Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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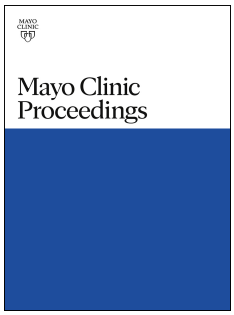

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Impact of a High-Risk, Ambulatory COVID-19 Remote Patient Monitoring Program on Utilization, Cost, and Mortality

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ABSTRACT

Objective: To evaluate care utilization, cost, and mortality among high-risk patients enrolled in a COVID-19 Remote Patient Monitoring (RPM) program.

Methods: This retrospective analysis included patients diagnosed with COVID-19 at risk for severe disease who enrolled in the RPM program between March 2020 - October 2021. The program included in-home technology for symptom and physiologic data monitoring with centralized care management. Propensity score matching established matched cohorts of RPM-engaged (defined as ≥1 RPM technology interactions) and non-engaged patients using a logistic regression model of 59 baseline characteristics. Billing codes and the electronic death certificate system were utilized for data abstraction from the EHR and reporting of care utilization and mortality endpoints.

Results: Among 5,796 RPM-enrolled patients, 80.0% engaged with the technology. Following matching, 1,128 pairs of RPM engaged and non-engaged patients comprised the analysis cohorts. Mean patient age was 63.3 years, 50.9% of patients were female sex, and 81.9% were non-Hispanic, white. RPM-engaged patients experienced significantly lower rates of 30-day, all-cause hospitalization (13.7% vs 18.0%, *P*=.01), prolonged hospitalization (3.5% vs 6.7%, *P*=.001), ICU admission (2.3% vs. 4.2%, *P*=.01), and mortality [0.5% vs. 1.7%, OR 0.31 (0.12, 0.78), *P*=.01], as well as cost of care ($2,306.33 USD vs $3,565.97 USD, *P*=0.04), than those enrolled in RPM but non-engaged.

Conclusions: High-risk, COVID-19 patients enrolled and engaged in an RPM program experienced lower rates of hospitalization, ICU admission, mortality, and cost than those enrolled and non-engaged. These findings translate to improved hospital bed access and patient outcomes.

ABBREVIATIONS

COVID-19: Coronavirus Disease 2019

RPM: Remote Patient Monitoring

ED: Emergency Department

ICU: Intensive Care Unit

EHR: Electronic health record

SMD: Standardized mean differences

USD: U.S. Dollars

INTRODUCTION

In response to the COVID-19 pandemic, many health care organizations implemented remote patient monitoring (RPM) programs to support patients with suspected or confirmed COVID-19 infections, following a confirmed diagnosis or upon hospital discharge for the disease[1-9]. These programs were enabled by various technologies, including automated short message service (SMS)[8], mobile applications[3], or preconfigured devices[1] with questionnaires for symptom tracking; peripheral medical devices or wearables for monitoring physiologic data; and/or telephone and video telehealth visits[6-7]. Most programs provided centralized clinical support, integration of the patient-generated health data with the electronic health record (EHR), and were associated with high patient satisfaction[4-5, 8, 10].

At Mayo Clinic, our team developed a COVID-19 RPM care model to support ambulatory patients with COVID-19 through the acute phase of illness, as well as those discharging from a complex COVID-19 hospitalization[1, 11-12]. For the high-intensity RPM program, all patients were required to be at risk for severe COVID-19 disease[13], and the in-home technology package was provided at no cost to patients. The technology-enabled monitoring was comprised of at least twice daily patient-reported symptom assessments and physiologic data obtained from connected devices. A centralized team of registered nurses (RNs) responded to alerts and escalated care as needed to COVID-19 care team providers. This high-intensity program was designed to meet Centers for Medicare and Medicaid Services criteria (CMS) requirements as a billable RPM program[14] which, in the absence of a universally accepted standard, represents the highest standard for an RPM program definition.

