

UC Berkeley

UC Berkeley Electronic Theses and Dissertations

Title

Health System Efforts to Address Health Related Social Needs: Implications for Public Health, Health Services Use, and Quality Outcomes

Permalink

<https://escholarship.org/uc/item/6c16z61d>

Author

Knox, Margae Joy

Publication Date

2023

Peer reviewed|Thesis/dissertation

Health System Efforts to Address Health Related Social Needs:
Implications for Public Health, Health Services Use, and Quality Outcomes

by

Margae Joy Knox

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Health Policy

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Amanda L. Brewster, Chair

Professor Hector P. Rodriguez

Professor Jennifer Ahern

Professor Stephen M. Shortell

Summer 2023

© Copyright 2023
Margae Joy Knox
All rights reserved

Abstract

Health System Efforts to Address Health Related Social Needs: Implications for Public Health, Health Services Use, and Quality Outcomes

by

Margae Joy Knox

Doctor of Philosophy in Health Policy

University of California, Berkeley

Professor Amanda L. Brewster, Chair

Health systems face increasing pressure to improve population health by addressing health related social needs such as adequate housing, transportation, or food insecurity. Current evidence around these initiatives is still nascent. One common intervention to address health related social needs is case management. There is need to better understand the holistic impacts of case management, the role of specific case management program components, and the effects of social needs interventions implemented as distinct activities. The three papers that comprise this dissertation examine social needs interventions from different angles. The first paper uses a rigorously designed, large-scale health and social needs case management program to identify whether case management services improved vaccination rates in the wake of the Covid-19 pandemic. The second paper builds on the same case management program to understand whether housing deposits, a unique program benefit, impacted health services use. The third paper analyzes whether hospital activities to address social needs are associated with better quality of care. Collectively, these papers suggest that health system efforts to address social needs hold promise yet may require continued tailoring for specific patient populations and local communities.

Dedication

For my family and especially my son, Nolan,
who has brought new life and much joy.

Table of Contents

Abstract.....	1
Dedication.....	i
Table of Contents.....	ii
List of Figures.....	iii
List of Tables.....	iv
Acknowledgments.....	v
1 Introduction.....	1
2 Greater Covid-19 Vaccine Uptake Among Enrollees Offered Health and Social Needs Case Management: Results from a Randomized Trial.....	4
2.1 Introduction.....	5
2.2 Methods.....	6
2.3 Results.....	10
2.4 Discussion.....	12
2.5 Conclusion.....	14
2.6 Tables.....	15
3 Rental Housing Move-In Deposits and Healthcare Use: Evidence from a Medicaid 1115 Waiver Pilot in Contra Costa, California.....	21
3.1 Introduction.....	22
3.2 Methods.....	23
3.3 Results.....	28
3.4 Discussion.....	29
3.5 Conclusion.....	31
3.6 Tables.....	32
4 Hospital Efforts to Address Health Related Social Needs: Associations with Potentially Preventable Hospitalizations.....	36
4.1 Introduction.....	37
4.2 Methods.....	38
4.3 Results.....	40
4.4 Discussion.....	42
4.5 Conclusion.....	44
4.6 Tables.....	45
5 Conclusion.....	63
6 References.....	65

List of Figures

Figure 1. Conceptual model of dissertation aims.....	3
Figure 2. CONSORT diagram of participants included in vaccination analysis	10
Figure 3. Vaccination hazard ratios: Intervention vs. control group, stratified by demographic subgroup	12
Figure 4. Participant matching and exclusions for housing deposit analysis	24
Figure 5. Pre/Post healthcare use trends for housing deposit recipients vs. a matched comparison group	27
Figure 6. Map of states included in the study sample.....	38
Figure 7. Prevalence of hospital efforts to address health related social needs (N = 813 hospitals).....	41
Figure 8. Marginal effects on potentially preventable hospitalization for each health related social need activity	42

List of Tables

Table 1. Comparison of intervention and control group demographics for Covid-19 vaccination analysis.....	15
Table 2. Increased vaccination found among case management intervention patients in Covid-19 vaccination analysis.....	17
Table 3. Adjusted hazard ratios for all covariates in main and interacted vaccination models.....	18
Table 4. Housing deposit group and comparison group characteristics, before and after matching	32
Table 5. Difference-in-differences in 6-month healthcare utilization between deposit and matched comparison groups	34
Table 6. Difference-in-differences in 12-month healthcare utilization between deposit and matched comparison groups	35
Table 7. Characteristics of hospitals in study sample	45
Table 8. Characteristics of patients in study sample, by potentially preventable admission status	46
Table 9. Balance in patient characteristics for each health related social need activity, before and after weighting.....	48
Table 10. Marginal effect for each activity to address health related social needs (percentage point change in probability of potentially preventable admission when activity is present).....	53
Table 11. Associations between potentially preventable hospitalizations and each hospital-based activity to address health related social needs (with odds ratios for all covariates modeled).....	54
Table 12. Mean number of activities to address health related social needs when each activity is present.....	62

Acknowledgments

My deep appreciation goes to my dissertation chair and advisor, Professor Amanda Brewster, who has been an incredible mentor throughout my time in the PhD program. I am grateful for her confidence in me, support for my growth, and leadership by example. I also greatly appreciate my dissertation committee members Professor Hector Rodriguez and Professor Stephen Shortell, who planted and watered the seeds for this work before I knew what a career in public health might look like. Their ongoing mentorship and advocacy have been instrumental to where I am today. Thank you also to my dissertation committee member Professor Jennifer Ahern for her graciousness, sharp methodological guidance, and fresh perspective which has greatly improved these dissertation papers. In addition, I am grateful to Professor Mark Fleming, who has been a wonderful collaborator and someone I have enjoyed learning from over the past four years.

Next, a huge thank you to collaborators at Contra Costa Health, especially Elizabeth Hernandez and Daniel Brown. Their support facilitating data access, their sense for policy-relevant and timely questions, and their ongoing commitment have made the first two dissertation papers not only possible but very rewarding. Relatedly, many thanks to the Contra Costa Health leadership, evaluation team members, and the case managers and patients who are represented in these dissertation papers.

I would also like to thank my classmates; it was a privilege to work alongside one another throughout our coursework and degree progress. Extra appreciation goes to Crystal Guo and Christine Lo, collaborators on Contra Costa Health data projects, and Emily Hauge and Xander Adia, co-authors of the third dissertation paper.

I am also grateful to the Center for Healthcare Organizational and Innovation Research (CHOIR), particularly administrative director Salma Bibi and data analyst Karl Rubio. Thank you also to Right Care Initiative Director Hattie Hanley who recognized potential and encouraged me to pursue this degree before the thought had crossed my mind. I am also grateful to colleagues at the UCSF Center for Excellence in Primary Care and the UCSF Social Interventions Research and Evaluation (SIREN) group.

In addition, thank you to my family for their constant love and encouragement. I especially appreciate my parents John and Jean Knox, brothers Josh Knox and J.T. Knox, sister-in-law Luana Knox, my parents-in-law Godfrey and Jillian Saldanha, brother-in-law Sandeep Saldanha, my grandma Jean Bennett, and my special aunts and uncles.

Finally, a heartfelt thank you to my husband, Suneet Saldanha, for his enduring support. He is the best crew member I could ask for. When I first shared plans to return to school, he expressed no reservations. Since then, we have weathered a global pandemic, said “I do,” and welcomed a baby boy. With patience and generosity, he has picked up pieces that fell of my plate and made it possible to finish this dissertation. Each day together is a gift. I look forward to the days to come.

1 Introduction

Health Systems and Health Related Social Needs

Health systems face increasing pressure to address health related social needs such as adequate housing, transportation barriers, and food insecurity—domains that extend beyond the scope of traditional medical care. Scientists have been aware of the deep connections between social factors and health since the early 19th century.¹ Now, newer evidence confirms that unmet social needs are associated with worse health outcomes including hospital readmissions,² emergency department visits,³ diabetes complications,⁴ depression,⁵ and alcohol or drug abuse.⁵ Consequently, health systems are beginning to systematically build new capabilities to identify and support social needs.

New federal and state policies have accelerated the implementation of activities to address health related social needs. Policies recognize the substantial burdens from health related social needs, particularly among Medicaid and underserved populations, and aim to support more equitable, improved patient outcomes.⁶ One influential policy mechanism is the Centers for Medicare and Medicaid Services' Section 1115 demonstration waiver, which allows states to incorporate new services into Medicaid benefit designs to address social needs.^{7,8} Waivers that include new, Medicaid funded services to address social needs have been adopted in 19 states and are pending in an additional 12 states.⁹ Further, new quality measures to assess social needs screening and assistance are also on the horizon.^{10,11}

Organizational Motivations to Address Health Related Social Needs

Organizational theories posit several rationales for healthcare organizations to implement new activities to address health related social needs. According to *institutional theory*,¹² organizations are influenced by 1) regulatory forces like new policies from the Centers for Medicare and Medicaid Services;¹³ 2) normative forces like endorsement of social needs activities by the American Medical Association and others;^{14,15} and 3) mimetic forces or the imitation of strategies from successfully-perceived peer organizations like Intermountain or UnitedHealthcare.¹⁶

In contrast, *resource dependence theory* states that organizations are motivated to control access to the resources in their environment.¹⁷ Under recent shifts toward value-based payments that reward better management of population health, organizations may embrace activities such as supporting access to nutritious food and addressing other social factors in addition to traditional medical activities like adjusting hypertension medication. As organization build new capabilities, they must choose whether to do so in-house or through contracts. *Transaction cost economics* indicates that organizations will add in-house capabilities in response to increased activity frequency, desire for greater certainty over inputs and processes, and ability to flexibly repurpose resources.¹⁸ Recent research supports the idea that healthcare organizations simultaneously hold various motivations to build capabilities to address health related social needs including beneficence, a sense of obligation, and as a survival tactic.¹⁹

Existing Evidence Gaps and Dissertation Structure

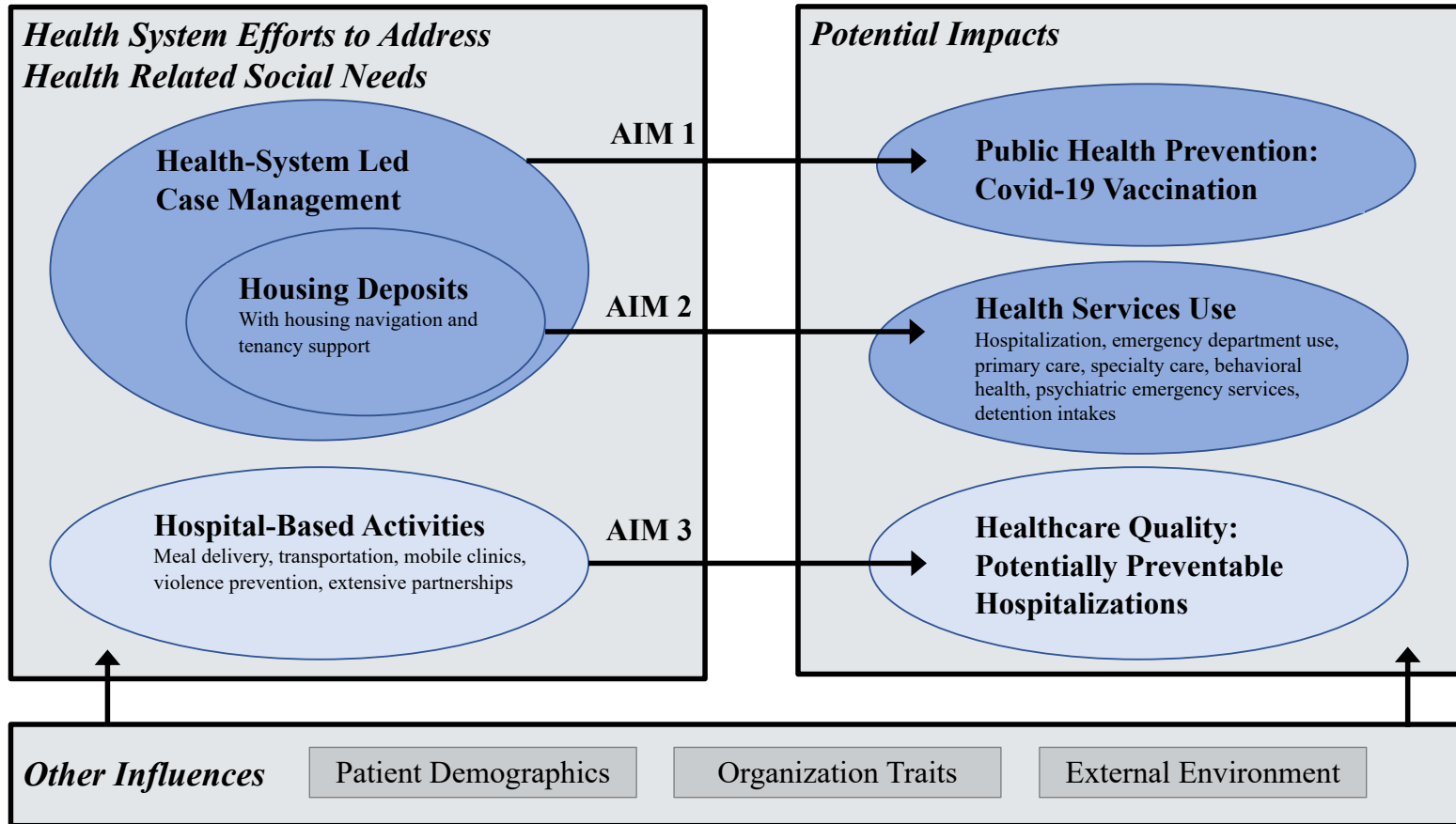
Despite strong momentum for health systems to address social needs, current evidence from health-related social needs interventions is still nascent.^{20,21} Systematic reviews thus far have reported mixed health, utilization, and cost outcomes and find limited use of high-quality study designs.²²⁻²⁴ A further complication is that interventions to address health and social needs are complex, involving multiple interacting components, such that results may vary in different settings or under different implementation fidelity.²⁵ There remains a need for rigorous evidence on both the complex social needs interventions as a whole and the intervention components that achieve better health and healthcare outcomes.

This dissertation is structured as three papers, each examining a different aspect of social needs interventions (Figure 1). *The first paper* (aim 1) builds on research examining a large-scale health and social needs case management program.²⁶ While multiple studies have investigated the impact of case management for health and social needs on hospitalization and emergency department,^{27,28} few have considered whether these services have spillover public health benefits. In the wake of the Covid-19 pandemic, this paper examines Covid-19 vaccination among those offered case management compared to a randomized control group.

