Impact of an outreach program for patients with COVID-19 in an integrated healthcare delivery system

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-073622
Article Type:	Original research
Date Submitted by the Author:	14-Mar-2023
Complete List of Authors:	Myers, Laura ; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Lawson, Brian L.; Kaiser Permanente, Division of Research Escobar, Gabriel; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Daly, Kathleen ; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Chen, Yi-fen; The Permanente Medical Group Inc Dlott, Richard; The Permanente Medical Group Inc Lee, Catherine; Kaiser Permanente, Division of Research Liu, Vincent; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc,
Keywords:	COVID-19, PUBLIC HEALTH, Public health < INFECTIOUS DISEASES

Impact of an outreach program for patients with COVID-19 in an integrated healthcare delivery system

Running title: *Outreach program during COVID-19 pandemic*

Laura C. Myers, MD, MPH[1,2], Brian L. Lawson, PhD[1], Gabriel J. Escobar, MD[1,2], Kathleen A. Daly, BS[1,2], Yi-Fen Chen, MD[2], Richard Dlott, MD[2], Catherine Lee, PhD[1], Vincent X. Liu, MD, MS[1,2]

1. Division of Research, Kaiser Permanente Northern California, Oakland CA
2. The Permanente Medical Group, Kaiser Permanente Northern California, Oakland CA

Corresponding Author:
Laura C. Myers MD MPH
Kaiser Permanente Northern California
Division of Research
2000 Broadway
Oakland, CA 94612
Email: Laura.c.myers@kp.org ORCID: 0000-0002-2872-3388
Twitter handle: @MDqualitysafety Telephone: (925) 433-3491

Key words: COVID-19, outreach program

Word Count:

Abstract: 298

Main: 2,854

Conflicts of Interest/Disclosures, Funding: The authors report no conflicts of interest. The work is not under consideration elsewhere for publication. Dr. Escobar had full access to the data. This work was supported by The Permanente Medical Group, Inc., and Kaiser Foundation Hospitals, Inc. Dr. Vincent Liu was also supported by NIH grant R35GM128672.

ABSTRACT

Objectives: In the first year of the coronavirus disease 2019 (COVID-19) pandemic, health systems implemented programs to manage outpatients with COVID-19. The goal was to expedite patients' referral to acute care and prevent overcrowding of medical centers. We sought to evaluate the impact of such a program, the COVID-19 Home Care Team (CHCT) program.

Design: Retrospective cohort

Setting: Kaiser Permanente Northern California

Participants: Adult members before COVID-19 vaccine availability (2/1/2020-1/31/2021) with positive SARS-CoV-2 tests

Intervention: Virtual program to track and treat patients with COVID-19 "CHCT program."

Outcomes: Outcomes were 1) COVID-19-related emergency department visit, 2) COVID-19-related hospitalization, 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, Generalized 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 COPS2 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 hospitalizations (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%, -0.3%) and hospitalization (-0.5%, 95% CI -0.9%, -0.1%) but lower inpatient mortality or 30-day hospice referral (-0.5%, 95% CI -0.7%, -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

- This is a retrospective cohort study that evaluated a real-world program “the COVID-19 Home Care Team program” in an integrated health system. The program reached a large population of diverse patients. While the program was not randomized, we capitalized on a natural control group when demand for the program (case incidence) went above capacity.
- 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.
- We used robust methods to conduct the analysis (propensity scores with ensemble super learner and augmented inverse probability weighting).
- We found a protective effect of the program despite the program following older and more comorbid patients. This program is scalable, successfully offloaded burden from primary care physicians and could be done in other populations for future waves of the pandemic or other respiratory pandemics.
- We were unable to assess patient or provider satisfaction or provider burnout.

INTRODUCTION

The coronavirus disease 2019 (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 hospitalized 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 their 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 centers that have 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 center that was not overcrowded. The novel intervention was 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 program on risk of hospitalization and death.

METHODS

This is a retrospective cohort study. The work was approved, and informed consent was waived by the Kaiser Permanente Northern California Institutional Review Board (#1634347).

Setting

Under a mutual exclusivity agreement, 9,500 physicians of The Permanente Medical Group care for >4.4 million Kaiser Foundation Health Plan members at 21 hospital facilities owned by Kaiser Foundation Hospitals.

Study Population

To establish our base population, we identified all records of members who were ≥18 years old as of 2/1/2020 who had a positive SARS-CoV-2 polymerase chain reaction test ordered between 2/1/2020-1/31/2021. Prior to 3/13/2020, 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 characteristics and outcomes of the first positive test. The study end date was chosen because it was prior to widespread dissemination of vaccinations for SARS-CoV-2. We excluded patients who were not eligible for CHCT service, such as those who had first positive test during or after a COVID-19-related emergency department visit or hospitalization. We also excluded patients who were hospitalized 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 neighborhood deprivation index, a composite index ranging from –5 to 5 with more positive values reflecting lower socioeconomic status.[14] We also captured 2 composite indices that are assigned to adults in the KPNC system: a longitudinal comorbidity score (COmorbidity Point Score, version 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 score, which is based on 14 laboratory tests obtained in the preceding month; higher scores are associated with increased physiologic derangement.[13,16] These variables are more fully described in published studies.[15,17-19]

Exposure

Prior to the pandemic, KPNC had several existing population health programs for non-pregnant adults with chronic conditions (e.g., diabetes,[20-22] cancer screening,[23,24] cardiovascular disease[25]). In addition, a variety of follow-up processes existed to support primary care providers, such as combinations of in-person and automated outreach for management of hypertensive patients.[26,27] At the start of the pandemic, KPNC leadership utilized this population health management infrastructure to develop a novel outpatient population health program, CHCT, with the goal of increasing frontline primary care provider support by re-purposing 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 (e.g., routine cervical cancer screening, colonoscopies), and routine specialty follow-up appointments were deprioritized. 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 COVID-19 patients using standardized 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 individualized follow-up of patients with early COVID-19 infection including education, assessment, and, if indicated, explicit directions for how to access emergency department care.

Starting in March 2020, patients were electronically enrolled in CHCT when they developed a positive SARS-CoV-2 test. Program 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 electronic medical record integrated population care platform allowed CHCT to document outreach attempts so that multiple outreach attempts could be made. 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. Based on standardized protocols developed by front line physicians, patients were escalated to video visits, in-person outpatient visits or acute care (emergency department). During COVID-19 surges, 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 were attempted to be reached at least once were included in the intervention group.

Outcome

The primary outcome was COVID-19-related acute care utilization. We examined 1) COVID-19-related emergency department visit or 2) COVID-19-related hospitalization within 2 weeks of positive test. Attribution of hospitalizations to COVID-19 was based on *International Classification of Diseases, Version 10* codes, timing of test orders and non-elective status using a previously published algorithm.[19,28] 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 standard deviation or median with interquartile range for continuous variables. We report number with percent for categorical variables. We compare univariate values with T tests, Wilcoxon rank sum tests or Chi Squared tests, as appropriate.

For each outcome, we estimated the average treatment effect of the CHCT program, comparing patients who were enrolled in CHCT to those who were not using an augmented inverse probability weighting (AIPW)[29] estimator. In AIPW, models are developed for the propensity of treatment and outcome probability as a function of covariates, utilizing 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[31] that employs the ensemble machine learning approach Super Learner (random forest, XGBoost, Generalized 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, neighborhood 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.[30] Month of the pandemic was included because outcomes of patients have improved over time.[6,11,31] We reported the standardized 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% confidence interval, which is the average treatment effect.[32] Threshold for significance was <0.05.