We previously reported the development and implementation of this multi-site, multi-regional, interdisciplinary COVID-19 RPM program[1] which included a descriptive analysis of a diverse cohort of 7,074 patients served by the program (including both low and high-intensity monitoring) across 41 U.S. states with an age range of 17-101 years and 27.5% racial/ethnic minority representation. Among patients engaged in high-intensity monitoring, the RPM technology engagement rate was 78.4%. Emergency department visit, hospital admission, and mortality rates within 30 days of RPM enrollment were 11.4%, 9.4%, and 0.6% respectively.

Herein we report results of a retrospective, matched cohort analysis of the high-intensity COVID-19 RPM program. The primary objective of this study was to evaluate care utilization among all eligible and enrolled in the RPM program, comparing those who did or did not engage with the technology. Secondary objectives were to evaluate cost and mortality in these cohorts. We hypothesized that identification of adverse health trends by the RPM technology and centralized care team would be associated with a reduction in hospital utilization.

METHODS

Patients

Patients were eligible for the RPM program if they had a positive SARS-CoV-2 test at a Mayo Clinic location and one or more risk factors for severe COVID-19 illness as defined by the Centers for Disease Control (CDC) and expert consensus[13]. Patients were required to reside within the United States; however, those living in a skilled nursing facility were not eligible. Patients were not required to speak English language or have a primary care provider, and they could participate regardless of underlying diseases and conditions.

Setting

Mayo Clinic is a nonprofit, specialty group practice with integrated research, education, and clinical practice activities. Patients were included in this study if they were diagnosed with COVID-19 at a Mayo Clinic hospital or ambulatory clinic within the Midwest tertiary campus (Rochester, Minnesota) or the affiliated Mayo Clinic Health System (MCHS), comprised of over 70 Midwest, community-based hospitals and clinics in Southern Minnesota, Northern Iowa, and Western Wisconsin.

RPM Intervention

At the outset of the COVID-19 pandemic, Mayo Clinic adapted its chronic disease and post-surgical/procedural RPM program to meet the unique needs of patients with acute COVID-19. Patients who enrolled in the high-intensity COVID-19 RPM program received a technology package comprised of a cellular-enabled tablet, preconnected, Bluetooth-enabled, medical grade devices (blood pressure cuff, pulse oximeter, and scale), and a thermometer for self-reported temperature. Vital sign measurements and symptom assessment questions were completed 2-4 times daily (four times for those immunosuppressed or receiving cancer-directed therapy). All patient generated health data were integrated into the EHR. Alerts were triggered based on pre-determined parameters. A centralized team of RNs responded to technology-generated alerts and utilized standardized care pathways for clinical assessments and patient management, including escalation to a COVID-19 care team of General Internal Medicine and Infectious Disease physicians and advanced practice providers. Clinical support was provided 24 hours per day, seven days a week, including weekends and holidays. Program

eligibility criteria, technology solution, and clinical operational model have been previously described[1].

Study Design and Endpoints

A retrospective cohort analysis was conducted evaluating patients enrolled in the COVID-19 RPM program. Study endpoints included all-cause healthcare utilization, total cost of care, and mortality outcomes within 30 days of the COVID-19 RPM program enrollment (index) date, regardless of attribution to COVID-19. Data were abstracted from the EHR (Epic Systems, version May 2020), using validated billing reports for utilization endpoints and electronic death certificate data for mortality.

All-cause costs during the 30-day follow-up were abstracted from the Mayo Clinic Cost Data Warehouse, which has been previously described[15]. Charges for hospital-based services were costed using Medicare cost-to-charge ratios, while the professional services were costed using the Medicare reimbursement rates for the corresponding CPT/HCPCS codes. The total cost was defined as the sum of both these costs and reported in U.S. Dollars (USD).

Analysis Plan

To control for possible confounding, a propensity score-matched cohort was constructed to compare patient outcomes among those enrolled in the RPM program and "engaged," as defined by one or more sets of vitals/symptoms submitted through the supplied technology, with those "non-engaged," who enrolled but did not engage with the RPM technology. Specifically, one-to-one nearest-neighbor caliper matching was used to match engaged and non-engaged patients using a caliper equal to 0.2 of the standard deviation of the logit of the

propensity score[16]. The propensity score was estimated using a logistic regression model based on 59 baseline characteristics including age, sex, race and other demographics, comorbidities, prior healthcare utilization, primary care empanelment at Mayo Clinic, EHR portal account access (web or mobile-based), and COVID-19 index date month/year. Standardized mean differences (SMD) were used to assess the balance of covariates after matching, with an SMD less than or equal to 0.1 indicating covariate balance. Baseline Elixhauser comorbidity scores, COVID-19 risk factors, and utilization were calculated using ICD-10 diagnosis codes within one year prior to index date. Logistic regression and t-test were used to compare engaged with non-engaged patients for binary and continuous outcomes, respectively.

