original contributions

CARE DELIVERY ReCAP

Association of a Remote Patient Monitoring (RPM) Program With Reduced Hospitalizations in Cancer Patients With COVID-19

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QUESTION ASKED: Does an interdisciplinary remote patient monitoring (RPM) program reduce acute care resource utilization and improve clinical outcomes in cancer patients diagnosed with COVID-19?

SUMMARY ANSWER: Implementation of a COVID-19 RPM program, composed of in-home technology and a centralized virtual care team, was associated with a reduction in hospital admission rate and lower overall acute care resource utilization among cancer patients with COVID-19. Rates of hospitalization for patients managed with and without RPM were 2.8% and 13%, respectively, implying that the use of RPM was associated with a 78% relative risk reduction in hospital admission rate (95% CI, 54 to 102; P = .002).

WHAT WE DID: The simultaneous deployment of the Mayo Clinic Cancer Center COVID-19 universal screening initiative and implementation of the Mayo Clinic COVID-19 RPM program across all sites presented a unique opportunity to conduct a comparative analysis and assess the association between RPM enrollment and risk of hospital admission through inverse propensity score weighting (IPW).

WHAT WE FOUND: Between March 18 and July 31, 2020, 224 patients with cancer were diagnosed with COVID-19, of which 187 patients (83%) were initially managed in the outpatient setting. Those managed with the RPM program were significantly less likely to experience hospitalization than those managed without RPM; furthermore, when hospitalized, RPM patients experienced a shorter length of stay and fewer prolonged hospitalizations, intensive care unit admissions, and deaths, although these trends did not reach statistical significance.

BIAS, CONFOUNDING FACTOR(S): Although this study is limited by its retrospective design, it was conducted with prospectively collected data as part of an observational study of the universal COVID-19 screening initiative for patients with cancer at our institution. The modest number of patients in the study cohort is a function of the predefined timeframe of the screening initiative. This study design aimed to minimize information and selection biases that typify retrospective analyses. Additionally, although the study was conducted at a single healthcare system, patients were enrolled and monitoring occurred at several diverse regional sites encompassing rural and urban locations throughout the United States.

REAL-LIFE IMPLICATIONS: Beyond the COVID-19 pandemic, a crisis is looming. With the continuous rise in cancer incidence and survival, as well as the soaring costs and complexities associated with cancer care, established hospital and ambulatory oncology practices will be unable to optimally support patients without a fundamental change in our models of cancer care delivery. Although initially a force of necessity, the unprecedented adoption and expansion of virtual care and telehealth services during the pandemic have offered a potential long-term solution to some of these challenges. Studies have demonstrated the effectiveness of RPM for longitudinal management of chronic conditions such as congestive heart failure; however, its value and impact in acute care and cancer populations had been unknown. This study is among the first reported evaluations of a novel RPM program to support the management of patients with cancer. We have demonstrated the feasibility, safety, and efficacy of an RPM program in cancer patients with COVID-19. Interdisciplinary RPM programs may offer oncology practices the opportunity to provide high-level, customizable care for patients with cancer at scale. Our findings support the urgent need for further implementation and evaluation of innovative RPM programs that can transform the model of cancer care delivery.

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ASSOCIATED CONTENT

Data Supplement

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abstract

PURPOSE The goal of this study was to assess the impact of an interdisciplinary remote patient monitoring (RPM) program on clinical outcomes and acute care utilization in cancer patients with COVID-19.

METHODS This is a cross-sectional analysis following a prospective observational study performed at Mayo Clinic Cancer Center. Adult patients receiving cancer-directed therapy or in recent remission on active surveillance with polymerase chain reaction–confirmed SARS-CoV-2 infection between March 18 and July 31, 2020, were included. RPM was composed of in-home technology to assess symptoms and physiologic data with centralized nursing and physician oversight.

