

Aftermath of fortnightly universal testing for severe acute respiratory corona virus-2 infection in maintenance hemodialysis patients

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Abstract

Introduction: Asymptomatic maintenance hemodialysis patients with acute respiratory corona virus-2 (SARS-CoV-2) are missed with pre-dialysis screening without testing. The possible ideal strategy of testing each patient before each shift with reverse transcription polymerase chain reaction (RT-PCR) is not feasible. We aimed to study the effectiveness of fortnightly screening with RT-PCR for SARS-CoV-2 in curbing transmission.

Methods: Between July 1, 2020 and September 30, 2020, all 273 patients receiving hemodialysis were subjected to fortnightly testing for SARS-Cov-2 in the unit to detect asymptomatic patients. The cost and effectiveness of universal testing in preventing transmission were analyzed using susceptible-infectious-removed (SIR) modeling assuming R_0 of 2.2.

Results: Of 273 MHD patients, 55 (20.1%) found infected with SARS-CoV-2 over 3 months. Six (10.9%) were symptomatic, and 49 (89.1%) asymptomatic at the time of testing. Six (10.9%) asymptomatic patients develop symptoms later, and 43 (78.2%) remained asymptomatic. A total of seven (6.1%) HCWs also tested positive for the virus. Fortnightly universal testing is cost-effective, and SIR modeling proved effective in preventing person-to-person transmission.

Conclusions: Repeated universal testing in maintenance hemodialysis patients detected 89% of asymptomatic SARS-CoV-2 patients over 3 months and appeared to be an effective strategy to prevent person-to-person transmission in the dialysis unit.

1 | INTRODUCTION

End-stage renal disease (ESRD) patients on in-center maintenance hemodialysis (MHD) are at a triple disadvantage during the COVID-19 pandemic. Firstly, they are at higher risk of acquiring severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) infection due to risk of exposure during frequent travel to the

dialysis center, assembling in the waiting halls before dialysis shifts, and exposure with fellow patients within the dialysis units.¹ Secondly, these patients may not have typical symptoms, for example, fever but only fatigue. The early symptoms of COVID-19 are often confused with uremia resulting in a delay in diagnosis and treatment.^{2,3} Lastly, these patients often have multiple comorbidities, for example, older age, diabetes, obesity, and cardiovascular disease, which are also known risk factors predisposing severe COVID-19 disease.^{2,3}

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Nevertheless, the continuation of uninterrupted dialysis services is essential for the survival of this cohort of patients. A recent study revealed that many patients missed dialysis or died due to a lack of dialysis during the COVID pandemic.⁴ Many professional societies have issued guidelines to prevent transmission of SARS-CoV-2 in dialysis units to protect both the patients and the dialysis staff from getting the infection.⁵⁻⁷ In addition to strict universal droplet and contact precautions, the guidelines suggested pre-dialysis screening for the temperature and other symptoms of COVID 19. The testing for SARS-CoV-2 of nasopharyngeal specimens by RT-PCR and isolation of infected individuals became essential components for preventing nosocomial transmission.

Recent reports have shown that a significant proportion of patients on MHD that tested positive for SARS-CoV-2 had no symptoms.^{8,9} Pre-dialysis screening for symptoms of COVID-19, followed by RT-PCR testing, will miss the asymptomatic MHD patients infected with the virus. The latter may spread the infection to fellow patients and staff in the unit leading to an outbreak. Hence, the ideal strategy would be identifying and early isolation of both symptomatic and asymptomatic SARS-CoV-2 infected individuals minimizing the potential for nosocomial transmission. However, the data of the repeated universal testing of the MHD patients and its outcomes are lacking. This study describes the outcomes of the early implementation of dialysis unit-specific infection control measures, including repeated universal testing of all MHD patients by RT-PCR.

2 | METHODS

The study was conducted at a tertiary care institute in the northern part of India between July 1, 2020 and September 30, 2020. The dialysis unit has 273 MHD patients and 114 health care staff, including physicians, nurses, dialysis technicians, allied health, and environmental services personnel. The institute ethics committee approved the study and was conducted as per the Declaration of Helsinki. Informed consent for the study was taken from patients and staff.