Two subgroup analyses were performed for those patients who enrolled in the RPM program: (1) at the time of hospital discharge (following acute illness), and (2) after diagnosis in the outpatient setting (during acute illness).

Propensity score modeling and analyses were performed utilizing Stata 16.1 (StataCorp, College Station, Texas). This study was approved by the Mayo Clinic Institutional Review Board (#18-009605).

RESULTS

Between March 16, 2020, and October 18, 2021, 9,679 high-risk patients enrolled in the COVID-19 RPM program. Among these patients, 5,796 were evaluable and comprised the analysis cohort (Figure 1). Reasons for exclusion included lack of authorization for retrospective research, assignment to low-intensity monitoring, sex and risk score missing (required for matching). Patients were also excluded if they died or were hospitalized within 1 day of

enrollment, as the RPM technology package is typically delivered to the patient's home the day after enrollment. Additionally, those managed in the Mayo Clinic Southwest (Scottsdale, AZ) and Southeast (Jacksonville, FL) regions (n=1,950) were excluded from the analysis given most patients only receive specialty care, but not routine care (including emergency department visits and hospitalizations), at Mayo Clinic, and to mitigate effect of regional variability on comparative outcomes assessment.

Of the evaluable patients, 1,162 (20.0%) did not engage with the technology. Prior to matching, non-engaged patients were generally older, with more comorbidities, or diagnosed with COVID-19 in the hospital (Table 1); however, sex, race, ethnicity, and primary language were similar between engaged and non-engaged cohorts.

After matching (Table 2), when compared with the non-engaged patients, those engaged in the RPM program experienced a significantly lower rate of one or more hospitalization (13.7% vs 18.0%, *P*=0.01), prolonged hospitalization 7 or more days (3.5% vs 6.7%, *P*=0.001), and ICU admission (2.3% vs 4.2%, *P*=0.01), as well as a significantly lower average hospital length of stay (6.7 vs 8.2 days, *P*=0.04). Total ICU days were markedly less for those engaged relative to those who were non-engaged (119 vs 313 days, *P*=.21); however, the difference was not statistically significant. Rates of one or more emergency department (ED) visits were similar among groups; however, those engaged were more likely to experience two or more ED visits (4.3% vs 2.4%, *P*=0.01) than those non-engaged.

Those who were engaged in RPM experienced a significantly lower overall 30-day cost of care than those non-engaged ($2,306.33 USD vs $3,565.97 USD, *P*=0.04). The average cost saving among engaged RPM patients was $1,259 per patient during the 30-day follow-up period.

All-cause, 30-day mortality rates were significantly lower for those who engaged in the RPM program than those non-engaged [0.5% vs. 1.7%, OR 0.31 (0.12, 0.78), *P*=0.01].

In a subgroup analysis of patients diagnosed with COVID-19 while hospitalized and RPM-enrolled upon discharge to home (Table 3), the rates of subsequent ED visits and re-hospitalizations were similar between groups. However, the rate of prolonged hospitalization and mean length of stay were significantly lower for those engaged than those non-engaged.

A separate subgroup analysis of patients with COVID-19 diagnosed and RPM-enrolled in the ambulatory setting (Table 4) revealed that when compared with non-engaged patients, engaged patients had higher rates of 2 or more ED visits, but lower rates of hospital admission, prolonged hospitalization, ICU admission, and mortality. These outcome trends were similar to those for the overall cohort.

