

Impact of Telemedicine on Hospitalisation and Mortality Rates in Community-Based Haemodialysis Centres in Singapore During the COVID-19 Pandemic

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Abstract

Introduction: With the unprecedented challenges imposed on the modern healthcare system due to the COVID-19 pandemic, innovative solutions needed to be swiftly implemented to maintain clinical oversight on patient care. Telemedicine was introduced in Singapore in community-based haemodialysis (HD) centres to comply with the Ministry of Health's directives on movement restriction of healthcare workers and related measures to minimise the spread of SARS-CoV-2 in healthcare facilities.

Methods: We describe here our experience of 26 community haemodialysis centres in Singapore, analysing clinical audit data, as well as comparing hospitalisation and mortality rates as outcomes in the time frames of pre- and post-introduction of telemedicine.

Results: We found that the hospitalisation rate was 13.9% (95% CI: 5.6%–21.5%, $P < 0.001$) lower in the period after telemedicine rounds were introduced. The mortality rates per 100 person-years (95% CI) were 11.04 versus 7.99 in the compared groups, respectively, with no significant increase in mortality during the months when telemedicine was performed.

Conclusion: Patients received appropriate care in a timely manner, with telemedicine implementation, and such measures did not lead to suboptimal healthcare outcomes. Telemedicine was a successful tool for physician oversight under movement control measures implemented during the COVID-19 pandemic and may continue to prove useful in the 'new normal' era of healthcare delivery for HD patients in community-based dialysis centres, operated by the National Kidney Foundation in Singapore.

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Introduction

Pandemics and natural adversities challenge healthcare delivery systems. The traditional model of care in Singapore's community-based haemodialysis centres has been nephrologist-led, with monthly physical rounds by nephrologists. During these rounds, patient care issues including haemodialysis parameters, metabolic disease management, anaemia control, iron supplementation, blood pressure regulation and multiple chronic disease-related management are optimised. Telemedicine was adopted as a new standard of care by the National

Kidney Foundation (NKF) during the COVID-19 pandemic. NKF is an organisation that is at the forefront of providing community-based dialysis treatment, with commitment to journey with the patients during every step of their end stage renal disease (ESRD) care. Telemedicine by NKF was set up in concurrence with the Singapore Ministry of Health (MOH) directives on movement restrictions of healthcare workers across different institutions, following the rapid escalation of community COVID-19 transmission cases.^{1,2} Details of the swift implementation of telemedicine service in NKF dialysis

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centres (DCs) and its challenges have been previously described by Ngoh et al.³

As part of this new model of tele-haemodialysis, virtual patient rounds were conducted via video-conferencing with the nephrologist (if the physician was based primarily in a hospital), while patients and dialysis nursing staff remained physically at dialysis centres. Laboratory and dialysis reports were reviewed on an electronic medical record and progress notes were electronically logged. Other models of telecare have been described in remote communities in Canada and Australia, such as tele-case reviews with multidisciplinary teams.⁴ Although reports described no difference in health condition or care utilisation with these methods, the rapid transition to telemedicine in Singapore has raised some concerns. Here we compare medical outcomes in our HD cohort before and after telemedicine was introduced.

Methods

This was a retrospective analysis of clinical audit data from NKF DCs. Eleven of 37 DCs were excluded from the analysis as they saw the continuation of physical physician rounds, because the physicians involved did not have any hospital duties. Twenty-six DCs accounting for 2590 patients were included in the analysis. The 2 periods chosen for comparison were that of pre-introduction of telemedicine rounds—1 November 2019 till 31 January 2020—and post-introduction of telemedicine rounds—1 February till 30 April 2020. Hospitalisation and mortality rates were chosen, as these represent a culmination of various patient care indices translating into measurable hard outcomes.

The various parameters assessed were expressed as a mean with standard deviation. The matched-pairs t-test was used to compare pre- and post-introduction of telemedicine rounds. All analyses were performed with PASW Statistics (Version 18, SPSS, Chicago).