2.1 | Structural changes and testing policy in the dialysis unit with reference to COVID 19

A dialysis unit-specific protocol for preventing nosocomial transmission of SARS-CoV-2 was developed after discussions with the hospital infection control committee (Table S1). The dialysis unit has 54 dialysis stations, 48 in the main unit, and 6 in the isolation unit, designed for hepatitis and HIV positive patients. Physical partitioning of the main dialysis unit created nine isolated cubicles, each having six dialysis stations. The distance between dialysis stations was increased minimum to 1 m. Both patients and staff were allocated to fixed dialysis cubicles. Universal masking, frequent hand hygiene with 70% alcohol-based sanitizers, and physical

distancing inside the dialysis unit were enforced on all patients. Patients with symptoms were tested for the SARS-CoV-2 by nasopharyngeal swab RT-PCR. Universal droplet and contact precautions with N95 mask with face shield and surgical gown were made mandatory for all dialysis staff during dialysis. Before entering the dialysis unit, everyone was screened for forehead temperature and a questionnaire (i.e., symptoms of COVID-19, residence, or travel to COVID-19 “hot spots” and contact history with persons or family members with known COVID-19). Those failing screening or with COVID-19 suspect symptoms were not allowed to enter the dialysis unit and were sent for SARS-CoV-2 RT-PCR test. Pending test reports, patients were dialyzed in the “holding area” dedicated to the COVID suspect patients. In addition to testing those with symptoms or pre-dialysis screening suggestive of COVID-19, testing was also done following a high-risk exposure with a confirmed positive case and before any elective intervention/surgery.

2.2 | Universal testing for SARS-CoV-2 by RT-PCR

Testing all patients visiting the hospital irrespective of symptoms was made mandatory by the hospital infection control committee from May 15, 2020. The policy of fortnightly universal testing for MHD patients was adopted. The first universal testing of all MHD patients was done on July 1–3, 2020, and subsequently, universal serial testing was continued fortnightly till the end of the study. Staff was only tested if they developed any COVID-19-related symptoms and after incidental exposure without protective gear.

2.3 | Clinical characteristics of the patients

Clinical data, including age, gender, body mass index (BMI), native kidney disease, comorbidity, viral serology, and dialysis-related variables (i.e., vintage, vascular access, frequency, and modality), were noted. Exposure characteristics like public transport, use of waiting area, residence in COVID “hot spots,” exposure history with a confirmed positive case, and family member positivity were noted. Information about RT-PCR testing (i.e., indication, date, and the result of the test) and dialysis session details (i.e., dialysis station, cubicle, day, and shift) was collected prospectively. Those testing positive for SARS-CoV-2, information regarding symptoms, date of symptom onset, and recent exposure with other patients and staff were noted. Patients were classified as symptomatic if they had symptoms at the time of testing, pre-symptomatic if they did not have symptoms at the time of testing but later developed any symptoms, and asymptomatic if they did not exhibit symptoms at any time till the end of the study period. The first available laboratory parameters (e.g., white blood count, percentage Lymphocyte/Neutrophil, C-reactive protein, ferritin, procalcitonin, fibrinogen, fibrinogen degradation products, D-Dimer, and albumin) after confirmation of SARS-CoV-2 infection were noted.

2.4 | Statistical analyses

Data were expressed as the mean (\pm standard deviation) or median (range) for continuous variables and number (%) for categorical variables. The Student's *t*-test or one-way analysis of variance (ANOVA) was used to compare continuous variables, and the Pearson chi-square test was used to compare categorical variables. Susceptible-infectious-removed (SIR) modeling was performed to show the effectiveness of universal testing. The detailed description of SIR modeling has been shown in Zhang et al.¹⁰ and Goicoechea et al.¹⁴ All statistical analyses were performed using SPSS version 20.0 (SPSS, Chicago, IL). The *P* value of <0.05 was considered significant.

3 | RESULTS

3.1 | Patients related outcomes

Of 273 hemodialysis patients, 55 (20.1%) got infected with SARS-CoV-2 over 3 months (Figure 1, Table 1). The indications of testing of the patients and health care personnel (HCPs) are shown in Table 1. The clinical characteristics of SARS-CoV-2 positive and negative MHD patients are shown in Table 2. Out of 273, 39 (14.2%) patients were elderly (≥ 65 years), and 224 (82.0%) of the patients had one or more comorbidity. There was no significant difference in age, gender, ESRD cause, and comorbidities between the two groups. At the time of testing for SARS-CoV-2, only six (10.9%) patients were symptomatic, and 49 (89.1%) patients were asymptomatic for COVID-19. Of

the asymptomatic patients, six (10.9%) became symptomatic during follow-up (i.e., pre-symptomatic; median, 5 days; range, 3–10 days), and 43 (78.2%) patients remained asymptomatic through their course of illness. The universal testing identified 41 (74.5%), whereas pre-dialysis screening identified 6 (10.9%) positive patients. One patient (1.8%) tested positive on pre-operative testing done before arteriovenous fistula angioplasty and another one (1.8%) after a high-risk exposure with a symptomatic patient in the waiting area. A significantly higher proportion of positive patients had family members positive for COVID-19 (7.2% vs. 1.3%, $P = 0.013$) and were using a common waiting area (16.3% vs. 6.8%, $P = 0.026$) as compared to negative patients. However, there was no correlation with contact history with confirmed positive case ($P = 0.548$), or use of public transport ($P = 0.663$), and residence in COVID “hot spots” ($P = 0.429$).