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 hospitalization, 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 to 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 (10/15/20-1/31/21).

The overall raw outcome rates were the following: 9.3% had COVID-19-related emergency department visits, 3.8% had COVID-19-related hospitalizations 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 hospitalizations (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 standardized differences in characteristics between patients followed by CHCT and not followed by CHCT. After inverse probability weighting, there were no significant differences in standardized differences of characteristics, as expected. After AIPW, there appeared to be a protective effect from the program. There were higher rates of COVID-19-related emergency department visits (estimated intervention effect -0.8%, 95% CI -1.4%, -0.3%) and hospitalizations (-0.5%, 95% CI -0.9%, -0.1%, **Table 3**) and lower inpatient mortality or 30-day hospice referral (-0.5%, 95% CI -0.7%, -0.3%).

The volume of COVID-19-related outpatient visits increased dramatically during the 3 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.

DISCUSSION

Using population-level data from an integrated health system and robust methods (AIPW), we found a protective effect of an outpatient management program 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 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 3 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 program. 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 program is scalable and generalizable, as the program 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=8,623–17,294) 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.[7,34-36] Programs 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 programs, such as CHCT, that can impact outcomes for a population of patients. Patients with early COVID-19 had tremendous need for both outpatient and inpatient care. One analysis reported patients required 5.6-9 visits in the 30 days after the diagnosis depending on whether they ultimately were hospitalized.[37] 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 capacity at certain points during the pandemic. Additionally, the majority of CHCT encounters were via telephone, which required fewer resources than video or in-person 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 programs like CHCT have been implemented and described in the literature. The direction of our results (favoring program benefit) is consistent with the other 3 programs described herein, but the details of the program and outcomes measured differed. First, the Cleveland Clinic Home Monitoring Program included telephone outreach to 3,975 patients after a positive SARS-CoV-2 test to assess patients' symptoms and escalate their care.[38] They performed a matched propensity score analysis and found lower odds of 30-day and 90-day outpatient visits and hospitalization, but not emergency department visits. In our study, which evaluated a program implemented at scale, we report more acute care hospitalization and improved clinical outcomes. Second, the University of Pennsylvania COVID Watch program was a texting intervention whereby 3,488 patients received twice daily texts to inquire about symptoms.[39] They performed a propensity score analysis and found a 64% relative reduction in death for enrolled patients. They found patients were reporting to the emergency department sooner and had more frequent telemedicine encounters. Our program was implemented on a larger scale but found similar reduction in inpatient mortality. Third, the Home Monitoring Program at Providence health system delivered pulse oximeters and thermometers to the home and administered surveys in English/Spanish to monitor symptoms over time.[40] The authors performed propensity scores with inverse probability of treatment weighting. Of 4,358 participants, the program was associated with more outpatient and emergency department encounters and resulted in high enrollee satisfaction. This study did not report hospitalization rates or rates of clinical outcomes, such as death.[40]

There are several limitations to the current analysis. We did not measure physician or patient satisfaction/experience related to the program. We also did not measure provider burnout created or alleviated by the program. In an effort to reach as many people as possible, the intervention was not randomized but we used the natural control group formed when program 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 disfavored the program, we found higher rates of acute care utilization even after adjusting for confounding and lower inpatient mortality or 30-day hospice referral. Additionally, we examined patients who had had at least 1 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, i.e., they were not hospitalized 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 hospitalized for COVID-19 and may be less likely to engage with the program.[33,41] 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,[35] and capitalized on the natural control group that occurred when program demand exceeded bandwidth.

In conclusion, we evaluated the KPNC CHCT program, 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 higher likelihood of presenting to acute care but lower likelihood of inpatient mortality. We found the program was successful in offloading outpatient clinical care onto repurposed providers during the early part of the pandemic. This type of program is scalable for future waves of the COVID-19 pandemic or future pandemics.

ACKNOWLEDGMENTS

We wish to thank the Kaiser Permanente Division of Research Strategic Programming Group for formatting the dataset and The Permanente Medical Group Consulting Services for consulting on data extraction and analysis.

AUTHOR'S CONTRIBUTIONS

LCM is the corresponding author and guarantor for the study. LCM, BLL, GJE, RD, CL, and VXL conceptualized the project. LCM, GJE, VXL, BLL, CL contributed to the data curation, formal analysis, and methodology. LCM wrote the first draft of the manuscript, with subsequent editing done by listed co-authors; following this, LCM prepared the final version which is submitted here.

DATA SHARING STATEMENT

DATASETS NOT PUBLICLY AVAILABLE

The datasets generated and/or analyzed during the current study are not publicly available due to their being the property of Kaiser Foundation Health Plan, Inc., but are available to interested collaborators in the context of a formal collaboration approved by the Kaiser Permanente Northern California Institutional Review Board for the Protection of Human Subjects.

