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Outcomes of a home telemonitoring program for SARS-CoV-2 viral infection at a large academic medical center

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Abstract

Introduction: Telemedicine serves as a viable option during the COVID-19 pandemic to provide in-home care, maintain home isolation precautions, reduce unnecessary healthcare exposures, and de-burden hospitals.

Methods: We created a novel telemedicine program to closely monitor patients infected with SARS-CoV-2 (COVID-19) at home. Adult patients with COVID-19 were enrolled in the program at the time of documented infection. Patients were followed by a team of providers via telephone or video visits at frequent intervals until resolution of their acute illness. Additionally, patients were stratified into high-risk and low-risk categories based on demographics and underlying comorbidities. The primary outcome was hospitalization after enrollment in the home monitoring program, including 30 days after discharge from the program.

Results: Over a 3.5-month period, 1128 patients met criteria for enrollment in the home monitoring program. 30.7% were risk stratified as high risk for poor outcomes based on their comorbidities and age. Of the 1128 patients, 6.2% required hospitalization and 1.2% required ICU admission during the outcome period. Hospitalization was more frequent in patients identified as high risk (14.2% vs 2.7%, $P < 0.001$).

Discussion: Enrollment in a home monitoring program appears to be an effective and sustainable modality for the ambulatory management of COVID-19.

Keywords

Home telecare, telemedicine, self-care, telehealth, COVID-19, pandemic, telemonitoring

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Introduction

Healthcare systems around the world are adopting models to manage patients infected with the SARS-CoV-2 virus. Unique challenges with SARS-CoV-2 include the combination of high rates of infectivity and of asymptomatic transmission, potential for rapid disease progression, and a high mortality rate in the elderly and those with underlying comorbidities.[1,2] Limited personal protective equipment (PPE), high rates of healthcare worker infection, and an overburdening of the healthcare system has made face-to-face ambulatory visits challenging.

Telemedicine and in-person visits have demonstrated similar outcomes and quality metrics in a variety of disciplines.[3,4] This modality also provides an approach for remote monitoring and management of patients infected with SARS-CoV2. However, these patients require close monitoring due to the risk of sudden decompensation.[2,5,6] In addition, a unique feature of SARS-CoV-2 infections is objective hypoxia without subjective dyspnea. This "silent hypoxia" has been shown to have similar rates of mortality to symptomatic hypoxia.[7,8] and may go undetected without frequent monitoring. Several

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telemedicine initiatives specific to COVID-19 have been successful, reporting low hospitalization rates and mortality.[9–15] Programs have varied from app-based symptom and vitals monitoring with escalation to nurses and/or providers if needed, to hospital at-home services.

We created a telemedicine service, structured around frequent, virtual appointments with providers, to monitor and manage patients infected with SARS-CoV2 at an academic, tertiary care center in a rural state. The goals were to avoid unnecessary hospitalizations, identify decompensating patients, expedite escalation of care when needed (e.g. same-day in-person evaluations, admissions, and emergency room referrals), and provide support to patients and their families.

Methods

Context

This is a single-center, retrospective cohort study of adult patients with COVID-19 viral infection followed by the University of Iowa Hospitals & Clinics (UIHC) Home Monitoring Program (HMP). The Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) were followed for the reporting of this observational study.[16]

Setting

UIHC is an 845-bed tertiary hospital located in Iowa City, Iowa. The Adult Hospitalist Program consists of more than 70 physicians and advanced practice providers (APPs) staffing different inpatient and consultative medicine services. The program has four years of telemedicine experience with various programs.[17,18] The Influenza-Like Illness (ILI) Clinic is an outpatient clinic, staffed by over 40 primary care physicians and APPs, that utilizes in-person and telemedicine visits to diagnose and treat acute respiratory illnesses. The HMP was a combined initiative between the Adult Hospitalist Program and the ILI clinic in response to the COVID-19 pandemic.

Intervention

Patients were diagnosed with SARS-CoV-2 in one of five locations: a UIHC inpatient ward, the UIHC emergency department, the ILI clinic, periprocedural testing, or an external site, in which case the patient transferred care to UIHC from another facility.

A team of nurses and pharmacists contacted all patients who tested positive for SARS-CoV-2 in the ambulatory setting by PCR. The patients were informed of the positive result, educated on isolation precautions, and had an initial assessment of their illness severity. If patients were interested in the HMP, a referral order was placed to schedule a telemedicine visit. Similarly, patients initially admitted at the time of diagnosis were automatically enrolled upon discharge unless they explicitly opted out of the program. Patients were excluded for any of the following: age under 18, residency outside the state of Iowa, no documented SARS-CoV-2 lab result, opting out of home monitoring, not attending any of the HMP telemedicine visits, correctional facility patients, discharge from the inpatient setting to a skilled nursing facility, long-term acute care, acute rehabilitation, or intermediate care facility.