Clinical and laboratory characteristics of symptomatic, pre-symptomatic, and asymptomatic patients are shown in Table 3. Symptomatic patients had a significant difference in white blood cell count ($P = 0.025$), % lymphocytes ($P = 0.000$), C-reactive protein ($P = 0.000$), and procalcitonin ($P = 0.007$) as compared to others. Serum ferritin ($P = 0.121$) and fibrinogen ($P = 0.118$) levels were similar among the three groups. All the positive patients were hospitalized with a stay of 22.8 ± 9.9 days (range, 6–52 days). The entire three groups had a similar length of hospitalization ($P = 0.559$). Six (10.9%), three (5.4%), and three (5.4%) patients had mild, moderate, and severe COVID-19 disease, respectively. Four (7.2%, two symptomatic and two asymptomatic) patients had required mechanical ventilation during hospitalization, and three (5.4%, two symptomatic and one pre-symptomatic) had died.

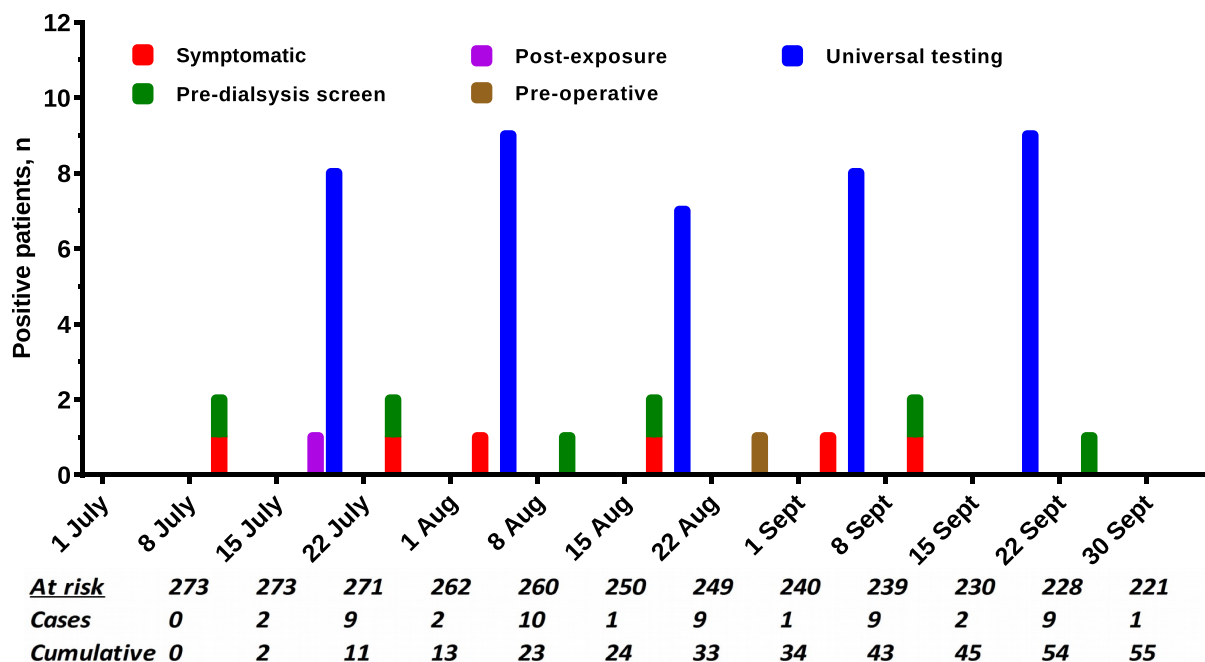


FIGURE 1 From July 1, 2020 to September 30, 2020, a total of 55 hemodialysis patients tested positive for SARS-CoV-2. Patients were tested either because of symptoms suggestive of COVID-19 (red), after failing pre-dialysis screening (green), after a high-risk exposure (violet), before an elective operative procedure (brown). All patients were also tested every fortnight as part of the universal testing protocol (blue) [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Indication for testing and symptoms among SARS-CoV-2 positive patients and health care personnel

