# A Unified Citywide Dashboard for Allocation and Scheduling Dialysis for COVID-19 Patients on Maintenance Hemodialysis

## Abstract

**Introduction:** The coronavirus disease 2019 (COVID-19) pandemic has caused significant global disruption, especially for chronic care like hemodialysis treatments. Approximately 10,000 end-stage kidney disease (ESKD) patients are receiving maintenance hemodialysis (MHD) at 174 dialysis centers in Greater Mumbai. Because of the fear of transmission of infection and inability to isolate patients in dialysis centers, chronic hemodialysis care was disrupted for COVID-19-infected patients. Hence, we embarked on a citywide initiative to ensure uninterrupted dialysis for these patients. **Materials and Methods:** The Municipal Corporation of Greater Mumbai (MCGM) designated 23 hemodialysis facilities as COVID-positive centers, two as COVID-suspect centers, and the rest continued as COVID-negative centers to avoid transmission of infection and continuation of chronic hemodialysis treatment. Nephrologists and engineers of the city developed a web-based-portal so that information about the availability of dialysis slots for COVID-infected patients was easily available in real time to all those providing care to chronic hemodialysis patients. **Results:** The portal became operational on May 20, 2020, and as of December 31, 2020, has enrolled 1,418 COVID-positive ESKD patients. This initiative has helped 97% of enrolled COVID-infected ESKD patients to secure a dialysis slot within 48 hours. The portal also tracked outcomes and as of December 31, 2020, 370 (27%) patients died, 960 patients recovered, and 88 patients still had an active infection. **Conclusions:** The portal aided the timely and smooth transfer of COVID-19-positive ESKD patients to designated facilities, thus averting mortality arising from delayed or denied dialysis. Additionally, the portal also documented the natural history of the COVID-19 pandemic in the city and provided information on the overall incidence and outcomes. This aided the city administration in the projected resource needs to handle the pandemic.

**Keywords:** *COVID-19, dashboard, end-stage kidney disease (ESKD), hemodialysis, Mumbai, Project Victory, web-based portal*

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## Introduction

The ongoing coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory coronavirus 2 (SARS-COV-2) infection has affected all populations. Several global and national agencies have created virtual dashboards for reporting country-/city-specific data of COVID-19-infected patients. The outcomes of COVID-19 disproportionately affect vulnerable populations such as the elderly, obese, diabetic, and immunocompromised people. Patients with end-stage kidney disease (ESKD) are also at a higher risk for infection and mortality.[1] These patients are exposed to each other at dialysis facilities with limited social distancing. Managing maintenance hemodialysis (MHD) patients,

therefore, remains a challenge due to the risk of cross-infection and the inability to isolate the infected patients. There is also an additional risk of death arising from missed dialysis due to inaccessible COVID-19-designated hemodialysis facilities.

India has 10.2 million confirmed cases of COVID-19 as of end of December 2020, with approximately 149,000 deaths. The city of Mumbai recorded 293,436 confirmed cases with 11,116 deaths on this date.[2] Mumbai is the sixth most populous city in the world with about 20 million inhabitants spread over 233 square miles (population density 73,000/square mile).[3] There are 174 hemodialysis facilities in Mumbai catering to about 10,000 estimated ESKD patients. Dialysis facilities in Mumbai operate on different models, including

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charitable trusts, government, municipal, and for-profit facilities. There is a wide disparity in the economic, educational, and social class of patients who are treated at these facilities. In the spring of 2020, the entire nephrology community of this metropolis was faced with twin problems – the high mortality associated with COVID-19 infection and the inability to manage the dialysis needs of an infected patient at the existing dialysis centers. The national lockdown in India initially resulted in the shutting down of some hospitals and lack of clear guidance to balance infection containment while maintaining life-saving treatments such as dialysis.[4] This was the stimulus to develop a solution to meet this unprecedented challenge. Hence, the local public health authority, the Municipal Corporation of Greater Mumbai (MCGM), intervened and designated certain dialysis facilities, strategically distributed across the city to treat only the COVID-positive/-suspect patients [Figure 1a]. But the onus of finding a suitable dialysis slot fell on the patients and their primary nephrologist. However, lack of information to direct a patient to an available slot at a specific facility caused widespread anxiety and led to chaos. Despite the mixed and fragmented model of dialysis services in Mumbai, the Nephrology community quickly responded by developing and deploying a strategic citywide dashboard with a focus on providing hemodialysis in a timely fashion to all COVID-19-infected ESKD patients across the city. [Appendix] We report on how this was developed and implemented with clinical outcomes.