Data was presented as a mean (SD) or median (IQR) for continuous variables (normal and non-normal distributions, respectively) and n (%) for categorical variables. Crude hospitalisation rates per 1,000 HD patients were calculated by dividing the number of hospital admissions by the total number of HD patients at the end of each time period. Hospitalisation rates per person-year were derived by dividing the hospital admissions by the total person-years in each time period. 95% confidence intervals were derived using Byar approximation of Poisson regression. Negative binomial regression model correcting for over-dispersion was used to compare the incidence rate ratios (IRR) between the 2 time periods after adjusting for case-mix.

Crude death rates (expressed in % for each quarter) were calculated by dividing total deaths by the total HD patients at the end of each time period. Absolute mortality rates were calculated per 100 patient-years of follow-up with 95% confidence intervals and comparisons made using Mid P Exact test. *P* values <0.05 were considered statistically significant.

Results

Patient characteristics

Overall, there were 2589 and 2590 patients available for analysis in pre- and post-introduction of telemedicine rounds, respectively. Table 1 shows the 2 comparison groups' characteristics. Despite patient flux related to change of modality of renal replacement therapy to and from peritoneal dialysis, or kidney transplantation, or death, the number of patients between pre- and post-introduction of telemedicine rounds remained relatively stable. There were also no significant differences in the demographics between the HD patient cohorts during the 2 time frames (Table 1).

About 57% of the patients had diabetic kidney disease as the cause of their end-stage renal disease, and 69.8% were classified as having a high medical acuity status, defined by a set of NKF internal assessment criteria (Appendix 1), at the time of admission into the DCs. These 2 parameters remained statistically unchanged between pre- and post-introduction of telemedicine rounds.

Table 1. Characteristics of audit cohort

	Pre-Introduction of Telemedicine Rounds	Post-Introduction of Telemedicine Rounds	<i>P</i> Value
Number	2589	2590	
Age (year)*	63.74±11.41	63.87±11.41	0.67
Male gender, no. (%)	1434 (55.4%)	1457 (56.3%)	0.53
Chinese ethnicity, no. (%)	1496 (57.8%)	1511 (58.3%)	0.69
Diabetes mellitus as aetiology of ESRD, no. (%)	1476 (57.0%)	1474 (56.9%)	0.94
High acuity status,† no. (%)	1806 (69.8%)	1813 (70.0%)	0.85

ESRD: End-stage renal disease

*Values are expressed as means ± standard deviation.

†High acuity status is defined by NKF internal assessment criteria (Appendix 1).