Figure 1: Offloading of outpatient COVID-19 related visits to CHCT providers

Figure 1 Legend

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

REFERENCES

1. Myers LC, Liu VX. The COVID-19 Pandemic Strikes Again and Again and Again. *JAMA Netw Open*. Mar 1 2022;5(3):e221760. doi:10.1001/jamanetworkopen.2022.1760
2. Parodi SM, Liu VX. From Containment to Mitigation of COVID-19 in the US. *JAMA*. Apr 21 2020;323(15):1441-1442. doi:10.1001/jama.2020.3882
3. Rouillard S, Liu VX, Corley DA. COVID-19 and long-term planning for procedure-based specialties during extended mitigation and suppression strategies. *Gastroenterology*. Jan 2021;160(1):4-9. doi:10.1053/j.gastro.2020.05.047
4. Dang A, Thakker R, Li S, Hommel E, Mehta HB, Goodwin JS. Hospitalizations and Mortality From Non-SARS-CoV-2 Causes Among Medicare Beneficiaries at US Hospitals During the SARS-CoV-2 Pandemic. *JAMA Netw Open*. Mar 1 2022;5(3):e221754. doi:10.1001/jamanetworkopen.2022.1754
5. Kadri SS, Sun J, Lawandi A, et al. Association Between Caseload Surge and COVID-19 Survival in 558 U.S. Hospitals, March to August 2020. *Ann Intern Med*. Sep 2021;174(9):1240-1251. doi:10.7326/M21-1213
6. Asch DA, Sheils NE, Islam MN, et al. Variation in US Hospital Mortality Rates for Patients Admitted With COVID-19 During the First 6 Months of the Pandemic. *JAMA Intern Med*. Apr 1 2021;181(4):471-478. doi:10.1001/jamainternmed.2020.8193
7. French G, Hulse M, Nguyen D, et al. Impact of Hospital Strain on Excess Deaths During the COVID-19 Pandemic - United States, July 2020-July 2021. *MMWR Morb Mortal Wkly Rep*. Nov 19 2021;70(46):1613-1616. doi:10.15585/mmwr.mm7046a5
8. Jeganathan N, Grewal S, Sathananthan M. Comparison of Deaths from COVID-19 and Seasonal Influenza in the USA. *Lung*. Oct 2021;199(5):559-561. doi:10.1007/s00408-021-00468-0
9. Piroth L, Cottenet J, Mariet AS, et al. Comparison of the characteristics, morbidity, and mortality of COVID-19 and seasonal influenza: a nationwide, population-based retrospective cohort study. *Lancet Respir Med*. Mar 2021;9(3):251-259. doi:10.1016/S2213-2600(20)30527-0
10. Horwitz LI, Jones SA, Cerfolio RJ, et al. Trends in COVID-19 Risk-Adjusted Mortality Rates. *J Hosp Med*. Oct 21 2020;doi:10.12788/jhm.3552
11. Anesi GL, Jablonski J, Harhay MO, et al. Characteristics, outcomes, and trends of patients with COVID-19-related critical illness at a learning health system in the United States. *Ann Intern Med*. Jan 19 2021;doi:10.7326/M20-5327
12. Myers LC, Parodi SM, Escobar GJ, Liu VX. Characteristics of hospitalized adults with COVID-19 in an integrated health care system in California. *JAMA*. Jun 2 2020;323(21):2195-2198. doi:10.1001/jama.2020.7202
13. Escobar GJ AA, Liu VX, Soltesz L, Chen YI, Parodi SM, Ray GT, Myers LC, Ramaprasad CM, Dlott R, Lee C. Racial Disparities in COVID-19 Testing and Outcomes : Retrospective Cohort Study in an Integrated Health System. *Annals of Internal Medicine*. 2020;174(6):786-793. doi:10.7326/M20-6979
14. Messer LC, Laraia BA, Kaufman JS, et al. The development of a standardized neighborhood deprivation index. *J Urban Health*. Nov 2006;83(6):1041-62. doi:10.1007/s11524-006-9094-x
15. Escobar GJ, Gardner MN, Greene JD, Draper D, Kipnis P. Risk-adjusting hospital mortality using a comprehensive electronic record in an integrated health care delivery system. *Med Care*. May 2013;51(5):446-53. doi:10.1097/MLR.0b013e3182881c8e
16. Escobar GJ, Greene JD, Scheirer P, Gardner MN, Draper D, Kipnis P. Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases. *Med Care*. Mar 2008;46(3):232-9. doi:10.1097/MLR.0b013e3181589bb6

17. Escobar G, Greene J, Scheirer P, Gardner M, Draper D, Kipnis P. Risk Adjusting Hospital Inpatient Mortality Using Automated Inpatient, Outpatient, and Laboratory Databases. *Medical Care*. March 2008;46(3):232-39.
18. Escobar GJ, Ragins A, Scheirer P, Liu V, Robles J, Kipnis P. Nonelective Rehospitalizations and Postdischarge Mortality: Predictive Models Suitable for Use in Real Time. *Medical care*. Nov 2015;53(11):916-23. doi:10.1097/MLR.0000000000000435
19. Escobar GJ, Adams AS, Liu VX, et al. Racial Disparities in COVID-19 Testing and Outcomes : Retrospective Cohort Study in an Integrated Health System. *Ann Intern Med*. Feb 9 2021;doi:10.7326/M20-6979
20. Sadur CN, Moline N, Costa M, et al. Diabetes management in a health maintenance organization. Efficacy of care management using cluster visits. *Diabetes Care*. Dec 1999;22(12):2011-7. doi:10.2337/diacare.22.12.2011
21. Schmittdiel JA, Uratsu CS, Fireman BH, Selby JV. The effectiveness of diabetes care management in managed care. *Am J Manag Care*. May 2009;15(5):295-301.
22. Rana JS, Karter AJ, Liu JY, Moffet HH, Jaffe MG. Improved Cardiovascular Risk Factors Control Associated with a Large-Scale Population Management Program Among Diabetes Patients. *Am J Med*. Jun 2018;131(6):661-668. doi:10.1016/j.amjmed.2018.01.024
23. Doubeni CA, Corley DA, Zhao W, Lau Y, Jensen CD, Levin TR. Association between Improved Colorectal Screening and Racial Disparities. *N Engl J Med*. Feb 24 2022;386(8):796-798. doi:10.1056/NEJMc2112409
24. Mehta SJ, Jensen CD, Quinn VP, et al. Race/Ethnicity and Adoption of a Population Health Management Approach to Colorectal Cancer Screening in a Community-Based Healthcare System. *J Gen Intern Med*. Nov 2016;31(11):1323-1330. doi:10.1007/s11606-016-3792-1
25. Rana JS, Karter AJ, Liu JY, Moffet HH, Jaffe MG. Improved Cardiovascular Risk Factors Control Associated with a Large-Scale Population Management Program Among Diabetes Patients. *The American Journal of Medicine*. 2018;131(6):661-668. doi:10.1016/j.amjmed.2018.01.024
26. Jaffe MG, Lee GA, Young JD, Sidney S, Go AS. Improved blood pressure control associated with a large-scale hypertension program. *JAMA*. Aug 21 2013;310(7):699-705. doi:10.1001/jama.2013.108769
27. Jaffe MG, Young JD. The Kaiser Permanente Northern California Story: Improving Hypertension Control From 44% to 90% in 13 Years (2000 to 2013). *J Clin Hypertens (Greenwich)*. Apr 2016;18(4):260-1. doi:10.1111/jch.12803
28. Myers LC, Ng K, Plimier C, Daly KA, Kipnis P, Liu VX. Trends in Outpatient Visits and Hospital and Intensive Care Unit Admissions of Adults With COVID-19 in an Integrated US Health Care System, March 2020 to January 2022. *JAMA Netw Open*. Jan 3 2023;6(1):e2253269. doi:10.1001/jamanetworkopen.2022.53269
29. Kurz CF. Augmented Inverse Probability Weighting and the Double Robustness Property. *Med Decis Making*. Feb 2022;42(2):156-167. doi:10.1177/0272989X211027181
30. Ko JY, Danielson ML, Town M, et al. Risk Factors for Coronavirus Disease 2019 (COVID-19)-Associated Hospitalization: COVID-19-Associated Hospitalization Surveillance Network and Behavioral Risk Factor Surveillance System. *Clin Infect Dis*. Jun 1 2021;72(11):e695-e703. doi:10.1093/cid/ciaa1419
31. Horby P, Lim WS, Emberson JR, et al. Dexamethasone in hospitalized patients with COVID-19. *N Engl J Med*. Feb 25 2021;384(8):693-704. doi:10.1056/NEJMoa2021436
32. Zhong Y, Kennedy EH, Bodnar LM, Naimi AI. AIPW: An R Package for Augmented Inverse Probability-Weighted Estimation of Average Causal Effects. *Am J Epidemiol*. Dec 1 2021;190(12):2690-2699. doi:10.1093/aje/kwab207