RESULTS During the study timeframe, 224 patients with cancer were diagnosed with COVID-19. Of the 187 patients (83%) initially managed in the outpatient setting, those who did not receive RPM were significantly more likely to experience hospitalization than those receiving RPM. Following balancing of patient characteristics by inverse propensity score weighting, rates of hospitalization for RPM and non-RPM patients were 2.8% and 13%, respectively, implying that the use of RPM was associated with a 78% relative risk reduction in hospital admission rate (95% CI, 54 to 102; P = .002). Furthermore, when hospitalized, these patients experienced a shorter length of stay and fewer prolonged hospitalizations, intensive care unit admissions, and deaths, although these trends did not reach statistical significance.

CONCLUSION The use of RPM and a centralized virtual care team was associated with a reduction in hospital admission rate and lower overall acute care resource utilization among cancer patients with COVID-19.

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INTRODUCTION

The COVID-19 pandemic has presented unprecedented challenges to patients and healthcare systems worldwide.[1] Studies have indicated that patients with cancer might have an increased risk of acquiring SARS-CoV-2 infection and poorer clinical outcomes following diagnosis.[2-9] For this vulnerable population, cancer centers have been charged with the difficult task of balancing access and continuity of care in the setting of widespread disease transmission.

Early in the pandemic, many cancer centers implemented rigorous screening initiatives in an effort to reduce the risk of exacerbating COVID-19 severity by cancer-directed therapy (CDT) and to minimize exposure and spread of asymptomatic illness.[10] These intensive screening programs appear to have been minimally impactful despite significant resource utilization and logistical burden,[10] and there remains a lack of evidence for additional clinical management strategies that may favorably affect outcomes in cancer patients diagnosed with COVID-19.

Mayo Clinic is a multisite institution with three geographically diverse main campuses in Minnesota, Florida, and Arizona, as well as several rural, community-based practice sites throughout the affiliated Mayo Clinic Health System (MCHS) in Western Wisconsin, Southern Minnesota, and Northern Iowa. In March 2020, the Mayo Clinic Cancer Center (MCCC) practice committee implemented a COVID-19 universal screening initiative for patients with cancer across all Mayo Clinic sites (Xie et al).[11]

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The declaration of the Public Health Emergency and executive shelter-in-place orders also urged US healthcare systems to develop new ways to provide medical care to ambulatory patients.[1] In response, Mayo Clinic began rapidly scaling established telemedicine and virtual care services while concurrently developing new services with existing products to meet the unique needs of those with COVID-19.[12-15] One such example is the Mayo Clinic interdisciplinary COVID-19 Remote Patient Monitoring (RPM) program that used the existing RPM technology products and supply chain, as well as the operational infrastructure of the Mayo Clinic Center for Connected Care. The original RPM program was designed and implemented in the MCHS practice in 2016, and subsequently expanded to all sites, to provide patients with complex chronic conditions with technology-enabled, centralized monitoring and nursing support. Leveraging this framework, an innovative COVID-19 RPM program was developed with an interdisciplinary team of Infectious Disease, Pulmonary or Critical Care, and General Internal Medicine specialists in COVID-19 diagnosis and management. The COVID-19 RPM program aimed to support ambulatory patients with COVID-19 at risk for severe illness.[13] As of November 2020, this program served more than 8,000 patients across 41 US states in rural and urban locations, many of whom suffer from complex comorbidities and illnesses including active cancer (Coffey et al, under review).

Studies have previously demonstrated the effectiveness of RPM programs for the longitudinal management of chronic conditions such as congestive heart failure[16,17] and diabetes.[18,19] The use of RPM in patients with peritoneal dialysis has also been shown to reduce the risk of hospitalization during the COVID-19 pandemic.[20] However, only a limited number of health systems nationwide have established RPM services as part of routine clinical care that meet the Centers for Medicare & Medicaid Services RPM billing code requirements.[21]

Evaluation of RPM technology platforms and corresponding clinical care models for patients at risk of, suspicion of, or confirmed diagnosis of COVID-19—a novel, acute illness with unpredictable disease course, variable clinical presentation, and risk for decompensation—has begun, and early results are encouraging. Ambulatory monitoring of patients with COVID-19 symptoms has been shown to be feasible, safe, and associated with high patient satisfaction.[22] In a separate study, the use of RPM in patients discharging from the hospital following acute COVID-19 illness has been associated with fewer subsequent emergency department (ED) visits and readmissions.[23] However, we are among the first to evaluate the use of an RPM program in the management of patients with cancer.