	SARS-CoV-2 positive patient (n = 55)	SARS-CoV-2 positive staff (n = 7)
Symptoms		
Symptomatic at the time of testing	6 (10.9%)	4 (57.1%)
Asymptomatic at the time of testing	49 (89.1%)	3 (42.8%)
Became symptomatic on follow-up	6 (10.9%)	1 (14.3%)
Remained asymptomatic throughout	43 (78.2%)	2 (28.6%)
Indication for testing		
Symptoms	6 (10.9%)	4 (57.1%)
Pre-dialysis screen	6 (10.9%)	1 (14.3%)
High-risk exposure ^a	1 (1.8%)	1 (14.3%)
Pre-operative ^b	1 (1.8%)	1 (14.3%)
Universal testing ^c	41 (74.5%)	-

^aOne patient tested positive after a high-risk exposure in the waiting area with another patient who was symptomatic and later tested positive; one staff tested positive after a high-risk exposure with the positive index staff.

^bOne patient tested positive when tested before AV fistula angioplasty; one staff tested positive when tested before an elective dental procedure.

^cUniversal testing of all patients was done by RT-PCR every fortnightly; universal testing of staff was not done.

3.2 | Staff related outcomes

Ninety-six (84.2%) of 114 staff had undergone RT-PCR tests at least once during the study period. Seven (6.1%) staff tested positive for SARS-CoV-2 till September 30, 2020 (Figure 2 & Table 1), of which four (57.1%) were symptomatic and three (42.9%) were asymptomatic at the time of testing. The index staff tested positive on July 17, 2020 and likely had acquired the infection from a social event. Of the three asymptomatic positive staff, one had a high-risk exposure with the index staff. Another positive family member and the third tested positive when screened before an elective dental procedure. The later became symptomatic on follow up. All five symptomatic staff had a milder disease, and all recovered.

3.3 | Distribution of positive cases

There were no statistically significant differences in the number of positive patients found across the dialysis cubicles and dialysis schedules (Figure 3 & Table S2). Also, there was no clustering of positive patients around any dialysis staff.

3.4 | Effectiveness of universal testing in preventing person-to-person transmissions and cost-effectiveness with expected and observed positive

SIR modeling was performed using cumulative case numbers from the initial 2 weeks (July 1, 2020 to July 15, 2020) and assuming a basic reproduction number (R_0) of 2.2.^{10,11} All MHD patients were assumed to be susceptible at the start, and all infected patients were considered infectious. Expected cumulative positive case numbers were calculated by removing symptomatic and screened positive patients

(Figure 4). With an assumption of R_0 2.2 and isolation of symptomatic patients only, all 273 patients could have been affected by September 30, 2020; with the isolation of both symptomatic patients and those testing positive after pre-dialysis screen, only 52 (19%) infections could have been prevented. However, at the end of the study period, 218 (80%) patients remained uninfected of SARS-CoV-2. The observed cumulative cases were significantly fewer than the predictive model supports the effectiveness of universal testing and isolation of asymptomatic SARS-CoV-2 positive patients in the dialysis unit.

During the study period, a total of 1966 RT-PCR tests were performed in 273 MHD patients (i.e., 7.2 tests per patient). The total cost of testing was USD 39320 (i.e., one RT-PCR test cost is about USD 20). Considering hospitalization cost (USD 16/day), length of hospitalization of 23 days, and wage loss of USD 5.2/day of a semi-skilled person in this part of India, 55 positive patients' cost of treatment was USD 26818. With the assumption of SARS-CoV-2 infection to all 273 patients without universal testing as found in SIR modeling, the total cost would have been USD133115, thus saving USD 106297.

4 | DISCUSSION

In this study, 20% of the MHD patients became infected with SARS-CoV-2 over 3 months. Initial reports from China estimated the prevalence of SARS-CoV-2 infection in hemodialysis units of 9.6% based on RT-PCR or IgM/G antibodies and 17% based on CT-based screening.^{12,13} Studies from Spain, the United Kingdom, and Italy report the prevalence of SARS-CoV-2 infection as 19%, 22%, and 26%, respectively.^{11,14,15}

In our study, most (89%) of the SARS-CoV-2 infected patients were asymptomatic at the time of testing, and the majority (78%)

TABLE 2 Characteristics of SARS-CoV-2 positive and negative hemodialysis patients