Patients enrolled in home monitoring were risk-stratified based on age and underlying comorbidities. To identify patients at risk for poor outcomes, a risk stratification scoring system was created based on current CDC guidelines on comorbidities associated with severe disease.[19] Comorbidities thought to be associated with severe disease were designated 1 to 2 points (Supplemental Figure 1). A score of 2 or higher was defined as high risk. A score of 0 or 1 was considered low risk. Additionally, any patient discharged from the hospital with COVID-19 was considered high risk, regardless of their risk stratification score. The scoring system was built into the electronic medical record, automatically run on any patient with documented COVID-19, and calculated a score based on age, documented history, and active medication list.

High-risk patients had a monitoring kit couriered to their home or provided to them at the time of discharge from the inpatient service. The monitoring kit included a pulse oximeter, an automated blood pressure cuff, vital signs and symptoms log sheet, contact information to report worsening symptoms, and instructions regarding home isolation. Printed instructions were available in English, Spanish, and French. The hospitalist team managed the high-risk patients enrolled in the HMP, while the ILI team managed the low-risk patients. Telemedicine visits were conducted via video or telephone and were performed by physicians or APPs. Once enrolled in the HMP, follow-up appointments were scheduled every 1–5 days based on clinical stability until patients had met CDC criteria to end quarantine, or until the patient declined further follow-up. If a patient followed by the HMP was admitted to the hospital, home monitoring would resume upon discharge. A low-risk patient could be transferred to the hospitalist team due to worsening clinical status at the discretion of the ILI provider, or if they were hospitalized after enrollment in the HMP.

An urgent-care-like encounter was created for the in-person evaluation and management of clinically worsening SARS-CoV-2 positive patients enrolled in home monitoring, with the goal of preventing unnecessary hospitalizations and emergency room visits. A call line was established for patients to call outside regular business hours, and was staffed 24/7. A nurse would triage the call based on severity of symptoms and pre-stablished care

escalation protocols (Supplemental Figure 2). Specifically, patients were instructed to contact the nurse triage line if they developed any of the following: SpO2 < 92%, new shortness of breath, rapid breathing, heart rate >110 bpm, temperature over 39 °C, decrease in systolic blood pressure >30 mmHg, inability to keep liquids down for 12 h, or the development of confusion.

Measures

We performed a retrospective analysis of all patients treated by the HMP with positive SARS-CoV-2 testing collected between 9 March 2020 and 30 June 2020. The primary outcome was 30-day hospitalization rates of patients enrolled in home monitoring. A qualifying hospitalization was defined as any hospitalization occurring at any point from enrollment through 30 days after discharge from home monitoring. Hospitalizations for planned procedures, or labor and delivery related admissions for women with term pregnancies were excluded. Secondary outcomes included ICU stay, need for mechanical ventilation, death within 30 days of discharge from HMP, and lost to follow-up rates.

Data was abstracted from the electronic health record (Epic) by seven researchers working independently. To promote consistency of data collection, detailed instructions on the chart review process were provided to all researchers, and random charts were audited to ensure quality control across the various reviewers. Information collected included age, sex, self-reported race and ethnicity, insurance variables, positive SARS-CoV-2 test date and location, symptom onset date, prior hospitalization for COVID-19 viral infection, number and type of telemedicine visits while enrolled in home monitoring, COVID-19-associated symptoms, comorbidities, date of discharge from home monitoring, information related to any hospitalization either during enrollment in home monitoring or within 30 days of discharge from home monitoring.

Table 1. Demographics of HMP patients.

	All patients	Risk score < 2 (low risk)	Risk score ≥ 2 (high risk)
Number of patients	1128	782	346
Age, median (IQR)	32 (22–49)	26 (21–39)	54 (37.25–62)
Sex, *n* female (%)	586 (52.0)	409 (52.3)	177 (51.2)
Race, *n* (%)			
White	614 (54.4)	444 (56.8)	170 (49.1)
Black	145 (12.9)	94 (12.0)	51 (14.7)
Hispanic/Latino	311 (27.6)	194 (24.8)	117 (33.8)
Other	58 (5.1)	50 (6.4)	8 (2.3)
Insurance, *n* (%)			
Medicare	66 (5.8)	5 (0.6)	61 (17.6)
Commercial	869 (77.0)	652 (83.4)	217 (62.7)
Medicaid	140 (12.4)	88 (11.3)	52 (15.0)
Other	5 (0.4)	2 (0.3)	3 (0.9)
Uninsured	48 (4.3)	35 (4.5)	13 (3.8)
Primary language, *n* (%)			
English	916 (81.2)	653 (83.5)	263 (76.0)
Spanish	157 (13.9)	87 (11.1)	70 (20.2)
Other	55 (4.9)	42 (5.4)	13 (3.8)

Analysis

We reported results using descriptive statistics for patient demographics, outcomes, and resource utilization. In addition, we performed univariate analysis on the subgroups of patients with low (0 or 1) and high (≥2) risk scores. We used chi-square testing to evaluate for subgroup differences of categorical variables when at least 10 events were captured, a chi-square with Yates correction when less than 10 events were observed, and a Mann–Whitney *U*-test for comparison of ordinal variables. Data was tabulated in Excel (Version 2008, Microsoft, Redmond, WA) and statistical analysis was performed in SPSS (Version 27, IBM, Armonk, NY).