The simultaneous deployment of the MCCC COVID-19 universal screening initiative and implementation of the Mayo Clinic COVID-19 RPM program across all sites presented a unique opportunity to assess the impact of the RPM program on patient outcomes. Our primary objective was to compare outcomes of cancer patients with COVID-19 when managed with or without the COVID-19 RPM program. Herein, we report the impact of the COVID-19 RPM program on clinical outcomes and acute care resource utilization in cancer patients diagnosed with COVID-19.

METHODS

MCCC COVID-19 Universal Screening Initiative

From March 18 to July 31, 2020, all patients scheduled to receive CDT at a Mayo Clinic site were universally screened for COVID-19 using a nasopharyngeal SARS-CoV-2 polymerase chain reaction test at least 24-96 hours before the scheduled treatment. Modes of CDT included parenteral chemotherapy, biologic therapy including immune checkpoint inhibitors, chimeric antigen receptor T-cell therapy, hematopoietic stem-cell transplant, surgery, and radiation therapy. In addition, adults (≥ 18 years old) with cancer diagnosed and/or treated within the past 5 years (excluding uncomplicated nonmelanoma skin cancers) were offered SARS-CoV-2 polymerase chain reaction testing at MCCC if they self-reported symptoms or exposure. These criteria defined our cohort of cancer patients with COVID-19.

An Institutional Review Board–approved prospective observational study was developed to assess the clinical effectiveness and impact of the universal screening initiative in this cohort (Xie et al).[11] Predefined clinical and lab data were collected from review of the electronic health record (EHR) of all patients who provided authorization to use EHR data for research purposes. Data were abstracted for 60 days after first positive test to allow sufficient assessment of COVID-19–associated outcomes.

Mayo Clinic Interdisciplinary COVID-19 RPM Program

Program design. The Mayo Clinic COVID-19 RPM program was designed and implemented by an interdisciplinary team composed of RPM clinical nurse specialists, physicians, patient education specialists, and COVID-19 physician experts from the Divisions of General Internal Medicine, Infectious Disease, and Pulmonary or Critical Care Medicine. Details related to this RPM program, including clinical workflow design and escalation parameters, have been described elsewhere (Coffey et al, under review)].[13] Briefly, once enrolled, the patient receives a technology package composed of a cellular-enabled tablet preloaded with vended clinical RPM software (Resideo Life Care Solutions, WI) and preconnected, Bluetooth-enabled devices (blood pressure cuff and monitor, pulse oximeter, thermometer, and scale) to passively collect physiologic data. For patients with cancer specifically, the tablet notifies patients to perform vital sign measurements and complete COVID-19 symptom assessments twice daily. For those who are immunosuppressed, the assessments are

conducted four times daily. Patient-generated data trigger alerts on the basis of predetermined parameters, and all data are integrated with the EHR (Epic). Key to the RPM program is the clinical care model that includes a centralized team of RPM nurse care coordinators who provide daily monitoring, education, and health coaching; complete clinical evaluations in response to alerts; use decision trees and protocols for interventions; and escalate care as necessary to the appropriate regional physician and advanced practice provider COVID-19 care teams supporting Mayo Clinic Arizona, FL, and the Midwest (Minnesota and all MCHS sites). The standard program duration is approximately 21 days with extension as needed to support recovery for patients who remain symptomatic.

Patient enrollment. Upon confirmation of a positive SARS-CoV-2 test at any Mayo Clinic site, patients are screened for RPM enrollment by a member of the regional COVID-19 care team. Patients were eligible for enrollment if they had one or more of the following risk factors for severe COVID-19 illness, as defined by the Centers for Disease Control and expert consensus[24]: age > 65 years, diabetes, current smoker, body mass index > 40, chronic liver disease, chronic lung disease, congestive heart failure, active cancer therapy, bone marrow or solid organ transplant, other immunocompromised state, and end-stage renal disease.

