Remote Patient Monitoring Identifies the Need for Triage in Patients with Acute COVID-19 Infection

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Abstract

Introduction: *Telehealth was frequently used in the provision of care and remote patient monitoring (RPM) during the COVID-19 pandemic. The Precision Recovery Program (PRP) remotely monitored and supported patients with COVID-19 in their home environment.*

Materials and Methods: *This was a single-center retrospective cohort study reviewing data acquired from the PRP clinical initiative.*

Results: *Of the 679 patients enrolled in the PRP, 156 patients were screened by a clinician following a deterioration in symptoms and vital signs on a total of 240 occasions, and included in the analyses. Of these 240 occasions, 162 (67%) were escalated to the PRP physician. Thirty-six patients were referred to emergency department, with 12 (7%) admitted to the hospital. The most common risk factors coinciding with hospital admissions were cardiac (67%), age >65 (42%), obesity (25%), and pulmonary (17%). The most common symptoms reported that triggered a screening event were dyspnea/tachypnea (27%), chest pain (14%), and gastrointestinal issues (8%). Vital signs that commonly triggered a screening event were pulse oximetry (15%), heart rate (11%), and temperature (9%).*

Discussion: *Common factors (risk factors, vital signs, and symptoms) among patients requiring screening, triage, and hospitalization were identified, providing clinicians with further information to support decision making when utilizing RPM in this cohort.*

Conclusion: *A clinician-led RPM program for patients with acute COVID-19 infection provided supportive care and screening for deterioration. Similar models should be considered for implementation in COVID-19 cohorts and other conditions at risk of rapid clinical deterioration in the home setting.*

Keywords: *remote monitoring*, *SARS-CoV-2*, *COVID-19*, *telehealth*, *telemedicine*, *hospitalization*, *triage*

Introduction

The SARS-CoV-2 (COVID-19) pandemic presented challenges to overwhelmed health systems and forced the urgent remodeling of care delivery. Specifically in New York, the lack of available hospital beds and clinical resources for patients with acute-COVID-19 infection[1] created a need for the deployment of remote patient monitoring (RPM) programs to facilitate the observation of vital signs and symptoms and detection of changes in clinical status.[2–6] The use of RPM also potentially assisted in the prevention of further crossinfection by allowing patients to be supported in the home environment and therefore avoiding visits to busy hospitals. Given that COVID-19 was a novel disease with many unknowns regarding the clinical course of acute infection, the use of RPM was greatly warranted to ensure that patients with COVID-19 infection received a level of care as comprehensive as possible under the circumstances.

While the severity of COVID-19 disease and symptomatology are diverse, there are several consistent features noted among those who are symptomatic and/or requiring hospitalization. These features should be taken into consideration when designing an RPM program. The most common signs and symptoms include fever, cough, dyspnea, respiratory failure, tachycardia, fatigue, and gastrointestinal issues.[7–9] There are also risk factors associated with higher severity of COVID-19 infection, including cardiovascular disease, pulmonary disease, diabetes, hypertension, and obesity.[10,11] Feelings of anxiety related to COVID-19 are common,[2,12] which may be intensified in patients diagnosed with the disease being managed in the home setting.[13] It is therefore important to utilize RPM strategies to assist in identifying

changes in clinical status and any associations between deterioration and patient risk factor profiles. It is also important to understand what changes in clinical status may lead to the need for the triage and escalation of care.

In the present study, we aimed to determine if the remote monitoring of symptoms and vital signs of people with COVID-19 infection helped to identify predictors of health care utilization outcomes, including need for referral and admission to the emergency department (ED). Furthermore, we sought to determine if RPM was an effective tool for facilitating the triage of care of patients with COVID-19 in their home environment. These data may help to better inform future patient triage and escalation of care in this cohort.

Materials and Methods

STUDY DESIGN

This was a single-center cohort study using data obtained retrospectively. The Mount Sinai Program for Protection of Human Subjects (Institutional Review Board 20-03315) provided approval for publication of data collected as part of the Precision Recovery Program (PRP) between March 1st and September 23rd, 2020.

PARTICIPANTS

Participants were patients enrolled in the Mount Sinai Health System's PRP. Inclusion criteria for this study were a confirmed (positive polymerase chain reaction [PCR]/antibody test) or probable (i.e., confirmed through a physician according to World Health Organization guidelines)[14] diagnosis of acute COVID-19 infection; living within the New York state area; completion of at least one screening event (a synchronous clinical interaction between a clinician and a patient as a result of worsening symptoms) using the PRP.

