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Evaluation of an outreach programme for patients with COVID-19 in an integrated healthcare delivery system: a retrospective cohort study

Laura C Myers ,[1,2] Brian L Lawson,[1] Gabriel J Escobar,[1,2] Kathleen A Daly,[1] Yi-fen Irene Chen,[2] Richard Dlott,[2] Catherine Lee,[1] Vincent Liu [1,2]

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[1]Division of Research, Kaiser Permanente, Oakland, California, USA
[2]The Permanente Medical Group Inc, Oakland, California, USA

Correspondence to
Dr Laura C Myers;
laura.c.myers@kp.org

ABSTRACT

Objectives In the first year of the COVID-19 pandemic, health systems implemented programmes to manage outpatients with COVID-19. The goal was to expedite patients' referral to acute care and prevent overcrowding of medical centres. We sought to evaluate the impact of such a programme, the COVID-19 Home Care Team (CHCT) programme.

Design Retrospective cohort.

Setting Kaiser Permanente Northern California.

Participants Adult members before COVID-19 vaccine availability (1 February 2020–31 January 2021) with positive SARS-CoV-2 tests.

Intervention Virtual programme to track and treat patients with 'CHCT programme'.

Outcomes The outcomes were (1) COVID-19-related emergency department visit, (2) COVID-19-related hospitalisation and (3) inpatient mortality or 30-day hospice referral.

Measures We estimated the average effect comparing patients who were and were not treated by CHCT. We estimated propensity scores using an ensemble super learner (random forest, XGBoost, generalised additive model and multivariate adaptive regression splines) and augmented inverse probability weighting.

Results There were 98 585 patients with COVID-19. The majority were followed by CHCT (n=80 067, 81.2%). Patients followed by CHCT were older (mean age 43.9 vs 41.6 years, p<0.001) and more comorbid with COmorbidity Point Score, V.2, score ≥65 (1.7% vs 1.1%, p<0.001). Unadjusted analyses showed more COVID-19-related emergency department visits (9.5% vs 8.5%, p<0.001) and hospitalisations (3.9% vs 3.2%, p<0.001) in patients followed by CHCT but lower inpatient death or 30-day hospice referral (0.3% vs 0.5%, p<0.001). After weighting, there were higher rates of COVID-19-related emergency department visits (estimated intervention effect −0.8%, 95% CI −1.4% to −0.3%) and hospitalisation (−0.5%, 95% CI −0.9% to −0.1%) but lower inpatient mortality or 30-day hospice referral (−0.5%, 95% CI −0.7% to −0.3%) in patients followed by CHCT.

Conclusions Despite CHCT following older patients with higher comorbidity burden, there appeared to be a protective effect. Patients followed by CHCT were more likely to present to acute care and less likely to die inpatient.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ While the programme was not randomised, a natural control group was used, when demand for the programme (number of cases) went above the capacity of the programme.
⇒ We ensured that patients included in the control group would have been eligible for the intervention had it been available and carefully defined the time period to be prior to vaccine availability.
⇒ Robust methods were used to conduct the analysis (propensity scores with ensemble super learner and augmented inverse probability weighting).

INTRODUCTION

The COVID-19 pandemic posed many operational challenges for health systems. During each pandemic wave, bed demand exceeded supply, causing strain within the system to accommodate the influx of patients.[1] Units had to adapt to treat patients with acute respiratory failure outside of the intensive care unit, non-urgent outpatient procedures were delayed, and providers were needed to work additional shifts.[2 3] Several studies have documented higher inpatient mortality during inpatient surge periods.[4–7]

Considerable attention has been given to outcomes of patients hospitalised with COVID-19.[6 8–12] However, limited attention has been given to outpatient care of patients with COVID-19, including managing increased volume of secure messages and clinic visits and developing guidelines for triage to the acute care setting. Integrated health systems have the unique capability of managing patients across inpatient and outpatient settings, providing opportunities to intervene prior to reaching the acute care setting and expediting their arrival to the acute care setting when necessary. Providing care upstream can reduce emergency department overcrowding by managing patients at

home or by outpatient-only touchpoints. Additionally, referring patients early to acute care centres that have the capacity, even if physically located further away, prevents overcrowding and actually expedites care. Also, having a handle on the number of referrals made to the emergency department allows providers to call in more staff to assist in triaging and managing patients in a timely way.