Under a separate Institutional Review Board–approved protocol, we retrospectively reviewed all patients from the above MCCC COVID-19 universal screening cohort for enrollment and utilization of RPM. For this study, those included in the RPM cohort were confirmed for enrollment by documentation of the EHR order for the service and received at least one day of monitoring as confirmed by the presence of at least one digital exchange with the technology platform.

Study End Points, Data Procurement, and Analysis

End points. For the MCCC COVID-19 universal screening initiative, the clinical end points recorded included 60-day all-cause hospital admission, intensive care unit (ICU) admission, and mortality. These were determined by manual EHR review for each patient in the study. In addition to this, system-level billing and encounter data were retrospectively queried for all study patients who were initially managed in the outpatient setting to independently identify and confirm instances of acute care utilization during a 30-day period following COVID-19 diagnosis. Acute care utilization end points included ED visit, ED conversion to inpatient hospital admission, ICU admission, hospital length of stay, prolonged hospitalization (defined as ≥ 7 inpatient days), and mortality. A 30-day follow-up period was chosen for this study because the average COVID-19 RPM program duration for patients is approximately 14 days and an acute exacerbation of COVID-19 illness rarely occurs beyond 30 days from initial diagnosis (Coffey et al, under review).[25,26]

EHR review. Manual EHR review was performed to obtain predefined clinical and demographic data for all patients enrolled in the MCCC prospective universal screening study, as outlined above and detailed elsewhere (Xie et al).[11] EHR review also included review of any records from institutions outside the Mayo Clinic available through the Epic Care Everywhere function. Notably, this information is only available for review if a patient has authorized access to this function. Additionally, information is only made available through Care Everywhere by partnering institutions that participate in this electronic record sharing tool.

When instances of acute care utilization were identified, all instances were rigorously reviewed to confirm that care utilization was properly assigned and documented before performing detailed comparative analysis. Additionally, all instances were also reviewed and assigned on the basis of whether the instance was associated directly with COVID-19 illness.

Comparative analysis. The association between RPM enrollment and risk of hospital admission among 187 patients who did not initially require urgent hospitalization was assessed through inverse propensity score weighting (IPW).[27] The IPW method helps estimate the treatment effect between the intervention (RPM) and control (no RPM) cohorts after balancing the observed patient characteristics.

IPW balancing was based on 15 key baseline covariates that multiple studies have identified as associated with poorer COVID-19 outcomes. These include age,[9,28-30] sex,[9,28-30] race,[31,32] ethnicity,[9,31-33] body mass index,[28,30,34] diabetes,[9,28,30,35,36] hypertension,[28,30,36] underlying cardiopulmonary disease (which we have characterized further by specific entities including coronary artery disease,[30,36,37] chronic obstructive pulmonary disease,[30,37-39] and/or asthma[9,40]), chronic kidney disease,[9,41,42] cancer type,[7-9] active cancer status,[7-9] symptomatic COVID-19 at diagnosis,[43-45] and diagnosis before June 1, 2020.[46,47]

The pre- and post-IPW balance in patient characteristics was assessed through standardized difference, with an absolute standardized difference < 10% in the value of variable between the intervention and control being considered as balanced.[27] Both absolute and relative risks of hospitalization for patients receiving RPM versus non-RPM were then calculated.[48-50]

RESULTS

Between March 18 and July 31, 2020, 224 patients with cancer were diagnosed with COVID-19 at a Mayo Clinic site. As highlighted in Figure 1, initial management included urgent hospitalization (within 48 hours of diagnosis) in 37 patients (17%), whereas the remaining 187 patients (83%) were managed in the outpatient setting with or without the