Appendix 1

MEDICAL ASSESSMENTS		NAME OF DOCTOR / NURSE :			
[A] Coronary Artery Disease		Yes	No	Score	Remarks
Recent Myocardial Infarct (<3mths)					
Myocardial Infarct (>3 mths)					
Ischaemic Heart Disease including Angina, Coronary Artery Disease					
Low Ejection Fraction <25% (If 'Yes', please indicate date Ejection Fraction reported:					
Uncontrolled Cardiac Arrhythmias					
[B] Bleeding Risk					
Dissecting Aneurysm					
Abdominal Aortic Aneurysm					
Coagulation Abnormality					
Others: E.g. Bleeding GIT, on anti-coagulant etc					
[C] Malignancy					
Advance malignancy with metastasis					
Any carcinoma					
[D] Advanced Organ Failure					
End Stage Liver Cirrhosis					
Chronic Obstructive Pulmonary Disease					
[E] Age					
<50 years (0 point)					
51-60 years (1 point)					
61-70 years (2 points)					
>71 years (3 points)					
[F] CVA					
Any CVA					
[G] Unstable During Dialysis (symptoms present in 1 out of 3 dialysis sessions in the last 3 dialysis sessions)					
Persistent Problematic Intradialytic Hypotension with symptoms					
Others (e.g Uncontrolled Hypertension [180/110] / SOB / Chest pain) Please indicate under Remarks column if patient develop symptoms which are not listed above					
SCORE FOR MEDICAL DEPENDENCY		Total of Score [A] to [G]			
FUNCTIONAL DEPENDENCY					
[H] Karnofsky Scoring (K Score)		Scale	K Score	NKF Score	Remarks
You can rate between 1 to 100 for Karnofsky Score under K Score; for NKF score, indicate '1' if K Score is ≥ 80 ; '2' if K Score is 50 to 79; '3' if K Score is 10 to 49					
Independent	Normal no complaints; no sign & symptoms of disease.	100			Able to carry on normal activity and to work; no special care needed
	Able to carry on normal activity; minor signs or symptoms of disease.	90			
	Normal activity with effort; some signs or symptoms of disease.	80			
Limited Mobility	Cares for self; unable to carry on normal activity or to do active work	70			Unable to work; able to live at home and care for most personal needs; varying amount of assistance needed.
	Requires occasional assistance, but able to care for most of personal needs.	60			
	Requires considerable assistance and frequent medical care	50			
Non-ambulant Patients	Disabled; requires special care and assistance.	40			Unable to care for self; requires equivalent of institutional or hospital care; disease may be progressing rapidly.
	Severely disabled; hospital admission is indicated although death not imminent	30			
	Very sick; hospital admission necessary; active supportive treatment necessary.	20			
	Moribund; fatal processes progressing rapidly.	10			
[I] Details of Mobility (Use Limited Mobility to indicate assistance needed)		Yes	No	Score	Remarks
Amputee (Specify details):					
Wheelchair Bound					
[J] Others		Yes	No	Score	Remarks
Visual Impairment					
Audio Impairment					
Neurological Impairment (Eg. Dementia, Retardation, Epilepsy etc)					
Problematic Vascular Access					
SCORE FOR FUNCTIONAL DEPENDENCY		Total Score [H] to [J]			
TOTAL MEDICAL & FUNCTIONAL DEPENDENCY SCORE (Total of Score [A] to [J])					

Hospitalisation rates

The crude hospitalisation rate was significantly lower post-introduction of telemedicine (630 per 1000 patient-years versus 541 per 1000 patient-years, $P<0.001$). Total number of hospital admissions across 26 dialysis centres in the 2 study time frames were 1,572 and 1,379, respectively, excluding 67 and 46 elective admissions in the respective pre- and post-telemedicine rounding datasets. The number of patients excluded due to missing data were relatively low in both groups: 4 and 5 patients, respectively, had missing discharge date (they remained hospitalised at the end of the period being reviewed), while a further 3 and 4 patients, respectively, had missing diagnostic codes (Table 2).

The hospitalisation rate per person-year was significantly lower post-introduction of telemedicine (pre-introduction of telemedicine rounds: 22.11 (95% CI: 21.74–22.48) versus post-introduction of telemedicine rounds: 16.31 (95% CI: 16.0–16.64), $P<0.001$). Similarly, after adjustment for case mix (adjusted for age, race, gender and ESRD cause; per person-year; IRR based on negative binomial regression models), the hospitalisation incidence was 13.9% (95% CI: 5.6%–21.5%, $P<0.001$) lower in the period after telemedicine rounds were introduced (Table 3).

Table 2. Hospitalisation rates for the 26 dialysis centres comparing pre- and post-introduction of telemedicine rounds

	Pre-Introduction of Telemedicine Rounds	Post-Introduction of Telemedicine Rounds
Duration	1 November 2019–31 January 2020	1 February 2020–30 April 2020
Total hospital admissions (after exclusions)	1572	1379
Exclusions (missing discharge date)	4	5
Exclusions (missing diagnostic code)	3	4
Exclusions (elective admissions)	67	46
Total prevalent HD patients	2493 (as of 31 January 2020)	2549 (as of 30 April 2020)
Crude hospitalisation rate per 1000 HD patients (95% CI)	630.6 (611.4–649.3)	541.00 (521.6–560.3)