In the first year of the pandemic, Kaiser Permanente Northern California (KPNC) repurposed resources to accommodate the increased demands on the healthcare system to support primary care physicians, manage patients with COVID-19 in the outpatient setting as much as possible and then expedite their referral to an acute care centre that was not overcrowded. The novel intervention was the COVID-19 Home Care Team (CHCT), which provided a coordinated system to track and treat outpatients who developed COVID-19. We sought to evaluate the impact of the CHCT programme on risk of hospitalisation and death.

METHODS

This is a retrospective cohort study. The work was approved, and informed consent was waived by the KPNC Institutional Review Board (#1634347). A Strengthening the Reporting of Observational Studies in Epidemiology checklist is presented in the online supplemental file 1, Supplemental Methods.

Setting

KPNC is an integrated healthcare delivery system that cares for 30% of the population in Northern California. Under a mutual exclusivity agreement, 9500 physicians of The Permanente Medical Group provide integrated healthcare for >4.4 million Kaiser Foundation Health Plan members at 21 hospitals owned by Kaiser Foundation Hospitals and 242 medical office buildings.

Study population

To establish our base population, we identified all records of members who were ≥18 years old as of 1 February 2020 and who had a positive SARS-CoV-2 PCR test ordered between 1 February 2020 and 31 January 2021. Prior to 13 March 2020, SARS-CoV-2 tests were performed by the Centers for Disease Control and Prevention and state/county health departments, but the results were uploaded into our electronic health record system and available in KPNC databases. If a patient had multiple positive tests, we examined the characteristics and outcomes of the first positive test. The study end date was chosen because it was prior to the widespread dissemination of vaccinations for SARS-CoV-2. We excluded patients who were not eligible for CHCT service, such as those who had the first positive test during or after a COVID-19-related emergency departments visit or hospitalisation. We also excluded patients who were hospitalised within 48 hours of their positive test, because contact with the CHCT team took up to 48 hours to initiate.

Variable extraction

We examined patients' electronic health records for demographic and clinical variables, including the following data elements: self-reported race and ethnicity (in order to show the delivery of CHCT across a population),[13] individual comorbid conditions based on diagnosis codes and neighbourhood deprivation index, a composite index ranging from −5 to 5 with more positive values reflecting lower socioeconomic status.[14] We also captured two composite indices that are assigned to adults in the KPNC system: a longitudinal comorbidity score (COmorbidity Point Score, V.2 (COPS2)) and an outpatient physiology-based severity of illness score (abbreviated Laboratory-based Acute Physiology Score (abLAPS)). Each month, all adults with a KPNC medical record number are assigned COPS2, which is based on diagnoses accrued in the preceding 12 months with higher scores associated with increasing mortality risk.[15] They are also assigned a monthly abLAPS, which is based on 14 laboratory tests obtained in the preceding month; higher scores are associated with increased physiological derangement.[13 16] These variables are more fully described in published studies.[13 15 17 18]

Exposure

Prior to the pandemic, KPNC had several existing population health programmes for non-pregnant adults with chronic conditions (eg, diabetes,[19–21] cancer screening[22 23] and cardiovascular disease[21]). In addition, a variety of follow-up processes existed to support primary care providers, such as combinations of inperson and automated outreach for the management of hypertensive patients.[24 25] At the start of the pandemic, KPNC leadership used this population health management infrastructure to develop a novel outpatient population health programme, CHCT, with the goal of increasing frontline primary care provider support by repurposing non-physician staff, including nurses and nurse practitioners, as well as physicians from departments outside Adult and Family Medicine. After the state of California issued a Shelter in Place order in March 2020, non-emergent surgeries, procedures (eg, routine cervical cancer screening and colonoscopies) and routine specialty follow-up appointments were deprioritised. KPNC was, thus, able to repurpose ~450 non-AFM physicians from over 20 specialties as well as non-physician staff to assist in assessing and caring for patients with COVID-19 using standardised protocols which provided recommendations for when to triage patients to a higher level of care. All CHCT staff underwent formal training by the medical director (RD). CHCT provided individualised follow-up of patients with early COVID-19 infection including education, assessment and, if indicated, explicit directions for how to access emergency department care.