TABLE 1. Baseline Data, All Patients

	RPM		Non-RPM	
	No.	%	No.	%
Total patients (N = 224)	109	49	115	51
Demographics				
Sex				
Male	67	61	64	56
Female	42	39	51	44
Age, years				
Median (range)	63 (35-90)		62 (22-89)	
< 65	64	59	72	63
≥ 65	45	41	43	37
Ethnicity				
Non-Hispanic or Latino	92	84	96	83
Hispanic or Latino	14	13	14	12
Unknown, not reported	3	3	5	4
Race and ethnicity				
White	60	55	66	57
Others, with Hispanic or Latino ethnicity	10	9	13	11
African American	6	6	6	5
American Indian or Alaska Native	1	1	0	0
Asian	1	1	3	3
Unknown, not reported	31	28	27	23
Region				
Midwest	51	47	16	14
Arizona	42	39	64	56
Florida	16	15	35	30
Clinical characteristics				
Underlying pulmonary disease				
Asthma	10	9	5	4
COPD	9	8	9	8
Obstructive sleep apnea	21	19	17	15
Other pulmonary diseases	4	4	3	3
Use of oxygen at home	1	1	0	0
Underlying nonpulmonary disease				
Hypertension	55	50	44	38
BMI > 30 kg/m^2	40	37	39	34
Diabetes mellitus	22	20	12	10
CKD	18	17	9	8
Coronary artery disease	14	13	11	10
Atrial fibrillation	10	9	9	8
Alcohol use disorder	8	7	13	11
Peripheral vascular disease	3	3	2	2
Smoking status				
Never smoker	63	58	71	62
Former smoker	44	40	38	33
Current smoker	2	2	4	3
Cancer characteristics				
Solid malignancy	83	76	96	83
Genitourinary	29	27	25	22
Breast	16	15	24	21
GI	13	12	12	10
Lung	6	6	4	3
Head and neck	5	5	8	7
CNS	3	3	3	3
Skin	3	3	7	6
Thyroid	3	3	3	3
Gynecologic	3	3	4	3
Neuroendocrine	2	2	4	3
Other solid malignancies	0	0	2	2
Hematologic malignancy	26	24	19	17
Dysproteinemia	11	10	5	4
Lymphoma	10	9	6	5
Myeloid	4	4	7	6
CLL	1	1	1	1
Cancer disease or treatment status				
Remission, no evidence of disease	51	47	71	62
Active disease, responding to treatment	23	21	16	14
Active disease, stable	15	14	9	8
Active disease, progressing	12	11	11	10
Unknown	5	5	5	4
COVID-19 characteristics				
Reason for COVID-19 testing				
Symptomatic	71	65	77	67
Routine screening	33	30	30	26
Exposure to COVID-19	5	5	8	7
Initial severity of COVID-19 disease				
Mild or asymptomatic (no hospitalization required)	74	68	100	87
Moderate (hospitalization indicated)	33	30	12	10
Severe (ICU admission indicated)	2	2	3	3
Symptoms at onset (most common)				
No symptoms	21	19	27	23
Cough	55	50	53	46

(continued on following page)

TABLE 1. Baseline Data, All Patients (continued)

	RPM		Non-RPM	
	No.	%	No.	%
Dyspnea	39	36	18	16
Fever	35	32	35	30
Hypoxemia with new oxygen requirement	29	27	11	10
Fatigue	28	26	26	23
Myalgia	23	21	32	28
Chills	17	16	17	15
Nausea	15	14	10	9
Diarrhea	13	12	28	24
Headache	13	12	14	12
Sore throat	12	11	17	15

Abbreviations: BMI, body mass index; CKD, chronic kidney disease (defined as an estimated glomerular filtration rate < 60 mL/min); CLL, chronic lymphocytic leukemia; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; RPM, remote patient monitoring.

COVID-19 RPM program (71 and 116, respectively). In total, 109 patients (49%) were enrolled in the RPM program at any point during the study timeframe.