## Materials and Methods

### Development of portal and dashboard

A real-time web-based portal was developed to offer COVID-19-infected ESKD patients seamless and timely access to a COVID-19 (positive/suspect) dialysis facility within the city. This involved building an information technology (IT) framework that tracked real-time information on ESKD patients who tested positive.

The framework was deployed in the following stages.

*Planning Stage*: This coordinated effort was named "Project Victory." The MCGM first designated 23 dialysis facilities as dedicated COVID-19 positive centers (11 public centers and 12 private centers), two as COVID-19 suspect centers (one public and one private), and 149 as COVID-19 (negative) dialysis centers [Figure 1a]. An advisory was issued that all COVID-19, positive or suspect, ESKD patients need to be moved to these dedicated centers to continue their dialysis care. This initiative was communicated via messaging in the dedicated WhatsApp (WhatsApp Inc., Menlo Park, California) Mumbai Nephrology Group to all 160 nephrologists and 174 dialysis centers, wherein the concept was discussed and accepted by all members.

*Establishment of a common portal:* A coordination portal called Covidialysis (https://covidialysis.in) was set up. Later this portal was closed in Feb 2021, when it was not required. The portal was designed as a progressive web application accessible from a variety of operating systems. A team of engineers from the Indian Institute of Technology–Bombay (IITB) built, tested, improvised the portal, and created a dashboard for real-time graph generation from the data. A dashboard coordinator was identified who had a comprehensive view of all enrolled patients and available dialysis slots. His primary role was to meet the demand for dialysis slots for COVID-19 (positive/suspect) patients in the minimum possible time, in coordination with the persons in charge of the centers.
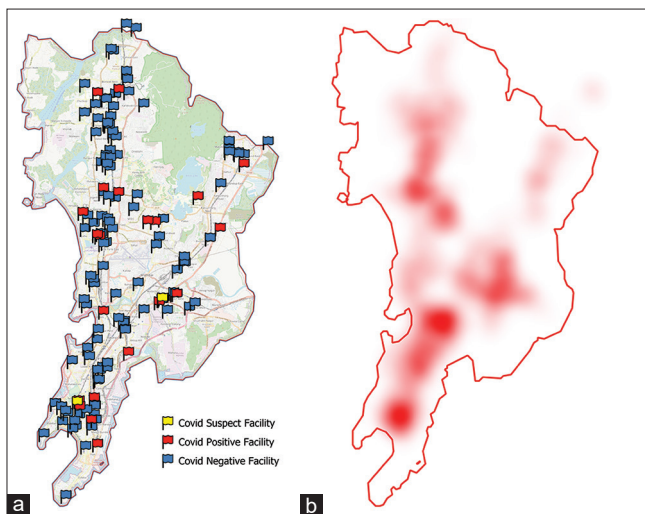


**Figure 1: Distribution of hemodialysis facilities and COVID-19 patients on MHD across the city of Mumbai. (a) Hemodialysis facilities were strategically classified as COVID-19 positive/suspect/negative by the Municipal Corporation, to segregate and isolate COVID-19-infected patients. (b) The density of infected patients as depicted by the heat map mirrored the population density. (COVID-19, Coronavirus disease 2019; MHD, maintenance hemodialysis)**

*Registration and Communication:* Each dialysis center was registered on the portal using a Google Form (Google Inc., Menlo Park, California), which included details of its location, capacity, and dialysis shifts. The designated person in charge of each center updated the portal with the patient data on a Google Form and could access it using a range of devices (laptops, tablets, or smartphones). These persons in-charge were responsible for transmitting information about new COVID-19 (positive/suspect) cases to the dashboard coordinator who guided the patient to a specified dialysis slot in the city.

As the portal evolved, a data analytics interface was incorporated. The results were visualized on a dashboard built using Redash (Redash Ltd., Tel Aviv, Israel). All tools that were used in putting together this platform were FOSS (Free and Open-Source Software).