The second paper (aim 2) builds on the same case management program to understand changes in health services use among case management participants who received housing deposits with tenancy support relative to a matched comparison group that received case management only. Many studies have linked housing stability to better health and lower healthcare utilization,^{29,30} but few have rigorously evaluated health system-based efforts to address housing. Findings from this paper provide policy-relevant evidence as an increasing number of states considers whether to offer housing deposits as a new benefit for certain Medicaid beneficiaries.

The third paper (aim 3) draws on a sample of over 6 million patients from more than 800 hospitals in 14 states, offering a unique lens on whether hospital-based activities to address social needs—specifically, meal delivery, transportation to health services, mobile clinics, violence prevention programs, and extensive partnership for population health—are associated with higher quality of care. Collectively, these papers suggest that health system efforts to address social needs hold promise yet likely require continued tailoring for local patient populations and local communities.

Figure 1. Conceptual model of dissertation aims



2 Greater Covid-19 Vaccine Uptake Among Enrollees Offered Health and Social Needs Case Management: Results from a Randomized Trial

Objective. To investigate Covid-19 vaccination as a potential secondary public health benefit of case management for Medicaid beneficiaries with health and social needs.

Data Sources and Study Setting. The CommunityConnect case management program for Medicaid beneficiaries is run by Contra Costa Health, a county safety net health system in California. Program enrollment data were merged with comprehensive County vaccination records.

Study Design. Individuals with elevated risk of hospital and emergency department use were randomized each month to a case management intervention or usual care. Interdisciplinary case managers offered coaching, community referrals, healthcare connections, and other support based on enrollee interest and need. Using survival analysis with intent-to-treat assignment, this study assessed rates of first-dose Covid-19 vaccination from December 2020 - September 2021. In exploratory sub-analyses we also examined effect heterogeneity by gender, race/ethnicity, age, and primary language.

Data Collection and Extraction Methods. Data were extracted from County and program records as of September 2021, totaling 12,866 intervention and 25,761 control enrollments.

Principal Findings. Approximately 58% of enrollees were female and 41% were under age 35. Enrollees were 23% White, 12% Asian/Pacific Islander, 20% Black/African American, and 36% Hispanic/Latino, and 10% other/unknown. 35% of the intervention group engaged with their case manager. 56% of all intervention and control enrollments were vaccinated at 9 months. Intervention enrollees had a higher vaccination rate compared to control enrollees (adjusted hazard ratio (aHR): 1.06; 95% confidence interval (CI): 1.02-1.10). In sub-analyses, the intervention was associated with stronger likelihood of vaccination among males and individuals under age 35.

Conclusions. Case management infrastructure modestly improved Covid-19 vaccine uptake in a population of Medicaid beneficiaries that over-represents social groups with barriers to early Covid-19 vaccination. Amidst mixed evidence on vaccination-specific incentives, leveraging trusted case managers and existing case management programs may be a valuable prevention strategy.

2.1 Introduction

Health systems are increasingly deploying new case management programs to address health and social risks among patients with complex care needs.^{24,31} While it is well established that social risks are associated with worse health and greater healthcare needs,³²⁻³⁴ the effectiveness of social risk interventions is less clear.³⁵ Early studies have investigated impacts on hospitalizations, emergency department visits, and cost of care.^{26,28} Potential spillover effects to public health measures and other prevention indicators are understudied.

During the Covid-19 pandemic, public health entities enacted unprecedented measures to curb virus spread. Existing health and social needs interventions may have provided valuable scaffolding for Covid-19 prevention efforts. Case managers were often on the front lines of educating patients,³⁶ and may have served as a pre-existing trusted source of information.³⁷ In particular, case managers may have helped clarify vaccine eligibility, availability, and why vaccination is important amidst changing information and common misinformation.³⁸

As in prior pandemics, minoritized and lower income communities experienced greater challenges meeting basic needs,³⁹ more Covid-19 hospitalizations,^{40,41} and less access to prevention^{42,43} including less vaccination uptake.^{44,45} Covid-19 outcomes are a reminder that longstanding structural vulnerabilities like economic opportunities, neighborhood environments, and racism continue to underlie health and healthcare inequities.^{46,47} It is possible that interventions to support health and social needs may have helped improve outcomes for groups that have been historically marginalized. For example, case management programs may have provided tailored, responsive, and culturally sensitive support to mitigate health inequities.

Accordingly, this study was designed to examine the CommunityConnect case management program in Contra Costa County, California. CommunityConnect is an established, large-scale program that supports adult Medicaid beneficiaries with complex health and social conditions.²⁶ Enrollees over-represent populations at greater risk of Covid-19 and who face greater obstacles to obtain vaccination. In prior analyses, beneficiaries offered the CommunityConnect case management program experienced significantly fewer hospitalizations within 12 months compared to the control group.²⁶

The analysis used comprehensive County vaccination records merged with CommunityConnect enrollment records to examine whether the program influenced Covid-19 vaccination uptake. Data span March 2020 to September 2021, encompassing the Covid-19 pandemic onset through the “Delta variant” wave. The main hypothesis was that case managers may have helped enrollees seek and obtain Covid-19 vaccination. A secondary hypothesis was that program enrollment may have stronger impacts among groups that have been historically marginalized including racially/ethnically minoritized groups and those with a primary language other than English.

2.2 Methods

Study Design

Case management enrollment records were matched to comprehensive vaccinations data from the Contra Costa County Public Health Department. Vaccination data included any vaccination that occurred in California for a Contra Costa County resident, including vaccinations administered through state vaccination sites, retail pharmacies, and other providers. Records contained the vaccination date and a designation for first dose or second dose.

This analysis leveraged CommunityConnect's randomized, Zelen-design clinical trial.⁴⁸ The Zelen design is a randomized controlled trial in which participants are enrolled based on existing records rather than via active recruitment. Individuals were randomly selected for the intervention or control arm if they were in the top 15% of predicted risk for avoidable hospital and emergency department visits. Predicted risk was calculated each month using a model that incorporated 91 variables including demographics, utilization history, clinical diagnoses, behavioral indicators, and social risk indicators, resulting in a population with heterogeneous health and social circumstances. Control patients remained eligible for random selection into the intervention in subsequent months if their predicted risk continued to be in the top 15%.

All intervention and control patients were observed for 12 months after their enrollment start except when control patients were selected into the intervention, ending follow-up as controls. The cross-over design allowed each eligible individual an equal opportunity to receive services. It also produced an informative censoring process where higher risk controls were more likely to be selected and have their follow-up terminated. Therefore, we applied inverse probability of censoring weights to account for cases of cross over from control to intervention.^{49,50} Additional details about the original trial design are described in Brown et al, 2022.²⁶

Study procedures were approved by the Contra Costa Regional Medical Center and Health Centers Institutional Review Committee. The trial design was registered as ClinicalTrials.gov number NCT04000074, however because trial registration occurred prior to the pandemic it did not anticipate analyzing Covid-19 outcomes. The study design, results and discussion are reported following guidance from the CONSORT statement and its extension for reporting of pragmatic trials.⁵¹

Setting

Contra Costa Health Services is an integrated county safety net health system in California's San Francisco Bay Area. The system encompasses the county public health department, the county hospital, a network of primary care clinics, and the Medicaid managed care plan that insures 87% of Medicaid beneficiaries. In 2016, Contra Costa Health Services initiated CommunityConnect, a major (\$200 million) investment through Medicaid's 1115 waiver pilot program. Medicaid 1115 waivers allow states to test state-specific policies to improve their Medicaid programs. Example pilot programs include

healthcare payments for new services like housing subsidies and transportation.⁸ In Contra Costa, the pilot program established new data infrastructure and case management services that deepened the county's alignment of public health, healthcare, and social services.

Participants and Eligibility

Eligibility for the CommunityConnect trial included: adults 18 years or older residing in Contra costa County; enrollment in full-scope Medicaid; not enrolled in a duplicative case management program; not currently in detention for more than 30 days; and not in a vegetative state. For this analysis, inclusion was limited to individuals newly enrolled in the CommunityConnect trial between March 2020 when the pandemic began through April 2021 when new trial enrollments stopped. This analysis includes participants for up to 12 months, consistent with the trial design, or until the September 2021 data cut-off. Individuals enrolled before March 2020 are excluded due to program changes induced by the pandemic (e.g., all in-person visits became telephonic). The March 2020 start also facilitates overlap between an enrollee's 12-month observation window and when vaccines became available in December 2020.

Sample size was pragmatically determined based on program capacity. CommunityConnect employed about 100 case managers who collectively served around 12,500 individuals at a given time. In most months the program had capacity to accept 800-1200 new individuals to the intervention depending on the number of existing enrollees that graduated or did not engage. For each intervention assignment, approximately two individuals were assigned to the control group from the same eligibility pool. The eligibility pool consisted of those in the top 15% of predicted risk for avoidable hospital or emergency department visit and numbered up to 25,000 individuals each month.

The Contra Costa Health Services business intelligence team identified eligible individuals, ran the predictive risk model, generated random assignments, and assigned new intervention patients to case managers via the electronic health record (EHR). Demographic characteristics including race and/or ethnicity were pre-defined from the electronic health record. Participants in the control arm received usual care from the health system. Blinding was not feasible. It was not possible for participants to decline enrollment in the study because study inclusion was conducted administratively, and outcomes were obtained from administrative records.

Intervention

Individuals assigned to the intervention were paired with a case manager, who made at least three phone attempts and sent one letter to connect with enrollees. Approximately 35% of intervention enrollees responded to the case manager and identified one or more needs such as food, utilities, transportation, employment, or health to address together during the study period. All intervention enrollees were analyzed as part of the intervention group, including those who did not respond to the case manager.

Case managers represented a variety of disciplines including community health workers, nurses, social workers, and behavioral health specialists. While case managers were able to draw on their professional background to align their support with patients' needs and interests, all case managers were expected to follow similar process standards such as reaching out to assigned patients on at least a monthly basis. Case managers began their work with enrollees by screening for needs related to healthcare access, behavioral health, and social determinants of health. Many screening questions were open-ended, developed through iterative quality improvement cycles. Case managers then tailored their support based on conversations with enrollees. They provided coaching, referrals to community services, help with applying for public benefits, and assistance communicating with healthcare providers. They also linked some enrollees to CommunityConnect-managed resources such as cell phones, emergency housing funds, and legal aid. For more information about the screening tool development, final screening questions, and case manager services, see supplementary materials published with Brown et al, 2022.²⁶

In March 2020, in-person visits were curtailed following Covid-19 shelter in place orders. All visits shifted to telephone, text, and email communications. Staffing challenges also arose during the pandemic as case managers were reassigned to efforts like Covid-19 testing and contact tracing. Nonetheless, over 90% of enrollees assigned to the intervention received at least one outreach call during the pandemic and the percent of enrollees engaging with case managers remained comparable to pre-pandemic levels.

Case managers supported vaccination efforts by answering standard questions about vaccine safety or potential side effects. For clinical questions, case managers referred enrollees to a physician or the County's Covid line, a dedicated 1-800 number. Case managers encouraged enrollees to advocate for themselves to get the vaccine. They also provided up to date information on where vaccines were available and how to schedule a vaccination online or by phone. For some enrollees, particularly those with less digital literacy, case managers scheduled vaccination appointments on the enrollee's behalf.

Usual Care

Patients assigned to usual care could continue to access County health services but received no additional services. Control group patients did not receive communication from the health system about the trial as all data collection was based on administrative records. As previously described, control group patients who remained at high risk for avoidable hospitalization and utilization could be selected for the intervention in future months.

Outcomes

The primary outcome was the rate of Covid-19 vaccination between intervention and control patients based on the date of first vaccine dose. The date of second vaccine dose was also examined as a sensitivity analysis. Covid-19 booster shots were not

examined as they became available after the end of the available timeframe for vaccine data.

Statistical Analysis

The baseline demographic and health characteristics of individuals selected into the intervention and control groups were compared using standardized mean differences. Covid-19 vaccination uptake was examined using Cox proportional hazards regression estimates. First-dose vaccination uptake between the intervention and control group was calculated using a risk period beginning December 1, 2020, the earliest date vaccinations became available. For individuals enrolled after December 1, 2020, and not yet vaccinated, the risk period began at their enrollment start. The risk period ended at the earliest occasion of one of the following events: when vaccination was received, at 12 months of enrollment, upon crossover among controls selected for the intervention, or on September 30, 2021, the last month of data availability based on when data was cut for analysis. Any enrollee who received a vaccine dose before his or her enrollment period start was excluded, based on standard survival analysis methods.⁵²

Inverse probability of censoring weights were used in all models. The weights correct for the likelihood that controls with higher risk scores would be more likely to crossover to the intervention in a future month, while controls with lower risk scores would more easily fall below enrollment risk score thresholds. Overall, approximately 45% of control enrollments crossed over to the intervention group before the end of their 12-month observation window. Thus, the inverse probability of censoring weights maintain the risk balance between study arms over time by upweighting higher-risk controls who remained in the control group. Survival models used the mean of an enrollee's time-varying weights. The intent-to-treat analysis maintains intervention and control group comparability.