DISCUSSION

This study suggests that patients with COVID-19 at risk for severe disease who enrolled and engaged in the RPM program experienced significantly lower rates of 30-day, all-cause hospital utilization, total cost of care, and mortality when compared with those who were non-engaged, especially when diagnosed and managed in the ambulatory setting through the acute phase of illness. We postulate the RPM program facilitated detection of adverse health trends and

enabled early supportive care interventions, which in turn favorably altered the COVID-19 disease trajectory. As hospital bed and ICU capacity have been severely strained during the pandemic[17], these findings build upon our prior observations[1, 11] and those of others[18], and they provide a potential strategy to improve hospital access.

Furthermore, as racial/ethnic minority populations were as likely to engage in the RPM program as non-Hispanic white patients, it is feasible that RPM programs could help improve outcomes in this cohort disproportionately impacted by COVID-19[19]. This was an important and unexpected observation given RPM program participation was declined by several racial/ethnic minority, migrant workers at a meatpacking plant in the early days of the pandemic[20].

Among those diagnosed while hospitalized during the acute phase of COVID-19, we expected the RPM program to enable earlier discharge, as demonstrated by others[3, 5]. Our findings suggest that post-discharge RPM engagement may not reduce subsequent ED visits and re-admissions during the recovery phase; however, it was associated with a reduced mean hospital length of stay, which still conveys an improvement in bed capacity.

ED visit rates were similar between groups; however, the multiple ED visit rate for those engaged with RPM was higher than for those non-engaged. These findings were anticipated as deteriorating patients were sent to the ED per established workflows. Future program iterations incorporating tele-emergency medicine and community paramedics are being explored to enhance in-home diagnostics, triage, and supportive care treatment interventions, such as IV fluid administration and initiation of supplemental oxygen.

Compared to non-engaged patients, the total cost savings for 1,128 matched patients that were engaged in the COVID-19 RPM program was approximately $1.4 million. Thus, a well-engaged RPM program not only results in lower hospital utilization and better patient outcomes, but it could potentially yield substantial healthcare cost savings for patients and health systems.

There are several strengths of this COVID-19 RPM program analysis: (1) large cohort size (1,128 matched pairs), (2) matching on 59 confounding variables, (3) inclusive representation of elderly, rural, and underrepresented minority populations, and (4) RPM program technology and clinical operational model that qualifies as a billable service by CMS criteria[14]. Importantly, this is among the first known reports to demonstrate improved care utilization rates among high-risk patients diagnosed with COVID-19 when managed and engaged in an ambulatory RPM program. Additionally, program engagement was associated with improved mortality and total cost of care.

However, results must be interpreted within the limitations of retrospective study design. We did not compare outcomes of those enrolled to the RPM program with those not enrolled under the “intention-to-treat” principle, as we could not identify a comparable high-risk control group managed without RPM. This finding was not entirely surprising, as our COVID-19 care team physicians depended on the RPM program for care delivery at scale, especially to support ambulatory management of patients with COVID-19 at risk for severe disease. For this reason, as well, they refused a prospective randomized trial of RPM versus usual care for COVID-19 management. Therefore, we focused on eligible and enrolled to the RPM program using an “as-treated” analysis. The authors recognize that patients who do not engage with the RPM

technology may have a general predisposition to not engage with healthcare and acknowledge that participation bias may exist with this analysis. That said, some patients were non-engaged simply by lack of timely receipt of the technology package, especially during surges which strained the supply chain. Finally, the propensity score matching adjusted only for the observed patient characteristics, but not the unobserved ones. The latter may include subjective factors that are associated with patient engagement; however, the cohorts were matched by portal access, an indicator of cellular or broadband telehealth access and indirect measure of digital literacy. Inability to adjust for unobserved or unmeasured variables is a well-acknowledged limitation of any retrospective study, including ours. Such unobserved confounding can be eliminated only through a prospective randomized controlled trial, which was not feasible at our institution during the COVID-19 pandemic.

Our findings on well-engaged RPM have potential policy and reimbursement implications for extending this acute care delivery model beyond the pandemic while additional prospective, confirmatory studies are performed. Further mixed-methods research is also needed to understand why enrolled patients do not engage with the technology and to evaluate the cost effectiveness of the program.