Precision recovery program. Patients were initially referred to the PRP, an RPM initiative established at the beginning of the COVID-19 pandemic[2] following diagnosis (confirmed or probable) with COVID-19. The PRP was staffed by a group of clinicians (physicians, physical therapists) and clinical coordinators (physician's assistants, clinical coordinators, and clinical research coordinators) and involved the daily reporting of symptoms and vital signs by patients on their own smart device using the MyCap application. MyCap facilitates the administration of surveys developed in Research Electronic Data Capture REDCap) tools. REDCap is a secure, Web-based software platform designed to support data capture for research studies. If a patient did not have access to a smart device, the reporting was completed through videoconference or telephone call.

This study reports data from the PRP regarding the screening and triage events that were triggered when a patient experienced a deterioration in symptoms or physiological measures. The subsequent health care utilization events, and common characteristics of patients admitted to hospital were also explored. A full description of the PRP and home monitoring procedures can be found in a previous PRP publication.[2]

OUTCOME MEASURES AND DATA COLLECTION

Demographics. Baseline demographic data were obtained from the patient's medical record and included gender, age, past medical history known to be risk factors for severe COVID-19 illness (age >65; cardiovascular comorbidity [hypertension, coronary artery disease, heart failure], pulmonary comorbidity [i.e., asthma, chronic obstructive pulmonary disease], immunosuppression [i.e., human immunodeficiency virus, solid organ transplant, or prolonged steroid use], type 2 diabetes, severe obesity [body mass index $\geq 40\ kg/m^2$], chronic kidney disease, or chronic liver disease), and COVID-19 test result.

Screening, triage, and health care utilization. Screening events were defined as the occasions when contact was initiated between a PRP clinician and the patient due to a deterioration in symptoms or vital signs. A triage event was defined as the escalation of the patient's care for review by a PRP physician, either directly by the PRP clinician or at the request of the patient during screening. The decision was then made whether to refer the patient to the ED for further assessment or recommend they remain home with ongoing monitoring.

Specific data captured included the triggering factor for the screening event (symptom or vital sign deterioration), number of events escalated to a PRP physician for triage, and other health care utilization outcomes (ED referral, hospital admission, intensive care unit (ICU) admission, need for mechanical ventilation, death, or continued home monitoring).

Patient-reported symptoms and vital signs. Patients were required to report whether they had chest pain, dyspnea, tachypnea, difficulty concentrating, cyanosis, diarrhea, and anosmia. It was also recorded whether the patient expressed feelings of anxiety related to their symptoms. Vital signs included body temperature, systolic and diastolic blood pressure, heart rate, and pulse oximetry.

DATA ANALYSES

Data were analyzed in Python (3.7.6). Triage events with any missing risk factors, symptoms, or outcome data were removed from analyses. Outcomes for triage events were

Table 1. Patient Characteristics ($n=156$)	
Female	87 (56)
Age, years, mean (range)	47 (23–84)
Past medical history	
Age >65	23 (15)
Cardiac comorbidity	59 (38)
Pulmonary comorbidity	43 (28)
Immunodeficiency/immunosuppression	16 (10)
Diabetes	16 (10)
Obesity	18 (12)
Kidney disease	4 (3)
Liver disease	1 (1)
COVID-19 PCR	
Positive	55 (35)
Unknown	81 (52)
Negative	20 (13)

All data are presented as *n* (%) unless stated.
PCR, polymerase chain reaction.

grouped into three categories: not referred to ED, referred to ED (but not admitted to hospital), and admitted to hospital (including ICU). Radar plots represent the percentage of individuals with the overlapping conditions out of the triaged patients.

Results

Of the 679 patients enrolled in the PRP between March and September 2020, 156 (23%) had at least one screening event containing complete outcome data and were included in the analyses (*Table 1*). Sixteen patients were excluded due to missing data. A total of 240 (median [range] 1 [1–9] per patient) screening events were recorded. Of the 156 patients with screening events, 120 (77%) reported their symptoms and vital signs through a smartphone, with the remaining patients being contacted by PRP clinicians.

PATIENT-REPORTED SYMPTOMS AND VITAL SIGNS

The most common symptoms reported that triggered a screening event were dyspnea/tachypnea (27%), chest pain (14%), and gastrointestinal issues (8%). The most common changes in vital signs that triggered a screening event were pulse oximetry (15%), heart rate (11%), and temperature (9%).

TRIAGE AND HEALTH CARE UTILIZATION

Of the 240 screening events, 162 (67%) were escalated to the PRP physician (*Fig. 1*). Of these 162 occasions, the PRP clinician escalated the event to the physician 99 (61%) times, with 63 (39%) requested by the patient. Participants expressed feelings of anxiety relating to their symptoms and vital signs during 42 (17%) of the screening events.