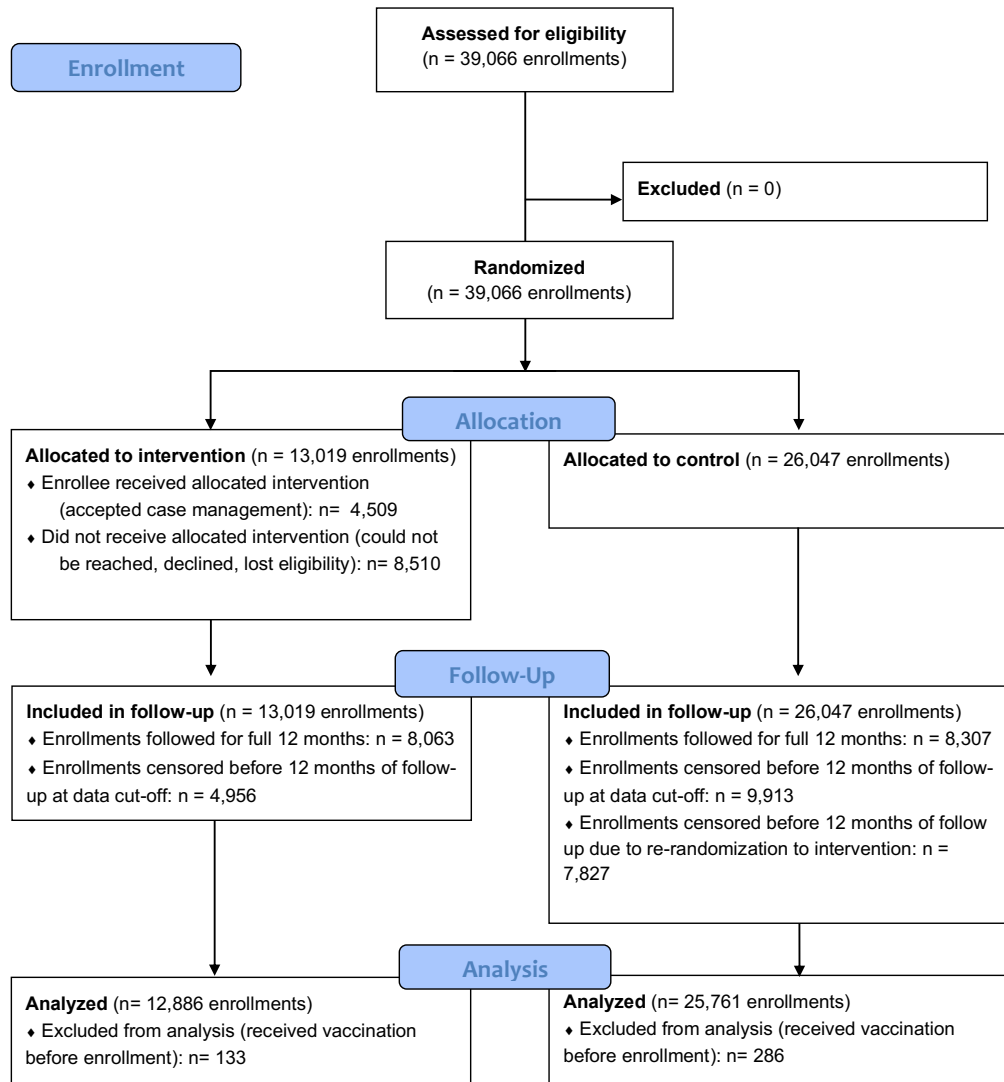
Cluster robust standard errors were used to account for patients with multiple enrollments. We present unadjusted and adjusted main analyses. Adjustments account for pre-specified demographic characteristics (gender, age, race, and primary language); health conditions (arthritis, back disorder, COPD, CHF, diabetes, anxiety, depression, and smoking status); behavioral health acuity; social conditions (employment, and homeless status); and time enrolled. These adjustments correct for possible imbalances despite randomization and potentially increase statistical power.⁵³ Exploratory sub-analyses were examined stratifying by gender, race/ethnicity, age, and language to examine whether the intervention differentially impacted key subpopulations, particularly those where case management support may have stronger influence due to lower vaccination uptake and greater structural obstacles to vaccination.^{45,54} As a sensitivity check, models were also examined with interaction effects between the same subpopulations in the stratified analysis and assignment to the intervention group. All analyses were performed using Stata version 17 BE.⁵⁵

2.3 Results

Sample Characteristics

The sample includes 12,866 out of 13,019 intervention enrollments and 25,761 out of 26,047 enrollments. 133 intervention enrollments and 286 control enrollments were excluded because they received the Covid-19 vaccination before their enrollment start (**Figure 2**). Analysis was intent-to-treat, with all enrollees assigned to the intervention analyzed in the intervention group. 35% of intervention enrollments engaged with a case manager, which was defined as case manager documentation of at least one patient goal.

Figure 2. CONSORT diagram of participants included in vaccination analysis



Enrollees were predominantly female (58% intervention vs. 59% control), under age 35 (40% intervention vs. 41% control) and represented diverse racial/ethnic backgrounds (e.g., 19% Black or African American / 37% Hispanic or Latino / 23% White in the intervention group vs. 20% Black or African American / 36% Hispanic or Latino / 23% White in the control group). Common chronic conditions include back disorder (30% intervention vs 30% control), anxiety (26% intervention vs. 25% control), and diabetes (16% intervention vs. 16% control). The absolute values of the standardized mean differences were 0.03 or less for all demographic characteristics, indicating that the intervention and control groups were well balanced (**Table 2**).

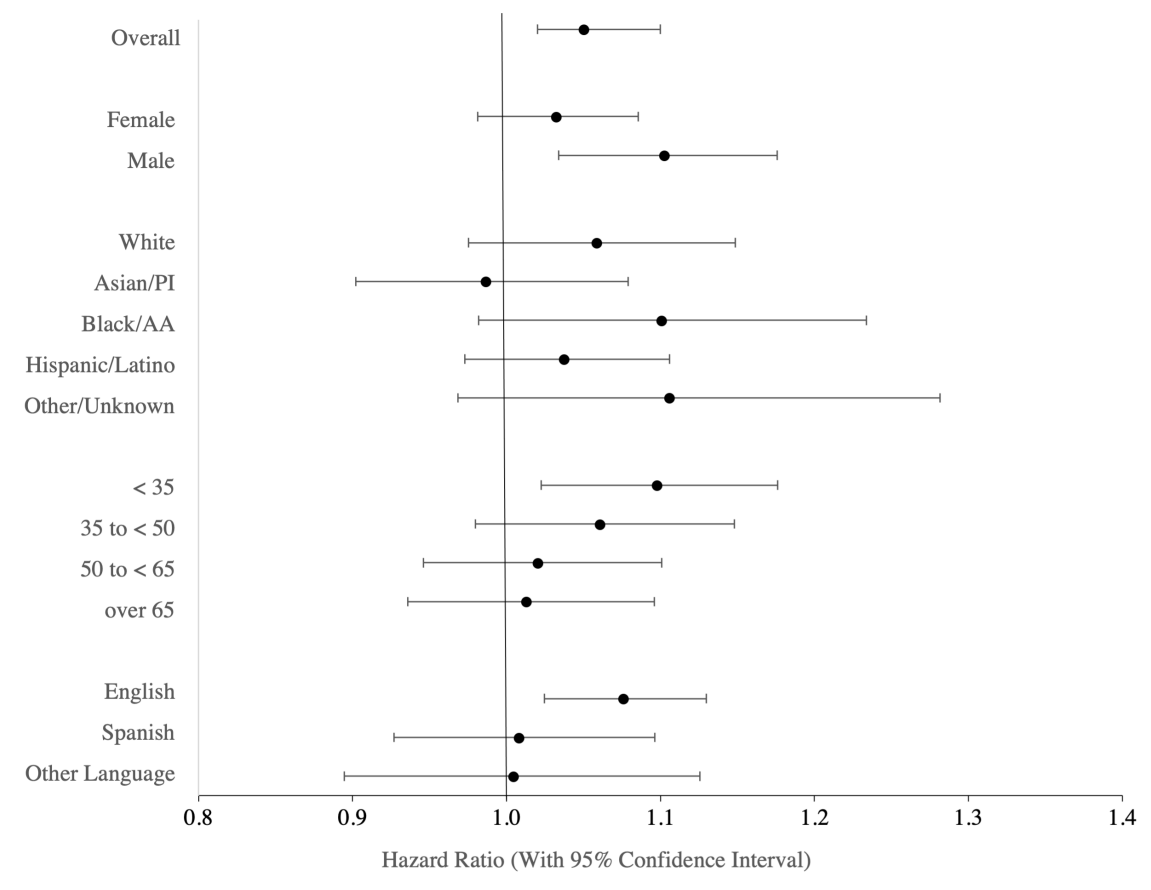
Immunization Outcomes

In weighted analyses, there were 12,026 first-dose vaccinations total. The percent of all enrollees with a first-dose vaccination was 10.3% at 3 months, 47.3% at 6 months, and 56.2% at 9 months. The overall incidence was 3.2 vaccinations per 1,000 person-months. In the intervention group, we observed 6,307 first-dose vaccinations, with 10.7% vaccinated at 3 months, 49.0% vaccinated at 6 months, and 57.7% vaccinated at 9 months. The intervention group incidence was 3.3 vaccinations per 1000 person-months. In the control group we observed 5,719 first-dose vaccinations, with 9.9% vaccinated at 3 months, 45.5% vaccinated at 6 months, and 54.5% vaccinated at 9 months. The control group incidence was 3.1 vaccinations per 1,000 person-months.

Results indicate there was a statistically significant greater likelihood of vaccination from December 1, 2020, to September 30, 2021 among enrollees offered case management. The unadjusted hazard ratio was 1.09 (95% confidence interval (CI): 1.05 – 1.13). The adjusted hazard ratio (aHR) was 1.05 (95% CI: 1.02 -1.10). Results were similar for analyses based on the date of second-dose vaccination (**Table 3** and **Table 4**).

In exploratory analyses stratified by subpopulation, males in the intervention group were significantly more likely to be vaccinated compared to males in the control group (aHR: 1.10, 95% CI: 1.04 – 1.18). There was no difference among females (aHR: 1.03, 95% CI: 0.98 – 1.09). Intervention group enrollees under age 35 were also more likely to be vaccinated compared to control group enrollees under age 35 (aHR: 1.10, 95% CI: 1.02 – 1.18). There were no differences among other age groups (age 35-under 50 aHR: 1.06, 95% CI: 0.98 – 1.15; age 50 to under 65 aHR: 1.02, 95% CI: 0.95-1.10; age 65+ aHR: 1.01, 95% CI; 0.94-1.10). In addition, intervention group enrollees whose primary language was English were more likely to be vaccinated compared to control group enrollees whose primary language was English (aHR: 1.08, 95% CI 1.03 – 1.13). There were no differences among those who primarily spoke Spanish (aHR: 1.01, 95% CI 0.93 – 1.10) or other languages (aHR 1.00, 95% CI: 0.90-1.13). Hazard ratios for Black or African American and Hispanic or Latino enrollees in the intervention group compared to those in the control group trended positive but were not statistically significant (**Figure 3**). In a model that included interaction terms for the same subpopulations examined in stratified analysis, patterns for male enrollees and those under age 35 were similar but interaction terms were not statistically significant at a p-value threshold of $p < 0.05$. There was no interaction between the intervention and the English-language subpopulation ($p = 0.66$) (**Table 3**).

Figure 3. Vaccination hazard ratios: Intervention vs. control group, stratified by demographic subgroup



2.4 Discussion

In support of the main hypothesis, case management enrollees had a 5% increased hazard of Covid-19 vaccination compared to similar individuals who were not offered case management. Further, the enrolled Medicaid beneficiaries over-represent social groups with barriers to early Covid-19 vaccination. Vaccination in the case management group particularly diverged from the control group around May 2021 (49.0% vs. 45.4%), approximately 6 months after vaccine roll-out started. During this time vaccines became more available to the general public, but there was still uncertainty about how and where to get vaccinated. One potential mechanism for greater vaccination in the intervention group is that some case managers helped enrollees navigate online scheduling platforms to sign up for a vaccination appointments, a commonly cited hurdle during early Covid-19 vaccination efforts.⁵⁶ It is also possible that case managers built trust when helping enrollees access resources for health and social needs⁵⁷ so that case managers were also trusted as a source of current and accurate Covid-19 information.

In sub-analyses, the case management intervention may have stronger benefits for male enrollees and enrollees under age 35, cohorts that typically access fewer preventive healthcare services.^{58,59} These results support the idea that case managers could be a

valuable bridge to underutilized services. In addition, the similar results for second dose vaccinations suggest that case management infrastructure could also bolster subsequent vaccination efforts.

The case management intervention did not have statistically significant impacts on vaccine uptake for minoritized racial/ethnic groups. On one hand, it is possible that our study was not adequately powered to detect statistically significant effects by race/ethnicity. For example, given the number of vaccinations observed, we estimate that an effect size (adjusted hazard ratio) of 1.14 or greater would be needed among Black or African American intervention group enrollees compared to Black or African American control group enrollees to reach statistical significance. On the other hand, the CommunityConnect case management intervention was relatively light touch. It is possible that deeper community engagement was needed to build trust and overcome barriers faced by minoritized populations.^{60,61}

Minoritized racial/ethnic groups also faced barriers such as less vaccine supply in their communities⁶² and disproportionate exposure to economic hindrances, such as having to take unpaid time off work to get vaccinated.⁶³ These structural barriers may have inhibited case managers' ability to influence vaccine uptake. The lagging vaccine uptake among minoritized populations both nationally⁴⁵ and in Contra Costa County⁶⁴ suggests more work is needed to close vaccination disparities.

Other efforts to increase Covid-19 vaccination have yielded ambiguous evidence. Estimates from Ohio's Vax-a-Million lottery, which offered a total of \$5 million to vaccinated Ohioans, attribute between 0.3 to 1 percentage points increased vaccination to the lottery incentive.^{65,66} Estimates are even higher among lower income counties.⁶⁷ However, results were inconsistent across state lottery programs.^{68,69} Other reports indicate that small monetary incentives (\$25) were influential to promote vaccination.^{70,71} Yet a review of incentive programs nationwide found that overall neither lotteries nor guaranteed rewards were associated with significant changes in vaccination rates.⁷²

This study is the first to the authors' knowledge to empirically study how an existing, cross-sector public health workforce influenced vaccination uptake. Findings suggest that CommunityConnect and other social needs case management programs may be part of an ecosystem of care⁷³ that can be flexibly adapted for new purposes. This flexibility may have been especially valuable in a crisis like the Covid-19 pandemic where guidelines on how to access vaccinations were unclear and frequently changed. CommunityConnect infrastructure may have served as a chassis for connecting community members at increased risk of Covid-19 with critical information and prevention resources.

Limitations

The study's strengths include the ability to adapt a pragmatic randomized trial design to understand alternative, unanticipated impacts of a large social needs case management program. Specifically, we link case management and county-wide Covid-19

vaccination records. While the vaccination records are comprehensive, they do not include vaccinations that took place outside California or without a Contra Costa County address.

An additional strength is that the study includes individuals who might not participate in recruitment-based trials. A limitation of this study design, however, is that only intent-to-treat analyses are valid. Though we anticipate a greater effect among enrollees who engaged with a case manager, we lack a valid comparison group. Nevertheless, the 35% engagement with case management services is in line with acceptance rates for other social needs assistance programs in health care settings.⁷⁴ The intent-to-treat estimate is also more relevant for policy decision makers who want to understand population impacts.

In addition, the external validity of the study may be limited since data reflect only one County which has an integrated public health system and robust public health functioning. Contra Costa County had one of the highest vaccination rates for a mid-size county in the United States, suggesting those in the usual care group also received substantial vaccination outreach. Programs like CommunityConnect may have different impacts in other settings.

Future research may benefit from data on outcomes such as stress/anxiety, quality of life, social connectedness, or other Covid-19 related experiences to holistically evaluate case management impacts. In addition, more granular information on characteristics such as neighborhoods or social networks could also provide valuable understanding of case management functioning and potentially related levers to improve vaccination.

2.5 Conclusion

This study builds on greatly needed social needs case management research and is among the first to examine impacts on vaccination, a public health outcome. Amidst mixed evidence on whether vaccine-specific incentives effectively influence vaccine uptake, the study found a modest increase in the rate of Covid-19 vaccination among enrollees offered case management compared to a usual care control group. The Covid-19 pandemic highlighted critical structural barriers to care. Leveraging social needs case management may be an important strategy to mitigate structural barriers and advance population health and prevention, especially in times of crisis.