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Author contributions

Tufia Haddad and Bijan Borah had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Tufia Haddad, Jordan Coffey, and Lindsey Sangaralingham with input from Bijan Borah, Ravindra Ganesh, and Joshua Pritchett.

Acquisition, analysis, or interpretation of data: Led by Lindsey Sangaralingham and Amy Glasgow with input from Jordan Coffey, Tufia Haddad, Yihong Deng, and Bijan Borah. Ravindra Ganesh, Robert Orenstein, and Leigh Speicher facilitated RPM care team oversight and direct patient-related data acquisition.

Drafting of manuscript: Initial draft of the manuscript was prepared by Tufia Haddad, Jordan Coffey, Laura Christopherson, Vishal Shah, Sarah Bell, Yihong Deng, Michael Maniaci, and Bijan Borah.

Critical revisions of manuscript for important intellectual content: All authors provided critical revisions as key stakeholders in the RPM program and analysis contributing to the overall intellectual content. All endorsed the final draft.

Statistical analysis: Yihong Deng and Lindsey Sangaralingham.

Obtained funding: Not applicable.

Administrative, technical, or material support: Tufia Haddad, Jordan Coffey, Sarah Bell, Laura Christopherson, and Lindsey Sangaralingham.

Supervision: Tufia Haddad and Bijan Borah.

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Figure 1. Flow diagram for patients enrolled in the COVID-19 RPM program and evaluable for the analysis

Table 1. Patient characteristics

Characteristic[a]	Pre-Matched Population			Matched Population		
	Non-Engaged (n= 1162)	Engaged (n= 4634)	SMD	Non-Engaged (n= 1128)	Engaged (n= 1128)	SMD
Age, years						
Mean (SD)	62.6 (18.4)	57.1 (17.7)	0.31	62.3 (18.4)	64.3 (17.5)	0.10
Median	66.0	59.0		66.0	68.0	
Age distribution						
18-49	278 (23.9%)	1521 (32.8%)	0.20	277 (24.5%)	230 (20.4%)	0.10
50-74	488 (42.0%)	2242 (48.4%)	0.13	476 (42.2%)	495 (43.8%)	0.03
74+	396 (34.1%)	871 (18.8%)	0.35	375 (33.2%)	403 (35.7%)	0.05
Sex						
Female	592 (50.9%)	2443 (52.7%)	0.04	569 (50.4%)	580 (51.4%)	0.02
Male	570 (49.1%)	2191 (47.3%)	0.04	559 (49.6%)	548 (48.6%)	0.02
Married	638 (54.9%)	2925 (63.1%)	0.17	629 (55.8%)	607 (53.8%)	0.04
Race/Ethnicity						
White, Non-Hispanic (NH)	941 (81.0%)	3638 (78.5%)	0.07	914 (81.0%)	933 (82.7%)	0.04
Hispanic (all races)	109 (9.4%)	530 (11.4%)	0.07	108 (9.6%)	92 (8.2%)	0.05
Black, NH	38 (3.3%)	176 (3.8%)	0.03	36 (3.2%)	39 (3.5%)	0.02
Asian, NH	13 (1.1%)	99 (2.1%)	0.08	13 (1.2%)	9 (0.8%)	0.04
All other, NH	28 (2.4%)	86 (1.9%)	0.04	26 (2.3%)	25 (2.2%)	0.01
Unknown/Missing	33 (2.8%)	105 (2.3%)	0.04	31 (2.7%)	30 (2.7%)	0.01
Primary Language						
English	1029 (88.6%)	4036 (87.1%)	0.05	997 (88.4%)	1013 (89.8%)	0.05