### Patient management and transfer

There were no uniform COVID-19 testing policies in dialysis centers in the city of Mumbai. Each center used its own discretion to test patients, either as a screening tool for all patients or testing only symptomatic ones. Once a COVID-19 (positive/suspect) patient was identified, the dashboard coordinator was notified, who promptly assigned the patient to an appropriate COVID-19 facility. Each patient was given the choice of COVID-positive facility (public/private) to be transferred to. This eliminated conflicts pertaining to payments. To handle COVID-19 (suspect) patients, the coordinator followed a similar procedure and accommodated them within the suspect centers until the test results became available, then they were triaged either to a COVID-19 (positive) facility or back to their home center based on the result. By capturing the PIN code of each patient registered on the portal, every attempt was made to accommodate these patients at the COVID-positive facilities closest to their respective home PIN codes. When there were bed availability issues, they were given more distant options. The MCGM made arrangements for dedicated COVID-positive vehicles to transport such patients. There were also private paid services available for the same. One of these available transportation options was adopted.

Until July 2020, the RT-PCR (reverse transcription polymerase chain reaction) test turnaround times (TAT) was 3 to 4 days. Later, as the TAT decreased to 24 hours, the need for suspect facilities waned, and by August 2020, few patients needed this service leading to decommissioning of machines at these suspect centers.

Once patients became noninfective, they were transferred back to their primary center. The duration of stay at the designated COVID-19 facility changed over time as the guidance changed from a test-based isolation to a symptom- and duration-based framework.

Initially, every COVID-19 (positive) patient had to test RT-PCR negative before being transferred out of the COVID-19 (positive) facility.[5] However, in May 2020, this guideline was modified, and any COVID-19 (positive) patient who was asymptomatic and spent 14 days in the COVID-19 (positive) facility could be transferred back to their primary center without mandatory retesting. The citywide population density of COVID-19 (positive) patients on MHD is shown in Figure 1b. The schematic in Figure 2a depicts the process of universal screening of all patients at the dialysis centers, identification of symptomatic patients, and transferring them into COVID-19 (positive/suspect) facilities. Figure 2b depicts the transfer process of COVID-19 (positive) patients from the community dialysis centers into the designated COVID-19 (positive) facilities assisted by the portal.

### Data collection, analysis, and outcome

*Data collection:* All clinical data (age; gender; comorbidities including hypertension, diabetes mellitus, and ischemic heart disease; and duration on dialysis), COVID-19 PCR status, testing dates, and hospitalization details were recorded. In addition, transfer dates, follow-up PCR test dates and transfers to primary dialysis units, and death data were also recorded. The dashboard captured data of the infected and suspect patients and documented their mortality, recovery, and activity status throughout the period of the pandemic. It also computed the efficiency of assigning COVID-19 (positive) patients to suitable dialysis centers. This provided precise data of case growth and projected resource needs. All collected data were stored in a PostgreSQL database management system on the Amazon Web Services (Amazon Inc., Seattle, Washington) cloud computing platform. The data presented in this study include all COVID-19 (positive) ESKD patients who were enrolled on the portal between May 20, 2020, and December 31, 2020. Institutional review board approval from IITB was taken to conduct this study.

*Analysis:* All continuous variables were described as mean with standard deviation, and categorical variables were described as frequency and percentages. The mortality rate was captured as a ratio of the number of deaths due to COVID-19 to the total number of COVID-19 (positive) cases. The analysis of outcomes between the survivors and non-survivors of COVID-19 infection in the ESKD population was done using the Fisher's exact test.

*Outcomes:* The data from the portal described the demographics of the affected population, mortality, risk factors, transfer time to designated dialysis centers, and the infection trend over time.