Ethical considerations

The University of Iowa Human Subjects Office Institutional Review Board (IRB) determined that the project described in the application did not meet the regulatory definition of human subjects research and was considered a quality improvement program.

Results

Between 9 March 2020 and 30 June 2020, 1128 unique patients tested positive for SARS-CoV-2, met eligibility requirements, and were enrolled in the HMP. Hospitalists treated 370 (32.8%) of these patients, family medicine 653 (57.8%), while 105 (9.3%) patients were treated by both services. Demographics of patients by risk status are listed in Table 1. Around half of the patients (54.4%) identified as white, and 18.8% required a language interpreter.

Table 2. Primary and secondary outcomes for HMP patients.

	All patients	Risk score <2 (low risk)	Risk score ≥ 2 (high risk)
Number of patients	1128	782	346
Hospitalizations, *n* (%)	70 (6.2)	21 (2.7)	49 (14.2)
ICU stay, *n* (%)	14 (1.2)	8 (1.0)	6 (1.7)
Need for mechanical ventilation, *n* (%)	6 (0.3)	1 (0.1)	5 (1.4)
Death, *n* (%)	2 (0.2)	0 (0)	2 (0.6)
Lost to follow-up, *n* (%)	79 (7.0)	70 (9.0)	9 (2.6)

Most patients had zero or one COVID risk factor. As intended, patients treated by family medicine providers alone had fewer risk factors than those treated by the hospitalists alone, or by a combination of both teams.

Most patients treated by the HMP did well (Table 2). Only 6.2% ($n = 70$) of patients required hospitalization from the time of enrollment in HMP, through 30 days after discharge from the HMP and 1.2% ($n = 14$) required ICU stay during that same period. Hospitalizations were much more frequent for high-risk patients (14.2% vs 2.7%, $P < 0.001$). We observed similar rates of ICU stay for high- and low-risk patients (1.0% vs 1.7%, $P = 0.494$); however high-risk patients more frequently needed mechanical ventilation (1.4% vs 0.1%, $P = 0.018$).

Seventy-nine of 1128 patients were lost to follow-up prior to discharging from HMP clinic. Patients lost to follow-up were more likely to be low risk (9.0% vs 2.6%, $P < 0.001$). Patients lost to follow-up had similar requirements for language interpretation (15.2% vs 19.1%, $P = 0.395$) and had similar racial composition (white race, 50.6% vs non-white, 54.7%, $P = 0.481$).

One patient died while being monitored by the HMP. The patient and his family detected his deterioration and he presented to a local emergency department for admission pre-mortem. One other patient died of vascular complications within 30 days of discharge from HMP. It was unclear if this patient's death was a result of COVID infection. Both deceased patients were high risk at the time of diagnosis. There were insufficient deaths in this cohort to draw meaningful statistical conclusions.

Patients required a median of 3 (IQR 2–4) telemedicine visits prior to discharge from HMP (Table 3). Patients with high-risk scores had more remote visits than those with low-risk scores (median 4 vs 3 visits, $P < 0.001$). High-risk patients also had more in-person encounters for worsening illness course (11.8 vs 7.2 per 100 patients treated) and were discharged later in their course of illness (15 vs 11 days, $P < 0.001$).

Discussion

Our Home Monitoring Program followed 1128 patients with PCR-proven SARS-CoV-2 virus infection, of whom >92% did not require hospitalization. Most patients required fewer than four visits. Despite the low intensity of the intervention, our results support the use of telehealth to effectively monitor patients with COVID-19 at home, detect clinical deterioration, and rapidly escalate care when needed. Our observed rates of hospitalization and mortality were very low compared with national and regional averages at the time of this study.[20–22] Additional potential benefits of this intervention were decreased exposure to medical personal, conservation of PPE, and increased convenience for patients and families.

Table 3. HMP characteristics: visit metrics and duration of active enrollment in HMP based on risk status.