CHCT was designed based on KPNC's 20+ years of doing population care. The framework for the programme was 'Right patients, right clinicians, right tools, right oversight'. Starting in March 2020, patients were electronically

enrolled in CHCT when they developed a positive SARS-CoV-2 test. Programme staff attempted to reach patients by phone soon after they were informed of their positive test result (usually within 24 hours after a positive result, including weekends). The population care platform that was embedded in the electronic medical record allowed CHCT to document outreach attempts so that multiple outreach attempts could be made. The platform allowed staff to easily record outreach attempts, customise follow-up intervals via electronic reminders and track multiple contact attempts per day. As most members were KP.org active for secure messaging, self-care instructions and care resource information were echoed by programme staff to eligible patients. Patients received in the mail a kit of supplies, including a pulse oximeter, to prevent them from needing to enter the public domain while contagious. Patients active on KPNC's web portal were sent an automated personal message with links to information about available resources and advice on managing their symptoms. Examples of patients who were prioritised for outreach and follow-up had a history of organ transplant, supplemental oxygen at home and active treatment for cancer. Patients at moderate risk were those who were aged >60, suffered from uncontrolled diabetes and were sent to cardiac or emergency department within 30 days. Patients with no high-risk features were offered an e-visit first. Based on standardised protocols developed by front-line physicians, patients were escalated to video visits, inperson outpatient visits or acute care (emergency department). During the surge of COVID-19, the number of patients with positive tests exceeded CHCT bandwidth, which provided a natural control group of patients who were not followed by CHCT that could be used to compare outcomes. Those who attempted to be reached at least once were included in the intervention group. Additional information about the programme is available in the Supplemental Methods.

Outcome

The primary outcome was COVID-19-related acute care utilisation. We examined (1) COVID-19-related emergency department visit or (2) COVID-19-related hospitalisation within 2 weeks of positive test. Attribution of hospitalisations to COVID-19 was based on the *International Classification of Diseases, V.10* codes, timing of test orders and non-elective status using a previously published algorithm.[13 26] As a secondary outcome, we also examined the composite outcome of inpatient mortality or hospice referral within 30 days after a positive test as we and others have done in the past.[6 13]

Statistical analysis

We report mean with SD or median with IQR for continuous variables. We report number with per cent for categorical variables. We compare univariate values with t tests, Wilcoxon rank sum tests or χ^2 tests, as appropriate.

For each outcome, we estimated the average treatment effect of the CHCT programme, comparing patients who were enrolled in CHCT with those who were not using an augmented inverse probability weighting (AIPW)[27] estimator. In AIPW, models are developed for the propensity of treatment and outcome probability as a function of covariates, using all available data. AIPW has the appealing property that only one of the models needs to be specified correctly, known as 'doubly robust'. We implemented the approach using the AIPW R package[28] that employs the ensemble machine learning approach super learner (random forest, XGBoost, generalised additive model and multivariate adaptive regression splines) to estimate the probability models. The following variables were used in both the propensity score and outcome probability models: age, sex, neighbourhood deprivation index, abLAPS, COPS2, obesity, diabetes, hypertension and month of the pandemic. These three comorbidities were chosen because they are highly prevalent in patients with COVID-19 and impact mortality.[29] Month of the pandemic was included because outcomes of patients have improved over time.[6 11 30] We reported the standardised between-group differences in covariates before and after inverse probability weighting based on the propensity score. We also reported the AIPW adjusted outcome prevalence depending on whether patients were followed by CHCT or not and the estimated intervention effect with 95% CI, which is the average treatment effect.[28] Threshold for significance was <0.05.

Patient involvement

Patients were not involved in the design or conduct of the study.