Patients that were escalated to a physician for triage most commonly reported respiratory symptoms (i.e., tachypnea or dyspnea >20 breaths/min) (21), chest pain (12), low O_2 saturation (SpO2 < 94%) (12), and elevated heart rate (>100 beats per minute) (9%) (*Fig. 2*). Twelve patients (7%) were admitted to hospital, on one occasion each (*Fig. 1*); 11 (92%) involved admission to a unit, and one (8%) to the ICU (without mechanical ventilation). Two patients died following admission to hospital. Of those admitted to hospital, 8 (67%) had tested positive for COVID-19 through PCR test. Ten (83%) of the patients admitted to hospital only had a single triage event leading to admission, with the remaining two patients having two and six triage events preceding admission.

Seven (58%) of the patients admitted to hospital were female, and 5 (42%) were >65 years of age. The most common deterioration in symptoms and vital signs coinciding with patients being admitted to hospital were respiratory

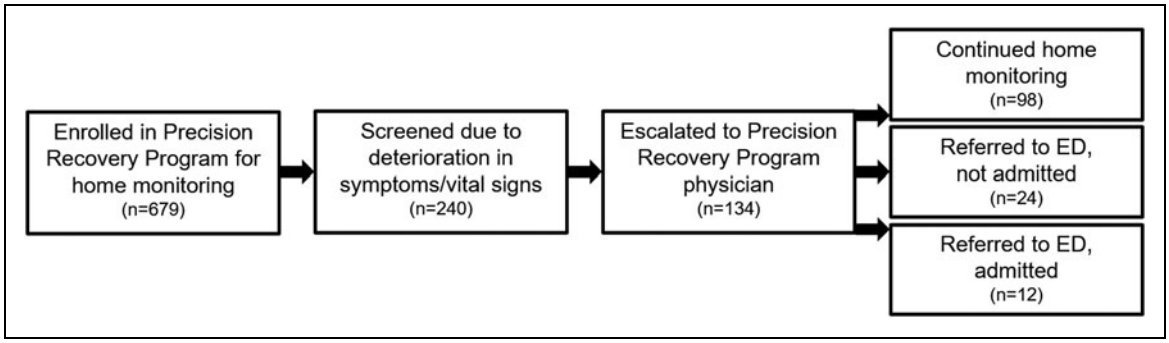

Fig. 1. Flowchart of screening and triage events for patients enrolled in the PRP ($n=679$). ED, Emergency Department; PRP, Precision Recovery Program.