CI: Confidence interval; HD: Haemodialysis

The commonest causes of hospitalisation among HD patients were vascular access dysfunction, infections, and cardiovascular disease. There was no statistically significant difference in overall hospitalisation rates in these subgroups between the 2 time frames. Hospitalisations related to vascular access dysfunction were 25.3% and 27.8%, respectively, in both the time periods. Respiratory diseases and infection-related hospitalisations at 21.2% versus 20.2% ($P=0.022$) and cardiovascular disease-related hospitalisations at 25.5% versus 20.9% ($P<0.001$), respectively, were significantly decreased in the post-telemedicine time period (Table 4). However, dialysis treatment-related hospitalisation rates, which include hospitalisation due to volume overload, severe hypotension, missed haemodialysis, pyrogenic reaction and hospitalisation for change in renal replacement therapy modality, demonstrated a statistically significant increase during the post telemedicine period (Table 4).

Mortality outcomes

There were 69 versus 49 deaths during the pre- and post-telemedicine time frames, with a crude mortality rate of 2.77% versus 1.92%, respectively (95% CI). The mortality rate per 100 person-years (95% CI) were 11.04 versus 7.99 in the compared groups respectively, with no significant increase in mortality during the months when telemedicine was performed.

Discussion

The immunocompromised nature of HD patients is well documented in the literature, with Italian and Spanish studies both reporting COVID-19 mortality rates in infected HD patients exceeding 25%.^{5,6} NKF has adopted precautionary measures and protocols during the COVID-19 pandemic to minimise the spread of the infection.

These include:

- Pre-dialysis enhanced screening with temperature measurement and declaration form (which includes travel history, health declaration of self and family) at entry.
- Compulsory surgical mask to everyone (patients, accompanying care givers and all DC staff) throughout the dialysis session and while inside the DC.
- Early referral to hospital/polyclinics for all with temperature more than 37.5 degree Celsius and those with acute respiratory symptoms.
- Enhanced infection control measures in DC, which include frequent hand sanitation, early reporting of fevers or new symptoms to the doctors, better access

Table 3. Hospitalisation rate and incidence rate ratio comparisons between pre- and post-introduction of telemedicine rounds

	Pre-Introduction of Telemedicine Rounds	Post-Introduction of Telemedicine Rounds	P Value
Hospital admissions/no. at risk	1572/2589	1379/2590	
Hospitalisation rate per person year (95% CI)	2.68 (2.55–2.81)	2.35 (2.23–2.48)	0.002
Mean length of stay (days)	8.79 days	7.26 days	0.018
Total hospital days per person-year (95% CI)	22.11 (21.74–22.48)	16.31 (16.0–16.64)	<0.001
Unadjusted IRR (with 95% CI)	1 (reference)	0.867 (0.791–0.951)	0.002
Case mix* adjusted IRR (with 95% CI)	1 (reference)	0.861 (0.785–0.944)	0.001

CI: Confidence interval; IRR: Incidence rate ratio, based on negative binomial regression models.

* Adjusted for age, race, gender and ESRD cause.

Table 4. Reasons for hospitalisation

Reason for Referral	Pre-Telemedicine Number (%)	Post-Telemedicine Number (%)	P Value
Vascular access-related	397 (25.3)	384 (27.8)	0.56
Cardiovascular disease*	401 (25.5)	288 (20.9)	<0.001
Respiratory disease and infections	334 (21.2)	279 (20.2)	0.022
Gastrointestinal disease	133 (8.5)	106 (7.7)	0.06
Dialysis treatment-related	67 (4.3)	105 (7.6)	0.023
Falls and trauma	103 (6.6)	77 (5.6)	0.05
Others†	137 (8.7)	140 (10.2)	0.75
Total	1572	1379	

*Includes coronary artery disease, other cardiac diseases, cerebrovascular disease and peripheral vascular disease.

†Includes endocrine, haematological, malignancy, genitourinary, dermatological, ear, nose or throat disorders, drug reactions, psychiatric disorders, rehabilitation requirements, obstetric or gynaecological disorders.

to infection control team for any queries, increased ventilation of the premises, frequent cleaning of all surfaces in patient care areas, enhanced sterilisation protocols for haemodialysis machines, including hot rinsing in the morning and chemical disinfection after each session.