2.6 Tables

Table 1. Comparison of intervention and control group demographics for Covid-19 vaccination analysis

		Intervention (n = 12,886 enrollees)		Control (n = 25,761 enrollees)		Standardized mean difference
		n	%	n	%	
Sex	Male	5,403	42%	10,605	41%	0.01
	Female	7,481	58%	15,154	59%	-0.01
Age Category	Under 35	5,177	40%	10,738	42%	-0.03
	35 to under 50	3,217	25%	6,299	25%	0.01
	50 to under 65	2,735	21%	5,299	21%	0.02
	65 and above	1,757	14%	3,425	13%	0.01
Race / Ethnicity	White	2,971	23%	5,929	23%	0.00
	Asian or Pacific Islander	1,463	11%	3,008	12%	-0.01
	Black or African American	2,432	19%	5,196	20%	-0.03
	Hispanic or Latino	4,741	37%	9,155	36%	0.03
	Other/Unknown	1,279	10%	2,473	10%	0.01
Preferred Language	English	9,629	75%	19,269	75%	0.00
	Spanish	2,333	18%	4,559	18%	0.01
	Other language	924	7%	1,933	8%	-0.01
Behavioral Health Acuity	None	10,154	79%	20,333	79%	0.00
	Mild - Moderate	1,744	14%	3,513	14%	0.00
	Moderate - Severe	988	8%	1,915	7%	0.01

Smoking status	Never	7,379	57%	14,730	57%	0.00
	Current	2,228	17%	4,385	17%	0.01
	Former	2,079	16%	4,079	16%	0.01
	Unknown	1,184	9%	2,547	10%	-0.03
Region	Central	3,106	24%	6,214	24%	0.00
	East	4,877	38%	9,669	37%	0.01
	Far East	1,217	9%	2,507	10%	-0.01
	West	3,569	28%	7,094	28%	0.00
History of Chronic Disease	Arthritis	2,155	17%	4,131	16%	0.01
	Back Disorder	3,861	30%	7,763	30%	0.00
	COPD	490	4%	957	4%	0.01
	CHF	287	2%	644	3%	-0.02
	CAD	400	3%	778	3%	0.00
	Diabetes	1,981	15%	3,958	15%	0.00
	Anxiety Disorder	3,341	26%	6,529	25%	0.02
	Depressive Disorder	3,431	27%	6,634	26%	0.02
Social Factors	Homeless	369	3%	692	3%	0.01
	Employed	9,698	75%	19,317	75%	0.01
Enrollment Start	Mar- Jun 2020	4,578	36%	9,164	36%	0.00
	Jul - Dec 2020	5,315	41%	10,631	41%	0.00
	Jan - Apr 2021	2,993	23%	5,966	23%	0.00

Table 2. Increased vaccination found among case management intervention patients in Covid-19 vaccination analysis

VACCINATIONS (WEIGHTED)				% Vaccinated (Based on survivor function)			Unadjusted Model			Adjusted Model		
	Events Observed	Events Expected	Incidence Rate (Per 1,000 enrollee- months)	3 months (Feb 2021)	6 months (May 2021)	9 months (Aug 2021)	Hazard Ratio	95% CI	p- value	Hazard Ratio	95% CI	p- value
Dose 1												
Control	5719.2	5980.2	3.1	9.9%	45.4%	54.5%	1.09	1.05- 1.13	< 0.001	1.06	1.02 - 1.10	0.02
Intervention	6307	6046.1	3.3	10.7%	49.0%	57.7%						
Dose 2												
Control	4879.3	5106.0	2.4	6.0%	39.7%	49.3%	1.09	1.05- 1.14	< 0.001	1.06	1.02 - 1.10	0.006
Intervention	5505	5278.2	2.7	9.3%	42.8%	52.7%						

CI = Confidence Interval

Table 3. Adjusted hazard ratios for all covariates in main and interacted vaccination models

	Dose 1 - main model			Dose 1 - with interactions			Dose 2 - main model			Dose 2 - with interactions		
	Hazard Ratio	95% Confidence Interval	p-value	Hazard Ratio	95% Confidence Interval	p-value	Hazard Ratio	95% Confidence Interval	p-value	Hazard Ratio	95% Confidence Interval	p-value
Intervention	1.057	[1.02,1.10]	0.006**	1.075	[0.87,1.32]	0.496	1.06	[1.02,1.11]	0.007**	1.069	[0.95,1.20]	0.27
Female	0.935	[0.90,0.98]	0.002**				0.946	[0.90,0.99]	0.017*			
White	1	[1.00,1.00]	.				1	[1.00,1.00]	.			
Asian/Pacific Islander	1.617	[1.50,1.74]	0.000***				1.6	[1.48,1.73]	0.000***			
Black/African American	0.661	[0.61,0.71]	0.000***				0.64	[0.59,0.69]	0.000***			
Hispanic/Latino	1.01	[0.95,1.08]	0.774				1.001	[0.93,1.07]	0.972			
Other/Unknown	1.043	[0.96,1.13]	0.329				1.037	[0.95,1.13]	0.408			
Age < 35	1	[1.00,1.00]	.				1	[1.00,1.00]	.			
Age 35 to < 50	1.287	[1.22,1.36]	0.000***				1.312	[1.24,1.39]	0.000***			
Age 50 to < 65	1.681	[1.58,1.78]	0.000***				1.738	[1.63,1.85]	0.000***			
Age over 65	2.037	[1.91,2.17]	0.000***				2.214	[2.07,2.37]	0.000***			
English	1	[1.00,1.00]	.				1	[1.00,1.00]	.			
Spanish	1.226	[1.15,1.31]	0.000***				1.192	[1.12,1.27]	0.000***			
Other Language	1.163	[1.08,1.26]	0.000***				1.15	[1.06,1.25]	0.001***			
HasHxArthritis	1.209	[1.14,1.28]	0.000***	1.21	[1.14,1.28]	0.000***	1.216	[1.15,1.29]	0.000***	1.217	[1.15,1.29]	0.000***
HasHxBack Disorder	1.092	[1.05,1.14]	0.000***	1.093	[1.05,1.14]	0.000***	1.109	[1.06,1.16]	0.000***	1.11	[1.06,1.16]	0.000***
HasHxCOPD	1.143	[1.02,1.28]	0.018*	1.139	[1.02,1.27]	0.020*	1.154	[1.03,1.29]	0.012*	1.152	[1.03,1.29]	0.013*
HasHxCHF	1.084	[0.95,1.24]	0.237	1.085	[0.95,1.24]	0.231	1.133	[0.99,1.30]	0.072	1.133	[0.99,1.30]	0.071
HasHxDiabetes	1.176	[1.11,1.24]	0.000***	1.174	[1.11,1.24]	0.000***	1.161	[1.10,1.23]	0.000***	1.16	[1.09,1.23]	0.000***
HasHxAnxiety Disorder	1.04	[0.99,1.10]	0.141	1.039	[0.99,1.09]	0.155	1.048	[0.99,1.11]	0.098	1.046	[0.99,1.11]	0.108
HasHxDepressiveDisorder	1.085	[1.03,1.14]	0.002**	1.086	[1.03,1.14]	0.002**	1.077	[1.02,1.14]	0.007**	1.079	[1.02,1.14]	0.006**

Behavioral Health Acuity: None	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.
Behavioral Health Acuity: Mild - Moderate	1.105	[1.04,1.17]	0.001**	1.105	[1.04,1.17]	0.001**	1.14	[1.07,1.21]	0.000***	1.141	[1.07,1.22]	0.000***
Behavioral Health Acuity: Moderate - Severe	0.981	[0.90,1.06]	0.635	0.983	[0.91,1.07]	0.685	0.993	[0.91,1.08]	0.865	0.995	[0.91,1.08]	0.905
IsEmployed	0.875	[0.84,0.92]	0.000***	0.875	[0.84,0.92]	0.000***	0.877	[0.84,0.92]	0.000***	0.878	[0.84,0.92]	0.000***
IsHomeless	0.764	[0.67,0.86]	0.000***	0.762	[0.67,0.86]	0.000***	0.737	[0.64,0.85]	0.000***	0.736	[0.64,0.85]	0.000***
Smoking Status: Never	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.
Smoking Status: Current	0.691	[0.65,0.74]	0.000***	0.69	[0.65,0.74]	0.000***	0.682	[0.64,0.73]	0.000***	0.682	[0.64,0.73]	0.000***
Smoking Status: Former	0.946	[0.89,1.00]	0.059	0.946	[0.89,1.00]	0.057	0.926	[0.87,0.98]	0.013*	0.925	[0.87,0.98]	0.012*
Smoking Status: Unknown	0.443	[0.40,0.49]	0.000***	0.443	[0.40,0.49]	0.000***	0.424	[0.38,0.47]	0.000***	0.424	[0.38,0.47]	0.000***
Central	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.	1	[1.00,1.00]	.
East	0.797	[0.76,0.84]	0.000***	0.797	[0.76,0.84]	0.000***	0.795	[0.75,0.84]	0.000***	0.795	[0.75,0.84]	0.000***
Far East	0.787	[0.73,0.85]	0.000***	0.788	[0.73,0.85]	0.000***	0.799	[0.74,0.87]	0.000***	0.8	[0.74,0.87]	0.000***
West	0.863	[0.82,0.91]	0.000***	0.864	[0.82,0.91]	0.000***	0.881	[0.83,0.93]	0.000***	0.882	[0.83,0.94]	0.000***
Enrollment Age (months)	1.022	[1.02,1.03]	0.000***	1.022	[1.02,1.03]	0.000***	1.025	[1.02,1.03]	0.000***	1.025	[1.02,1.03]	0.000***
Interaction Effects												
Male				0.903	[0.84,0.97]	0.004**				0.917	[0.85,0.99]	0.022*
Intervention # Male				1.067	[0.98,1.16]	0.12				1.059	[0.97,1.16]	0.205
White				0.982	[0.85,1.13]	0.791				1.657	[1.47,1.87]	0.000***
Intervention # White				0.961	[0.81,1.13]	0.637				0.936	[0.81,1.08]	0.377
Asian/Pacific Islander				1.657	[1.43,1.92]	0.000***				0.627	[0.55,0.71]	0.000***
Intervention # Asian/Pacific Islander				0.884	[0.74,1.06]	0.173				1.042	[0.89,1.21]	0.601

Black/African American				0.625	[0.54,0.73]	0.000***				1.008	[0.90,1.13]	0.895
Intervention # Black/African American				1.032	[0.86,1.24]	0.73				0.987	[0.86,1.13]	0.853
Hispanic/Latino				0.991	[0.86,1.14]	0.895				1.027	[0.89,1.19]	0.716
Intervention # Hispanic/Latino				0.959	[0.81,1.13]	0.618				1.016	[0.85,1.21]	0.859
Other/Unknown				1	[1.00,1.00]	.				1	[1.00,1.00]	.
Intervention # Other/Unknown				1	[1.00,1.00]	.				1	[1.00,1.00]	.
Age < 35				0.469	[0.43,0.51]	0.000***				1.303	[1.19,1.43]	0.000***
Intervention # Age < 35				1.09	[0.97,1.22]	0.131				1.013	[0.90,1.13]	0.826
Age 35 to < 50				0.615	[0.56,0.68]	0.000***				1.801	[1.63,1.99]	0.000***
Intervention # Age 35 to < 50				1.052	[0.93,1.18]	0.402				0.936	[0.83,1.05]	0.264
Age 50 to < 65				0.827	[0.75,0.91]	0.000***				2.288	[2.08,2.52]	0.000***
Intervention # Age 50 to < 65				0.996	[0.88,1.12]	0.942				0.939	[0.83,1.06]	0.302
Age over 65				1	[1.00,1.00]	.				1	[1.00,1.00]	.
Intervention # Age over 65				1	[1.00,1.00]	.				1	[1.00,1.00]	.
English				0.875	[0.77,0.99]	0.033*				1.193	[1.07,1.33]	0.002**
Intervention # English				0.967	[0.83,1.12]	0.663				0.999	[0.88,1.14]	0.991
Spanish				1.094	[0.94,1.28]	0.257				1.113	[0.98,1.26]	0.099
Intervention # Spanish				0.936	[0.78,1.13]	0.492				1.065	[0.91,1.24]	0.429
Other Language				1	[1.00,1.00]	.				1	[1.00,1.00]	.
Intervention # Other Language				1	[1.00,1.00]	.				1	[1.00,1.00]	.

* p<0.05, ** p<0.01, *** p<0.001

3 Rental Housing Move-In Deposits and Healthcare Use: Evidence from a Medicaid 1115 Waiver Pilot in Contra Costa, California

Objective. Housing deposits and tenancy supports are new benefits under Medicaid 1115 demonstration waivers in Arizona, Arkansas, California, Massachusetts, Arizona, and Oregon. There is interest in expanding these benefits to other states.

While housing stability has been demonstrated to improve health, there is limited evidence documenting impacts from health system-based funding for housing deposits. This study investigated how housing deposits within a case management program impacted several measures of healthcare use.

Study design. A difference-in-differences study design was used to compare changes in health services use among 708 Medicaid beneficiaries who received housing deposits against a 1:1 matched comparison group of 708 beneficiaries who did not receive deposits. All beneficiaries were enrolled in a social needs case management program for populations with high risk of acute care utilization in Contra Costa County, California. Deposits were coupled with tenancy support and distributed October 2018-June 2021. Deposits averaged \$1,986 per recipient. Changes in healthcare use between the deposit and comparison groups were compared using a pre-period 6 months before the deposit to a post-period 6 months after the deposit. For each beneficiary in the comparison group, we calculated a post-period start date equal to the average lag from case management enrollment to deposit date for matched deposit recipients enrolled in the same quarter.

Population. The analytic sample included 1416 individuals: 53% female, 39% under age 40, 35% African American, 13% Latinx, and 38% White. There was a high prevalence of behavioral health diagnoses: 54% depressive disorder history, 24% psychosis disorder history, and 56% alcohol or drug dependence history. Characteristics were balanced across the deposit and comparison groups.

Principal Findings. Mean health services use among deposit recipients in the pre-period was 0.15 inpatient admissions (vs. 0.21 in the comparison group, $p=0.09$), 1.2 ED visits (vs. 1.2, $p=0.56$), 3.3 primary care visits (vs. 2.1, $p<0.001$), 1.7 specialty care visits (vs. 1.4, $p=0.26$), 4.2 behavioral health visits (vs. 2.7, $p=0.04$), 0.11 psychiatric emergency services (vs. 0.13, $p=0.70$), and 0.13 detention intakes (vs. 0.12, $p=0.75$). All services demonstrated pre-intervention parallel trends in accordance with difference-in-differences analytic assumptions.