	All patients (N = 273)	SARS-CoV-2 positive (n = 55, 20.1%)	SARS-CoV-2 negative (n = 218, 79.9%)
Age (years)	40.9 ± 14.2	41.0 ± 13.8	40.9 ± 14.3
Gender (male: female)	209:64	42:13	167:51
BMI (kg/m ²)	21.0 ± 3.4	21.5 ± 2.8	20.9 ± 3.5
Native kidney disease			
Chronic glomerulonephritis	98 (35.9%)	19 (34.5%)	79 (36.2%)
Chronic interstitial nephritis	85 (31.1%)	17 (30.9%)	68 (31.2%)
Diabetic nephropathy	38 (13.9%)	9 (16.3%)	29 (13.3%)
Chronic allograft nephropathy	22 (8.0%)	5 (9.1%)	17 (7.8%)
Cystic kidney disease	8 (2.9%)	1 (1.8%)	7 (3.2%)
Others	22 (8.0%)	4 (7.2%)	18 (8.2%)
Comorbidities			
Hypertension	209 (76.5%)	45 (81.8%)	164 (75.2%)
Diabetes	42 (15.4%)	12 (21.8%)	30 (13.7%)
Cardiovascular disease	31 (11.3%)	8 (14.5%)	23 (10.5%)
Obesity	29 (10.6%)	7 (12.7%)	22 (10.1%)
COPD/Asthma	8 (2.9%)	1 (1.8%)	7 (3.2%)
Malignancy	2 (0.7%)	1 (1.8%)	1 (0.4%)
Dialysis vintage (months)	36.8 ± 25.5 (5–156)	39.3 ± 27.2	36.2 ± 25.1
Dialysis frequency			
2 per week	202 (74.0%)	38 (69.1%)	164 (75.2%)
3 per week	71 (26.0%)	17 (30.9%)	54 (24.8%)
Dialysis modality			
Hemodialysis	249 (91.2%)	49 (89.1%)	200 (91.7%)
Hemodiafiltration	24 (8.8%)	6 (10.9%)	18 (8.3%)
Access			
AV fistula	256 (93.8%)	51 (92.7%)	205 (94.0%)
Tunneled catheter	17 (6.2%)	4 (7.3%)	13 (6.0%)
Viral serology			
HBV	11 (4.0%)	2 (3.6%)	9 (4.1%)
HCV	18 (6.6%)	4 (7.3%)	14 (6.4%)
HIV	2 (0.7%)	0	2 (0.9%)
Exposure risks			
Use of public transport for travel to dialysis center	87 (31.9%)	19 (34.5%)	68 (31.2%)
Residence in COVID “hot spots”	10 (3.7%)	3 (5.5%)	7 (3.2%)
Exposure history with confirmed positive case	11 (4.0%)	3 (5.5%)	8 (3.6%)
Family member COVID positivity	7 (2.6%)	4 (7.3%)	3 (1.4%)
Use of common waiting area	24 (8.8%)	9 (16.4%)	15 (6.9%)

Abbreviations: BMI, body mass index; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; SARS-CoV-2, severe acute respiratory corona virus-2.

remained asymptomatic throughout the follow-up period. Few (11%) infected patients who were initially asymptomatic later became symptomatic. Other studies also reported a high (50%–60%) prevalence of asymptomatic infection among MHD patients.^{8,9} The paucity of symptoms in these patients may be attributed to immune dysfunction due

to uremia or underreporting of milder symptoms. Pre-dialysis screening-based testing identified only 11% positive patients indicating either lack of typical clinical signs (i.e., fever) or atypical clinical features (i.e., fatigue), which is usually attributed/imputed to uremia. In this study, universal testing detected the majority (74.5%) of the

