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Telemedicine monitoring of high-risk coronavirus disease 2019 (COVID-19) patients by family medicine service after discharge from the emergency department

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Abstract:

BACKGROUND: Up to 25% of the total coronavirus disease 2019 (COVID-19) admissions comprise patients with comorbidities who present to the emergency department (ED) with only mild-to-moderate disease. It is unclear whether as an alternative to hospitalization, telemedicine can be used to monitor these "high-risk" comorbid patients. The aim of our study was to answer this question by comparing the outcome of such patients discharged under a family medicine service (FMS) telemonitoring program and those admitted to hospital.

MATERIALS AND METHODS: Patients with three or more risk factors for progression to severe COVID-19 disease were designated as "high-risk" in our study. In the absence of acute indication for hospitalization, these high-risk patients with mild-to-moderate disease were discharged home under the supervision of FMS led telemonitoring between October 2020 and February 2021 and were labelled as "Telemedicine group." They were compared to similar patients who were admitted to hospital between March-August 2020 before the implementation of telemedicine service (TMS) and were taken as "Control group." Outcome measures included intubation, number of inpatient days, 28-day mortality and cost analysis for the two groups.

RESULTS: Out of 572 COVID-19 patients who presented to the ED, 70 met the inclusion criteria for the "Telemedicine Group" and 35 were included in the "Control Group". In the Telemedicine group, 21 (30.0%) patients were brought back to ED for re-evaluation and 16 (22.9%) were eventually admitted to the hospital. There was no difference in terms of oxygen requirements, intubation, and intensive care unit admission ($P > 0.74$) between the groups, and none of the study patients died. The Family Medicine-led TMS saved 77% inpatient admissions and on average 4.4 hospital days and $3400 per patient ($P < .0001$).

CONCLUSION: Family medicine-led telemonitoring of high-risk COVID-19 patients presenting to the ED with mild-to-moderate disease is a feasible and cost-effective alternative to hospitalization.

Keywords:

Cost effective, COVID-19, discharge, emergency department, family medicine, high-risk, telemedicine

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Introduction

Coronavirus disease 2019 (COVID-19) caused by the SARS-CoV-2 virus has a spectrum of illnesses that vary from asymptomatic infection to mild, moderate, severe, or critical disease.[1,2] The deterioration usually occurs as a result of pneumonia, with shortness of breath and hospital admission occurring after a

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median of 5 and 7 days from the start of the symptoms, respectively.[3,4] Progression to acute respiratory distress syndrome can be rapid thereafter and may happen within 2–3 days from the onset of dyspnea.[4,5] Overall case fatality rate is around 2%.[2] However, COVID-19 in patients with preexisting medical problems has been associated with severe illness and higher mortality.[6,7] An analysis of 600,000 confirmed COVID-19 cases in the United States, showed a mortality rate 12 times higher in patients with reported co-morbidities compared to those without any underlying medical conditions.[8] The risk increases with the number of comorbidities. In a report of 355 patients who died from COVID-19 in Italy, the mean number of preexisting comorbidities was 2.7, and only 3 patients had no underlying condition.[9] This presents a difficult situation for emergency physicians when symptomatic patients with multiple comorbidities present to the emergency department (ED) but are not sick enough to warrant hospital admission. There is a possibility of rapid deterioration of these high-risk patients if they are discharged home, yet admitting them for observation would burden the already stretched healthcare system.

Telemedicine service (TMS) came to the rescue early in the COVID-19 pandemic throughout the world, Saudi Arabia not excepted, and was successfully used both in primary as well as tertiary care ambulatory settings to reduce personal visits to the clinics.[10-12] The scope of the TMSs was then expanded and found to be helpful in monitoring large scale general populations, follow- up on low-risk symptomatic patients discharged from the ED, as well as COVID-19 patients after their hospital discharge, to decrease the rates of ED revisits and hospital admissions.[12-15] However, these studies excluded high-risk patients with pre-existing comorbidities.