Spanish	90 (7.7%)	411 (8.9%)	0.04	90 (8.0%)	80 (7.1%)	0.03
Other	38 (3.3%)	184 (3.9%)	0.03	37 (3.3%)	32 (2.9%)	0.02
Missing	5 (0.4%)	3 (0.1%)	0.07	4 (0.4%)	3 (0.3%)	0.02
Paneled to Primary Care	769 (66.2%)	3266 (70.5%)	0.09	753 (66.8%)	770 (68.3%)	0.03
Portal Account[c]	793 (68.2%)	3768 (81.3%)	0.31	789 (69.9%)	746 (66.1%)	0.08
Diagnosed in Hospital	255 (21.9%)	679 (14.7%)	0.19	240 (21.3%)	254 (22.5%)	0.03
ED Visits[b]	196 (16.9%)	650 (14.0%)	0.08	188 (16.7%)	197 (17.5%)	0.02
Office Visits[b]	667 (57.4%)	2826 (61.0%)	0.07	651 (57.7%)	652 (57.8%)	0.00
Hospitalizations[b]	264 (22.7%)	798 (17.2%)	0.14	251 (22.3%)	265 (23.5%)	0.03
COVID-19 Risk Factors per Patient (Sum)[21]						
Mean (SD)	3.5 (2.2)	3.0 (2.1)	0.17	3.5 (2.2)	3.7 (2.2)	0.09
Median	4.0	3.0		3.0	4.0	
Q1, Q3	2.0, 5.0	1.0, 4.0		2.0, 5.0	2.0, 5.0	
Monoclonal Allocation Screening Score[22]						
Mean (SD)	4.4 (3.1)	3.8 (2.9)	0.19	4.3 (3.1)	4.5 (2.9)	0.06
Median	4.0	3.0		4.0	5.0	
Q1, Q3	2.0, 7.0	1.0, 6.0		2.0, 7.0	2.0, 7.0	
Elixhauser Score						
Mean (SD)	3.1 (3.2)	2.6 (2.8)	0.17	3.0 (3.2)	3.3 (3.2)	0.07
Median	2.0	2.0		2.0	2.5	
Q1, Q3	0.0, 5.0	0.0, 4.0		0.0, 5.0	0.0, 5.0	
Risk factors for severe COVID-19 illness						

Cancer patient	150 (12.9%)	664 (14.3%)	0.04	149 (13.2%)	154 (13.7%)	0.01
Congestive heart failure	214 (18.4%)	569 (12.3%)	0.17	206 (18.2%)	231 (20.5%)	0.06
Chronic lung disease	276 (23.8%)	970 (20.9%)	0.07	267 (23.7%)	277 (24.6%)	0.02
Coronary artery disease	287 (24.7%)	845 (18.2%)	0.16	279 (24.7%)	294 (26.1%)	0.03
Immune compromised	147 (12.7%)	812 (17.5%)	0.13	146 (12.9%)	130 (11.5%)	0.04
End-Stage Renal Disease	248 (21.3%)	703 (15.2%)	0.16	239 (21.2%)	258 (22.9%)	0.04
Arrhythmia	336 (28.9%)	976 (21.1%)	0.18	323 (28.6%)	354 (31.4%)	0.06
Depression	157 (13.5%)	597 (12.9%)	0.02	151 (13.4%)	169 (15.0%)	0.05
Diabetes with chronic complications	231 (19.9%)	777 (16.8%)	0.08	223 (19.8%)	237 (21.0%)	0.03
Diabetes without chronic complications	203 (17.5%)	812 (17.5%)	0.00	197 (17.5%)	201 (17.8%)	0.01
Fluid electrolyte disorder	176 (15.1%)	480 (10.4%)	0.14	166 (14.7%)	190 (16.8%)	0.06
Hypertension, complicated	260 (22.4%)	727 (15.7%)	0.17	251 (22.3%)	274 (24.3%)	0.05
Hypertension, uncomplicated	334 (28.7%)	1263 (27.3%)	0.03	322 (28.5%)	329 (29.2%)	0.02
Hypothyroid	150 (12.9%)	500 (10.8%)	0.07	145 (12.9%)	158 (14.0%)	0.03
Obesity	255 (21.9%)	998 (21.5%)	0.01	250 (22.2%)	268 (23.8%)	0.04
Peripheral vascular disorders	145 (12.5%)	424 (9.1%)	0.11	139 (12.3%)	166 (14.7%)	0.07
Renal failure	214 (18.4%)	588 (12.7%)	0.16	205 (18.2%)	221 (19.6%)	0.04
Mood disorder	405 (34.9%)	1448 (31.2%)	0.08	388 (34.4%)	409 (36.3%)	0.04
Current smoker	333 (28.7%)	1065 (23.0%)	0.13	318 (28.2%)	338 (30.0%)	0.04