Baseline patient characteristics are provided in Table 1. There were no significant differences in age, race, or ethnicity observed with regard to RPM enrollment at MCCC during the study timeframe. More male patients were diagnosed with COVID-19, consistent with known features of the disease, although the rate of RPM enrollment did not differ significantly according to sex. Regionally, although the Arizona region accounted for the majority of COVID-19 cases (47% *v* 30% and 23% in Midwest and Florida, respectively), the Midwest region demonstrated a higher rate of RPM enrollment (76% of patients enrolled in RPM *v* 40% and 31% in Arizona and Florida, respectively), because of earlier deployment and availability of the RPM program at Midwest sites during the study timeframe (Data Supplement, online only). Consistent with eligibility guidelines for enrollment in the RPM program, patients receiving RPM were found to have increased rates of underlying pulmonary disease and higher rates of underlying nonpulmonary comorbidities including hypertension, obesity, diabetes, chronic kidney disease, and coronary artery disease. Although underlying cancer disease groups were similarly represented, patients enrolled in RPM predictably demonstrated a trend toward more active cancer, whereas non-RPM patients were more likely to be in remission. Finally, although the reason for initial COVID-19 testing was relatively consistent between groups, patients enrolled in RPM demonstrated higher severity of COVID-19 disease at onset as characterized by higher rates of dyspnea and hypoxia with new oxygen requirement.

Patients initially managed in the outpatient setting without RPM were more likely to have experienced inpatient hospitalization within 30 days after COVID-19 diagnosis than those enrolled in RPM, as demonstrated in Table 2. The difference in the risk of hospital admission on the basis of RPM utilization was assessed through inverse propensity score weighting (IPW). As shown in Figure 2, all patient characteristics were balanced following IPW. The estimated risk of hospital admission without RPM was 13% (95% CI, 6.9 to 18.3), whereas the estimated risk of hospital admission with RPM was 2.8% (95% CI, −0.06 to 5.7). Thus, independent of measured baseline covariates, the estimated treatment effect was −0.098 (P = .002; 95% CI, −0.160 to −0.036), implying that the RPM program was associated with an approximately 10% absolute risk reduction and 78%

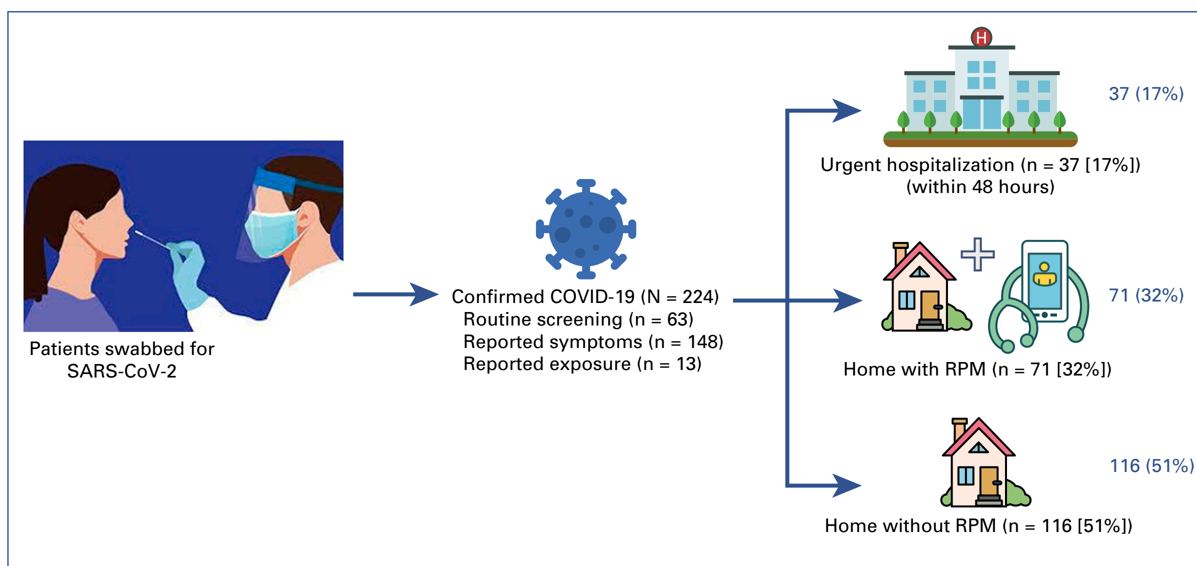

FIG 1. Initial management and disposition of cancer patients diagnosed with COVID-19 at Mayo Clinic. RPM = enrollment in the Mayo Clinic COVID-19 RPM program with centralized virtual care team support, as detailed in Methods. RPM, remote patient monitoring.