- e) Segregation of DC staff with their allocated patients in each shift, with no mixing or changing of shifts for patients and DC staff, unless absolutely necessary.
- f) Social distancing measures at work.

Electronic medical record was already in place at NKF when the decision to start virtual rounds in dialysis

centres was implemented in the first week of February 2020. The aim was to mitigate the risk of COVID-19 spread with cessation of in-person dialysis rounds and switching to teleconsultation.

All rounding physicians already had remote access-enabled tablet computers (iPads). As part of the teleconsultation practice, the physicians were able to communicate with the dialysis nurses for all patients via phone or Microsoft Teams platform to conduct their rounds, with easy access to electronic medical record containing all necessary dialysis treatment records. These teleconsultation rounds were conducted on a set monthly basis and on additional ad hoc basis if needed.

With such a teleconsultation method, one concern was the difficulty in assessing the patient's fluid status and the resultant estimated dry weight titration. Trained NKF clinical nurse managers, who underwent proficiency assessment in fluid assessment for patients, helped mitigate these concerns for the rounding physicians.

Telemedicine was swiftly implemented to limit patient-physician interactions. These measures have been largely successful, as to-date, there have been only 3 reported cases of COVID-19 in the NKF HD cohort. The potential advantages and challenges of using telemedicine during the COVID-19 pandemic have been discussed elsewhere.^{7,8}

Difference in hospitalisation and mortality rates

Mortality rates were unchanged by the introduction of telemedicine. Unexpectedly, we found that the overall hospitalisation rates were lower in the period after introduction of telemedicine rounds (Tables 5 and 6). There are several plausible reasons for this. Firstly, hospitals have scaled back on non-urgent investigations and elective surgeries in preparation for the COVID-19 pandemic. Secondly, the triage protocol and enhanced infection control measures put in place during this pandemic likely helped. All patients in NKF HD centres were actively screened during each dialysis session for signs and symptoms suggestive of COVID-19 infection, including temperature monitoring. Patients who failed triage were referred to the local primary care physicians in polyclinics for further management where COVID-19 diagnostic swabs were performed, if indicated. This led to more patients being screened, undergoing diagnostic testing and receiving treatment in outpatient settings, effectively reducing hospital visits.

In addition, the closure of food and recreation outlets during government-mandated 'circuit breaker phase 1', which was implemented between 7 April 2020 and 1 June 2020, coincided with the time period under review. HD patients had better salt and fluid control as a result of these social restrictions, which led to better blood pressure and volume control. This would explain the significantly reduced volume of cardiac-related admissions after the introduction of telemedicine rounds. To our knowledge, this phenomenon has not been reported elsewhere. Finally, a reduction in traumatic injuries from road traffic accidents or street crimes during this period of movement control measures may have contributed as well. However, reports have demonstrated an uptick of domestic violence and psychological affects during these periods of prolonged social isolation,⁹⁻¹¹ the effects

of which cannot be commented on for the purpose of this analysis.

Hospitalisations related to vascular access dysfunction

There was no significant difference noted in the number of hospitalisations related to vascular access dysfunction during both the time frames under review. This indicates that vascular access surveillance can be safely carried out with telemedicine model of care. Patients with urgent vascular needs were managed by telemedicine consultation, followed by day surgery procedures. Day surgery admissions were not captured as hospitalisations in the clinical audit data being reported.