The extrapolation of the concept of telemedicine monitoring of COVID-19 patients with multiple comorbidities seems a logical option at a time when healthcare systems have been pushed to their limits. However, there is scant evidence to support the safety of this practice, and high-risk COVID-19 patients with mild to moderate disease are still admitted to the hospital in many places.[16,17] The aim of this study was to compare the utilization and outcome of telemedicine monitoring by family medicine service versus hospital admission for these high-risk COVID-19 patients who presented to the ED of our hospital with mild-to-moderate disease.

Materials and Methods

This study was conducted in King Faisal Specialist Hospital and Research Center, Jeddah, a tertiary care teaching hospital with over 500 beds, including 52 ED and 26 medical intensive care unit (ICU) beds. In addition to taking care of the tertiary care medical, surgical, cardiovascular, and oncology patients, the hospital runs active solid organ and bone marrow transplant programs. Ethical approval was obtained from the Institutional Review Board (IRB) vide Letter No. IRB 2020-115 dated 28/01/2021 and informed written consent was waived for all participants by the IRB since this was a retrospective study.

We used various definitions in our study. We described COVID-19 patients with "Mild Illness" as individuals who had any of the various signs and symptoms of COVID-19 (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste, and smell) but who did not have shortness of breath, dyspnea, or abnormal chest imaging.[18] "Moderate Illness" in patients was defined as evidence of lower respiratory disease in the form of shortness of breath, dyspnea, or abnormal chest imaging but with saturation of oxygen (SpO_2) ≥94% on room air and with no need of supplemental oxygen.[18] The risk factors for "progression to serious or critical COVID-19 disease" were also delineated as per the CDC guidelines.[19] "*Established Risk Factors*" included *c*ancer, chronic kidney disease, chronic obstructive pulmonary disease (COPD), Immunocompromised state from solid organ transplant, Obesity (body mass index ≥ 30 kg/m^2), Serious cardiovascular disease (including heart failure, coronary artery disease, and cardiomyopathies), type 2 diabetes mellitus, Down syndrome, and sickle cell disease. Smoking status was not used as a risk factor in our study as accurate smoking history available for the majority of the patients was unavailable. "*Possible Risk Factors*" were lung diseases (excluding COPD), immuno-compromised state, cerebrovascular disease, liver disease, hypertension, overweight, Type 1 Diabetes Mellitus, and neurological conditions.[19] We defined "*High Risk Patients*" in our cohort as patients with 3 or more risk factors for COVID-19, out of which 2 must be from the 'Established Risk Factors' category. This number of comorbidities was derived from the Italian cohort of patients who died from COVID-19.[9]

The Family Medicine-led COVID-19 TMS was formulated as a designated team comprising Family Medicine nurses, physicians, and coordinators who made contact with the patient via the telephone for follow-up of their COVID-19 symptoms and arranged for ED re-evaluation or direct hospital admission if there was any deterioration. TMS was formulated with existing hospital personnel and resources with no additional expenses. The hospital set up a mechanism whereby a designated on-call Physician would evaluate the ED patients with diagnostic COVID-19 PCR for enrollment in TMS. Once enrolled, the patient would be discharged home with quarantine instructions, and that information would be passed on

to the TMS. The default enrollment in TMS was 10 days; however, this could be modified by the TMS physician if required. The next morning, the TMS nurse from Family Medicine would contact the patient by phone and send via text message detailed instructions, including digital pamphlets regarding COVID-19 symptoms, guidance for monitoring of any warning signs and contact information in case of any deterioration. Using a checklist the TMS nurse would get daily clinical updates from the patients, reassure them regarding expected symptoms or refer them to the Family Medicine TMS physician if symptoms worsen or if there are new warning signs. The TMS physician would contact only referred patients the same day and triage whether they should be taken back to the ED or could stay at home under TMS monitoring. If a patient had to be taken back to the ED, the TMS would arrange the transfer by ambulance and alert the ED physician and on-call COVID-19 team regarding the patient. If admitted to hospital, the patient may still be re-enrolled for TMS after their discharge. At the end of the 10-day telemonitoring period, the TMS physician would discharge the recovered patients from the service or extend the enrollment on a day-to-day basis for symptomatic patients.