33. Myers LC, Kipnis P, Greene J, et al. Adults hospitalized with breakthrough COVID-19 have lower mortality than matched unvaccinated adults. *J Intern Med*. May 9 2022;doi:10.1111/joim.13504
34. Anesi GL, Chowdhury M, Small DS, et al. Association of a Novel Index of Hospital Capacity Strain with Admission to Intensive Care Units. *Ann Am Thorac Soc*. Nov 2020;17(11):1440-1447. doi:10.1513/AnnalsATS.202003-228OC
35. Anesi GL, Jablonski J, Harhay MO, et al. Characteristics, Outcomes, and Trends of Patients With COVID-19-Related Critical Illness at a Learning Health System in the United States. *Ann Intern Med*. May 2021;174(5):613-621. doi:10.7326/M20-5327
36. Anesi GL, Liu VX, Gabler NB, et al. Associations of intensive care unit capacity strain with disposition and outcomes of patients with sepsis presenting to the emergency department. *Ann Am Thorac Soc*. Nov 2018;15(11):1328-1335. doi:10.1513/AnnalsATS.201804-241OC
37. Huang BZ, Creekmur B, Yoo MS, Broder B, Subject C, Sharp AL. Healthcare Utilization Among Patients Diagnosed with COVID-19 in a Large Integrated Health System. *J Gen Intern Med*. Mar 2022;37(4):830-837. doi:10.1007/s11606-021-07139-z
38. Misra-Hebert AD, Ji X, Jehi L, et al. COVID-19 Home Monitoring After Diagnosis and Health Care Utilization in an Integrated Health System. *JAMA Health Forum*. 2021;2(5):e210333-e210333. doi:10.1001/jamahealthforum.2021.0333
39. Delgado MK, Morgan AU, Asch DA, et al. Comparative Effectiveness of an Automated Text Messaging Service for Monitoring COVID-19 at Home. *Ann Intern Med*. Feb 2022;175(2):179-190. doi:10.7326/M21-2019
40. Vartanian KB, Holtorf M, Cox EJ, et al. Patient experience and healthcare utilization for a COVID-19 telemedicine home monitoring program offered in English and Spanish. *PLoS One*. 2022;17(6):e0270754. doi:10.1371/journal.pone.0270754
41. Kipnis P, Soltesz L, Escobar G, Myers L, VX L. Evaluation of Vaccination Strategies to Compare Efficient and Equitable Vaccine Allocation by Race and Ethnicity Across Time. *JAMA Health Forum*. 2021;(2(8)):e212095. doi:10.1001/jamahealthforum.2021.2095

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

	All patients n=98,585	Patients followed by CHCT n=80,067	Patients not followed by CHCT 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%)	9,131 (49.3%)	<0.001
Race, n (%)				
Asian	13,796 (14.0%)	10,890 (13.6%)	2,906 (15.7%)	<0.001
Black	5,721 (5.8%)	4,541 (5.7%)	1,180 (6.4%)	
Hispanic	43,082 (43.7%)	35,111 (43.9%)	7,971 (43.0%)	
White	27,646 (28.0%)	22,958 (28.7%)	4,688 (25.3%)	
Other/unknown race [a]	8,340 (8.5%)	6,567 (8.2%)	1,773 (9.6%)	
NDI (median, Q1-Q3) [b]	-0.07 [-0.61, 0.64]	-0.08 [-0.63, 0.64]	-0.03 [-0.53, 0.62]	<0.001
COPS2 (median, Q1-Q3) [c]	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%)	1,350 (1.7%)	205 (1.1%)	<0.001
Comorbidities				
Diabetes, n (%)	10,176 (10.3%)	9,122 (11.4%)	1,054 (5.7%)	<0.001
Obesity, n (%)	6,988 (7.1%)	6,105 (7.6%)	883 (4.8%)	<0.001
Hypertension, n (%)	12,505 (12.7%)	10,948 (13.7%)	1,557 (8.4%)	<0.001
Chronic pulmonary disease, n (%)	7,119 (7.2%)	6,142 (7.7%)	977 (5.3%)	<0.001
Congestive heart failure, n (%)	764 (0.8%)	665 (0.8%)	99 (0.5%)	<0.001
Cancer, n (%)	1,363 (1.4%)	1,173 (1.5%)	190 (1.0%)	<0.001
abLAPS (median, Q1-Q3) [d]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	<0.001
abLAPS ≥ 4, n (%)	3,219 (3.3%)	2,753 (3.4%)	466 (2.5%)	<0.001
Wave, n (%)				<0.001
1 (2/1/20-5/31/20)	2,476 (2.5%)	1,978 (2.5%)	498 (2.7%)	<0.001
2 (6/1/20-10/14/20)	26,959 (27.3%)	21,580 (27.0%)	5,379 (29.1%)	
3 (10/15/20-1/31/21)	69,150 (70.1%)	56,509 (70.6%)	12,641 (68.3%)	
COVID-19-related emergency department visit, n (%)	9,165 (9.3%)	7,587 (9.5%)	1,578 (8.5%)	<0.001
COVID-19-related hospitalization, n (%)	3,703 (3.8%)	3,116 (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

Abbreviations: CHCT=Coronavirus disease 19 Home Care Team

FOOTNOTE

a Other race includes: American Indian, Alaska Native, Asian Pacific, Native Hawaiian, Pacific Islander, multiracial.

b Neighborhood deprivation index ranges between -5 to +5 with more positive values indicating lower status. See text of Messer et al. (2006) for additional detail.

c The COmorbidity Point Score, version 2 (COPS2) described in Escobar et al. (2013) 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%; 65+, 17.2%.

d 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. (2008). Range is from 0 to 256; higher scores indicate increasing physiologic 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%; 10+, 1.32%.

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

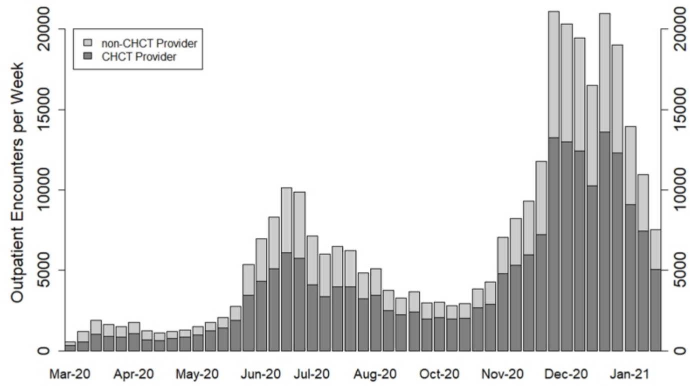
	Before Weighting			After Weighting		
	Patients followed by CHCT n=80,067	Patients not followed by CHCT n=18,518	Standardized Difference	Patients followed by CHCT	Patients not followed by CHCT	Standardized Difference, %
Age, median (IQR)	43 [31, 55]	40 [30, 52]	0.15	42 [31, 55]	42 [31, 55]	0.01
Sex, male (%)	36,052 (45.0%)	9,131 (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 (%)	6,105 (7.6%)	883 (4.8%)	0.13	6991.7 (7.1)	6,693.1 (7.3)	-0.01
Diabetes, n (%)	9,122 (11.4%)	1,054 (5.7%)	0.25	10,172.2 (10.4)	9,822.9 (10.7)	-0.01
Hypertension, n (%)	10,948 (13.7%)	1,557 (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	1,061.3 (1.1)	1,011.3 (1.1)	0.00
June 2020, n (%)	3,687 (5%)	827 (4%)	0.01	4,538.3 (4.6)	4,310.7 (4.7)	0.00
July 2020, n (%)	8,316 (10%)	2,277 (12%)	-0.06	10,575.5 (10.8)	10,142.7 (11.0)	-0.01
August 2020, n (%)	5,087 (6%)	1,290 (7%)	-0.02	6,348.4 (6.5)	5,979.4 (6.5)	0.00
September 2020, n (%)	3,118 (4%)	703 (4%)	0.01	3,803.9 (3.9)	3,628.0 (3.9)	0.00
October 2020, n (%)	3,611 (5%)	676 (4%)	0.05	4,293.8 (4.4)	4,243.5 (4.6)	-0.01
November 2020, n (%)	10,888 (14%)	2,416 (13%)	0.02	13,227.8 (13.5)	12,639.9 (13.8)	-0.01
December 2020, n (%)	26,592 (33%)	6,059 (33%)	0.01	32,458.2 (33.1)	29,917.7 (32.6)	0.01
January 2021, n (%)	16,790 (21%)	3,772 (20%)	0.01	20,416.6 (20.8)	18,567.2 (20.2)	0.01

Abbreviations: NDI=neighborhood deprivation index, COPS2=Comorbidity Point Score, Version 2, abLAPS=Abbreviated Laboratory-based Acute Physiology Score

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

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

The intervention effect being negative indicates a protective effect of the intervention.