Hospitalisations related to dialysis treatment complications

Hospitalisations related to dialysis treatment complications increased after the introduction of telemedicine rounds. This is more likely a reflection of changing healthcare policies in response to the COVID-19 situation and altered workflows.¹² The majority (>60%) of these referrals were initiated by the DCs for reasons including fever, which was more stringently defined as a reading above 37.5 degree Celsius, with the enhanced screening measures implemented. These patients may not have been sent to the hospital in the pre-pandemic era, due to absence of such infection control measures then. A significant number of these patients were labelled as dialysis-related admissions as they had no positive bacteriology during hospital admission, but required dialysis for fluid overload, having missed a planned community-based dialysis session. Other reasons for cases being categorised as dialysis treatment-related hospitalisation in our analysis were those with hypotension, hypertensive urgency, shortness of breath with fluid overload secondary to baseline cardiac dysfunction or arrhythmias, asthma exacerbation and fluid indiscretion. These scenarios leading to increased hospitalisation can be partially explained by the change in workflows prohibiting extra HD sessions, which was implemented once again as an infection control protocol to avoid cross-contamination between different HD shifts and to aid in contact tracing of potential COVID-19 cases.

Seasonal variation is noticed in some countries when respiratory and cardiovascular illnesses are common in winter, and gastrointestinal infectious illnesses predominate in summer. However, as Singapore is situated in the tropics, the seasonal variation is minimal and no diurnal peaks are seen in disease distribution. Our study

Table 5. Mortality rates for the 26 dialysis centres during the 2 time periods

	Pre-Telemedicine	Post-Telemedicine	P Value
Duration	1 November 2019–31 January 2020	1 February 2020–30 April 2020	
Total number of deaths	69	49	
Total prevalent HD patients	2493 (as of 31 January 2020)	2549 (as of 30 April 2020)	
Crude mortality rate (%) per quarter (95% CI)	2.77% (2.18–3.47)	1.92% (1.44–2.51)	
Mortality rate per 100 person-years (95% CI)	11.04 (8.59–13.97)	7.99 (5.91–10.56)	0.08

CI: Confidence interval; HD: Haemodialysis

Table 6. Causes of death

Cause	Pre-Telemedicine Number (%)	Post-Telemedicine Number (%)	P Value
Cardiovascular disease*	32 (46.4)	21 (42.9)	0.71
Infections†	19 (27.5)	14 (28.6)	0.90
Malignancy	3 (4.3)	3 (6.1)	Nil‡
Miscellaneous§	15 (21.7)	11 (22.4)	0.93
Total deaths	69	49	

*Includes coronary artery disease and cerebrovascular disease.

†Includes sepsis and pneumonia.

‡No P value due to small sample.

§Includes GI bleeding, head injury, hepatic failure, old age, pending death certificates, unknown (no death certificate), ESRD-NOS (not otherwise specified).

design was time-bound, which started with the beginning of the COVID-19 outbreak in February 2020. We do not expect any difference in seasonal variations, if the outbreak had occurred at a different time of the year.

The limitations of this analysis include reliance on clinical audit data with a short duration of follow-up. Our study compared 2 equal time periods before and after the beginning of the COVID-19 pandemic in Singapore. The interventions put in place during this time frame, including switching from in-person rounds to teleconsultation, was time-sensitive, and reverted back to in-person rounds with directions received via MOH circulars, as the number of COVID-19 cases in the community declined. This limits any increase in the duration of the study, which is time-barred to the period being reported here.

All the hospitalisation and mortality data have been extracted from electronic medical records and related data systems. Some potential errors in categorising patients, such as reasons for hospitalisations and the exact cause of death, were inevitable. There were also some data that could not be captured due to the non-availability of death certificate and incorrect coding from the hospital's staff by merely mentioning that admission diagnosis as ESRD.

Conclusion

In conclusion, a model of healthcare delivery utilising telemedicine for the care of HD patients had similar outcomes in comparison to conventional in-person physician rounding. Telemedicine can be considered as a useful tool for physician oversight in the setting of a

community-based HD centre. This is especially pertinent in situations where access to such centres may have to be limited, such as in an infectious disease outbreak. It may even be considered as an innovation in the delivery of modern healthcare, as part of the ‘new normal’ for the future. Added advantages, such as decreased commuting time for physicians, may greatly help in increasing work efficiency and aid in capacity-building at times of strains being felt by the healthcare system during pandemics. Further studies assessing other aspects of telemedicine models of HD care delivery, including patients’ psychological acceptance of remote physician oversight and detailed cost-benefit analysis to the healthcare system, are required.

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