TABLE 2. Comparative Analysis of Patients Initially Managed in the Outpatient Setting With RPM Versus No Monitoring

Acute Care Utilization for 30 Days Following COVID-19 Diagnosis	RPM n = 71	%	Non-RPM n = 116	%
Complete home recovery[a]	64	90	98	84
ED visit	7	10	18	16
COVID-19–related[b]	5		17	
Not related to COVID-19	2		1	
ED visit converted to inpatient hospitalization[c]	3	4	15	13
Hospitalization details				
Median days, diagnosis to admission (range)	7 (3-8)		6 (3-18)	
Median days in hospital (range)	3 (2-4)		6 (1-35)	
Prolonged hospitalization (7 or more days)	0		6	
Patients requiring ICU	0		6	
Death at discharge	0		4	
Discharged to home	3		11	
Discharged with RPM	3		7	
Discharged with no monitoring	0		4	

Abbreviations: BMI, body mass index; CAD, coronary artery disease; CKD, chronic kidney disease (defined as an estimated glomerular filtration rate
< 60 mL/min); COPD, chronic obstructive pulmonary disease; ED, emergency department; ICU, intensive care unit; RPM, remote patient monitoring.

[a]No ED visits or hospitalizations for 30 days following COVID-19 diagnosis.

[b]Symptoms of acute pulmonary disease or other symptoms directly attributed to COVID-19.

[c]All hospitalizations during the follow-up period were found to be COVID-19–related, characterized by symptoms of acute pulmonary disease directly attributable to COVID-19 disease.

relative risk reduction in hospital admission (95% CI, 54 to 102; *P* = .002).

Furthermore, although ED visit rates were similar between groups (10% RPM and 16% non-RPM), conversion to hospital admission occurred less frequently for patients who were enrolled in RPM (42.9% *v* 83.3%). Additionally, when hospitalized, the RPM patients experienced shorter length of stay (median 3 days *v* 6 days) and were also less likely to experience prolonged hospitalization (0% *v* 5%), ICU admission (0% *v* 5%), and death (0% *v* 3%), although these trends did not reach statistical significance.

DISCUSSION

In the setting of a global pandemic associated with inpatient bed, ventilator, and personal protective equipment shortages, the RPM program provided an effective strategy for clinical management of cancer patients with COVID-19 in the ambulatory setting while simultaneously offering an opportunity to mitigate the increased risks of exposure, transmission, and resource utilization associated with conventional care. This study represents one of the first known evaluations of an RPM program for the management of patients with cancer.

During the design of the Mayo Clinic COVID-19 RPM program, co-primary objectives were established to optimize the clinical outcomes of patients and to reduce hospital utilization attributed to COVID-19. The RPM program leaders hypothesized that early detection of adverse trends in patient generated health data and early supportive care interventions could favorably alter the disease trajectory for vulnerable patient populations. However, it was unknown how the program would affect acute care utilization.

Within our study population of cancer patients with COVID-19, those managed through the RPM program during the study timeframe, despite being more symptomatic of COVID-19 and having more risk factors for severe illness, experienced better clinical outcomes and lower overall acute care resource utilization than patients not enrolled in the program.

It is worth noting that patients in this study could be enrolled in the RPM program either in the outpatient setting immediately following COVID-19 diagnosis or upon hospital discharge following acute COVID-19 illness. Given that patients with COVID-19 are on different trajectories with the disease at initial diagnosis (acute phase) and following hospital discharge (recovery phase), the value proposition for RPM and patient care goals were distinct for each setting. As such, we elected to focus our RPM program analysis on the majority of patients who were initially managed with RPM in the ambulatory setting upon diagnosis, with the aim of determining whether early detection of patient decompensation was associated with improved outcomes.