[a]Other factors not listed that were used for balancing cohorts included: month/year of COVID-19 index date, testing site, and any risk factor for severe COVID-19 occurring at a frequency of <10% (pregnancy, chronic liver disease, active chemotherapy, alcohol, blood loss anemia, coagulopathy, deficiency anemia, drug abuse, HIV/AIDS, liver disease, lymphoma, metastatic cancer, other neurological disorders, paralysis, peptic ulcer disease, psychosis, pulmonary circulation disorder, rheumatoid arthritis/collagen vascular disease, solid tumor metastasis, valvular disease, weight loss, bone marrow/organ transplant).
[b]Healthcare utilization in the 3 months prior to COVID-19 index date.
[c]Portal Account denotes Mayo Clinic's EHR-integrated web or mobile patient online services platform that facilitates secure messaging, appointment scheduling, bill pay, etc.

Table 2. Care utilization and mortality outcomes between non-engaged and engaged patients enrolled in the COVID-19 RPM program

Outcomes[a]	Non-Engaged (n=1128)	Engaged (n=1128)	OR (95% CI)	P-Value
ED Visits				
≥1 ED Visit (Unique Patients)	158 (14.0%)	171 (15.2%)	1.10 (0.87, 1.39)	0.44
>1 ED Visit (Unique Patients)	27 (2.4%)	49 (4.3%)	1.85 (1.15, 2.98)	0.01
ED Visit Converted to Inpatient Hospitalization	87 (7.7%)	99 (8.8%)	1.15 (0.85, 1.55)	0.36
Hospital Admissions				
≥1 Admission (Unique Patients)	203 (18.0%)	154 (13.7%)	0.72 (0.57, 0.90)	0.01
>1 Admission (Unique Patients)	41 (3.6%)	29 (2.6%)	0.70 (0.43, 1.13)	0.15
Prolonged Hospitalization (7 or more days)	76 (6.7%)	39 (3.5%)	0.50 (0.33, 0.74)	0.001
ICU Admissions	47 (4.2%)	26 (2.3%)	0.54 (0.33, 0.88)	0.01
Mortality (30 day)	19 (1.7%)	6 (0.5%)	0.31 (0.12, 0.78)	0.01
Outcomes			**Mean Difference (95% CI)**	**P-Value**
Average Length of Stay[b]				
Mean (SD)	6.7 (6.0)	5.4 (4.7)	-1.3 (-2.4, -0.1)	0.03
Median (Range)	5 (1-30)	5 (1-30)		
Total Hospital Days[b]				
Total	1660	1026		
Mean (SD)	8.2 (7.2)	6.7 (6.0)	-1.5 (-2.9, -0.1)	0.04
Median (Range)	6 (1-30)	5 (1-30)		
Total ICU Days[c]				
Total	313	119		

Mean (SD)	6.7 (7.6)	4.6 (4.9)	-2.5 (-5.4, 1.2)	0.21
Median (Range)	3 (1-30)	3 (1-21)		
Overall Cost of Care				
Mean (SE)	$3,565.97 ($525.25)	$2,306.33 ($325.22)	-$1,259.64	0.04

[a]All data are reported for events that occurred within 30 days of RPM program enrollment for outpatient diagnosis or 30 days from discharge of a hospitalized patient.
[b]Data reported for those patients who were hospitalized.
[c]Data reported for those patients who had an ICU admission.

Table 3. Subgroup analysis – care utilization and mortality outcomes among those with COVID-19 diagnosed while hospitalized and RPM-enrolled upon discharge to home