RESULTS

There were 98 585 patients with positive tests, the majority of whom were followed by CHCT (n=80 067, 81.2%). Very few patients (n=18) died in the 4 weeks after a positive test without hospitalisation, and there was no difference in the percentage who died depending on whether they were followed by CHCT (n=16, 5.1%) or not (n=2, 4.9%, p=0.40). Patients followed by CHCT were older (mean age 43.9 compared with 41.6 years, p<0.001) and more comorbid with COPS2 score ≥65 (1.7% vs 1.1%, p<0.001, table 1). They were less likely to be male (45.0% vs 49.3%, p<0.001). Patients studied were diverse with 14.0% Asian, 43.7% Hispanic and 5.8% Black. They were also more likely to have diabetes (11.4% vs 5.7%, p<0.001), obesity (7.6% vs 4.8%, p<0.001) and hypertension (13.7% vs 8.4%, p<0.001). The majority of patients (n=69 150, 70.1%) had positive tests during the third wave of the pandemic (15 October 2020–31 January 2021). The time from positive test result to first contact with CHCT staff was median 1 day (IQR 0, 4). In the 30 days after positive test, the median time until the first ambulatory encounter was 1 day (IQR 1, 4) for patients followed by CHCT and 3 days (IQR 1, 7) for patients not followed by CHCT. The median time between positive test and presentation to acute care (emergency department) was 4 days (IQR 2,

Table 1 Characteristics of patients with COVID-19+ who were and were not followed by COVID-19 Home Care Team

	All patients	Patients followed by CHCT	Patients not followed by CHCT	
	n=98 585	n=80 067	n=18 518	P value
Age in years, mean (SD)	43.47 (15.54)	43.90 (15.65)	41.61 (14.91)	<0.001
Sex, male (%)	45 183 (45.8%)	36 052 (45.0%)	9131 (49.3%)	<0.001
Race, n (%)				
Asian	13 796 (14.0%)	10 890 (13.6%)	2906 (15.7%)	<0.001
Black	5721 (5.8%)	4541 (5.7%)	1180 (6.4%)	
Hispanic	43 082 (43.7%)	35 111 (43.9%)	7971 (43.0%)	
White	27 646 (28.0%)	22 958 (28.7%)	4688 (25.3%)	
Other/unknown race*	8340 (8.5%)	6567 (8.2%)	1773 (9.6%)	
NDI (median, Q1–Q3)†	−0.07 (−0.61, 0.64)	−0.08 (−0.63, 0.64)	−0.03 (−0.53, 0.62)	<0.001
COPS2 (median, Q1–Q3)‡	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	10.0 (10.0, 10.0)	<0.001
COPS2 ≥65, n (%)	1555 (1.6%)	1350 (1.7%)	205 (1.1%)	<0.001
Comorbidities				
Diabetes, n (%)	10 176 (10.3%)	9122 (11.4%)	1054 (5.7%)	<0.001
Obesity, n (%)	6988 (7.1%)	6105 (7.6%)	883 (4.8%)	<0.001
Hypertension, n (%)	12 505 (12.7%)	10 948 (13.7%)	1557 (8.4%)	<0.001
Chronic pulmonary disease, n (%)	7119 (7.2%)	6142 (7.7%)	977 (5.3%)	<0.001
Congestive heart failure, n (%)	764 (0.8%)	665 (0.8%)	99 (0.5%)	<0.001
Cancer, n (%)	1363 (1.4%)	1173 (1.5%)	190 (1.0%)	<0.001
abLAPS (median, Q1–Q3)§	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	<0.001
abLAPS ≥4, n (%)	3219 (3.3%)	2753 (3.4%)	466 (2.5%)	<0.001
Wave, n (%)				<0.001
1 (1 February 2020–31 May 202)	2476 (2.5%)	1978 (2.5%)	498 (2.7%)	<0.001
2 (1 June 2020–14 October 2020)	26 959 (27.3%)	21 580 (27.0%)	5379 (29.1%)	
3 (15 October 2020–31 January 2021)	69 150 (70.1%)	56 509 (70.6%)	12 641 (68.3%)	
COVID-19-related emergency department visit, n (%)	9165 (9.3%)	7587 (9.5%)	1578 (8.5%)	<0.001
COVID-19-related hospitalisation, n (%)	3703 (3.8%)	3116 (3.9%)	587 (3.2%)	<0.001
Inpatient death or 30-day hospice referral, n (%)	365 (0.4%)	265 (0.3%)	100 (0.5%)	<0.001