In analyses adjusted for demographics and health history, deposits were associated with an average differential change of 1.0 fewer primary care visits over 6 months (95% CI -1.2 to -0.24). A differential change of fewer behavioral health visits was observed in

unadjusted analyses, but the effect was not significant in adjusted analyses. There was no association between receiving a deposit and change in inpatient admissions, ED visits, specialty care visits, psychiatric emergency services, or detention intakes.

Conclusions. Beneficiaries who received housing deposits experienced greater reductions in primary care visits. New Medicaid housing benefits may help improve health and wellbeing among individuals facing housing instability but did not manifest differences in costly acute care services in the short term.

3.1 Introduction

As healthcare payers and delivery systems devote increasing attention to patients' social determinants of health, housing insecurity is a top concern.⁷⁵ Housing insecurity has been associated with increased emergency and urgent care use.⁷⁶ Among people experiencing homelessness, use of hospital and emergency department services was two to nine times higher, and rates of outpatient office-based were almost double compared to similar housed peers.²⁹ Consequently, some state Medicaid programs are implementing new benefits to support housing needs. According to the Kaiser Family Foundation, the latest Medicaid 1115 Demonstration Waivers (2022-2027) in at least 9 states will offer individualized case management to secure and maintain housing, services also known as housing transition navigation or tenancy support. In addition, Medicaid waivers in at least 4 states will offer funding for housing deposits and other one-time transition/moving costs including first month's rent, utility activation fees, and other relocation expenses.^{9,77}

Interventions that provide housing directly, such as permanent supportive housing or hotel placements, have been shown to reduce health spending and hospital utilization.^{30,78-80} There is also some evidence that rental assistance is associated with lower odds of poor health, less psychological distress, and fewer unmet healthcare needs.⁸¹⁻⁸⁴ However, to our knowledge, no prior studies have examined healthcare-based funding for housing deposits and tenancy support. As additional states consider similar Medicaid waiver benefits, evidence is needed to inform expectations of changes in use of healthcare services and potential savings.

Our study makes a key contribution by investigating an intervention that provided housing deposit funding with tenancy support. We examine impacts on use of key healthcare services: inpatient admissions, emergency department visits, primary care visits, specialty care visits, behavioral health visits, psychiatric emergency services, and detention intakes. Like current CMS Medicaid 1115 waivers, housing deposits covered the first month's rent and a security deposit. Recipients were required to have sufficient income to make ongoing monthly rent payments. All deposit recipients also received tenancy support as part of their participation in a case management program for beneficiaries with high risk of acute care use. To identify housing deposit impacts, we compare changes in healthcare utilization six months before and six months after deposit

receipt versus changes in healthcare utilization in a propensity-score matched comparison group that received case management services only.

3.2 Methods

Study Design

The CommunityConnect case management program in Contra Costa County, California administered housing deposits as part of a Whole Person Care pilot. Contra Costa County is a large county in San Francisco's Bay Area with over 1.1 million residents and 220,000 Medicaid beneficiaries.^{85,86} Whole Person Care was California's Medicaid Section 1115 waiver from 2016-2021 to address complex health and social needs among high-risk/high-utilizing enrollees.⁸⁷ Further details about Contra Costa's CommunityConnect case management program are described in other publications.^{26,57,88,89}

All CommunityConnect case management participants were Medicaid beneficiaries. Case management program enrollment occurred automatically each month beginning in 2017 for individuals at the highest risk of future hospital or emergency department utilization. Housing deposits were allocated to case management participants who were actively working with a case manager, had secured a rental lease or rental agreement, and had a source of income to continue ongoing rental payments. Deposit funding was administered on a rolling basis beginning in October 2018. In total, the program distributed \$1.9 million in housing deposits over 3 years. The maximum amount allowed was \$5,000. The median deposit amount was \$1,750 (interquartile range \$920 - \$2,900). Recipients were primarily individuals who had long-term experiences of homelessness. In some cases, the housing deposits helped recipients move to lower cost housing after circumstances such as losing a job. Funds were often used to secure a single room in a shared unit given the region's high-cost, competitive housing market. The program was administered through the county and 1 full-time personnel managed applications for deposit funding, auditing, and payment distribution processes.

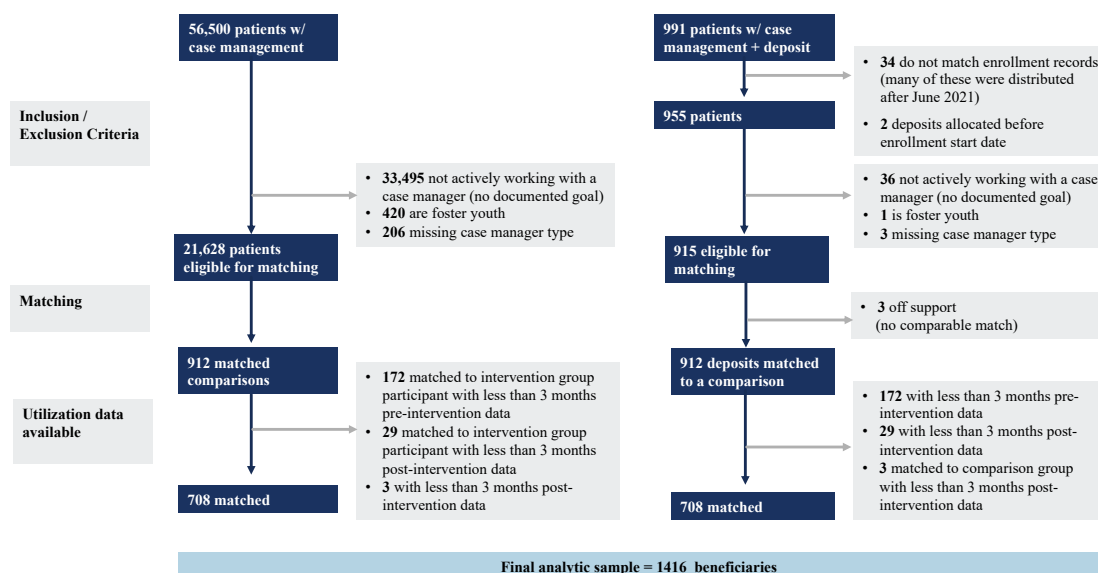
All participants, including those who did not receive housing deposits, received ongoing case management services. Case managers supported both groups with coordination for healthcare needs and connections to resources for other social needs. The case management only group was eligible to receive the same housing navigation and tenancy supports provided to deposit recipients, which included assistance with bill pay setup and landlord communication, establishing cleaning and maintenance routines, and check-ins to avoid isolation,

Analytic Sample

There were 991 housing deposit recipients from October 2018 to December 2021. To be included in the analysis, the deposit recipient must have been linkable to a case management participant record in which the enrollee had actively worked with a case

manager, evidenced by documentation in the participant’s care plan of at least “goal” or an area to address together. We excluded 34 deposit recipients who did not match to an enrollment record and two deposit recipients whose deposit was allocated before their enrollment start date. Of the 955 deposit recipients matched to an enrollment record, 40 were excluded before matching: 36 did not have a documented goal to indicate they had actively worked with their case manager; one was a foster youth (all foster youth were excluded from analysis due to their unique housing circumstances); and three were missing case manager type, a key matching variable. The total analytic sample after matching and exclusions based on available utilization data, detailed below, included 1416 participants. 708 participants received a move-in deposit and 708 participants with comparable characteristics did not receive a deposit (Figure 4).

Figure 4. Participant matching and exclusions for housing deposit analysis



Matched Comparison Group

Housing deposit recipients were 1:1 propensity-score matched to program participants who worked with a case manager but did not receive a move-in deposit. Matching characteristics included demographics, health conditions, case manager discipline, responses to housing questions, and enrollment type. Matching characteristics are further described in the covariates section. Matches were chosen using nearest neighbor matching with no replacement among other enrollees in the same enrollment year. Matching within enrollment year accounted for program maturity over time. As the program matured, lag time from program enrollment to deposit funding distribution decreased.

Deposit index dates for enrollees in the comparison group were assigned using the average lag time from case management enrollment to deposit date for matched deposit

recipients enrolled in the same quarter. 172 deposit recipients with less than three months pre-intervention data and 29 deposit recipients with less than three months post intervention data were dropped with their matched comparison group counterparts. In addition, three comparison group participants had less than three months post-intervention data and were dropped with their matched deposit recipients.

Data Structure

We summed counts of each outcome for the 6 months before and after the deposit date or calculated index date. Because outcome data was structured by month, the month in which the deposit or index date occurred was not included in the analysis to clearly delineate the before and after time frames. As a sensitivity analysis, we also examine each outcome 12 months before and after the deposit date or calculated index date, however we use 6 months as the primary specification due to outcome data completeness. Using 6 months pre-post data, 90% of participants have complete pre-intervention data (6 months or more) and 94% of participants have complete post-intervention data. Using 12 months pre-post data, 70% of participants have complete pre-intervention data and 86% of participants have complete post-intervention data.

Outcomes

The outcomes analyzed were changes in counts of hospitalizations, emergency department visits, primary care visits, specialist visits, and behavioral health visits, psychiatric emergency services, and jail intakes in the 6 months before and after deposit receipt compared to a before and after comparison of the propensity score matched comparison group. Outcomes were identified from a data warehouse managed by the Contra Costa Health business intelligence team. The data warehouse combines Medicaid claims and electronic health records from the county-run hospital and a network of outpatient clinics, capturing all relevant visits for case management program participants.

Primary and specialty care visits include encounters with MD, DO, or NP providers across the health system and reflect both in-person and telephonic care. In both the deposit-recipient and comparison groups, telephonic care represented about 6% of pre-intervention primary care visits. Behavioral health visits include all visits with an MFT, LCSW, or psychologist. All outpatient encounters are distinct from visits with CommunityConnect case management personnel. Psychiatric emergency services include all admissions to a 23-bed facility for adult patients, the County's only psychiatric emergency services unit. Jail intakes are documented in the County health system's electronic health record since County Health Services provide healthcare for all County detention facilities.

Covariates

The covariates used for matching include participant characteristics that may affect both housing deposit receipt and the trajectory of healthcare service use. Covariates were determined in part by examining differences between CommunityConnect enrollees

who received a housing deposit compared to other CommunityConnect enrollees working with a case manager who did not receive a deposit.

Demographic covariates included sex, age (under 40, 40-60, over 60), race (White, Black, Asian, Hispanic/Latino, or other/unknown), and discipline of the participant's assigned case manager (community health worker, nursing, social work, substance use counselor, or housing specialist). Covariates derived from medical record documentation included histories of hypertension, diabetes, and chronic obstructive pulmonary disorder, as well as behavioral health acuity (non, mild-moderate, or moderate-severe), histories of psychosis disorder, depressive disorder, alcohol or other drug dependence, and detention history, and experience of homelessness. In addition, covariates included participant responses to housing screening questions that case managers asked all enrollees at intake. Housing questions included "What is your current living situation?", "Do you believe you are at risk of losing your housing in the next 6 months", "Would you like information about rental assistance resources?", and "Would you like information about shelters in your area?" Last, we include as a covariate whether the participant was automatically offered program enrollment based on elevated predicted risk of future hospital or emergency department use or manually enrolled for reasons such as a clinician referral.

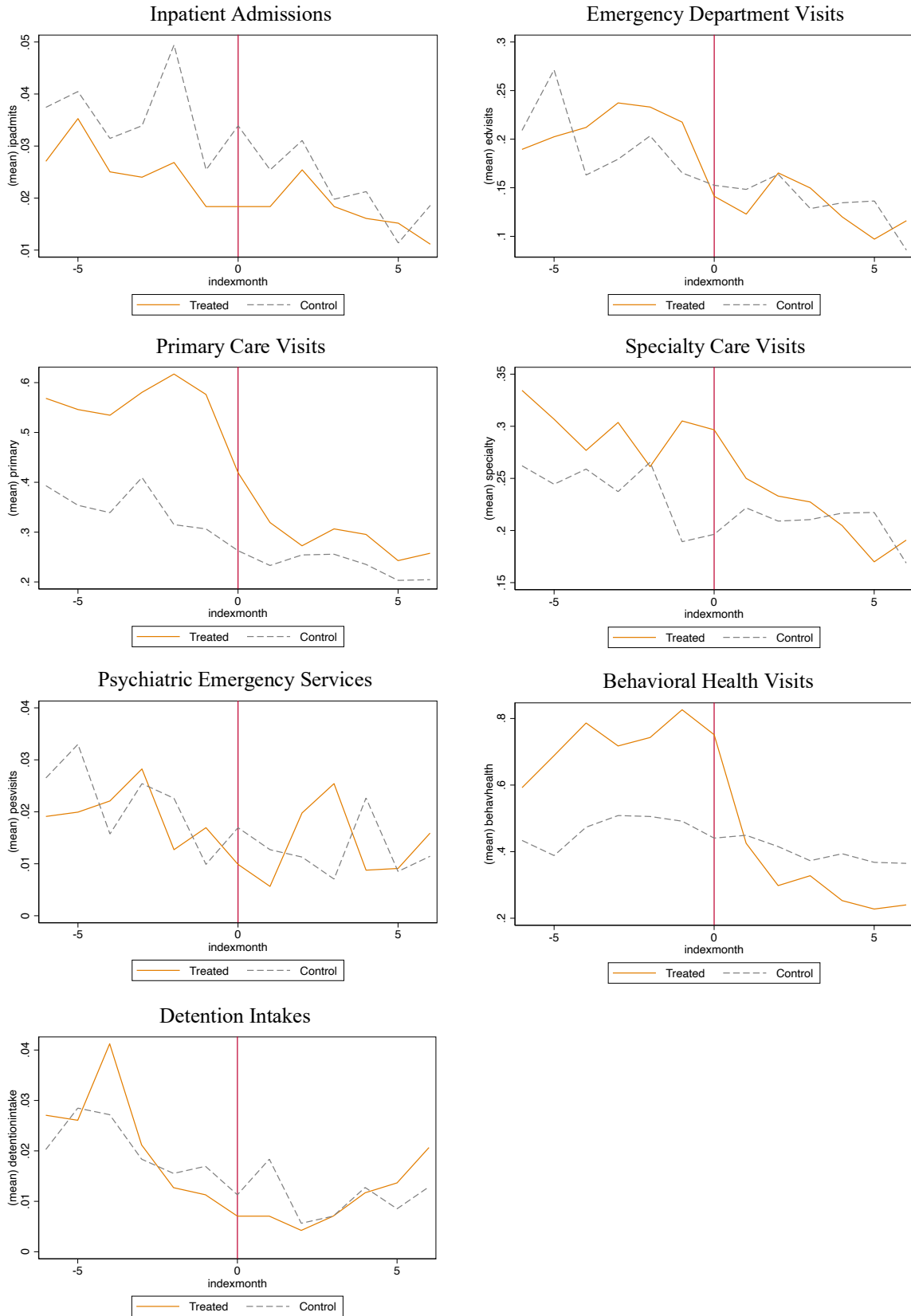
Difference-in-Differences Analytic Strategy

Effect estimates were calculated using a difference-in-differences design, which examines the change in healthcare services use among individuals who received move-in deposits relative to the change in healthcare services use in the comparison group.⁹⁰ The difference-in-differences design was chosen since pre-intervention healthcare use among those that received a deposit was not equivalent to the comparison group for primary care and behavioral health visits, despite balance across matching characteristics.