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

338x190mm (300 x 300 DPI)

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-073622.R1
Article Type:	Original research
Date Submitted by the Author:	14-Nov-2023
Complete List of Authors:	Myers, Laura ; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Lawson, Brian L.; Kaiser Permanente, Division of Research Escobar, Gabriel; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Daly, Kathleen ; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc Chen, Yi-fen; The Permanente Medical Group Inc Dlott, Richard; The Permanente Medical Group Inc Lee, Catherine; Kaiser Permanente, Division of Research Liu, Vincent; Kaiser Permanente, Division of Research; The Permanente Medical Group Inc,
Primary Subject Heading:	Infectious diseases
Secondary Subject Heading:	Infectious diseases, Public health
Keywords:	COVID-19, PUBLIC HEALTH, Public health < INFECTIOUS DISEASES

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

Running title: *Outreach program during COVID-19 pandemic*

Laura C. Myers, MD, MPH[1,2], Brian L. Lawson, PhD[1], Gabriel J. Escobar, MD[1,2], Kathleen A. Daly, BS[1,2], Yi-Fen Chen, MD[2], Richard Dlott, MD[2], Catherine Lee, PhD[1], Vincent X. Liu, MD, MS[1,2]

1. Division of Research, Kaiser Permanente Northern California, Oakland CA
2. The Permanente Medical Group, Kaiser Permanente Northern California, Oakland CA

Corresponding Author:
Laura C. Myers MD MPH
Kaiser Permanente Northern California
Division of Research
2000 Broadway
Oakland, CA 94612
Email: Laura.c.myers@kp.org ORCID: 0000-0002-2872-3388
Twitter handle: @MDqualitysafety Telephone: (925) 433-3491

Key words: COVID-19, outreach program

Word Count:

Abstract: 298

Main: 3,259

Conflicts of Interest/Disclosures: The authors report no conflicts of interest. The work is not under consideration elsewhere for publication. Dr. Escobar had full access to the data.

ABSTRACT

Objectives: In the first year of the coronavirus disease 2019 (COVID-19) pandemic, health systems implemented programs to manage outpatients with COVID-19. The goal was to expedite patients' referral to acute care and prevent overcrowding of medical centers. We sought to evaluate the impact of such a program, the COVID-19 Home Care Team (CHCT) program.

Design: Retrospective cohort

Setting: Kaiser Permanente Northern California

Participants: Adult members before COVID-19 vaccine availability (2/1/2020-1/31/2021) with positive SARS-CoV-2 tests

Intervention: Virtual program to track and treat patients with COVID-19 "CHCT program."

Outcomes: Outcomes were 1) COVID-19-related emergency department visit, 2) COVID-19-related hospitalization, 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, Generalized 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 COPS2 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 hospitalizations (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%, -0.3%) and hospitalization (-0.5%, 95% CI -0.9%, -0.1%) but lower inpatient mortality or 30-day hospice referral (-0.5%, 95% CI -0.7%, -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.

FUNDING

This work was supported by The Permanente Medical Group, Inc., (award/grant number N/A) and Kaiser Foundation Hospitals, Inc. (award/grant number N/A). Dr. Vincent Liu was also supported by NIH grant R35GM128672. The funder(s) had no involvement in the study design; in the collection, analysis and interpretation of the data; in the writing of the report; and in the decision to submit the paper for publication.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- While the program was not randomized, a natural control group was utilized, when demand for the program (number of cases) went above capacity of the program.
- 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 coronavirus disease 2019 (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 hospitalized 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 their 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 centers that have 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 center that was not overcrowded. The novel intervention was 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 program on risk of hospitalization and death.

METHODS

This is a retrospective cohort study. The work was approved, and informed consent was waived by the Kaiser Permanente Northern California Institutional Review Board (#1634347). A STROBE checklist is presented in the Supplemental Methods.

Setting

Kaiser Permanente Northern California is an integrated healthcare delivery system that cares for 30% of the population in northern California. Under a mutual exclusivity agreement, 9,500 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 2/1/2020 who had a positive SARS-CoV-2 polymerase chain reaction test ordered between 2/1/2020-1/31/2021. Prior to 3/13/2020, 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 characteristics and outcomes of the first positive test. The study end date was chosen because it was prior to widespread dissemination of vaccinations for SARS-CoV-2. We excluded patients who were not eligible for CHCT service, such as those who had first positive test during or after a COVID-19-related emergency department visit or hospitalization. We also excluded patients who were hospitalized 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 neighborhood deprivation index, a composite index ranging from –5 to 5 with more positive values reflecting lower socioeconomic status.[14] We also captured 2 composite indices that are assigned to adults in the KPNC system: a longitudinal comorbidity score (COmorbidity Point Score, version 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 score, which is based on 14 laboratory tests obtained in the preceding month; higher scores are associated with increased physiologic derangement.[13, 16] These variables are more fully described in published studies.[15, 17-19]

Exposure

Prior to the pandemic, KPNC had several existing population health programs for non-pregnant adults with chronic conditions (e.g., diabetes,[20-22] cancer screening,[23, 24] cardiovascular disease[25]). In addition, a variety of follow-up processes existed to support primary care providers, such as combinations of in-person and automated outreach for management of hypertensive patients.[26, 27] At the start of the pandemic, KPNC leadership utilized this population health management infrastructure to develop a novel outpatient population health program, CHCT, with the goal of increasing frontline primary care provider support by re-purposing 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 (e.g., routine cervical cancer screening, colonoscopies), and routine specialty follow-up appointments were deprioritized. 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 COVID-19 patients using standardized 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 individualized 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 Kaiser Permanente Northern California's 20+ years of doing population care. The framework for the program 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. Program 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, customize 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 program 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 prioritized 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 aged >60, uncontrolled diabetes, cardiac or emergency department within 30 days. Patients with no high risk features were offered an e-visit first. Based on standardized protocols developed by front line physicians, patients were escalated to video visits, in-person outpatient visits or acute care (emergency department). During COVID-19 surges, 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 were attempted to be reached at least once were included in the intervention group. Additional information about the program is available in the Supplemental Methods.

Outcome

The primary outcome was COVID-19-related acute care utilization. We examined 1) COVID-19-related emergency department visit or 2) COVID-19-related hospitalization within 2 weeks of positive test. Attribution of hospitalizations to COVID-19 was based on *International Classification of Diseases, Version 10* codes, timing of test orders and non-elective status using a previously published algorithm.[19],[28] 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 standard deviation or median with interquartile range for continuous variables. We report number with percent for categorical variables. We compare univariate values with T tests, Wilcoxon rank sum tests or Chi Squared tests, as appropriate.