*Other races include American Indian, Alaska Native, Asian Pacific, Native Hawaiian, Pacific Islander and multiracial.
†Neighbourhood deprivation index ranges from −5 to +5 with more positive values indicating lower status. See text of Messer *et al*[14] for additional detail.
‡The COmorbidity Point Score, V.2 (COPS2), described in Escobar *et al*[15] is a score assigned every month to all adults with a Kaiser Permanente Northern California medical record number. Range is from 0 to 1010; higher scores indicate worse mortality risk. The univariate relationship between the COPS2 and 1-year mortality is as follows: 0–39, 0.3%; 40–64, 5.3%; and 65+, 17.2%.
§The abbreviated Laboratory-based Acute Physiology Score (abLAPS) is a monthly score employing 14 laboratory tests based on the LAPS score described in Escobar *et al*. Range is from 0 to 256; higher scores indicate increasing physiological abnormalities in the preceding month. The univariate relationship between the abLAPS and 30-day mortality is as follows: 0–4, 0.06%; 4–9, 0.18%; and 10+, 1.32%.
abLAPS, abbreviated Laboratory-based Acute Physiology Score; CHCT, COVID-19 Home Care Team; COPS2, COmorbidity Point Score, V.2; NDI, neighbourhood deprivation index.

7) for those followed by CHCT and 4 days (IQR 1, 8) for those not followed by CHCT.

The overall raw outcome rates were the following: 9.3% had COVID-19-related emergency department visits, 3.8% had COVID-19-related hospitalisations and 0.4% had inpatient death or 30-day hospice referral (table 1). There were more COVID-19-related emergency department visits (9.5% vs 8.5%, p<0.001) and hospitalisations (3.9% vs 3.2%, p<0.001) in patients followed by CHCT but lower inpatient death or 30-day hospice referral (0.3% vs 0.5%, p<0.001).

Table 2 shows the standardised differences in characteristics between patients followed by CHCT and not followed by CHCT. After inverse probability weighting, there were no significant differences in standardised differences of characteristics, as expected. After AIPW, there appeared

Table 2 Selected characteristics of patients who were and were not followed by COVID-19 Home Care Team before and after weighting

	Before weighting			After weighting		
	Patients followed by CHCT n=80 067	Patients not followed by CHCT n=18 518	Standardised difference	Patients followed by CHCT	Patients not followed by CHCT	Standardised difference, %
Age, median (IQR)	43 (31, 55)	40 (30, 52)	0.15	42 (31, 55)	42 (31, 55)	0.01
Sex, male (%)	36 052 (45.0%)	9131 (49.3%)	−0.09	44 889.3 (45.7)	42 202.6 (45.9)	0.00
NDI, median (IQR)[1]	0.08 (−0.63, 0.64)	0.03 (−0.53, 0.62)	−0.04	−0.07 (−0.61, 0.64)	−0.08 (−0.63, 0.63)	0.01
abLAPS, median (IQR)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.05	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.02
COPS2, median (IQR)	10.00 (10.00, 10.00)	10.00 (10.00, 10.00)	0.10	10.00 (10.00, 10.00)	10.00 (10.00, 10.00)	0.04
Obesity, n (%)	6105 (7.6%)	883 (4.8%)	0.13	6991.7 (7.1)	6693.1 (7.3)	−0.01
Diabetes, n (%)	9122 (11.4%)	1054 (5.7%)	0.25	10 172.2 (10.4)	9822.9 (10.7)	−0.01
Hypertension, n (%)	10 948 (13.7%)	1557 (8.4%)	0.19	12 520.3 (12.8)	12 463.6 (13.6)	−0.02
March 2020, n (%)	388 (0%)	112 (1%)	−0.02	498.3 (0.5)	549.7 (0.6)	−0.01
April 2020, n (%)	719 (1%)	199 (1%)	−0.02	915.4 (0.9)	903.9 (1.0)	−0.01
May 2020, n (%)	871 (1%)	187 (1%)	0.01	1061.3 (1.1)	1011.3 (1.1)	0.00
June 2020, n (%)	3687 (5%)	827 (4%)	0.01	4538.3 (4.6)	4310.7 (4.7)	0.00
July 2020, n (%)	8316 (10%)	2277 (12%)	−0.06	10 575.5 (10.8)	10 142.7 (11.0)	−0.01
August 2020, n (%)	5087 (6%)	1290 (7%)	−0.02	6348.4 (6.5)	5979.4 (6.5)	0.00
September 2020, n (%)	3118 (4%)	703 (4%)	0.01	3803.9 (3.9)	3628.0 (3.9)	0.00
October 2020, n (%)	3611 (5%)	676 (4%)	0.05	4293.8 (4.4)	4243.5 (4.6)	−0.01
November 2020, n (%)	10 888 (14%)	2416 (13%)	0.02	13 227.8 (13.5)	12 639.9 (13.8)	−0.01
December 2020, n (%)	26 592 (33%)	6059 (33%)	0.01	32 458.2 (33.1)	29 917.7 (32.6)	0.01
January 2021, n (%)	16 790 (21%)	3772 (20%)	0.01	20 416.6 (20.8)	18 567.2 (20.2)	0.01

