annual turnover of 1 billion USD are operated inside Dharavi. Hence, the dearth of hygiene, miniature homes, illiteracy, and lack of awareness has intensified the living conditions in the Dharavi dwelling. These are severe confines the precautions such as ‘physical distancing’ and ‘home quarantine’ to prevent the spread of COVID-19. At the point, when the first COVID-19 case was identified in Dharavi, a packed trap of one-room shacks in the core of India’s financial capital, epidemiologists raised concern about the rapid and out of control COVID-19 spread in Dharavi. Therefore, the Maharashtra government recognized Dharavi as one of the threatening

![Fig. 5. CFR comparison of COVID-19 cases in Dharavi and Mumbai from April–July 2020.](image)

- April: 491 cases, 18 days doubling rate
- May: 1771 cases, 43 days doubling rate
- June: 2304 cases, 78 days doubling rate
- July: 2556 cases, 430 days doubling rate

![Fig. 6. Challenges in Dharavi to control transmission of COVID-19 virus.](image)

- Dense population
- Miniature houses
- Community toilets
- Inadequate water supply
- Improper waste management
- Illiteracy/ lack of awareness
- Paucity of health care services
- Large number of industrial units

Fig. 7. Timeline of doubling rate of COVID-19 in Dharavi (Mumbai).
zones of Mumbai city. Despite all the challenges, COVID-19 doubling rate of the virus decreases and infection gets controlled in Dharavi as depicted in Fig. 7.

The transmission of the COVID-19 infection in Dharavi is successfully controlled through an innovative 4-Ts model as described in Fig. 8. The government authorities decided to “chase the virus” in concern to high risk of transmission of the virus in a densely populated area. The authorities don’t want the Dharavi to become Lombardy (Italy) or New York (USA) where COVID-19 spread at a very high rate and resulted in hundreds of causalities. So, the health officials decided not to wait for people to become COVID positive and then confirm through testing. They start the testing rather than wait for the patients to report. The 4-Ts model i.e. Tracing, Tracking, Testing, and treating model was adopted by authorities to control the spread of the disease. For the successful operation of this model, a multi-sectoral approach has been adopted. The bureaucrats, politicians, government health officials, private doctors, municipal corporation workers, communities, families and individuals all played a significant role in the control of pandemics.

The administration sealed the border and set up 24 check-posts at entry points of the slum with immediate effect. To implement containment measures in hotspots, several actions have been taken. All types of shops, small factories and markets were closed; public and private transportation was stopped; people movement was restricted strictly and drones are employed for reporting to police. A number of volunteers came forward for effective executing of these containment measures. The Corona war room was also established to keep eye on a very minute development in each aspect of tracing, tracking, testing, and treating the COVID patients in the slum area.

Approximately 700,000 people screened in the slum area through temperatures and oxygen levels measuring. The fever clinic has been set up inside the slum area which becomes very helpful in tracing the virus and the symptomatic patients immediately shifted to quarantine centers. Kiran Dighavkar, the assistant commissioner of the G Northward of the BMC, with the consent of state officials, changed the traditional approach style of waiting for patients at the health care center. The civic bodies took the help of 350 local and private medical practitioners of the same vicinity and equipped them with PPE kits and essential medical tools to commence proactive screening door to door at Dharavi. Due to the highly congested area, it was impossible to keep social distancing and lockdown. Local religious places, 15,000 mobile vans operated for the awareness of COVID-19 symptoms by announcements. Nine quarantine centers were arranged in nearby schools, sports complexes, marriage palaces, and community halls. For providing critical care, the BMC took over five private hospitals in the area. Approximately 7 lakh people were screened and suspected 14,000 were tested and 13,000 placed in quarantine centers. These were provided with a free community kitchen. In the April, 491 corona virus positive cases were reported which gradually increased to 1212 in May. Therefore, at the first stage, state authorities directed 2450 health workers for mass testing and containment to gradually slow down the spread of the virus. Due to clinical management, hard-hitting testing initiated on potential cases, and positive detected were isolated, and quarantine at separate COVID centers. Suspected cases were placed under different COVID Care centers and marked as CCC 1, who were asymptomatic, CCC2 having slight symptoms, and severe cases held under Clinical Management. Contact tracing, generating huge quarantine services, and separating the susceptible population were major steps, which pave the way for controlling the cases in Dharavi. More than 70% of people in Dharavi use Community toilets and it was the main apprehension in the enhancement of positive cases so to reduce this factor, community toilets were sanitized every hour by civic authorities. Many migrants in Dharavi who were daily wagers and in May, nearly 1.5 lakh returned to their homes and it also further decreases the burden of civic bodies. BMC and many NGO’s also distributed more than 25,000 grocery kits, food packets for lunch and dinner to minimize the movement of people from their homes. Hence, the collective efforts of BMC, local clinical management, NGOs, and media could be able to curb the corona virus spread and slow down the cases in Dharavi.