TABLE 3 Characteristics of SARS-CoV-2 positive hemodialysis patients

	Symptomatic ^a (n = 6)	Pre-symptomatic ^a (n = 6)	Asymptomatic ^a (n = 43)
Age (years)	42.3 ± 12.4	38.5 ± 8.2	40.7 ± 14.0
Gender (male: female)	4:2	5:1	34:10
Comorbidities			
Hypertension	7	5	31
Diabetes	2	3	7
Cardiovascular disease	2	1	5
Obesity	1	2	4
Symptoms			
Sore throat	4	5	—
Rhinorrhea	2	1	—
Cough	3	3	—
Dyspnea	1	1	—
Fever	4	4	—
Myalgia	3	3	—
Headache	3	2	—
Laboratory parameters ^b			
White blood count (×1000/μl)	8.4 ± 4.7	6.0 ± 1.2	5.5 ± 2.1
Lymphocytes (%)	13.8 ± 9.3	19.1 ± 5.1	25.4 ± 6.5
C-reactive protein (mg/dl)	36.4 ± 25.4	15.1 ± 14.0	10.8 ± 8.4
Serum ferritin (ng/ml)	748.9 ± 391.5	869.7 ± 317.0	598.8 ± 314.3
Serum procalcitonin (ng/dl)	8.1 ± 16.1	0.7 ± 0.3	0.9 ± 0.6
Fibrinogen (mg/dl)	445.6 ± 159.8	302.0 ± 109.6	394.4 ± 117.7
D-dimer ^c	3	2	8
Fibrin degradation products ^c	3	3	7
Disease severity			
Mild	3	4	—
Moderate	1	1	—
Severe	2	1	—
Supplemental oxygen	4	3	—
Mechanical ventilation	2	2	—
Death	2	1	0
Length of hospital stay	26.5 ± 12.9	20.3 ± 6.7	23.0 ± 9.8

^aPatients were classified as symptomatic if they had symptoms at the time of testing, pre-symptomatic if they had no symptom at the time of testing but later developed any symptom, and asymptomatic if they did not exhibit symptoms at any time till the end of the study.

^bFirst available laboratory values of admission. Reference values: white blood count (WBC) = 4.5–11.0 × 1000/μl; lymphocytes (%) = 20%–40%;

C-reactive protein = 0–6 mg/dl; ferritin = 16–200 ng/ml; procalcitonin = 0–0.5 ng/dl; fibrinogen = 200–400 mg/dl.

^cQualitative test for D-dimer and FDP.

SARS-CoV-2 infected patients who were asymptomatic at the time of testing. Two cross-sectional studies, which tested all MHD patients following a COVID-19 outbreak in the unit, found a prevalence of SARS-CoV-2 infection of 4.6% and 8.2%, respectively.^{16,17} However, universal testing was not repeated in both the studies, and follow-up testing was done only for symptomatic patients. In a skilled nursing facility experiencing a COVID-19 outbreak, weekly universal testing identified 8.4% of its inmates with SARS-CoV-2 infection.¹⁸ We detected a significant number of asymptomatic patients with SARS-CoV-2 with universal serial testing by RT-PCR. As all the infected

patients were admitted to a COVID facility, this testing strategy allowed us to isolate them early. A large proportion of infected patients can be asymptomatic, and the latter could be the source of nosocomial transmission in a hemodialysis unit. Therefore, identifying and isolating asymptomatic individuals (i.e., both patients and staff) may be prudent. It can be done by testing all with a sensitive test, preferably done at frequent intervals, for example, nasopharyngeal swabs for RT-PCR before each dialysis session. This ideal scenario is seldom possible without the cost and patient discomfort. However, it was reassuring that despite the presence of a large number of