abLAPS, Abbreviated Laboratory-based Acute Physiology Score; CHCT, COVID-19 Home Care Team; COPS2, COmorbidity Point Score, V.2; NDI, neighbourhood deprivation index.

Table 3 Estimated intervention effect of COVID-19 Home Care Team

	Adjusted outcome prevalence		Estimated intervention effect
Outcome	CHCT	No CHCT	(95% CI)
COVID-19-related emergency department visit	9.3%	10.1%	−0.8% (−1.4% to −0.3%)
COVID-19-related hospitalisation	3.8%	4.3%	−0.5% (−0.9% to −0.1%)
Inpatient death or 30-day hospice referral	0.3%	0.8%	−0.5% (−0.7% to −0.3%)

The intervention effect being negative indicates a protective effect of the intervention.
CHCT, COVID-19 Home Care Team.

to be a protective effect from the programme. There were higher rates of COVID-19-related emergency department visits (estimated intervention effect −0.8%, 95% CI −1.4% to −0.3%) and hospitalisations (−0.5%, 95% CI −0.9% to −0.1%, table 3) and lower inpatient mortality or 30-day hospice referral (−0.5%, 95% CI −0.7% to −0.3%).

The volume of COVID-19-related outpatient visits increased dramatically during the three waves of the pandemic. The majority was conducted by CHCT providers (dark portion of stacked bar chart, figure 1), demonstrating an offloading of outpatient work to CHCT providers. In the 30 days after a positive test, patients followed by CHCT had the following encounter types (71% telephone only, 6% video only and 23% both), and patients not followed by CHCT had the following encounter types (70% telephone only, 16% video only and 12% both). In the 30 days after a positive test, patients followed by CHCT had encounters with the following clinicians (58% medical doctor (MD) only, 10% registered nurse (RN) only and 32% both), and patients not followed by CHCT had encounters with the following clinicians (96% MD only, 1% RN only and 3% both).

DISCUSSION

Using population-level data from an integrated health system and robust methods (AIPW), we found a protective effect of an outpatient management programme for COVID-19 which was implemented very early in the pandemic to manage patients at home and expedite their referral to acute care when needed. Patients followed by CHCT were older and had higher comorbidity burden, which argues against the possibility of cherry picking. We interpret the results to mean that patients followed by CHCT were more likely to be referred to acute care because of proactive outpatient outreach and