This was a retrospective cohort study. To be included in the study, the patients had to meet all the following "*inclusion criteria*:" Age 18 years or older, nonpregnant, had symptoms of COVID-19, presented to the ED due to worsening symptom, had diagnostic COVID-19 testing in the ED, were evaluated by the ED team, and found to have "Mild" or "Moderate" disease with no acute indication for hospital admission, and were "High Risk".

Early in the pandemic from March till August 2020, all tertiary care patients who presented to the ED with symptomatic mild to moderate disease were admitted to our hospital for observation due to their increased risk of deterioration. From these admitted patients, we identified patients who met the inclusion criteria for "high-risk" as described above, and they constituted our "Control Group." Owing to the rise in the volume of patients infected with COVID-19, the scope of TMS had to be expanded out of necessity after August 2020. Even "high-risk" patients with mild to moderate disease who did not meet the admission criteria in the initial ED evaluation, were then directly discharged home from ED under the supervision of the TMS led by the Family Medicine staff. Patients in this cohort who met the inclusion criteria comprised our "intervention group," which we termed as "Telemedicine Group."

The ratio of patients in the intervention to control group was kept 2:1, as we anticipated fewer patients in the control group. Excluding September as the transition month, we included all eligible patients in the intervention group between October 2020 and February 2021 who met the inclusion criteria. They were compared to the eligible patients in the control group of March 2020 till August 2020, starting from the beginning of the study period till the 2:1 ratio was reached.

Outcome measures included in-hospital mortality, number of inpatient days, need for ICU admission, intubation, hospital days saved, and cost analysis. We also explored various parameters specific to the monitoring in the telemedicine group. Descriptive statistics were used to organize the collected data. Data were expressed as mean and standard deviation for continuous variables, and number and percentage for categorical variables. Data were analyzed using *t*-test for continuous variables and Fisher's exact test for categorical variables, as appropriate. All statistical tests were 2-tailed with significance set at $P < 0.05$. The hospital costs were estimated at $950 (Saudi Riyal SR 3562) per inpatient day taking the averages of some of the lowest reported figures and ED visit was estimated at $1200 (SR 4500) per occurrence.[20,21]

Results

A total of 1192 patients were diagnosed with COVID-19 in our hospital from the start of the surge in March 2020 till February 2021. Of these, 572 were seen in the ED. Forty-four patients from September 2020 (transition month) were excluded and another 416 patients were excluded as they did not meet the inclusion criteria. Out of the remaining patients from October 2020 and February 2021, 70 patients met the inclusion criteria and were included in the "Telemedicine Group." Forty two patients from March 2020 till August 2020 fulfilled the inclusion criteria for "Controls" and as per the prespecified 2:1 ratio between 'telemedicine' and 'control' groups, the first 35 hospitalized patients from the start of study duration were taken as "Control" [Figure 1]. The demographics of patients in the two groups are outlined in Table 1. There was no difference in terms of age and comorbidities. Patients in both groups were borderline obese. These patients first presented to the ED on average 4 days after the onset of symptoms. One third had moderate disease, the rest had mild disease, and none were hypoxic [Table 2]. The inflammatory markers, though abnormal did not differ in the two groups.

The TMS nurse called and checked on the patients in the Telemedicine group daily; however, the physician only had to call each patient twice a week on average during the enrollment period. The symptoms of these patients lasted on average for 4 days post-ED discharge [Table 3].