*Oversight:* The MCGM backed this effort. It sent a mandate to all dialysis centers to ensure compliance with full participation with this project.
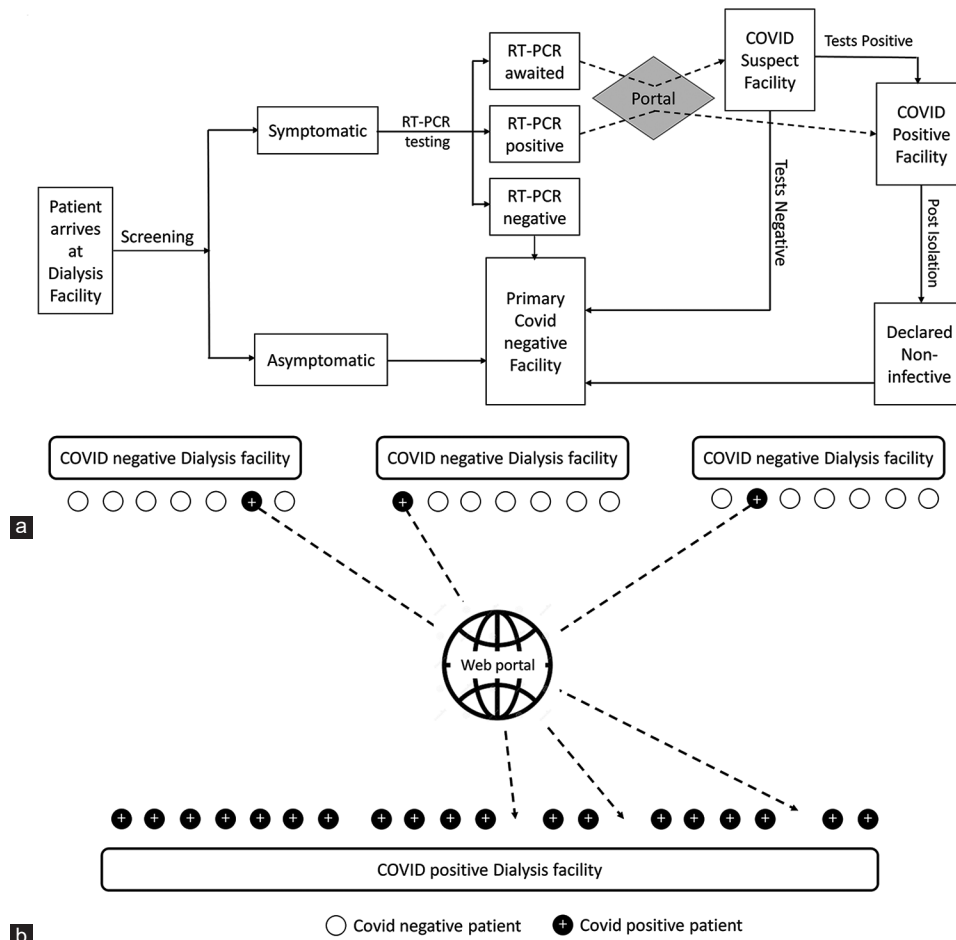
**Figure 2:** COVID-19 positive/suspect MHD patient handling and assignment to designated hemodialysis facilities. (a) Flow diagram – primary screening, testing, enrollment, and transfer. (b) Schematic of portal-directed assignment of patients to designated hemodialysis facilities. (COVID-19, Coronavirus disease 2019; MHD, maintenance hemodialysis; RT-PCR, reverse transcription polymerase chain reaction)

## Results

### Study population

Of an estimated 10,000 ESKD patients on MHD in the city of Mumbai, 1,418 (14%) patients developed COVID-19 infection over the period of study. COVID-19-infected patients originated from 106 of the 174 (61%) hemodialysis facilities across the city and were transferred to 23 designated COVID-19 (positive) centers. Figure 1a shows the distribution of hemodialysis centers in the city. The heat map of the concentration of COVID-19 (positive) cases across the city is shown in Figure 1b. The origin of infected patients roughly mirrored the population density across the city. There were 870 men (61%, mean age = 56 ± 15 years) and 548 women (39%, mean age = 53 ± 13 years). Symptomatic patients constituted 67% of all infected patients.

### Incidence of COVID-19 infection

The number of incident COVID-19 (positive) patients peaked by late June and declined thereafter. There have been minor spikes in the number of new cases during certain periods, without a noticeable second wave as of December 2020. The portal's primary objective was to allocate a COVID-19 (positive) hemodialysis slot to every enrolled patient. This was met within 24 hours for 73% patients, 48 hours for 97% patients, and 72 hours for all patients. As shown in Figure 3, there was an initial surge of COVID-19 (positive) cases in May, 2020. This was because of the inclusion of not just the incident but also the prevalent cases when the portal initially rolled out. Over time, there was a general decline in the number of new cases.

### COVID-19 suspect cases

There were 156 patients who were COVID-19 (suspect) over the period, of which 78 (50%) eventually tested COVID-19 (positive).

### Follow-up COVID-19 testing

During the study period, 47% of COVID-19 (positive) patients underwent retesting by RT-PCR based on the prevalent guidelines. In these patients, repeat COVID test was negative after a median of 12 days (interquartile range 7–20 days).