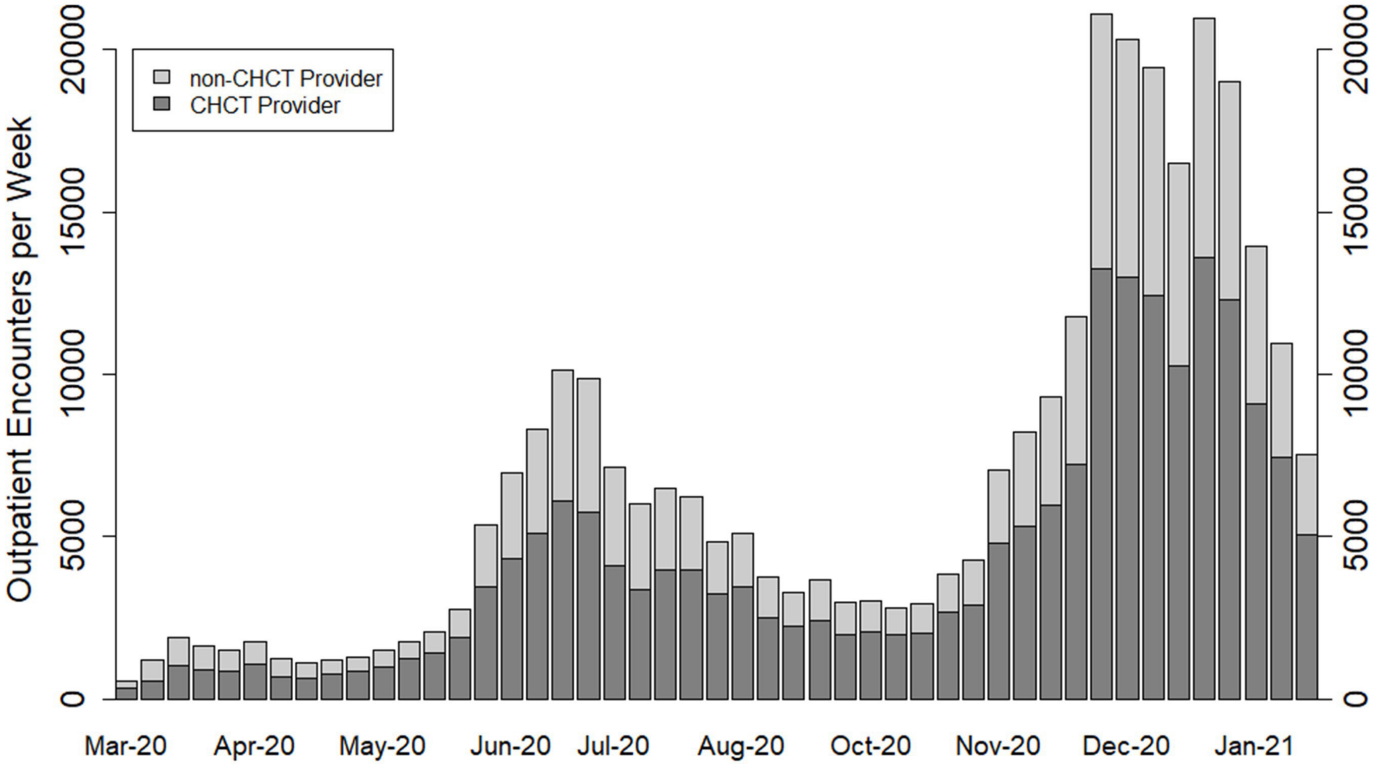

Figure 1 Offloading of outpatient COVID-19-related visits to COVID-19 Home Care Team (CHCT) providers. The figure shows the number of COVID-19-related outpatient encounters per week depending on whether providers were part of CHCT (dark grey) or not (light grey). The bars shown are stacked.

monitoring, which likely explains the lower inpatient mortality or 30-day referral to hospice. We showed that there were drastic increases in the volume of COVID-19-related outpatient visits during the three surge periods and that much of the outpatient COVID-19-related visits were conducted by CHCT providers, demonstrating an offloading of outpatient burden by the programme. We believe these findings are important to disseminate as other health systems struggle to manage entire populations of patients through the waves of the current pandemic. The programme is scalable and generalisable, as the programme itself is delivered completely virtually.

Strain is a term that refers to the time when a clinical care team's ability to provide high-quality care is exceeded due to high occupancy, acuity or turnover. During the pandemic, the Centers for Disease Control and Prevention estimated that if the critical care bed capacity reached 75% nationwide, 12 000 (95% CI=8623 to 17 294) excess deaths would occur nationally 2 weeks later.[7] Preventing emergency room overcrowding due to unnecessary visits during periods of high transmission was critical to prevent strain-related deaths.[7 11 31 32] Programmes such as CHCT attempted to streamline the management of patients with COVID-19 in the outpatient setting and to facilitate appropriate emergency room care when patients demonstrate the need for acute care.