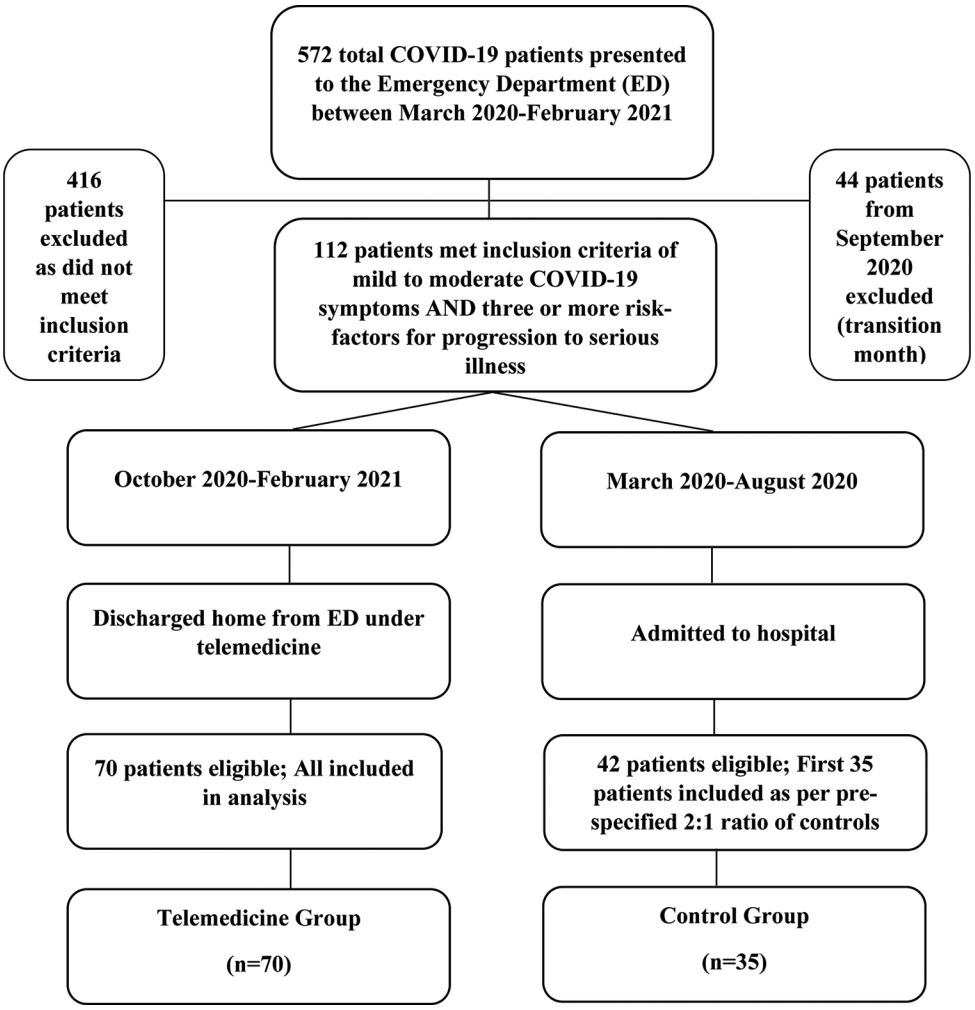

Figure 1: Patient selection and classification in the two groups (*n* = number of patients)

Of the 70 patients in the Telemedicine group, 21 were brought back to ED for re-evaluation and 16 (23%) of them were admitted into the hospital. Since the on-call COVID-19 team had been alerted regarding these patients by Telemedicine team, they were evaluated immediately upon arrival and received any indicated therapy for COVID-19 including steroids, remdesivir or convalescent plasma promptly. This meant that inpatient admission was avoided by TMS in the remaining 77% of the telemedicine group.

None of the patients in the study died even though the cohort were "high-risk". There was no difference in the Telemedicine and the control groups in terms of the requirement for oxygen, intubation, and ICU admission [Table 4]. An average of 4.4 hospital days per patient were saved through the TMS resulting in an average saving of $3400 per patient. This saving was arrived at after the costs of the patients' repeat ED visits in the "Telemedicine" group had been included.

Discussion

Most patients with COVID-19 can be managed as outpatients because the illness does not warrant medical evaluation or hospitalization in approximately 80 percent of the patients.[8,22] However, the odds of survival declines with the combination of worsening symptoms and increasing number of comorbidities.[8,9] TMSs have been widely adopted across the globe for low-risk COVID-19 patients with mild disease to mitigate hospitalizations, but these low-risk patients represent only a fraction of the actual deaths.[10-13] Our study is unique as it focuses on telemonitoring of mild-to-moderate COVID-19 patients at high risk of disease progression and shows that these patients have outcomes comparable to similar patients admitted to hospital. This potential new role of telemedicine can have a huge impact on resource utilization in hospitals overwhelmed in COVID-19 hot spots.