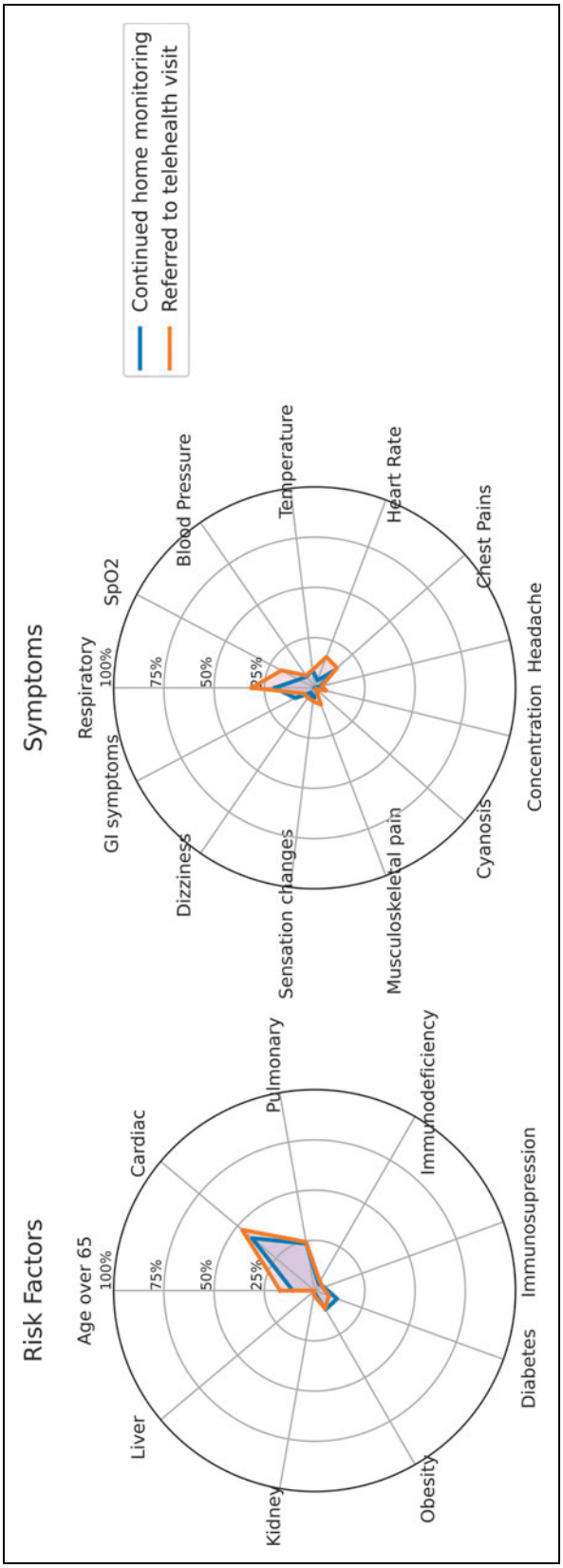

Fig. 2. Risk factors and symptoms in patients who were screened by a PRP clinician ($n = 162$), stratified by whether they were escalated to the physician for triage. Each point on the periphery of the radar plot represents a risk factor/symptom, with the line from center representing the proportion (%) of participants with that risk factor/symptom. GI, gastrointestinal; SpO2, oxygen saturation.

symptoms (50%), low pulse oximetry (42%), fever, and dizziness (*Fig. 3*). The most common risk factors (besides age >65) coinciding with hospital admissions were cardiac (67%), obesity (25%), and pulmonary (17%) (*Fig. 3*). During the screening events that led to hospital admissions, feelings of anxiety were not reported by any of the patients.

Discussion

A clinician-led RPM program for patients with acute COVID-19 infection facilitated the escalation of care to physicians, and subsequent triage to the ED and hospital unit. The low rate of hospital admissions substantiates the role of RPM in delivering clinical support to patients with acute COVID-19 in the home setting. Common factors (medical history, and vital signs and symptoms) among patients requiring screening, triage, and hospitalization were identified, providing clinicians with further information to support decision making when utilizing RPM in this cohort.

Notable limitations of this research include the retrospective nature of the study, and the lack of any comparison group which was not justified in the midst of the surging pandemic. Furthermore, the PRP clinicians screening the patient's symptoms and vital signs, and the physicians providing review were investigators in the study, which could potentially lead to unconscious bias in clinical judgment. This limitation, however, is countered by one of the strengths of the study: the ED, urgent care, and hospital medical teams being naive to the participation of the patients in PRP; therefore, their decision making (and results pertaining to hospital admissions) could in no way be influenced. With any RPM program, there is always a risk that the monitoring makes the patient more aware of their symptoms, although this was unlikely to impact referral to ED and hospital admissions in our study, given they were assessed by a clinician and physician before being referred. To our knowledge, we captured the total number of patients who were hospitalized during enrollment in this program; however, it is possible that patients may have been admitted to other health systems and failed to report this to the PRP team. Due to the low number of hospital admissions observed in our data, there was insufficient power to determine predictors of hospitalization.

RPM and screening supported patients within their home environment, potentially improving the safety of care at a time when the hospital system was at capacity. Furthermore, the PRP may have contributed to the avoidance of ED visits by patients who felt deterioration in their symptoms and would have otherwise presented to the hospital. With only 15% of the screening events referred to the ED, it could be suggested that enrollment in the PRP reduced unnecessary ED visits, which