## Outcomes

Outcomes over time in all patients are depicted in Figures 4a and 4b. Of the 1,351 patients with known outcomes, 370 died giving a mortality rate of 27% in COVID-19 (positive) patients on MHD. This is against a rate of 4% in the general population [Figure 4b].[2] The mean age of patients who died was 60 ± 13 years as compared with 52 ± 14 years in survivors. Time to death was 7 days (interquartile range 2–15). There was no statistical difference in mortality between the genders. Those patients who had one or more comorbidities (hypertension, diabetes, or ischemic heart disease) had a mortality of 51% as against 17% in those without comorbidities. Mortality figures varied among different COVID-19 (positive) health care facilities ranging from 20% to 48%.

*COVID-19 infection among dialysis staff:* The portal also gathered information on COVID-19 infection in hemodialysis personnel from 116/174 dialysis centers (67%). COVID-19 infection occurred in 191 of 1,725 hemodialysis personnel (11%) from these 116 centers, with no deaths.

Thus, our prospective study showed a COVID-19 infection rate of 14% among a large cohort of chronic MHD patients from multiple centers in a big metropolitan city. The mortality rate in this group was 27%. The IT platform and a collaborative approach between nephrologists with oversight from the city Municipal Corporation helped ensure the continuation of dialysis care for these patients.

## Discussion

Across the world, dashboards have taken a center stage during the COVID-19 pandemic. The online interactive dashboard from the Johns Hopkins University, Baltimore, was the first such publicly shared resource.[6] It has helped researchers, public health authorities, and the public to visualize and track reported cases of COVID-19 infections and assisted with critical policy decision making as the outbreak unfolded.[7-10]
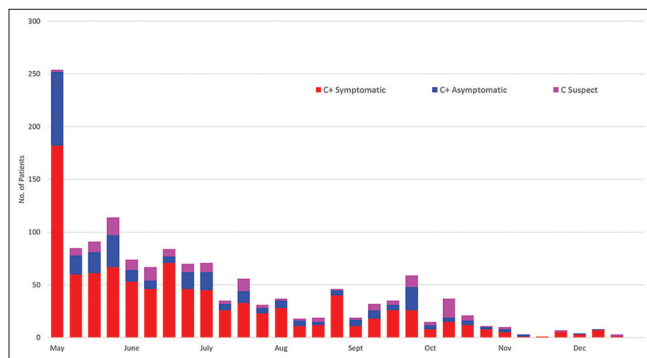
We have previously reported a high incidence of infection among ESKD patients on MHD in Mumbai.[1] In this study, the crude incidence of COVID-19 is at least 14% with possible ascertainment bias due to changing testing criteria over time. The creation and deployment of the COVID-19 dashboard allowed the relatively seamless provision of dialysis services across the public and private sector dialysis facilities within the city, with 97% provision within 48 hours and 100% within 72 hours for all COVID-19 suspect and positive cases. This is in stark contrast to reports from other places in the country where approximately 28% patients missed one or more dialysis sessions, about 3% required emergency dialysis sessions, and about 4% stopped reporting for dialysis.[11] The portal closely tracked the outcomes of each of the 1,418 patients registered on it. It ensured that each one received timely dialysis. None of these patients, therefore, dropped out from dialysis owing to this appropriate and timely intervention.