The 4-Ts model i.e. Tracing, Tracking, Testing, and treating proactive patients, adopted by BMC was highly appreciated by WHO also. This model appeared as a role model to combat the virus across the globe. The WHO acknowledged the Dharavi success as “Dharavi should be seen as an example across the world.” The WHO confirmed that the 4-Ts model has become a success story and helpful in breaking the chain of virus transmission. Thus, this 4-Ts model becomes the template for the densely populated urban areas globally around the world to prevent the spread of COVID 19. This is also important to note that the Dharavi model is an ideal of setting where social distancing is impossible or difficult to follow. For instance, the other populated areas of world such as Makoko in Lagos (Nigeria), Mbare in Harare (Zimbabwe) and Kibera in Nairobi (Kenya) where seven people on average sharing a shed and it is not possible social distancing or lockdown in these slums (Kuguyo et al., 2020). As most people living in these areas depends upon daily wages and had to step out to earn their livelihood and a strict lockdown is impossible without proper planning. To control the pandemic in these areas, the officials could look into the model and the policies adopted in Dharavi.

Despite of high population living in unhygienic conditions in Dharavi, the case fatality rate is found to be quite low. This can be possible only with 4T’s model of timely chasing, screening, isolating and regular monitoring of patients infected with virus. The decision of chasing the virus before spread also ruled out high fatality in the area like Dharavi with poor health resources. This could be eye opener for nations with high COVID-19 fatality rate like USA and Italy which are known for their best health services. Still, the transmission of virus is not under control in many parts of world. The second wave of transmission of virus is also seen in some European nations. Hence, the policymakers around the globe the developed as well as developing nations could replicate this model to curb COVID-19. In future, the Dharavi model plays a significant role as a case study in control such pandemics.

5. Conclusion

COVID-19 pandemic is still up-and-coming; many new approaches and policies are sprouting from best-employed practices around all over the world. Many countries like Iceland, South Korea, Taiwan, Spain, Papua New Guinea, New Zealand, Greece, Montenegro, Fiji, Vatican city, and Mauritius have effectively controlled the COVID-19 pandemic and set an example for other nations. The strategy followed by these nations may be applied to developed nations equipped with well-functioned health systems. However, these cannot be feasible for developing nations and resource-limited nations. For such nations, the approach followed in Dharavi (Mumbai), a highly-populated area of the world to control COVID-19 pandemic could be a boon. The 4-Ts (Tracing, Tracking, Testing, and treating) model approach adopted in Dharavi proven to control the COVID-19 virus spread through the breakdown of the chain of virus transmission. Mumbai still has emerged as a hotspot of the COVID-19 outbreak where Dharavi spelled the unprecedented doom. Despite being with zero possibility of social

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15 The Hindu https://www.thehindu.com/opinion/op-ed/covid-19-involv

16 The Hindu https://www.thehindu.com/news/cities/mumbai/how-dharav

17 News 18 https://www.news18.com/news/india/tracing-tracking-testing-tr"
distancing, the Dharavi people set an example for the entire world for not only to curb the spread of the virus but also to control fatality rate. Thus, the “Dharavi Model” can be a role model for not only in controlling pandemic in informal settlements, slums etc. but also for developed nations where fatality rate is quite high. The success of the Dharavi model narrated the gritty groundwork, farsighted management, practical approach, efficient government-private sector, and most important people commitment. The other densely populated slums around the world could take a lesson from the Dharavi people. COVID-19 pandemics also provided opportunities for policymakers to create more comprehensive and flexible health policies in cities which in turn, strengthens public health improves the living standards of people, and improves the economy of the nation.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Fig. 8. 4-Ts Dharavi model.