Matching characteristics did not include pre-intervention healthcare use for two reasons. First, the index date in the comparison group (a counterfactual deposit receipt date) was calculated after matching based on matched counterparts enrolled in the same quarter. This index date is the basis for determining pre and post-intervention utilization. Second, matching on time-varying pre-intervention outcomes may induce spurious effects due to regression to the mean. For example, lower-than-average-risk deposit recipients would revert to higher healthcare services use and higher-than-average-risk comparison group members would revert to lower healthcare services use.^{91,92}

To examine the difference-in-differences assumption of pre-intervention parallel trends, we generated plots of healthcare use for each outcome (**Figure 5**). The appearance of pre-intervention parallel trends was confirmed for each outcome by statistical tests for parallel trends at the $p > 0.05$ level (Stata postestimation command `estat ptrends`).

Figure 5. Pre/Post healthcare use trends for housing deposit recipients vs. a matched comparison group



We estimated the impact of housing deposits for each outcome by calculating both raw difference-in-differences and using negative binomial regression models with a group-by-time interaction. Model covariates included the same demographics, health, behavioral health, and housing screening question variables used in the matching process. We then converted model estimates to marginal effects to derive average treatment effects for the study population. Negative binomial models were chosen due to the count distribution of our outcomes, though the same models were also examined using linear regression as a sensitivity check. All analysis was conducted using Stata version 17 statistical software

3.3 Results

Participant Characteristics

The final sample comprised 1,416 CommunityConnect case management participants, 708 who received a housing deposit and 708 who received case management only. Participants in the final sample who received a move-in deposit were 48% male; 40% under age 40, 42% ages 40-60, and 18% over age 60; and 38% White, 35% Black, and 14% Hispanic/Latino. 11% of participants who received a housing deposit had mild-moderate behavioral health acuity and 15% had moderate-severe behavioral health acuity. 56% had a history of alcohol and other drug dependence. 30% had homeless status documented in their medical record. In a standardized screening conducted through conversations with case managers, 44% of participants reported living in a shelter, on the street, doubled up, in a residential treatment facility, or in a sober living environment, and 45% of participants believed they were at risk of losing housing within 6 months. P-values when testing differences between the deposit group and the comparison group were > 0.05 for all demographic, health, and housing status characteristics, indicating that the intervention and comparison groups were well matched on observable characteristics. (**Table 4**).

Baseline Healthcare Use

Mean health services use among deposit recipients in the pre-period was 0.15 inpatient admissions (vs. 0.21 in the comparison group, $p=0.09$), 1.2 ED visits (vs. 1.2, $p=0.56$), 3.3 primary care visits (vs. 2.1, $p<0.001$), 1.7 specialty care visits (vs. 1.4, $p=0.26$), 4.2 behavioral health visits (vs. 2.7, $p=0.04$), 0.11 psychiatric emergency services (vs. 0.13, $p=0.70$), and 0.13 detention intakes (vs. 0.12, $p=0.75$). All services demonstrated pre-intervention parallel trends.

Healthcare Use Trends

Healthcare use declined in the post-intervention period relative to the pre-intervention period for both the deposit and comparison groups. In the deposit group, declines were statistically significant for emergency department visits (1.2 pre vs. 0.74 post, $p < 0.001$), primary care (3.3 pre vs. 1.6 post, $p < 0.001$), specialty care visits (1.7 pre vs. 1.2 post, $p = 0.019$), detention intakes (0.13 pre vs. 0.06 post, $p = 0.002$), and behavioral health visits (4.2 pre vs. 1.7 post, $p<0.001$). In the comparison group, declines

were statistically significant for inpatient admissions (0.21 pre vs. 0.12 post, $p = 0.023$), emergency department visits (1.2 pre vs. 0.80 post, $p = 0.020$), psychiatric emergency services (0.13 pre vs. 0.07 post, $p = 0.10$), and detention intakes (0.12 pre vs. 0.07 post, $p = 0.035$). (Figure 3).

Difference-in-Differences Outcomes

In models fully adjusted for demographics, health history, and other covariates, deposit recipients had a significantly greater reduction in primary care visits relative to the comparison group, with an average greater decrease of 1.0 primary care visits per deposit recipient over six months. (95% CI -1.5 to -0.51). In unadjusted analyses, deposit recipients also had significantly greater reductions in behavioral health visits of -2.5 visits on average over 6 months relative to the comparison group (95% CI -3.5 to -1.4), however the difference was no longer statistically significant in the fully adjusted model. There was no differential change in healthcare use for inpatient admissions, emergency department visits, specialty care visits, psychiatric emergency services, and detention intakes. (Table 5).

Sensitivity Analyses

Like the 6-month results, in analysis of 12-month outcomes there was a statistically significant greater reduction in primary care visits (marginal effect: -1.6 visits over 12 months, 95% CI -2.4 to -0.87). Patterns for behavioral health use were also similar, and there were no statistically significant differences for inpatient admissions, emergency department visits, specialty care visits, psychiatric emergency services, and detention intakes. Results from linear regression modeling were also consistent (Table 6).

3.4 Discussion

This analysis of a Medicaid case management program for health and social needs identified reductions in health services use among both those who received a housing deposit with case management and a propensity-score matched comparison group that received case management only. Significantly greater reductions in primary care visits were observed among who received a housing deposit relative to the matched comparison group. Significantly greater reductions in behavioral health visits were also observed in unadjusted analysis among the deposit group relative to the comparison group but differences were not significant in fully adjusted analysis. Reductions in other health services were not statistically different between the two groups.

The greater decreases in primary care visits among participants who received housing deposits relative to the comparison group differed from our expectations that housing deposits would increase housing stability to a greater extent than case management alone, improving access to routine, preventive primary care services, as found for other housing stability interventions.^{80,93} Trends toward greater decreases in behavioral visits similarly differed from our expectations. Consequently, health system

navigation by case managers, which was offered to both groups, likely minimized differences in access to primary care and behavioral health services. The high pre-intervention visit rates, which averaged more than three primary care visits and four behavioral health visits over six months, also provides some assurance that the greater reduction in the deposit group does not necessarily indicate a lack of engagement in key preventive health services.

Therefore, the differentially fewer post-intervention primary care and behavioral health visits presumably reflect better health and wellbeing. Other work has documented that residential stability can in turn improve health and wellbeing through multiple mechanisms such as lower stress, better management of health conditions, and more consistent receipt of other social services benefits.⁹⁴⁻⁹⁶ Deposit recipients who obtained stable housing may have benefited from improved rest, a clean environment for wound care among patients with diabetes, a kitchen to cook nutritious and cost-effective meals, and the ability to leverage Supplemental Nutrition Assistance Program or food pantry supports. Future studies should confirm that housing deposits do not detrimentally impact access or care continuity due to relocation and potential isolation.⁹⁷

The analysis did not find statistically significant differential reductions in use of inpatient admissions, emergency department visits, specialty care visits, psychiatric emergency services, and detention intakes among the intervention group relative to the comparison group. It is possible that these services reflect the presence of more severe health conditions where housing deposits with tenancy support may not lead to changes relative to case management alone, particularly on the shorter timelines observed in our study. As relatively rare outcomes, inpatient visits, psychiatric emergency visits, and detention intakes may also be more difficult to impact.

As state Medicaid programs evolve, there is increasing interest in non-traditional benefits like housing navigation, tenancy support, and housing deposits as part of one-time transition/moving costs. Our study builds on a well-documented relationship between housing stability and healthcare use by evaluating a unique, policy-relevant intervention while considering a broader range of health care use measures than past research.^{98,99} Similar to other studies of housing interventions,^{78,100} concurrent mental and behavioral health challenges were common in our sample, where about one in four deposit recipients had a history of psychosis and nearly three in five had a history of alcohol or other drug dependence. While nearly one-third of housing deposit recipients with a documented history of homelessness, this likely underrepresents true housing needs given challenges for health systems to identify housing insecurity.¹⁰¹⁻¹⁰³

It is also important to note that results reflect the impact of housing deposits above and beyond housing transition navigation and tenancy support, since both groups in our study actively worked with a case manager. However, case managers emphasized that coupling deposit funding with tenancy support was critical to help enrollees remain housed. In addition, case managers expressed that being an embedded member of the health system allowed them to better address health and social needs concurrently.

Limitations

This analysis was limited to data come from a single, county-based health system in the San Francisco Bay Area, where housing availability and affordability is especially challenging. In some cases, rental housing deposit funds may have been available, but affordable housing was difficult to find. Thus, program effects may not generalize to areas with different levels of housing availability. A second limitation is that the analysis time period overlaps with the onset of the Covid-19 pandemic in March 2020, which caused routine healthcare utilization to decline broadly.¹⁰⁴ Temporal trends related to Covid-19 should similarly impact both groups with the difference-in-differences study design. Future research may still benefit from testing related interventions over time periods not influenced by Covid-19. Third, the analysis benefits from robust electronic health records integrated with case management records, though additional enrollee characteristics that may influence housing deposit allocation were likely unobservable in our data and remain unaccounted for in the matching process. Nevertheless, the existing data facilitate matching on both formally documented health conditions such as behavioral health acuity and substance use diagnoses as well as specific housing circumstances gathered through structured case manager conversations. A remaining limitation is that available data elements do not include whether the deposit recipient successfully retained housing, an important process metric to understand program impact more fully.

Much of the discussion around new Medicaid benefits for housing and other health related social needs involves an assumption of cost savings. In this analysis, the lack of differential changes in use of costly, acute care outcomes indicates that housing deposits do not generate short-term return on investment. However, they may still play an important role in longer-term, holistic strategies to improve population health. According to case managers who supported enrollees in our study, the housing deposits were a key resource amidst short windows of opportunity in both housing availability and participant readiness to move. Future research may benefit from study designs with more specific focus populations, expanded time horizons, and deeper examination of patient-centered measures including self-rated health or quality of life.

3.5 Conclusion

Healthcare systems increasingly emphasize social determinants of health, yet evidence on health-system based interventions remains limited. We leveraged data from a Medicaid 1115 demonstration program to identify impacts of housing deposits with tenancy support on health services use. We found that participants who received housing deposit funding experienced differentially fewer primary care visits with a trend toward differentially fewer behavioral health visits compared to a matched comparison group that received the same case management services without housing deposit funding. Housing deposits, coupled with case management, may be a meaningful strategy to improve health among people experiencing long-term homelessness or housing instability but did not yield differential changes in costly acute care utilization in the short term.

3.6 Tables

Table 4. Housing deposit group and comparison group characteristics, before and after matching

		Before Matching			After Matching		
		Deposit Group N = 915	Comparison Group N = 21428	p-value	Deposit Group N=708	Comparison Group N=708	p-value
		N (%)	N (%)		N (%)	N (%)	
Case Manager Type	CHW	163 (17.8%)	12362 (57.7%)	<0.001	146 (20.6%)	163 (23.0%)	0.77
	CHW-Specialist	34 (3.7%)	1019 (4.8%)		25 (3.5%)	32 (4.5%)	
	Nursing	133 (14.5%)	3193 (14.9%)		118 (16.7%)	106 (15.0%)	
	Social Worker	66 (7.2%)	1301 (6.1%)		52 (7.3%)	51 (7.2%)	
	Mental Health	51 (5.6%)	1270 (5.9%)		44 (6.2%)	40 (5.6%)	
	Housing Specialist	105 (11.5%)	658 (3.1%)		94 (13.3%)	101 (14.3%)	
	Substance Use Counselor	363 (39.7%)	1625 (7.6%)		229 (32.3%)	215 (30.4%)	
Sex	Male	472 (51.6%)	8053 (37.6%)	<0.001	337 (47.6%)	331 (46.8%)	0.75
	Female	443 (48.4%)	13375 (62.4%)		371 (52.4%)	377 (53.2%)	
Age	< 40	395 (43.2%)	8204 (38.3%)	<0.001	281 (39.7%)	273 (38.6%)	0.81
	40 to < 60	365 (39.9%)	8043 (37.5%)		299 (42.2%)	298 (42.1%)	
	over 60	155 (16.9%)	5181 (24.2%)		128 (18.1%)	137 (19.4%)	
Race	White	366 (40.0%)	5693 (26.6%)	<0.001	266 (37.6%)	271 (38.3%)	0.91
	Asian/PI	28 (3.1%)	2166 (10.1%)		24 (3.4%)	21 (3.0%)	
	Black/AA	300 (32.8%)	4766 (22.2%)		245 (34.6%)	256 (36.2%)	
	Hispanic/Latino	135 (14.8%)	6919 (32.3%)		100 (14.1%)	91 (12.9%)	
	Other/Unknown	86 (9.4%)	1877 (8.8%)		73 (10.3%)	69 (9.7%)	
Language	English	872 (95.3%)	15932 (74.4%)	<0.001	676 (95.5%)	659 (93.1%)	0.052
	Other Language	43 (4.7%)	5496 (25.6%)		32 (4.5%)	49 (6.9%)	
History of Stroke		29 (3.2%)	602 (2.8%)	0.52	26 (3.7%)	28 (4.0%)	0.78
History of Hypertension		369 (40.3%)	9332 (43.6%)	0.054	323 (45.6%)	339 (47.9%)	0.39
History of CHF		51 (5.6%)	1309 (6.1%)	0.51	50 (7.1%)	51 (7.2%)	0.92
History of Diabetes		172 (18.8%)	5473 (25.5%)	<0.001	151 (21.3%)	162 (22.9%)	0.48
History of HIV/AIDS		18 (2.0%)	223 (1.0%)	0.008	15 (2.1%)	18 (2.5%)	0.60