For each outcome, we estimated the average treatment effect of the CHCT program, comparing patients who were enrolled in CHCT to those who were not using an augmented inverse probability weighting (AIPW)[29] estimator. In AIPW, models are developed for the propensity of treatment and outcome probability as a function of covariates, utilizing 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[30] that employs the ensemble machine learning approach Super Learner (random forest, XGBoost, Generalized 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, neighborhood 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.[31] Month of the pandemic was included because outcomes of patients have improved over time.[6, 11, 32] We reported the standardized 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% confidence interval, which is the average treatment effect.[30] 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 hospitalization, 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 to 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 (10/15/20-1/31/21). 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 first ambulatory encounter was 1 day (IQR 1,4) for patients followed by CHCT and 3 days (1,7) for patients not followed by CHCT. The median time between positive test until presentation to acute care (emergency department) was 4 days (IQR 2,7) 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 hospitalizations 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 hospitalizations

(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 standardized differences in characteristics between patients followed by CHCT and not followed by CHCT. After inverse probability weighting, there were no significant differences in standardized differences of characteristics, as expected. After AIPW, there appeared to be a protective effect from the program. There were higher rates of COVID-19-related emergency department visits (estimated intervention effect -0.8%, 95% CI -1.4%, -0.3%) and hospitalizations (-0.5%, 95% CI -0.9%, -0.1%, **Table 3**) and lower inpatient mortality or 30-day hospice referral (-0.5%, 95% CI -0.7%, -0.3%).

The volume of COVID-19-related outpatient visits increased dramatically during the 3 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, 23% both), and patients not followed by CHCT had the following encounter types (70% telephone only, 16% video only, 12% both). In the 30 days after a positive test, patients followed by CHCT had encounters with the following clinicians (58% MD only, 10% RN only, 32% both), and patients not followed by CHCT had encounters with the following clinicians (96% MD only, 1% RN only, 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 program 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 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 3 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 program. 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 program is scalable and generalizable, as the program 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=8,623–17,294) 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, 33-35] Programs 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 programs, such as CHCT, that can impact outcomes for a population of patients. Patients with early COVID-19 had tremendous need for both outpatient and inpatient care. One analysis reported patients required 5.6-9 visits in the 30 days after the diagnosis depending on whether they ultimately were hospitalized.[36] 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 capacity at certain points during the pandemic. Additionally, the majority of CHCT encounters were via telephone, which required fewer resources than video or in-person 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 programs like CHCT have been implemented and described in the literature. The direction of our results (favoring program benefit) is consistent with the other 3 programs described herein, but the details of the program and outcomes measured differed. First, the Cleveland Clinic Home Monitoring Program included telephone outreach to 3,975 patients after a positive SARS-CoV-2 test to assess patients' symptoms and escalate their care.[37] They performed a matched propensity score analysis and found lower odds of 30-day and 90-day outpatient visits and hospitalization, but not emergency department visits. In our study, which evaluated a program implemented at scale, we report more acute care hospitalization and improved clinical outcomes. Second, the University of Pennsylvania COVID Watch program was a texting intervention whereby 3,488 patients received twice daily texts to inquire about symptoms.[38] They performed a propensity score analysis and found a 64% relative reduction in death for enrolled patients. They found patients were reporting to the emergency department sooner and had more frequent telemedicine encounters. Our program was implemented on a larger scale but found similar reduction in inpatient mortality. Third, the Home Monitoring Program at Providence health system delivered pulse oximeters and thermometers to the home and administered surveys in English/Spanish to monitor symptoms over time.[39] The authors performed propensity scores with inverse probability of treatment weighting. Of 4,358 participants, the program was associated with more outpatient and emergency department encounters and resulted in high enrollee satisfaction. This study did not report hospitalization rates or rates of clinical outcomes, such as death.[39]

There are several limitations to the current analysis. We did not measure physician or patient satisfaction/experience related to the program. We also did not measure provider burnout created or alleviated by the program. In an effort to reach as many people as possible, the intervention was not randomized but we used the natural control group formed when program 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 disfavored the program, we found higher rates of acute care utilization even after adjusting for confounding and lower inpatient mortality or 30-day hospice referral. Additionally, we examined patients who had had at least 1 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, i.e., they were not hospitalized 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 hospitalized for COVID-19 and may be less likely to engage with the program.[40, 41] 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,[34] and capitalized on the natural control group that occurred when program demand exceeded bandwidth.

In conclusion, we evaluated the KPNC CHCT program, 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 higher likelihood of presenting to acute care but lower likelihood of inpatient mortality. We found the program was successful in offloading outpatient clinical care onto repurposed providers during the early part of the pandemic. This type of program is scalable for future waves of the COVID-19 pandemic or future pandemics.

FIGURE LEGEND

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

Figure 1: Offloading of outpatient COVID-19 related visits to CHCT providers

ACKNOWLEDGMENTS

We wish to thank the Kaiser Permanente Division of Research Strategic Programming Group for formatting the dataset and The Permanente Medical Group Consulting Services for consulting on data extraction and analysis.

AUTHOR CONTRIBUTIONS

LCM is the corresponding author and guarantor for the study. LCM, BLL, GJE, YFC, RD, CL, and VXL conceptualized the project. LCM, GJE, VXL, BLL, CL, YFC contributed to the data curation, formal analysis, and methodology. KAD provided administrative support and contributed to generating tables and figure. LCM wrote the first draft of the manuscript, with subsequent editing done by listed co-authors; following this, LCM and KAD prepared the final version which is submitted here.

DATA SHARING STATEMENT

DATASETS NOT PUBLICLY AVAILABLE

The datasets generated and/or analyzed during the current study are not publicly available due to their being the property of Kaiser Foundation Health Plan, Inc., but are available to interested collaborators in the context of a formal collaboration approved by the Kaiser Permanente Northern California Institutional Review Board for the Protection of Human Subjects.

ETHICAL APPROVAL STATEMENT

The work was approved, and informed consent was waived by the Kaiser Permanente Northern California Institutional Review Board (#1634347).