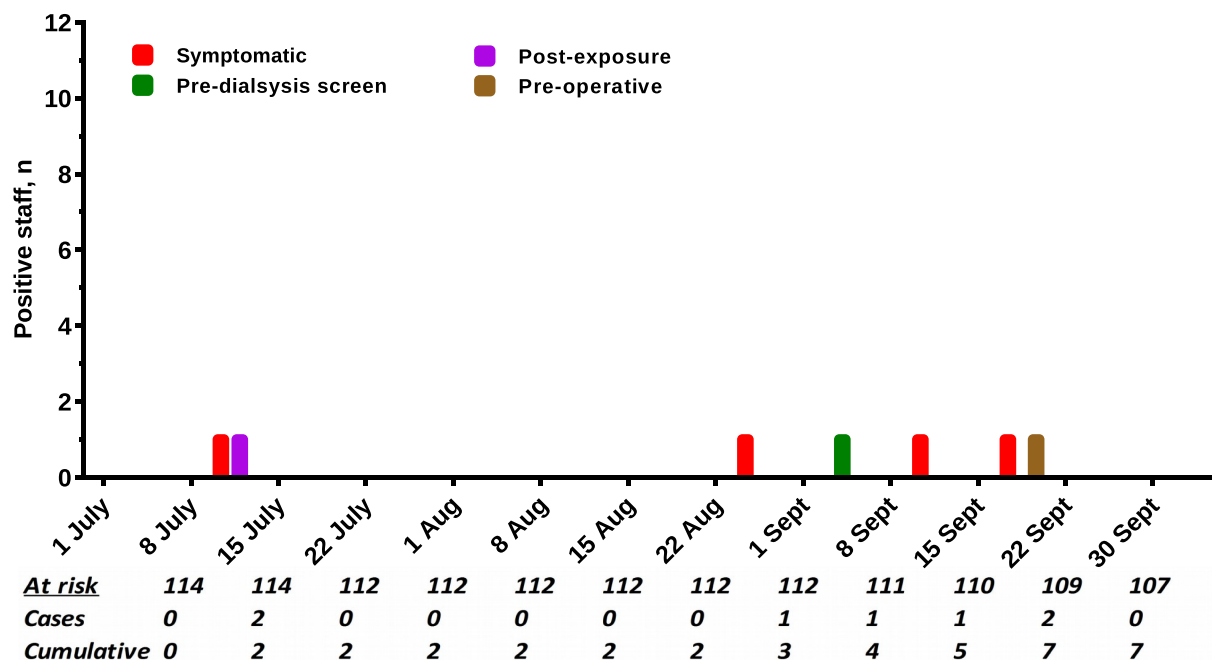


FIGURE 2 From July 1, 2020 to September 30, 2020, a total of seven hemodialysis unit staff tested positive for SARS-CoV-2. Patients were tested either because of symptoms suggestive of COVID-19 (red), after failing pre-dialysis screening (green), after a high-risk exposure (violet), before an elective operative procedure (brown) [Color figure can be viewed at wileyonlinelibrary.com]

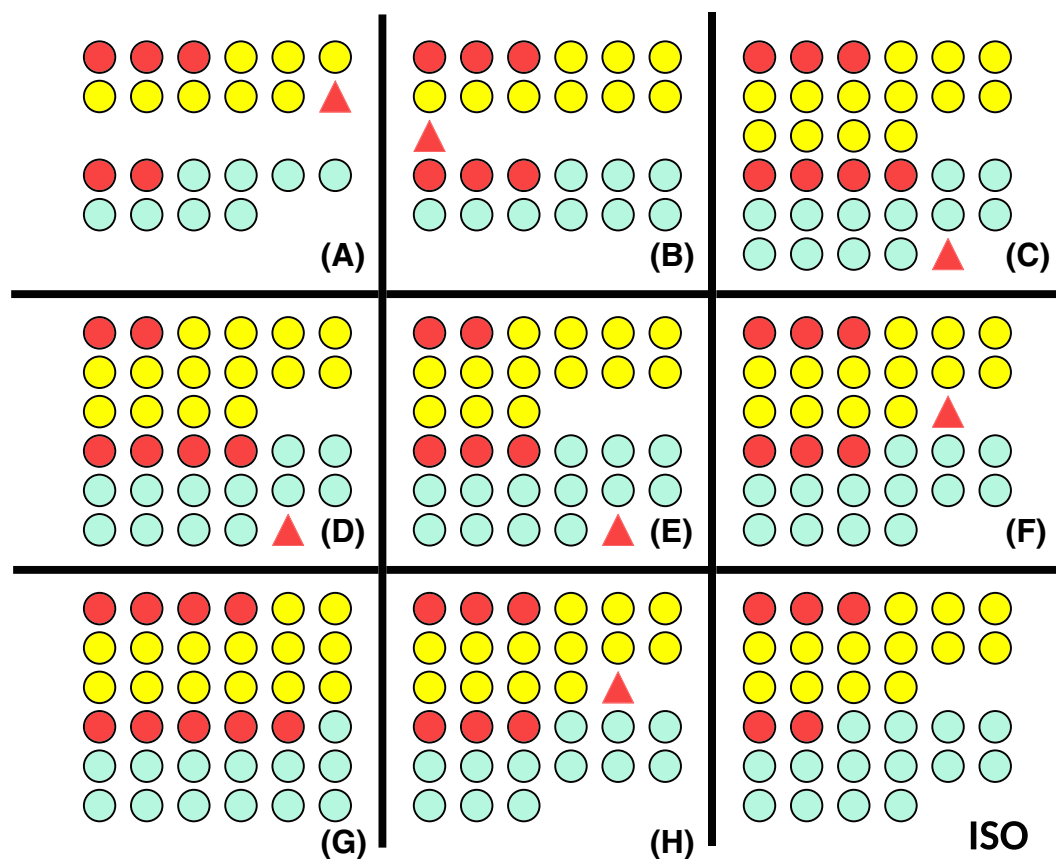
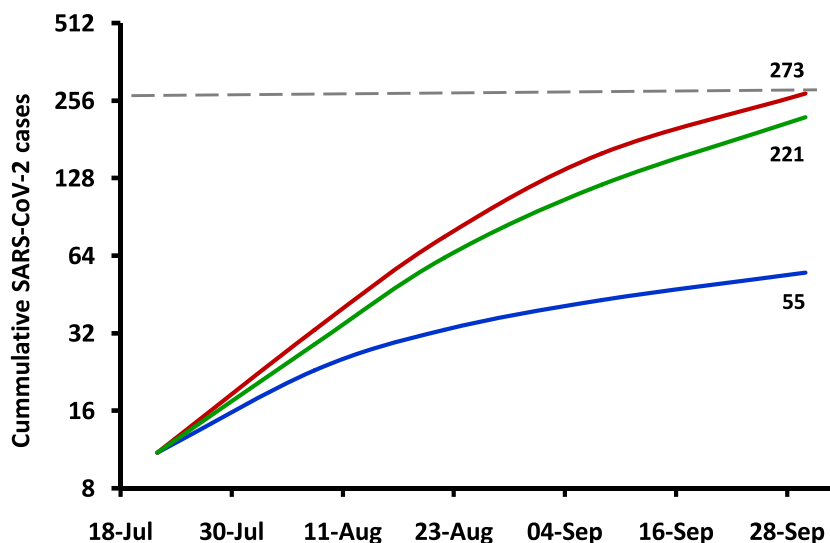