Table 1: Patient characteristics

Characteristic	Telemedicine group (*n*=70) *N* (%)	Control group (*n*=35) *N* (%)	*P-value*
Age (years), Mean±SD	50.22±16.0	50.22±16.08	0.58
Gender			
Male	31 (44.3)	19 (54.3)	0.40
Female	39 (55.7)	16 (45.7)	
BMI (kg/m^2) Mean±SD	29.43±6.06	29.88±5.35	0.71
Most common established risk factors			
Diabetes mellitus, type 2	36 (51.4)	17 (48.6)	0.78
Obesity/severe obesity	35 (50.0)	19 (54.3)	0.83
Cardiovascular disorders	31 (44.3)	14 (40.0)	0.82
Solid organ transplant	13 (18.6)	10 (28.6)	0.31
Cancer	11 (15.7)	6 (17.1)	0.99
Chronic kidney disease	11 (15.7)	5 (14.3)	0.98
Other	20 (28.6)	9 (25.7)	0.82
Most common possible risk factors			
Hypertension	48 (68.6)	26 (74.3)	0.65
Other immunocompromised	15 (21.4)	7 (20.0)	0.98
Diabetes mellitus, type 1	4 (5.7)	3 (8.6)	0.68
Known positive contact	29 (41.4)	13 (37.1)	0.83

SD=Standard deviation, BMI=Body mass index

Table 2: Signs and symptoms and laboratory findings of patients at the initial visit to the emergency department

Signs and symptoms and Lab results	Telemedicine group (*n*=70) *N* (%)	Control group (*n*=35) *N* (%)	*P-value*
Main presenting complaints			
Malaise/body aches	49 (70.0)	20 (57.1)	0.19
Fever	44 (62.9)	26 (74.3)	0.27
Cough	34 (48.6)	22 (62.9)	0.21
Shortness of breath	16 (22.9)	9 (25.7)	0.80
Gastrointestinal symptoms	8 (11.4)	6 (17.1)	0.54
Symptom duration before ED visit (days) Mean±SD	4.0±1.92	4.0±1.78	0.45
Moderate disease	23 (32.9)	9 (25.7)	0.50
Mild disease	47 (67.1)	26 (74.3)	
Chest radiograph in ED	59 (84.3)	31 (88.6)	0.55
SpO_2 in ED, Mean±SD	97.0±1.97	97.0±1.12	0.76
C reactive protein, Mean±SD†	24.92±48.25	37.38±40.7	0.19
Ferritin‡, Mean±SD‡	189.7±217.3	262.4±294.7	0.15
D-dimer*, Mean±SD*	0.673±0.843	0.904±1.75	0.19

†Telemedicine *n*=37, Control *n*=32, ‡Telemedicine *n*=37, Control *n*=30, *Telemedicine *n*=37, Control *n*=26. Mild disease=any symptoms but no dyspnea or abnormal chest imaging; moderate disease=lower respiratory disease/abnormal imaging but $SpO_2 \geq 94\%$ on room air. SD=Standard deviation, SpO_2=Oxygen saturation, ED=Emergency department

Our patients were middle aged, like other studies looking at hospitalized patients.[4,23] Their symptoms and risk factors also reflected what has been reported for COVID-19.[4,6,19] The patients presented to the ED after an average of 4 days of symptoms. This is slightly earlier than what was reported in other studies with COVID-19 patients and may be due to their underlying comorbidities.[4] Our study patients largely reflected the same COVID-19 characteristics as reported in other COVID-19 studies for mild-to-moderate illness.

Our TMS was run without utilizing any additional resources whether financial or personnel. The physicians had to call each patient twice during the 10-day follow-up on the average, which was manageable with their other duties. Even though the majority of these high-risk patients coped well with the disease, one-fourth of the telemedicine cohort were eventually hospitalized. This hospitalization rate is higher than seen in general COVID-19 population, but in accord with the published data regarding high-risk COVID-19 patients.[2,4,6,7] The hospitalization occurred on the average of 4 days after the initial ED visit, which translates to a cumulative period of 8 days from the onset of symptom, similar to the disease progression timelines reported in the literature.[3,4] Having said that, from our high-risk cohort, we could not predict which patients would deteriorate. This highlights the importance of close observation for these patients whether via telemedicine or as inpatients. The telemedicine cohort that got admitted via TMS was promptly given the COVID-19 treatment as per the guidelines including steroids, antivirals, or convalescent plasma as needed. This could explain the excellent outcome, as any delay in treatment adversely impacts mortality.[24]