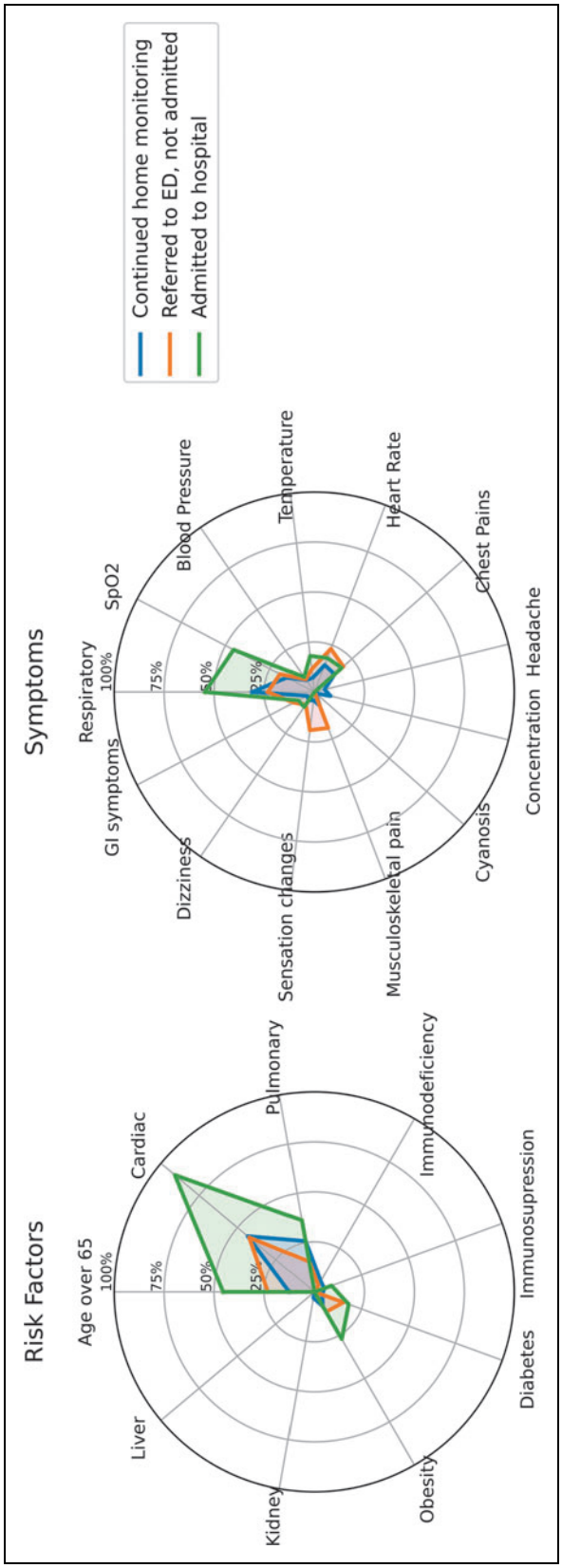

Fig. 3. Risk factors and symptoms in patients escalated to the physician for triage ($n = 134$), stratified by triage outcome. Each point on the periphery of the radar plot represents a risk factor/symptom, with the line from center representing the proportion (%) of participants with that risk factor/symptom.

would have potentially created COVID-19 exposure and contributed to the hospital burden. Contrarily, only one-third of the patients referred to ED were admitted, which may be interpreted as the physicians having a low threshold for referral; however, this is potentially a reflection of the lack of access to hospital beds and staffing pressures experienced during the peak of the pandemic surge. The rapid integration of these types of RPM and other telehealth programs has seen changes in government policy that will ensure the sustainability of this service model into the future.[15]

The comorbidities common among this cohort with COVID-19 (obesity, cardiac disease, pulmonary disease, and immunosuppression) were similar to those identified previously in cohorts at greater risk of developing severe COVID-19 infection.[16] In the patients who were hospitalized, cardiac and pulmonary disease, as well as obesity, were the most common comorbidities. This reflects published predictive models for hospitalization,[17] which found that patients with cardiac and pulmonary disease, obesity, immunosuppression, and of older age, were more likely to be hospitalized. Patients admitted to hospital usually presented with respiratory symptoms and low pulse oximetry, which is unsurprising. Only two-thirds were positive for COVID-19 on PCR, reflecting issues experienced with PCR testing throughout the early stages of the pandemic regarding potential inaccuracies and false-negative results.[18,19]

RPM is an effective method of detecting deterioration in symptoms and vital signs, and provides clinicians with an opportunity to screen and triage care in patients with acute COVID-19 infection. This is important given the paradigm shift in health care delivery that may remain permanently following the resolution of the COVID-19 pandemic. With the increased burden placed on hospitals, leveraging technology and telehealth programs that can assist in clinical decision making is of critical importance in future service design. Further longitudinal data relating to the impact of RPM during this pandemic can be used to inform the optimization and scalability of such programs, ultimately aiming to sustain improvements in care and reduce the burden on the health care system.

Conclusion

A clinician-led RPM program for patients with acute COVID-19 infection provided support care and screening for deterioration, and potentially reduced unnecessary ED visits. Similar models should be considered for implementation in COVID-19 cohorts and other conditions at risk of clinical deterioration in the home setting.

Authors' Contributions

L.T. conceptualized the study and wrote the first article draft; J.W. assisted with data analysis, wrote and edited the first article draft; K.E.L. performed data analysis; N.M. assisted in data collection and article elaboration; J.T. led the clinical procedures; S.D., L.N., and E.B. supported the clinical procedures and data collection; D.P. and C.K. conceptualized the PRP. All authors read and approved the final version of the article.

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No competing financial interests exist.

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