Even within the constraints of this focused analysis, a significant reduction in hospital admission rate directly attributable to RPM enrollment was observed in patients who were initially monitored in the outpatient setting. Although ED visits occurred at a relatively comparable rate among patients, fewer of those enrolled in RPM were subsequently admitted. Importantly, when hospitalized, the RPM patients experienced a shorter duration of stay and fewer prolonged hospitalizations, ICU admissions, and deaths, although further research is needed to confirm these trends.

Limitations of this study include retrospective design, modest number of patients, and single healthcare system; however, patients and monitoring occurred at several diverse regional sites encompassing rural and urban locations. Additionally, although every effort was made to capture and confirm instances of acute care utilization experienced by the patients in this study throughout the

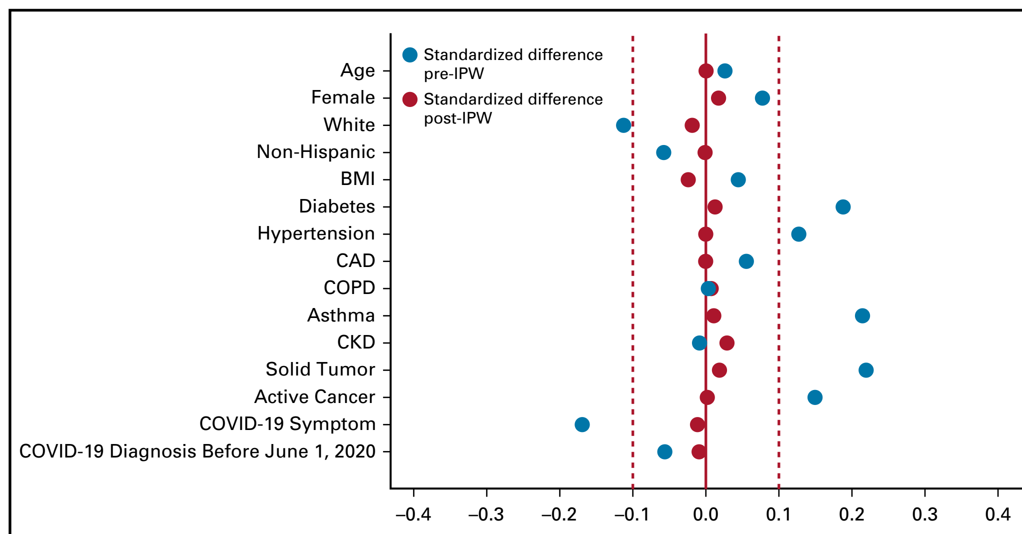

FIG 2. IPW (balance checking through standardized difference). Points within the dashed vertical lines indicate balance in the corresponding covariate. BMI, body mass index; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; IPW, inverse propensity score weighting; RPM, remote patient monitoring.

follow-up period, we acknowledge the inherent limitations of such data elements, which include the possibility of study patients being evaluated at outside institutions that may not be visible or accessible through the Mayo Clinic EHR.

In conclusion, the use of a novel RPM program and centralized virtual care team was associated with a significant reduction in hospital admission rate and lower overall acute care resource utilization among cancer patients with COVID-19. Throughout the COVID-19 pandemic, innovative methods of care delivery have proved to be essential to ensure ongoing care for many of our most vulnerable populations. The success of this RPM program was made possible only through commitment to a team-based, interprofessional, and multidisciplinary collaboration across our health system.

Our findings affirm the emerging evidence regarding the feasibility, safety, and effectiveness of an RPM program to support the management of acute conditions, such as COVID-19. Additionally, this is among the first reported evaluations of an RPM program for the management of patients with cancer. Future directions include the need for pragmatic trials to further evaluate the impact and value of RPM for the management of other acute and chronic conditions and in postacute or postoperative settings. Additional studies are needed to validate the safety of escalating care in the home with low-risk diagnostic and treatment interventions that can complement the monitoring and further drive down acute care utilization.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Association of a Remote Patient Monitoring (RPM) Program With Reduced Hospitalizations in Cancer Patients With COVID-19

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

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