FIGURE 3 Distribution of SARS-CoV-2 positive cases in the dialysis unit. Patients (red circle) and staff (red triangle) tested positive for SARS-CoV-2. Patients tested negative for SARS-CoV-2 (yellow circle-morning session & blue circle-afternoon session) [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 4 Expected and observed SARS-CoV-2 positive patients in the dialysis unit. Deviation of observed cumulative SARS-CoV-2 cases from susceptible-infectious-removed (SIR) predictive model suggested the effectiveness of control measures. Observed cumulative number of infections (log scale) between July 22, 2020 and September 30, 2020, starting from the twelfth case with universal testing (blue); expected number of infections assuming an R_0 of 2.2, with the isolation of symptomatic patients only (red) and expected number of infections assuming an R_0 of 2.2, with the isolation of symptomatic patients along with patients testing positive after pre-dialysis screen (green line) [Color figure can be viewed at wileyonlinelibrary.com]



asymptomatic SARS-CoV-2 positive patients, we did not find clustering of positive cases in any dialysis cubicle or shift, indicating that transmission has not occurred in the dialysis unit. Early implementation of preventive measures, for example, physical compartmentalization of dialysis unit, mandatory use of a mask by patients, along with strict droplet and contact precautions by staff, may have prevented nosocomial transmission. The SIR modeling showed that universal testing was effective as only 55 patients got infected with universal testing. Otherwise, all patients in the unit could have been infected over the study period.

In this study, only about 6% of the dialysis unit staff became positive over 3 months. Testing of all the staff done following an outbreak in a dialysis unit of Canada reported a prevalence of SARS-CoV-2 infection of about 12%.¹⁷ Lower incidence of staff positivity rates in our study may be due to strict droplet and contact precautions inside the dialysis unit and the policy of mandatory N95 masks throughout the hospital.

Ours is probably the first study describing the implementation and outcomes of repeated universal testing on MHD patients in a hemodialysis unit. The study showed that a significant number of asymptomatic SARS-CoV-2 infected patients could be identified on universal testing, and isolation of the latter from the dialysis unit can be implemented. However, the study remains limited because of the lack of a controlled population without universal testing. There are several other limitations to our study. Asymptomatic infections among dialysis staff may not have been detected as universal testing was not done. The dialysis staff underwent testing only if they had symptoms or had an exposure with a confirmed positive individual. All staff wore N95 masks, face shields, and isolation gowns during the working hours; the policy of not testing them if asymptomatic was thought to pose a minimal risk for nosocomial transmission. Given the limited sensitivity of SARS-CoV-2 nasopharyngeal swabs, false-negative test results may still have underestimated the dialysis unit's true disease burden. This fact stresses the importance of strict universal droplet and contact

precautions even if RT-PCR based universal testing protocol is being implemented to prevent transmission from individuals with false-negative test results. Although it is not known whether RT-PCR positivity in asymptomatic individuals represents the ability to transmit the virus, it seems prudent to isolate such individuals from the dialysis facility.

5 | CONCLUSION

In conclusion, repeated universal testing effectively prevents the person-to-person transmission of infection in the MHD units. It may add to pre-dialysis screening directed testing to identify asymptomatic individuals infected with SARS-CoV-2. Early isolation of infected individuals and physical compartmentalization of the dialysis unit, and universal droplet and contact precautions prevented an outbreak in the MHD unit.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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