The portal concurrently compiled data of these patients developing into a useful data resource for COVID-19 infection in hemodialysis patients in the city. In the present study, 1,418 COVID-19 (positive) ESKD patients in Mumbai constituted approximately 14% of all MHD patients and 0.48% of the total number of infected cases in the city as of December 31, 2020. The infection was reported from 61% of all hemodialysis centers in the city.
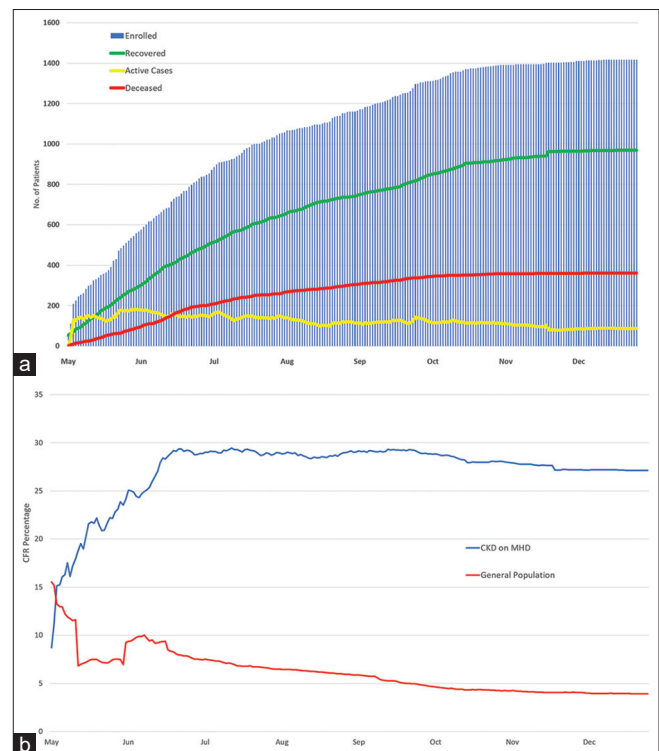
**Figure 4: Outcomes of COVID-19 positive hemodialysis patients. (a) Cumulative number of enrollments, recoveries, deaths, and active patients over the study period. (b) Mortality rate due to COVID-19 infection in hemodialysis patients (blue curve) and in the general population (red curve) during the study period. (COVID-19, Coronavirus disease 2019)**

**Figure 3: Weekly enrollments of symptomatic/asymptomatic/suspect patients onto the portal**

The overall mortality of COVID-19 in this MHD setting was 27%, in line with the reported literature.

The incidence of COVID-19 in published literature varies from 2% (Wuhan) to 20% (London).[12,13] The cumulative cases of COVID-19 in MHD patients in England ranged from 0.9% to 33% in the individual region/centers, with an overall incidence of 11%.[14] This variability could be dependent on the community prevalence, testing policies wherein all or only symptomatic patients were tested, and other confounding factors. There were no uniform COVID-19 testing policies in dialysis centers in the city of Mumbai. Each center used its own discretion to test patients, either as a screening tool for all patients or testing only symptomatic ones. Of the patients registered on the portal, 33% were asymptomatic. In the Brescia study, 19% of COVID-19 (positive) patients were asymptomatic.[15] This is in sharp contrast to a previous study from Mumbai where all dialysis patients were tested and 74% of infected patients were found to be asymptomatic.[1] It is yet unclear whether the proportion of symptomatic and asymptomatic patients is related to an impaired immune response due to underlying CKD.[16]

The time to retest negative after enrollment was 16 ± 14 days (median 12 days). A previous study in Mumbai that was done in the early epidemic period when retesting was the rule, reported a 96% viral clearance rate by Day 17.[1] Data from the United Kingdom reported that on retesting in MHD patients after COVID-19 diagnosis, only 59% tested negative by Day 15.[17] The available data suggest that prolonged viral RNA (ribonucleic acid) shedding after symptom resolution is not clearly associated with prolonged infectiousness and may reflect replication-incompetent SARS-CoV-2.[18-20]

The mortality due to COVID-19 was 18% in the previous study done in Mumbai and 16% in the Wuhan study.[1,21] Several case series from Europe and the United States with varying follow-up suggest a high mortality rate in the dialysis population with rates ranging from 20% to 41%.[22-25] The mortality rate of 27% in MHD patients in our study captures a longer duration of the pandemic and a larger caseload than published data to date and is within the range reported from the high-income countries mentioned above.

The mortality rate was initially low when the portal was deployed in late May 2020 (5%) possibly due to more aggressive testing for the virus during this period with a dilution of the numbers from milder and asymptomatic cases that could lower the mortality rate.[26,27] This reached a peak in July 2020 and then maintained a plateau until December 2020, when the rate stood at 27%. This stability of the number subsequently might also indicate a degree of expertise in handling these patients as well as standardization in testing protocols after July 2020.

It is now known that older age, cardiovascular disease, diabetes, chronic respiratory disease, hypertension, and cancer are associated with an increased risk of death in COVID-19 infection.[28] Patients on MHD are at high risk as they share similar comorbidities.[29] In our study, patients who had at least one of three comorbidities (hypertension, diabetes, or ischemic heart disease) had a mortality of 51% as against 17% in those with none, reflecting published literature. The mortality in the top 10 hospitals that serviced the maximum number of COVID-19 (positive) patients ranged from 20% to 48%. This wide range in mortality could be attributed to a referral bias, overburdening of selective hospitals, and variation in treatment protocols.