	All patients	Risk score < 2	Risk score ≥ 2
Number of patients	1128	782	346
No. televisits, median (IQR)	3 (2–4)	3 (2–4)	4 (2–6)
No. in-person, *n* (rate per 100 patients)	98 (8.6)	57 (7.3)	41 (11.8)
Day of illness on discharge, *N* (IQR)	12 (10–16)	11 (9–14)	15 (11–20)

Early in the pandemic, 12% of patients diagnosed with COVID-19 required hospitalization.[6] This high morbidity has motivated the deployment of several telehealth interventions to decrease hospitalizations. One feasibility study showed a hospitalization rate of 8% within the first month after SARS-CoV-2 diagnosis; however, that study included only 50 patients and did not rely on home self-monitoring kits as employed in this program.[11] Similarly, a retrospective study in Wuhan, China, using a symptom monitoring phone-based app, reported hospitalization of 8% of patients as well, but did not include vital signs monitoring.[15] One study including 3000 patients at the University of Pennsylvania Health Systems recorded hospitalization rates of 3.5% in patients monitored through a text-message based system.[13] However, it included patients with presumed SARS-CoV-2 infection, even if the patient tested negative, whereas our study's design focused on patients with a PCR-proven test. This study also followed patients for a fixed duration of 14 days as opposed to the flexible follow-up duration used. Additionally, our HMP was unique in that it was a collaborative effort between predominantly inpatient providers (hospitalists) and outpatient primary care providers to pool resources and best provide care across a wide spectrum of patient acuity.

Our patient population was racially and ethnically diverse. Only 54.4% of patients identified as white, compared to 90.6% of Iowa residents on the 2020 census.[23] This is of particular significance, as when compared with whites, non-whites have higher rates of infection, hospitalization, and death from SARS-CoV-2.[24,25] At the time of this study, there was a large outbreak of COVID-19 in various meatpacking plants and agricultural factories throughout Eastern Iowa, which disproportionally affected non-white populations. Responding to these outbreaks, we were able to translate the instructions in our home monitoring kit to Spanish and French, and expand our interpretation services for both telephone and video visits. Our hope was to make telemedicine more accessible to historically underserved communities and populations.

Our low lost to follow up-rate of 7% reflected the simplicity of the HMP. Enrollment, the visits themselves, and scheduling were streamlined and efficient, requiring minimal effort from the patient. The higher rate seen in low-risk patients is not surprising, as those patients tended to be younger, with milder disease courses.

There are limitations to this study. This intervention was carried out at a single academic center in a rural state, and 69% of our patients had 0 or 1 risk factors for severe illness. In addition, the mean age of our patient population was lower than what is described in similar studies,[11,26] which may contribute to the observed low mortality, low hospitalization rate, and high adherence. The minimal exclusion criteria provide a broad look at our institutional experience during the early months of the pandemic. We acknowledge that the exclusion of patients residing in skilled nursing and intermediate care facilities may exclude populations with much higher risk of complications. It is not clear whether similar interventions would be sufficient in these settings where the rate of patient adverse outcomes would be much higher. This study is also limited by the electronic medical record, which allowed us mostly to only be able to see if a patient had been hospitalized at our institution, but not at other institutions, therefore it is possible that the hospitalization rate could be underestimated if some patients lost to follow-up were admitted to other institutions. Finally, the lack of a control group limits the ability to demonstrate the efficacy of our intervention.

There are also limiting factors to sustaining a model such as ours in future practice. A major hinderance in past studied telemedicine models has been a clinician unwillingness to adapt and learn a new system. Methods that have been suggested to remediate this issue include professional association recognition for completing telemedicine training, incorporating virtual health training into professional curricula, and a reformation of funding to focus on patient-centered outcomes.[27,28] Additionally, while there were not established or widely available anti-viral therapies for COVID-19 infection at the time of this study, such as monoclonal antibodies, their presence now has broadened our options for outpatient management.[29,30]

This study highlights a novel method of providing healthcare in a technology-driven world, reducing the utilization of hospital resources, while also allowing timely identification of disease progression and rapid escalation to inpatient care when necessary. It is also important to know that, in the event of a future pandemic, we have a tested method of risk-assessing patients and providing healthcare while minimizing healthcare worker exposures. Sustainability of this model is reasonable, with a high cost-effectiveness, and a low burden to the patient. In the future, similar methods should be replicated in prospective trials to confirm efficacy and safety.

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Author contributions

Bryant contributed to conceptualization, data curation, investigation, methodology, project administration, supervision, writing (draft preparation, review & editing). Robinson contributed to investigation, methodology, writing (draft preparation). Gutierrez-Perez & Manning contributed to conceptualization, investigation, methodology, writing (review & editing). Glenn contributed to conceptualization, resources, writing (review & editing). Imborek contributed to conceptualization, methodology, writing (review & editing). Kuperman contributed to conceptualization, formal analysis, investigation, methodology, writing (draft preparation, review & editing).

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Supplemental material

Supplemental material for this article is available online.

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