Outcomes[a]	Non-Engaged (n=240)	Engaged (n=254)	OR (95% CI)	P-Value
ED Visits				
≥1 ED Visit (Unique Patients)	37 (15.4%)	37 (14.6%)	0.94 (0.57, 1.53)	0.79
>1 ED Visit (Unique Patients)	10 (4.2%)	9 (3.5%)	0.84 (0.34, 2.12)	0.72
ED Visit Converted to Inpatient Hospitalization	39 (16.3%)	40 (15.8%)	0.96 (0.60, 1.56)	0.88
Hospital Admissions				
≥1 Admission (Unique Patients)	51 (21.3%)	40 (15.8%)	0.69 (0.44, 1.09)	0.12
>1 Admission (Unique Patients)	10 (4.2%)	10 (4.0%)	0.94 (0.39, 2.31)	0.90
Prolonged Hospitalization (7 or more days)	23 (9.6%)	9 (3.5%)	0.35 (0.16, 0.77)	0.01
ICU Admissions	14 (5.8%)	8 (3.2%)	0.52 (0.22, 1.28)	0.16
Mortality (30 day)	5 (2.1%)	2 (0.8%)	0.37 (0.07, 1.94)	0.24
Outcomes			**Mean Difference (95% CI)**	**P-Value**
Average Length of Stay[b]				
Mean (SD)	7.5 (7.0)	4.8 (3.5)	-2.7 (-5.1, -0.3)	0.03
Median (Range)	6 (1-30)	4 (1-18)		
Total Hospital Days[b]				
Total	450	262		
Mean (SD)	8.8 (7.8)	6.6 (6.4)	-2.3 (-5.3, 0.8)	0.14
Median (Range)	7 (1-30)	5 (1-28)		
Total ICU Days[c]				

Total	68	27		
Mean (SD)	4.9 (5.7)	3.4 (3.3)	-1.5 (-6.1, 3.1)	0.51
Median (Range)	3 (1-19)	2 (1-10)		

[a]All data are reported for events that occurred within 30 days of RPM program enrollment for outpatient diagnosis or 30 days from discharge of a hospitalized patient.
[b]Data reported for those patients who had a hospital admission.
[c]Data reported for those patients who had an ICU admission.

Table 4. Subgroup analysis – care utilization and mortality outcomes among those diagnosed with COVID-19 and RPM-enrolled in the ambulatory setting

Outcomes[a]	Non-Engaged (n=888)	Engaged (n=874)	OR (95% CI)	P-Value
ED Visits				
≥1 ED Visit (Unique Patients)	121 (13.6%)	134 (15.3%)	1.15 (0.88, 1.50)	0.31
>1 ED Visit (Unique Patients)	17 (1.9%)	40 (4.6%)	2.46 (1.38, 4.37)	0.002
ED Visit Converted to Inpatient Hospitalization	48 (5.4%)	59 (6.8%)	1.27 (0.86, 1.88)	0.24
Hospital Admissions				
≥1 Admission (Unique Patients)	152 (17.1%)	114 (13.0%)	0.73 (0.56, 0.94)	0.02
>1 Admission (Unique Patients)	31 (3.5%)	19 (2.2%)	0.61 (0.34, 1.10)	0.10
Prolonged Hospitalization (7 or more days)	53 (6.0%)	30 (3.4%)	0.56 (0.35, 0.89)	0.01
ICU Admissions	33 (3.7%)	18 (2.1%)	0.54 (0.30, 0.98)	0.04
Mortality (30 day)	14 (1.6%)	4 (0.5%)	0.29 (0.09, 0.88)	0.03
Outcomes			**Mean Difference (95% CI)**	**P-Value**
Average Length of Stay[b]				
Mean (SD)	6.4 (5.6)	5.6 (5.0)	-0.8 (-2.1, 0.5)	0.23
Median (Range)	5 (1-30)	5 (1-30)		
Total Hospital Days[b]				
Total	1210	764		
Mean (SD)	8.0 (7.0)	6.7 (5.8)	-1.3 (-2.9, 0.3)	0.12
Median (Range)	5 (1-30)	5 (1-30)		
Total ICU Days[c]				
Total	245	92		

Mean (SD)	7.4 (8.2)	5.1 (5.4)	-2.3 (-6.6, 2.0)	0.29
Median (Range)	4 (1-30)	3 (1-21)		

[a]All data are reported for events that occurred within 30 days of RPM program enrollment for outpatient diagnosis or 30 days from discharge of a hospitalized patient.
[b]Data reported for those patients who had a hospital admission.
[c]Data reported for those patients who had an ICU admission.