It is important to evaluate real-world programmes, such as CHCT, that can impact outcomes for a population of patients. Patients with early COVID-19 had a tremendous need for both outpatient and inpatient care. One analysis reported that patients required 5.6–9 visits in the 30 days after the diagnosis depending on whether they ultimately were hospitalised.[33] Given the rapidity of the onset of the pandemic, this demand for healthcare resources strained our healthcare system. We showed that the majority of COVID-19-related outpatient visits were managed by CHCT providers, repurposed from specialties who had the capacity at certain points during the pandemic. Additionally, the majority of CHCT encounters were via telephone, which required fewer resources than video or inperson visits. In this study, we demonstrated the management of large demand upswings due to deployment and redeployment of resources which had a positive impact on patient care.

Other programmes like CHCT have been implemented and described in the literature. The direction of our results (favouring programme benefit) is consistent with the other three programmes described here, but the details of the programme and outcomes measured differed. First, the Cleveland Clinic Home Monitoring Programme included telephone outreach to 3975 patients after a positive SARS-CoV-2 test to assess patients' symptoms and escalate their care.[34] They performed a matched propensity score analysis and found lower odds of 30- and 90-day outpatient visits and hospitalisation, but not emergency department visits. In our study, which evaluated a programme implemented at scale, we report more acute care hospitalisation and improved clinical outcomes. Second, the University of Pennsylvania COVID Watch Programme was a texting intervention whereby 3488 patients received twice daily texts to inquire about symptoms.[35] They performed a propensity score analysis and found a 64% relative reduction in death for enrolled patients. They found that patients were reporting to the emergency department sooner and had more frequent telemedicine encounters. Our programme was implemented on a larger scale but found similar reduction in inpatient mortality. Third, the Home Monitoring Programme at Providence Health System delivered pulse oximeters and thermometers to the home and administered surveys in English/Spanish to monitor symptoms over time.[36] The authors performed propensity scores with inverse probability of treatment weighting. Of 4358 participants, the programme was associated with more outpatient and emergency department encounters and resulted in high enrollee satisfaction. This study did not report hospitalisation rates or rates of clinical outcomes, such as death.[36]

There are several limitations to the current analysis. We did not measure physician or patient satisfaction/experience related to the programme. We also did not measure provider burnout created or alleviated by the programme. In an effort to reach as many people as possible, the intervention was not randomised, but we used the natural control group formed when programme demand exceeded bandwidth.

There are several key takeaways and advantages to our study. We showed that patients followed by CHCT were older, more comorbid and from diverse racial backgrounds. While being older and more comorbid could have disfavoured the programme, we found higher rates of acute care utilisation even after adjusting for confounding and lower inpatient mortality or 30-day hospice referral. Additionally, we examined patients who had had at least one outreach by CHCT into the intervention group to make it harder to find a statistically significant difference between the groups. We ensured that patients included in the analysis were eligible for CHCT services, that is, they were not hospitalised at the time of receiving a positive test or within 48 hours because it took CHCT 48 hours to initiate contact. We appropriately examined the period of the pandemic prior to widespread vaccination; including the post-vaccination period would complicate the interpretation of the result given that unvaccinated patients are more likely to be hospitalised for COVID-19 and may be less likely to engage with the programme.[37 38] We also demonstrated that the number of patients who died in the 4 weeks after a positive test were few and not different between whether they were followed by CHCT or not. We performed a robust analysis using AIPW and adjustment for confounding, including month of the pandemic,[11] and capitalised on the natural control group that occurred when programme demand exceeded bandwidth.

In conclusion, we evaluated the KPNC CHCT programme, which was developed and implemented early in the pandemic and at scale to manage rises in outpatient care needs related to COVID-19 surges. Despite CHCT following older patients with higher comorbidity burden,

there appeared to be a protective effect with a higher likelihood of presenting to acute care but a lower likelihood of inpatient mortality. We found the programme was successful in offloading outpatient clinical care onto repurposed providers during the early part of the pandemic. This type of programme is scalable for future waves of the COVID-19 pandemic or future pandemics.

Twitter Laura C Myers @MDqualitysafety

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ORCID iDs
Laura C Myers http://orcid.org/0000-0002-2872-3388
Vincent Liu http://orcid.org/0000-0001-6899-9998

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