In our study, Telemedicine did result in significant cost savings per patient and a drastic reduction of inpatient days, as well as reduced hospitalization in this group by 77%. More importantly, there was no difference in outcomes between hospitalizing these high-risk patients and monitoring them under TMS. There was no mortality in either group, which is different than the reported mortality of similar patients.[9] This could be either due to the small sample size or because patients admitted to the hospital before the requirement of oxygen have significantly less mortality than those who present with hypoxia.[17] We hypothesize that widespread early testing, usually advocated for epidemiolocal purposes, may in fact be used to place these high-risk COVID-19 patients under TMS and potentially decrease their mortality. Randomized trials are needed to confirm this proposition.

The strengths of our study are that it proposes a novel utilization of telemonitoring in a high-risk population not studied before, using existing personnel with no additional financial burden; it shows comparable outcomes of ICU admission and death under telemonitoring when compared to similar admitted patients, and results in

Table 3: Parameters during telemedicine monitoring in the intervention group

Parameter during telemedicine care (*n*=70)	*N* (%)
Duration for which patients enrolled in telemedicine (days) Mean±SD	9.8±1.71
Number of days physician called the patients (days)* Mean±SD	2.0±1.35
Symptoms lasted after discharge from the first ED visit (days)* Mean±SD	4.0±2.41
Medications prescribed by telemedicine team	
Acetaminophen	24 (34.3)
Antitussives	13 (18.6)
Oral antibiotic	9 (12.9)
Albuterol inhaler	4 (5.7)
Patients brought back to ED for re-evaluation	21 (30.0)
Total number of ED visits	23.0
Patients admitted to hospital during telemedicine follow-up, *n* (%)	16 (22.9)
Days followed in telemedicine clinic before admission (n=16) Mean±SD	4.5±1.83

*Rounded to nearest 0.5 decimal. SD=Standard deviation, ED=Emergency department

Table 4: Comparison of outcomes between the telemedicine and control groups

Outcomes	Telemedicine group (*n*=70) *N* (%)	Control group (*n*=35) *N* (%)	*P-value*
28-day/in hospital mortality	0	0	NA
Patients required oxygen anytime	16 (22.9)	9 (25.7)	0.80
Patients admitted to intensive care unit	3 (4.3)	2 (5.7)	0.98
High flow oxygen	4 (5.7)	2 (5.7)	
Noninvasive ventilation	0	0	>0.99
Invasive ventilation/ intubation	1 (1.4)	0	
Total number of hospital days	55	182	<0.001
Repeat ED visit	23	NA	NA
Average hospital days in cohort per patient, Mean±SD†	0.79±1.83	5.2±2.62	<0.001
Total inpatient cost per patient*	$750 (SR 2812)	$4150 (SR 15563)	<0.001

†Admitted to hospital in telemedicine, *n*=16; Control, *n*=35, *Per day estimate of one hospital day of $950 and accounting for ED visit cost of $1200 per occurrence in telemedicine group. NA=Not applicable, SD=Standard deviation, SR=Saudi Riyal, ED=Emergency department

significant cost-cutting by reducing hospitalization. However, the study has a few limitations as well. Our patients were middle aged, but elderly patients with 3 or more established risk-factors may not be suitable for TMS monitoring. We had relatively strict inclusion criteria and a smaller cohort. Larger trials will have to be done to replicate the results. Some outcomes or characteristics that showed no difference could also be due to the small sample size. There was no mortality in our study, which may be coincidental or may reflect timely and aggressive intervention before disease deterioration. The early involvement of the patient in a monitoring system and its impact on mortality needs to be tested in larger randomized trials.

Conclusion

Telemedicine home monitoring, led by Family Medicine staff, of high-risk COVID-19 patients presenting to the ED with mild-to-moderate disease appears to be a feasible cost-effective alternative to hospitalization. As the COVID-19 pandemic still rages, this approach can ease the burden on future hospital admissions.[25]

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Conflicts of interest

There are no conflicts of interest.

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