History of COPD		123 (13.4%)	2278 (10.6%)	0.007	118 (16.7%)	115 (16.2%)	0.83
History of Detention		345 (37.7%)	2499 (11.7%)	<0.001	255 (36.0%)	244 (34.5%)	0.54
Behavioral Health Acuity	None	658 (71.9%)	17778 (83.0%)	<0.001	523 (73.9%)	532 (75.1%)	0.84
	Mild-moderate	109 (11.9%)	2303 (10.7%)		80 (11.3%)	78 (11.0%)	
	Moderate-severe	148 (16.2%)	1347 (6.3%)		105 (14.8%)	98 (13.8%)	
History of Psychosis Disorder		213 (23.3%)	2128 (9.9%)	<0.001	168 (23.7%)	175 (24.7%)	0.66
History of Depression		483 (52.8%)	8071 (37.7%)	<0.001	389 (54.9%)	376 (53.1%)	0.49
History of Chronic Pain		401 (43.8%)	8703 (40.6%)	0.053	352 (49.7%)	358 (50.6%)	0.75
History of Drug or Alcohol Dependence		534 (58.4%)	5261 (24.6%)	<0.001	396 (55.9%)	406 (57.3%)	0.59
Documented Homelessness		263 (28.7%)	1482 (6.9%)	<0.001	210 (29.7%)	210 (29.7%)	1.00
Social need based on living situation		450 (49.2%)	1890 (8.8%)	<0.001	313 (44.2%)	315 (44.5%)	0.91
Believe at risk of losing housing within 6 months		428 (46.8%)	2794 (13.0%)	<0.001	319 (45.1%)	317 (44.8%)	0.91
Would like info about rental assistance resources		355 (38.8%)	2829 (13.2%)	<0.001	254 (35.9%)	240 (33.9%)	0.44
Would like info about shelters in your area		85 (9.3%)	608 (2.8%)	<0.001	64 (9.0%)	65 (9.2%)	0.93
Manual Enrollment Reason (not automatic)		410 (44.8%)	5661 (26.4%)	<0.001	262 (37.0%)	281 (39.7%)	0.30
Enrollment Year	2017	276 (30.2%)	8194 (38.2%)	<0.001	271 (38.3%)	271 (38.3%)	1.00
	2018	208 (22.7%)	5443 (25.4%)		201 (28.4%)	201 (28.4%)	
	2019	285 (31.1%)	3559 (16.6%)		172 (24.3%)	172 (24.3%)	
	2020-2021	146 (16.0%)	4232(19.7%)		64 (9.0%)	64 (9.0%)	

CHW = community health worker; CHF = congestive heart failure; HIV/AIDS = human immunodeficiency virus / acquired immunodeficiency syndrome; COPD = chronic obstructive pulmonary disorder

Table 5. Difference-in-differences in 6-month healthcare utilization between deposit and matched comparison groups

Descriptive Mean Utilization (6-months)								
Outcome	Deposit Group			Comparison Group			Deposit Difference (before/after)	Comparison Difference (before/after)
	Before	After	P-value	Before	After	P-value		
Inpatient Admissions	0.150	0.102	0.075	0.212	0.127	0.023	-0.048	-0.085
Emergency Department Visits	1.246	0.747	<0.001	1.154	0.795	0.020	-0.499	-0.359
Primary Care Visits	3.294	1.638	<0.001	2.055	1.381	<0.001	-1.655	-0.674
Specialty Care Visits	1.715	1.236	0.019	1.415	1.240	0.560	-0.479	-0.175
Psychiatric Emergency Services	0.114	0.082	0.450	0.129	0.073	0.100	-0.032	-0.055
Detention Visits	0.133	0.061	0.002	0.123	0.065	0.035	-0.072	-0.058
Behavioral Health Visits	4.201	1.720	<0.001	2.732	2.356	0.570	-2.480	-0.376

Mean Utilization Models (6-months)						
Outcome	Unadjusted DID*		DID IRR**		Marginal Effect**	
	Estimate	p-value	Estimate	95% CI	Estimate	95% CI
Inpatient Admissions	0.037	0.425	1.212	[0.699, 2.104]	0.038	[-0.041, 0.116]
Emergency Department Visits	-0.140	0.475	0.868	[0.637, 1.183]	-0.212	[-0.514, 0.089]
Primary Care Visits	-0.982	0.001	0.743	[0.590, 0.936]	-0.995	[-1.48, -0.507]
Specialty Care Visits	-0.304	0.403	0.847	[0.549, 1.307]	-0.283	[-0.881, 0.315]
Psychiatric Emergency Services	0.023	0.678	1.054	[0.447, 2.485]	-0.011	[-0.106, 0.084]
Detention Visits	-0.014	0.693	0.861	[0.452, 1.642]	-0.013	[-0.072, 0.0453]
Behavioral Health Visits	-2.105	0.019	0.757	[0.471, 1.218]	-1.351	[-2.864, 0.161]

Bold = models are statistically significant at $p < 0.05$; * = Calculated as the raw difference in differences (i.e., deposit difference minus comparison difference) with p-value derived from unadjusted linear regression modeling. ** = Model controls for care manager type, age category, sex, race, behavioral health acuity, enrollment reason, diabetes dx, hypertension dx, copd dx, depression dx, psychosis dx, alcohol and other drug dependence, detention history, homeless status from medical record documentation, and responses to housing security screening questions.

Table 6. Difference-in-differences in 12-month healthcare utilization between deposit and matched comparison groups

Descriptive Mean Utilization (12-months)								
Outcome	Deposit Group			Comparison Group			Deposit Difference (before/after)	Comparison Difference (before/after)
	Before	After	P-value	Before	After	P-value		
Inpatient Admissions	0.315	0.181	0.003	0.370	0.184	<0.001	-0.134	-0.186
Emergency Department Visits	2.331	1.246	<0.001	2.309	1.155	<0.001	-1.085	-1.154
Primary Care Visits	5.843	2.664	<0.001	3.912	2.438	<0.001	-3.179	-1.475
Specialty Care Visits	3.291	2.117	<0.001	2.774	2.239	0.360	-1.174	-0.535
Psychiatric Emergency Services	0.278	0.136	0.140	0.239	0.106	0.029	-0.143	-0.133
Detention Visits	0.291	0.095	<0.001	0.257	0.107	0.009	-0.196	-0.150
Behavioral Health Visits	6.634	3.018	<0.001	5.027	3.849	0.260	-3.616	-1.178

Mean Utilization Models (12-months)						
Outcome	Unadjusted DID*		DID IRR**		Marginal Effect**	
	Estimate	p-value	Estimate	95% CI	Estimate	95% CI
Inpatient Admissions	0.052	0.443	1.299	[0.81,2.09]	0.068	[-0.053, 0.189]
Emergency Department Visits	0.069	0.852	0.942	[0.70,1.28]	-0.234	[-0.775, 0.307]
Primary Care Visits	-1.705	< 0.001	0.747	[0.60,0.93]	-1.644	[-2.417, -0.870]
Specialty Care Visits	-0.638	0.345	0.908	[0.60,1.39]	-0.374	[-1.468, 0.719]
Psychiatric Emergency Services	-0.010	0.93	0.754	[0.35,1.62]	-0.056	[-0.200, 0.088]
Detention Visits	-0.047	0.009	0.724	[0.39,1.33]	-0.067	[-0.183, 0.0492]
Behavioral Health Visits	-2.438	0.091	0.796	[0.48,1.32]	-1.229	[-3.631, 1.174]

Bold = models are statistically significant at $p < 0.05$; * = Calculated as raw difference-in-differences (deposit difference minus comparison difference) with p-value derived from unadjusted linear regression modeling. ** = Model controls for care manager type, age category, sex, race, behavioral health acuity, enrollment reason, diabetes dx, hypertension dx, copd dx, depression dx, psychosis dx, alcohol and other drug dependence, detention history, homeless status from medical record documentation, and responses to housing security screening questions.

4 Hospital Efforts to Address Health Related Social Needs: Associations with Potentially Preventable Hospitalizations

Objective: There is limited evidence about whether hospital efforts to address health related social needs influence quality of care. We examine associations between meal delivery, transportation to health services, mobile clinics, violence prevention programs, or extensive partnerships and potentially preventable hospitalizations.

Methods: This analysis merged 2017 Healthcare Cost Utilization Project State Inpatient Databases (HCUP-SID) with 2017 American Hospital Association survey data to analyze 6.2 million adult all-payer hospital admissions from 813 hospitals in 14 states. Potentially preventable hospitalizations were identified using the Agency for Healthcare Research and Quality's Prevention Quality Indicator composite definition. For each hospital activity to address health related social needs, relationships with potentially preventable hospitalizations were separately estimated using generalized linear regression with a logit link and inverse probability of treatment weights. Covariates included hospital ownership, size, system membership, teaching hospital status, accountable care organization participation, bundled payment participation, rurality, patient gender, age, payer, race, number of comorbidities, and zip code income quartile. Sensitivity analyses examined associations restricted to adult Medicaid and Medicare beneficiaries.

Results: 13% of hospital admissions were potentially preventable. 24% of hospitals offered transportation to health services, 16% offered mobile clinic services, 16% offered violence prevention programs in the community, and 9% offered meal delivery. 57% of hospitals had extensive partnerships.

Hospital meal delivery was associated with 1.1% lower predicted probability of a potentially preventable hospitalization (95% confidence interval (CI): -2.1% to -0.1%). Among Medicaid beneficiaries, hospital meal delivery was associated with 2.3% fewer potentially preventable hospitalizations (95% CI -3.5 to -1.0%). Associations between other activities and potentially preventable hospitalizations were not statistically significant.

Conclusions: Hospital meal delivery was associated with significantly lower probability of potential preventable hospitalizations, with larger effects for Medicaid beneficiaries. Meal delivery may be an effective strategy for managing potentially preventable utilization, especially among Medicaid beneficiaries.

4.1 Introduction

As payment reforms in U.S. healthcare shift to value-based contracting, there is greater scrutiny of hospital quality of care and efforts to support population health. Increasing evidence links burdens from health related social needs to worse health outcomes and greater hospital and emergency department use.^{105,106} Consequently, new 2023 guidance from the Centers for Medicare and Medicaid Services (CMS) encourages health systems to implement cost-effective, innovative strategies to address health-related social needs,¹³ consistent with recommendations from a 2019 National Academies of Science, Engineering and Medicine report.¹⁰⁷ Further, new quality measures will assess the extent to which patients are screened and offered assistance for health related social needs.¹¹

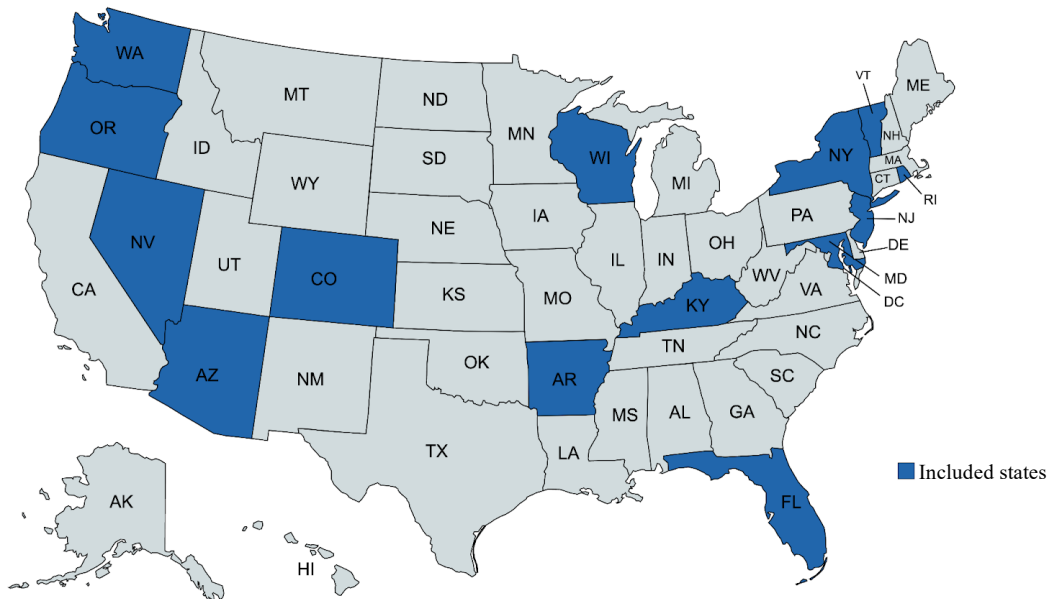
Several promising studies indicate that interventions to address health related social needs can improve health and save costs.^{21,27,108} However, the methodological quality of studies varies, with many relying on single-site small samples and lacking rigorous comparison groups.²⁰ Further, few studies have examined hospital-based efforts to address health related social needs. Hospitals are uniquely positioned to offer social needs interventions, with non-profit hospitals required to invest in community needs.^{109,110}

This study examines hospital provision of five health related social needs activities: meal delivery, transportation to health services, mobile clinics, community-oriented violence prevention programs, and partnerships with multiple stakeholders to improve population health. These activities may support preventive health behaviors or help patients overcome social barriers to care by alleviating food insecurity, expanding the ability to access care, reducing community violence and related stress, and improving connections to care in community-based settings. The main hypothesis is that each activity will be associated with improved quality of care, evidenced by fewer potentially preventable hospitalizations. A widely used health services quality indicator, the potentially preventable hospitalizations measure reflects timely and effective care coordination across the hospital, outpatient setting, and home. The measure is a composite of ten diagnoses where high-quality preventive and follow-up care may have mitigated the need for hospitalization.¹¹¹

Existing evidence on the five activities to address health related social needs has not assessed potentially preventable hospitalizations as the outcome. Studies suggest that meal delivery programs may decrease hospitalizations and emergency department visits,^{112,113} shorten length of hospital stay,¹¹³ decrease readmissions,¹¹⁴ and lower total expenditures.^{115,116} Nonemergency medical transportation interventions have improved appointment attendance rates, though there is limited evidence on subsequent utilization outcomes.¹¹⁷ Mobile clinics have been associated with avoided emergency department visits and decreased length of stay.¹¹⁸ Community-oriented violence prevention programs were found to increase quality-adjusted life years and save costs in one study, though other evaluations have found no impact.¹¹⁹ Hospital partnerships with community-based social service organizations have mixed evidence on hospital and emergency department visit outcomes.¹²⁰

Despite many studies suggesting potential efficiencies when health systems provide services that address health-related social needs, few have used large, diverse samples to assess the impact of hospital-based efforts on quality of care across multiple states. Our study makes a unique contribution with its large sample of over 6 million adult hospital admissions from 813 hospitals in 14 states (**Figure 6**).

Figure 6. Map of states included in the study sample



4.2 Methods

Data sources and study design

We conducted a cross sectional analysis of 2017 American Hospital Association annual survey responses linked to 2017 Healthcare Cost and Utilization Project State Inpatient Databases (HCUP-SID) admissions data from 14 diverse states: Arkansas, Arizona, Colorado, Florida, New Jersey, New York, Oregon, Rhode Island, Vermont, Washington, Kentucky, Maryland, Nevada, and Wisconsin. States represent diverse geographic, urban/rural, and policy environments and were selected based on the quality of HCUP-SID data available. Admissions represent all payers including Medicare, Medicaid, private insurance, and others.

The American Hospital Association (AHA) survey is a voluntary survey of all hospitals in the United States and has a response rate at or near 80%.¹²¹ We restricted the AHA data to all general medical and surgical hospitals with complete responses to survey questions about social risk-related services, resulting in 6,003,739 adult inpatient admissions across 813 hospitals.