REFERENCES

1. Myers, L.C. and V.X. Liu, *The COVID-19 Pandemic Strikes Again and Again and Again.* JAMA Netw Open, 2022. **5**(3): p. e221760.
2. Parodi, S.M. and V.X. Liu, *From Containment to Mitigation of COVID-19 in the US.* JAMA, 2020. **323**(15): p. 1441-1442.
3. Rouillard, S., V.X. Liu, and D.A. Corley, *COVID-19 and long-term planning for procedure-based specialties during extended mitigation and suppression strategies.* Gastroenterology, 2021. **160**(1): p. 4-9.
4. Dang, A., et al., *Hospitalizations and Mortality From Non-SARS-CoV-2 Causes Among Medicare Beneficiaries at US Hospitals During the SARS-CoV-2 Pandemic.* JAMA Netw Open, 2022. **5**(3): p. e221754.
5. Kadri, S.S., et al., *Association Between Caseload Surge and COVID-19 Survival in 558 U.S. Hospitals, March to August 2020.* Ann Intern Med, 2021. **174**(9): p. 1240-1251.
6. Asch, D.A., et al., *Variation in US Hospital Mortality Rates for Patients Admitted With COVID-19 During the First 6 Months of the Pandemic.* JAMA Intern Med, 2021. **181**(4): p. 471-478.
7. French, G., et al., *Impact of Hospital Strain on Excess Deaths During the COVID-19 Pandemic - United States, July 2020-July 2021.* MMWR Morb Mortal Wkly Rep, 2021. **70**(46): p. 1613-1616.
8. Jeganathan, N., S. Grewal, and M. Sathananthan, *Comparison of Deaths from COVID-19 and Seasonal Influenza in the USA.* Lung, 2021. **199**(5): p. 559-561.
9. Piroth, L., et al., *Comparison of the characteristics, morbidity, and mortality of COVID-19 and seasonal influenza: a nationwide, population-based retrospective cohort study.* Lancet Respir Med, 2021. **9**(3): p. 251-259.
10. Horwitz, L.I., et al., *Trends in COVID-19 Risk-Adjusted Mortality Rates.* J Hosp Med, 2020.
11. Anesi, G.L., et al., *Characteristics, outcomes, and trends of patients with COVID-19-related critical illness at a learning health system in the United States.* Ann Intern Med, 2021.
12. Myers, L.C., et al., *Characteristics of hospitalized adults with COVID-19 in an integrated health care system in California.* JAMA, 2020. **323**(21): p. 2195-2198.
13. Escobar GJ, A.A., Liu VX, Soltesz L, Chen YI, Parodi SM, Ray GT, Myers LC, Ramaprasad CM, Dlott R, Lee C., *Racial Disparities in COVID-19 Testing and Outcomes : Retrospective Cohort Study in an Integrated Health System.* Annals of Internal Medicine, 2020. **174**(6): p. 786-793.
14. Messer, L.C., et al., *The development of a standardized neighborhood deprivation index.* J Urban Health, 2006. **83**(6): p. 1041-62.
15. Escobar, G.J., et al., *Risk-adjusting hospital mortality using a comprehensive electronic record in an integrated health care delivery system.* Med Care, 2013. **51**(5): p. 446-53.
16. Escobar, G.J., et al., *Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases.* Med Care, 2008. **46**(3): p. 232-9.
17. Escobar, G., et al., *Risk Adjusting Hospital Inpatient Mortality Using Automated Inpatient, Outpatient, and Laboratory Databases.* Medical Care, 2008. **46**(3): p. 232-39.
18. Escobar, G.J., et al., *Nonelective Rehospitalizations and Postdischarge Mortality: Predictive Models Suitable for Use in Real Time.* Medical care, 2015. **53**(11): p. 916-23.
19. Escobar, G.J., et al., *Racial Disparities in COVID-19 Testing and Outcomes : Retrospective Cohort Study in an Integrated Health System.* Ann Intern Med, 2021.
20. Sadur, C.N., et al., *Diabetes management in a health maintenance organization. Efficacy of care management using cluster visits.* Diabetes Care, 1999. **22**(12): p. 2011-7.

21. Schmittdiel, J.A., et al., *The effectiveness of diabetes care management in managed care.* Am J Manag Care, 2009. **15**(5): p. 295-301.
22. Rana, J.S., et al., *Improved Cardiovascular Risk Factors Control Associated with a Large-Scale Population Management Program Among Diabetes Patients.* Am J Med, 2018. **131**(6): p. 661-668.
23. Doubeni, C.A., et al., *Association between Improved Colorectal Screening and Racial Disparities.* N Engl J Med, 2022. **386**(8): p. 796-798.
24. Mehta, S.J., et al., *Race/Ethnicity and Adoption of a Population Health Management Approach to Colorectal Cancer Screening in a Community-Based Healthcare System.* J Gen Intern Med, 2016. **31**(11): p. 1323-1330.
25. Rana, J.S., et al., *Improved Cardiovascular Risk Factors Control Associated with a Large-Scale Population Management Program Among Diabetes Patients.* The American Journal of Medicine, 2018. **131**(6): p. 661-668.
26. Jaffe, M.G., et al., *Improved blood pressure control associated with a large-scale hypertension program.* JAMA, 2013. **310**(7): p. 699-705.
27. Jaffe, M.G. and J.D. Young, *The Kaiser Permanente Northern California Story: Improving Hypertension Control From 44% to 90% in 13 Years (2000 to 2013).* Journal of clinical hypertension, 2016. **18**(4): p. 260-1.
28. Myers, L.C., et al., *Trends in Outpatient Visits and Hospital and Intensive Care Unit Admissions of Adults With COVID-19 in an Integrated US Health Care System, March 2020 to January 2022.* JAMA Netw Open, 2023. **6**(1): p. e2253269.
29. Kurz, C.F., *Augmented Inverse Probability Weighting and the Double Robustness Property.* Med Decis Making, 2022. **42**(2): p. 156-167.
30. Zhong, Y., et al., *AIPW: An R Package for Augmented Inverse Probability-Weighted Estimation of Average Causal Effects.* Am J Epidemiol, 2021. **190**(12): p. 2690-2699.
31. Ko, J.Y., et al., *Risk Factors for Coronavirus Disease 2019 (COVID-19)-Associated Hospitalization: COVID-19-Associated Hospitalization Surveillance Network and Behavioral Risk Factor Surveillance System.* Clin Infect Dis, 2021. **72**(11): p. e695-e703.
32. Horby, P., et al., *Dexamethasone in hospitalized patients with COVID-19.* N Engl J Med, 2021. **384**(8): p. 693-704.
33. Anesi, G.L., et al., *Association of a Novel Index of Hospital Capacity Strain with Admission to Intensive Care Units.* Ann Am Thorac Soc, 2020. **17**(11): p. 1440-1447.
34. Anesi, G.L., et al., *Characteristics, Outcomes, and Trends of Patients With COVID-19-Related Critical Illness at a Learning Health System in the United States.* Ann Intern Med, 2021. **174**(5): p. 613-621.
35. Anesi, G.L., et al., *Associations of intensive care unit capacity strain with disposition and outcomes of patients with sepsis presenting to the emergency department.* Ann Am Thorac Soc, 2018. **15**(11): p. 1328-1335.
36. Huang, B.Z., et al., *Healthcare Utilization Among Patients Diagnosed with COVID-19 in a Large Integrated Health System.* J Gen Intern Med, 2022. **37**(4): p. 830-837.
37. Misra-Hebert, A.D., et al., *COVID-19 Home Monitoring After Diagnosis and Health Care Utilization in an Integrated Health System.* JAMA Health Forum, 2021. **2**(5): p. e210333-e210333.
38. Delgado, M.K., et al., *Comparative Effectiveness of an Automated Text Messaging Service for Monitoring COVID-19 at Home.* Ann Intern Med, 2022. **175**(2): p. 179-190.
39. Vartanian, K.B., et al., *Patient experience and healthcare utilization for a COVID-19 telemedicine home monitoring program offered in English and Spanish.* PLoS One, 2022. **17**(6): p. e0270754.
40. Kipnis P, et al., *Evaluation of Vaccination Strategies to Compare Efficient and Equitable Vaccine Allocation by Race and Ethnicity Across Time.* JAMA Health Forum, 2021(2(8)): p. e212095.