Although 11% of the dialysis personnel contracted COVID-19 infection, none of them died. The Wuhan study had a lower rate of infection in hemodialysis staff (3%).[30] This higher infection rate among staff in our study is likely because it covered a longer duration of the epidemic (7 months) compared with the Wuhan study (2 weeks), as well as a higher community prevalence in Mumbai compared with Wuhan. Younger age and lack of comorbidities could potentially have contributed to the zero mortality in dialysis caregivers.

This report has certain inherent limitations. Patients with acute kidney injury due to COVID-19 were not included in this study. This study was focused on ESKD patients on MHD alone. We did not have the exact figure of the number of patients undergoing MHD in the city. Also, "Project Victory" was primarily aimed at ensuring the allotment of dialysis slots to COVID-19 (positive) ESKD patients; hence, the portal did not capture granular data on hospitalization or intensive care admissions, ventilator needs, or response to specific anti-COVID-19 therapies.

In conclusion, "Project Victory" is unique in being the only such citywide, centralized, large, collective effort utilizing a web-based portal to help COVID-19-infected MHD patients secure a quick dialysis slot. It has the largest number of reported cases of COVID-19 (positive) ESKD patients from a single city. This project has helped health care providers and administrators guide patients to access chronic MHD services efficiently. The overall incidence of infection was 14% with a mortality of 27% among COVID-19 positive cases. This mortality was due to the complications arising out of COVID-19 infection and not due to delayed or denied dialysis. With isolation, we may have prevented the patient-to-patient and patient-to-staff spread of the infection. The nephrology community and the city administration embraced this multidimensional initiative for a common cause, demonstrating the value of collaborative health care management during a pandemic.

Municipal Corporation of Greater Mumbai, and the Indian Institute of Technology, Bombay.

### Conflicts of interest

There are no conflicts of interest.

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## Appendix:

### Other members of the Mumbai Nephrology Group (Project Victory)

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Vaibhav, Dharap

Atit, Dharia

Haresh, Dodeja

Arun, Doshi

Rekha, Dubey

Bhupendra, Gandhi

Sohum, Gohil

Rajendra, Gunjotikar

Sachin, Gupta

Arun, Halankar

Atul, Ingale

Swapnil, Jadhav

Amit, Jain

Pankaj, Jawandhiya

Deepa, Jayaram

Makhija, Jhoomar

Vidya, Kadam

Shailesh, Kakde

Nikhil, Kedia

Vaibhav, Keskar

Jitendra, Khandge

Umesh, Khanna

Mustafa, Khokawala

Ashok, Kirpalani

Dilip, Kirpalani

Sachin, Kodgire

Amar, Kulkarni

Mihir, Kulkarni

Chaitanya, Kulkarni

Niranjan, Kulkarni

Arvind, Kunde

Siddharth, Lakhani

Amit, Langote

Dinesh, Mahajan

Jhoomar, Makhija

Raman, Malik

Hemant, Mehta

Mahendra, Merchant

Majid, Momin

Amit, Nagrik

Ravindra, Nikalji

Atim, Pajai

Aashay, Pandya

Harish, Pathak

Amjadkhan, Pathan

Ashwin, Patil

Rohan, Pradhan

Mahesh, Prasad

Prashant, Rajput

Akash, Ranka

Alka, Rao

Ramesh, Rao

Ruchi, Samdhani

Salman, Sayyed

Neha, Shah

Sohil, Shah

Arun, Shah

Bharat, Shah

Hemal, Shah

Rechal, Shah

Hardik, Shah

Wasiyeeullah, Shaikh

Suyash, Sharma

Mukesh, Shete

Sharad, Sheth

Ashay, Shingare

Abhishek, Shrikhande

Anurag, Shukla

Akash, Singhada

Nitin, Sonawane

Lohitaksh, Suratkal

Rudramani, Swami

Shruti, Tapiawala

Aseem, Thamba

Parag, Tilve

Kirti, Upadhyay

Deepa, Usulumarthy

Bhavesh, Vora

Harshal, Vora

Sameer, Vyahalkar

Menal, Wali

Jyotsna, Zope