41. Myers, L.C., et al., *Adults hospitalized with breakthrough COVID-19 have lower mortality than matched unvaccinated adults.* J Intern Med, 2022.

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

	All patients n=98,585	Patients followed by CHCT n=80,067	Patients not followed by CHCT 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%)	9,131 (49.3%)	<0.001
Race, n (%)				
Asian	13,796 (14.0%)	10,890 (13.6%)	2,906 (15.7%)	<0.001
Black	5,721 (5.8%)	4,541 (5.7%)	1,180 (6.4%)	
Hispanic	43,082 (43.7%)	35,111 (43.9%)	7,971 (43.0%)	
White	27,646 (28.0%)	22,958 (28.7%)	4,688 (25.3%)	
Other/unknown race [a]	8,340 (8.5%)	6,567 (8.2%)	1,773 (9.6%)	
NDI (median, Q1-Q3) [b]	-0.07 [-0.61, 0.64]	-0.08 [-0.63, 0.64]	-0.03 [-0.53, 0.62]	<0.001
COPS2 (median, Q1-Q3) [c]	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%)	1,350 (1.7%)	205 (1.1%)	<0.001
Comorbidities				
Diabetes, n (%)	10,176 (10.3%)	9,122 (11.4%)	1,054 (5.7%)	<0.001
Obesity, n (%)	6,988 (7.1%)	6,105 (7.6%)	883 (4.8%)	<0.001
Hypertension, n (%)	12,505 (12.7%)	10,948 (13.7%)	1,557 (8.4%)	<0.001
Chronic pulmonary disease, n (%)	7,119 (7.2%)	6,142 (7.7%)	977 (5.3%)	<0.001
Congestive heart failure, n (%)	764 (0.8%)	665 (0.8%)	99 (0.5%)	<0.001
Cancer, n (%)	1,363 (1.4%)	1,173 (1.5%)	190 (1.0%)	<0.001
abLAPS (median, Q1-Q3) [d]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	<0.001
abLAPS ≥ 4, n (%)	3,219 (3.3%)	2,753 (3.4%)	466 (2.5%)	<0.001
Wave, n (%)				<0.001
1 (2/1/20-5/31/20)	2,476 (2.5%)	1,978 (2.5%)	498 (2.7%)	<0.001
2 (6/1/20-10/14/20)	26,959 (27.3%)	21,580 (27.0%)	5,379 (29.1%)	
3 (10/15/20-1/31/21)	69,150 (70.1%)	56,509 (70.6%)	12,641 (68.3%)	
COVID-19-related emergency department visit, n (%)	9,165 (9.3%)	7,587 (9.5%)	1,578 (8.5%)	<0.001
COVID-19-related hospitalization, n (%)	3,703 (3.8%)	3,116 (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

Abbreviations: CHCT=Coronavirus disease 19 Home Care Team

FOOTNOTE

a Other race includes: American Indian, Alaska Native, Asian Pacific, Native Hawaiian, Pacific Islander, multiracial.

b Neighborhood deprivation index ranges between -5 to +5 with more positive values indicating lower status. See text of Messer et al. (2006) for additional detail.

c The COmorbidity Point Score, version 2 (COPS2) described in Escobar et al. (2013) 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%; 65+, 17.2%.

d 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. (2008). Range is from 0 to 256; higher scores indicate increasing physiologic 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%; 10+, 1.32%.

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

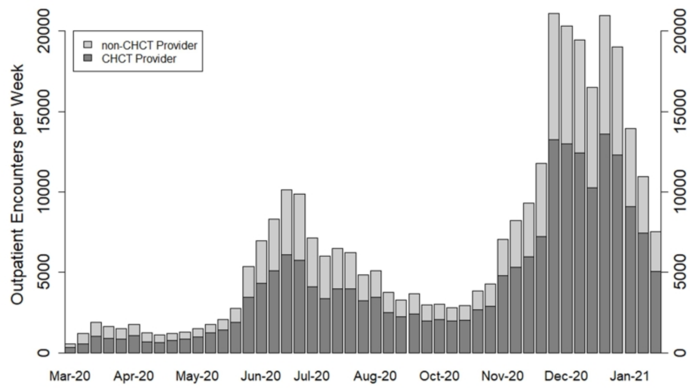
	Before Weighting			After Weighting		
	Patients followed by CHCT n=80,067	Patients not followed by CHCT n=18,518	Standardized Difference	Patients followed by CHCT	Patients not followed by CHCT	Standardized Difference, %
Age, median (IQR)	43 [31, 55]	40 [30, 52]	0.15	42 [31, 55]	42 [31, 55]	0.01
Sex, male (%)	36,052 (45.0%)	9,131 (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 (%)	6,105 (7.6%)	883 (4.8%)	0.13	6991.7 (7.1)	6,693.1 (7.3)	-0.01
Diabetes, n (%)	9,122 (11.4%)	1,054 (5.7%)	0.25	10,172.2 (10.4)	9,822.9 (10.7)	-0.01
Hypertension, n (%)	10,948 (13.7%)	1,557 (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	1,061.3 (1.1)	1,011.3 (1.1)	0.00
June 2020, n (%)	3,687 (5%)	827 (4%)	0.01	4,538.3 (4.6)	4,310.7 (4.7)	0.00
July 2020, n (%)	8,316 (10%)	2,277 (12%)	-0.06	10,575.5 (10.8)	10,142.7 (11.0)	-0.01
August 2020, n (%)	5,087 (6%)	1,290 (7%)	-0.02	6,348.4 (6.5)	5,979.4 (6.5)	0.00
September 2020, n (%)	3,118 (4%)	703 (4%)	0.01	3,803.9 (3.9)	3,628.0 (3.9)	0.00
October 2020, n (%)	3,611 (5%)	676 (4%)	0.05	4,293.8 (4.4)	4,243.5 (4.6)	-0.01
November 2020, n (%)	10,888 (14%)	2,416 (13%)	0.02	13,227.8 (13.5)	12,639.9 (13.8)	-0.01
December 2020, n (%)	26,592 (33%)	6,059 (33%)	0.01	32,458.2 (33.1)	29,917.7 (32.6)	0.01
January 2021, n (%)	16,790 (21%)	3,772 (20%)	0.01	20,416.6 (20.8)	18,567.2 (20.2)	0.01

Abbreviations: NDI=neighborhood deprivation index, COPS2=Comorbidity Point Score, Version 2, abLAPS=Abbreviated Laboratory-based Acute Physiology Score

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

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

The intervention effect being negative indicates a protective effect of the intervention.



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

338x190mm (300 x 300 DPI)

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

Myers et al

Supplemental Methods

This study was approved by KPNC Institutional Review Board (Protocol #1045), who allowed a waiver of informed consent. See STROBE checklist below for details. Outpatient encounters could be telephone, video or in-person clinic visits. We describe patients' clinical characteristics, including self-identified race, which we extracted electronically from the electronic health record. "Other" race included: American Indian, Alaska Native, Asian Pacific, Native Hawaiian, Pacific Islander, multiracial.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	**Item #**	**Recommendation**	**Reported on page #**
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7, 8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7, 8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8, 9, 10
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of	7, 8

		assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	17
		(*b*) Describe any methods used to examine subgroups and interactions	12
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	13
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA

Outcome data	15	Report numbers of outcome events or summary measures over time	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	15
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1