Analysis was conducted at the admission level, with each admission classified as potentially preventable or not. Multivariate models were used to examine whether the presence of activities to address social needs at the hospital where an admission occurred was associated with the admission being potentially preventable admission.

Outcome variable

The primary outcome is whether the hospitalization was potentially preventable. Potentially preventable admissions were defined as a binary variable (yes/no) using AHRQ's Prevention Quality Indicators composite.¹¹¹ The composite classifies potentially preventable admissions based on ten primary diagnoses where the admission may have been avoided through high-quality care coordination. Diagnoses include diabetes complications, chronic obstructive pulmonary disease (COPD), asthma, hypertension, heart failure, community-acquired pneumonia, and urinary tract infection.

Independent variables

The primary independent variables are five hospital-based activities to address health related social needs, as self-reported by American Hospital Association survey respondents. The activities are: 1) meal delivery, 2) transportation to health services, 3) mobile clinics, 4) community-oriented violence prevention programs, and 5) partnerships with multiple stakeholders for population health improvement. Each activity was analyzed separately because a composite measure had a low Cronbach alpha score (alpha = 0.47), suggesting that hospitals do not implement these activities as a part of a cohesive strategy. In addition, evidence may be more actionable when examined by specific activity rather than based on a composite score.

Activities were defined as present (vs. not present) for meal delivery, transportation to health services, mobile clinics, and community-oriented violence prevention programs if the respondent indicated that the hospital owns or provides the activity. Partnership-based activity was defined as extensive (vs. not extensive) if the respondent indicated a collaboration or formal alliance with 8 or 9 of the partner categories on the AHA survey (range: 0-9 partners, median: 8 partners). Partner categories included: 1) health care providers outside your system, 2) local or state public health organizations, 3) local or state human/social service organizations, 4) other local or state government, 5) non-profit organizations, 6) faith-based organizations, 7) health insurance companies, 8) schools, and 9) local businesses or chambers of commerce.) Partnerships were analyzed dichotomously at the median due to the bimodal distribution of responses and to facilitate interpretation.

Covariates

Hospitalization-level covariates are based on HCUP admissions data and include patient sex, age (19-39, 40-64, or 65+), primary payer (private insurance, Medicare, Medicaid, or other), race (White, Black/African American, Hispanic, Asian/Pacific Islander, or other), zip-code income quartile, and Charlson Comorbidity Index (0, 1, 2, or 3+ conditions). For patients dually eligible for Medicare and Medicaid, HCUP

methodology categorizes the primary payer as Medicare in most cases.¹²² Hospital covariates are based on AHA survey responses and include ownership (public, nonprofit, for-profit), size (0-99 beds, 100-299 beds, 300+ beds), belonging to a health system, participating in an accountable care organization, participating in bundled payment, and rurality (metropolitan, micropolitan, or rural).

Statistical analysis

The association between each activity to address health related social needs and potentially preventable hospitalizations was analyzed using separate generalized linear models with a logit link for binomial outcomes and clustering by hospital.

Stabilized inverse propensity of treatment weights (IPTW) were calculated for each model to correct for the potential that hospitals may be more likely to develop social needs services and partnerships for different patient populations. The patient-level weights are based on all patient characteristics (sex, age, race, payer, zip code level income, and comorbidity index) and predict the likelihood that a patient will receive care at a hospital where the activity to address health related social needs is present. For example, many hospitals more commonly offer health related social needs activities among patients in the highest quartile of zip-code level income and less commonly offer health related social needs activities among patients in the lowest quartile of zip-code level income. To achieve balance, the weights down-weight patients in the highest quartile of zip-code level income and upweight patients in the lowest quartile of zip-code level income. Propensity scores for each independent variable had no observations were outside the region of common support. Final models incorporated IPTW weights and adjusted for both patient level and hospital level covariates. All results are reported as marginal effects, or the percentage point change in probability of a potentially preventable hospital admission.

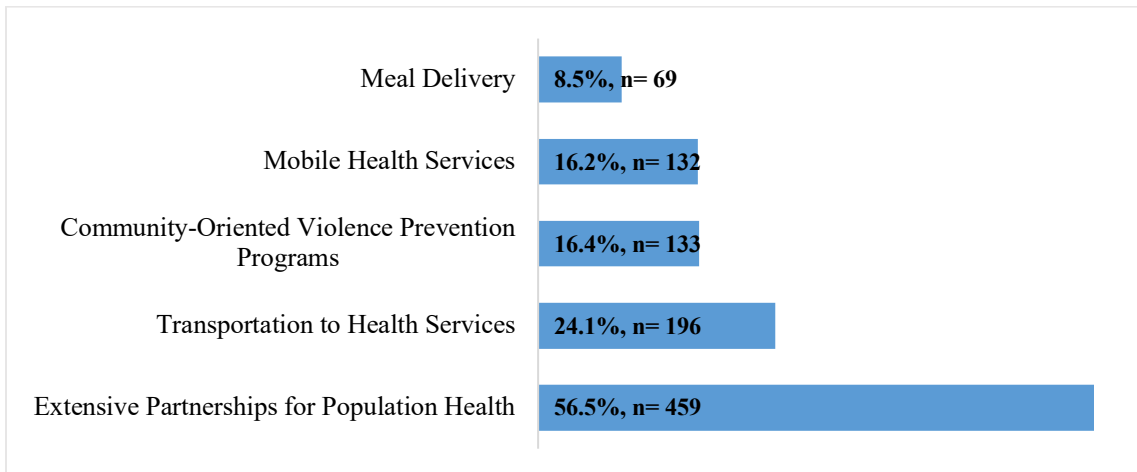
Sensitivity analyses

In sub-analyses, results specific to Medicare beneficiaries and specific to Medicaid beneficiaries were also examined. The presence of health related social needs activities was anticipated to have a stronger influence among Medicare and Medicaid beneficiaries compared to private-pay beneficiaries due to greater health related social needs among low-income and elderly populations. Additionally, the Centers for Medicare and Medicaid's present leadership in value-based contracting, and leadership over the last decade, may have supported more robust availability of health related social needs activities for Medicare and Medicaid beneficiaries.^{13,123}

4.3 Results

A minority (13.3%) of hospital admissions were classified as potentially preventable. Of the 813 hospitals, 8.6% (n=69) offered meal delivery, 24.1% (n=196) offered transportation to health services, 16.2% (n=132) offered mobile clinics, 16.4% (n=133) offered community-oriented violence prevention programs, and 56.6% (n=459) reported extensive partnerships for population health (**Figure 7**).

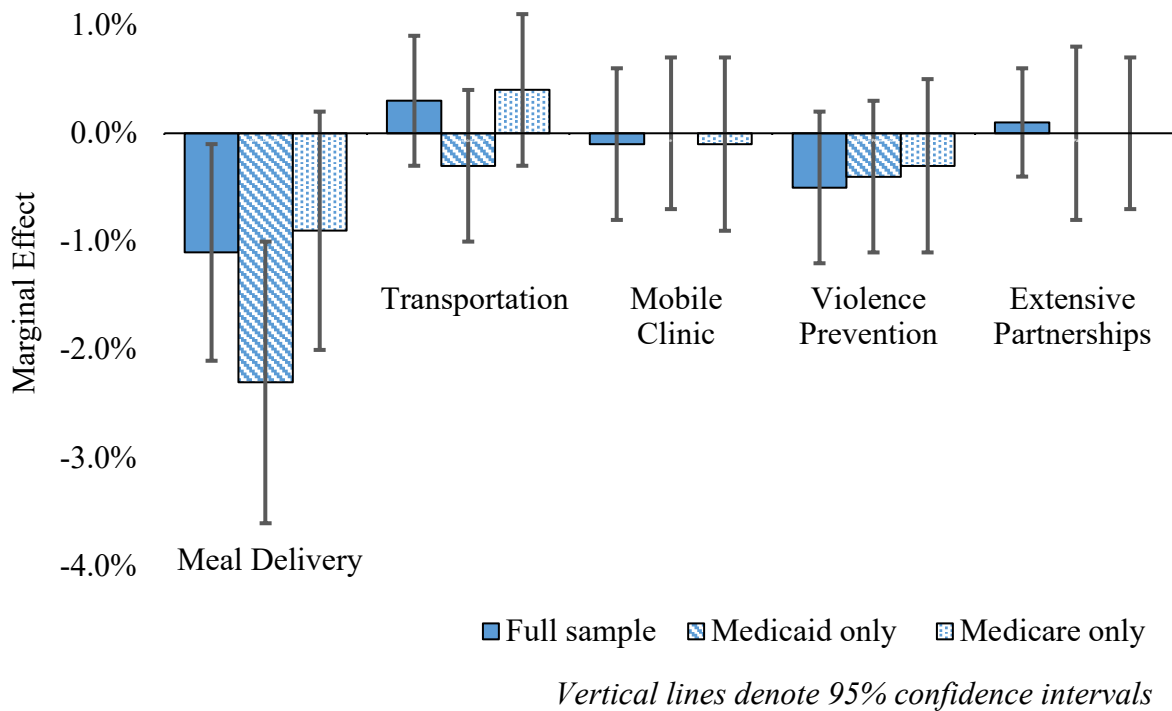
Figure 7. Prevalence of hospital efforts to address health related social needs (N = 813 hospitals)



Most patients (51.2%) were female. 49.6% were over age 65 and 37.2% were 40 to less than age 65. Over two-thirds of patients (68.3%) were White, 14.5% were Black/African American, 10.0% were Hispanic, 2.2% were Asian or Pacific Islander and 5.1% were other race/ethnicity. One-third (33.2%) had three or more comorbidities while 28.8% had none. Hospital size included small (up to 99 beds, 39.6%), medium (100-299 beds, 34.8%), and large (300+ beds, 25.6%) capacity. The payer mix included 54.0% Medicare, 16.5% Medicaid, 23.2% private insurance, and 6.3% other payer (e.g., self-pay, no charge). Most hospitals (78.4%) were not-for-profit. 70.1% of hospitals were members of a larger health system, 7.8% were academic medical centers, 44.3% were accountable care organization members, and 25.2% participated in bundled payments. 67.6% were in metropolitan areas while 17.0% were rural hospitals (**Tables 7&8**). After weighting, for each health related social needs activity, participant characteristics were mostly balanced between hospitals that offered a specific activity and hospitals that did not offer that activity (**Table 9a-e**). Across the 811 hospitals, the median number of patient admissions was 4,836 (interquartile range: 982 - 11,077).

In adjusted analyses, the marginal effect of hospital meal delivery was a 1.1% lower predicted probability of potentially preventable hospital admission (95% confidence interval: -2.1% to -0.1%). The association was slightly stronger among admissions for Medicaid beneficiaries, with a 2.3% lower predicted probability (95% confidence interval: -3.5% to -1.0%) of potentially preventable hospitalization among hospitals providing meal delivery. Among admissions for Medicare beneficiaries, the association between meal delivery and potentially preventable hospitalization was not statistically significant. There was no association between transportation to medical appointments, community-oriented violence prevention programs, mobile health clinics, or extensive partnerships and potentially preventable hospitalizations, which was consistent for Medicaid and Medicare beneficiaries (**Figure 8; Tables 10 & 11a-e**).

Figure 8. Marginal effects on potentially preventable hospitalization for each health related social need activity



4.4 Discussion

This analysis of whether hospital efforts to address health-related social needs are associated with potentially preventable hospitalizations found a small, statistically significant association with meal delivery provision, but no association with other services nor extensive partnerships. The association between meal delivery and reduced potentially preventable hospitalizations suggests that meal delivery may be an important avenue to reduce exacerbation of health conditions. Prior evidence indicates that meal delivery is potentially effective through multiple pathways including enhanced nutrition provided by the meals themselves, positive benefits from enhanced social connections with those who deliver meals, and the ability to use limited resources for other needs.¹¹⁶

124

In addition, given that meal delivery was provided by less than 9% of hospitals and was the least common activity, it is possible that meal delivery serves as an indicator of a hospital’s culture or strategy and commitment to addressing social needs. Other work has found better outcomes among organizations that innovative and develop new operations over those that follow trends,¹²⁵ and meal delivery may be a signal for a hospital at the frontier innovative, holistic patient services. In post-hoc analysis, organizations that offered meal delivery implemented a mean of 3.24 social needs activities, compared to means between 2.17 – 2.94 for hospitals implementing each of the other social needs activities (**Table 12**). Further, hospitals offering meal delivery may

have other structures and care processes that are not documented in the AHA survey, but also address health related social needs and avert avoidable hospitalizations.

One potential explanation for the lack of association between other efforts to address health-related social needs and potentially preventable hospitalizations may be low reach even when services or partnerships exist. On one hand, it is possible that services are not offered broadly and systematically. Though value-based payments may encourage hospitals and health systems to address health related social needs,¹²⁶ services may be offered to only a specific payer's patients or based on eligibility such as "high-cost/high-need" classification. On the other hand, services may have low uptake even when broadly available, as documented in clinical trials of transportation assistance.¹²⁷ It is also possible that current screening for social needs may not sufficiently uncover needs,¹²⁸ or patients may not find the services useful when offered.¹²⁹

Another consideration is that hospital efforts to address health-related social needs may impact the social determinants of health in alternate ways. For example, community-oriented violence prevention programs improve outcomes such as returning to schooling, which could have long-term dividends, but would not be captured in this study's primary outcome, potentially preventable hospitalizations.¹³⁰ Given that hospitalization is an extreme outcome, future work should also incorporate more commonly occurring outcomes than could be assessed in this study.

As CMS and others promote expansion of health related social needs activities, evidence from multiple contexts is needed. Although some hospitals and health systems have publicized strong returns on investments from activities to address health related social needs,¹³¹ our study indicates that current hospital-based implementation of health related social needs activities is not associated with fewer potentially preventable hospitalizations. Additional work is needed to better understand implementation factors and pathways to achieve better health and healthcare quality. The new quality measures on social needs screening and assistance are likely a valuable initial step for systematically documenting the reach of health related social needs interventions.

Health related social needs activities will likely need to be tested and tailored locally to meet the needs of specific settings, rather than directly replicated from programs used elsewhere.¹²⁵ Prior evidence highlights the importance of innovation capacity when implementing screening for health related social needs.¹³² Thus, to spread effective implementation of additional health related social needs activities, CMS and other stakeholders should consider investments in continuous quality improvement processes, including processes to incorporate user experience feedback.

Limitations

Our findings should be considered in light of some limitations. Data on hospital efforts to address health-related social needs is reported dichotomously at the hospital level. The reach and effectiveness of each activity to address health related social needs was not assessed. Relatedly, we cannot determine which patients received health related social needs services to understand direct impacts. In addition, potentially preventable

hospitalizations as an outcome captures healthcare quality but also depends on primary care and community resources, which may dampen the influence of hospital-based efforts to coordinate patient care. Last, we cannot draw causal conclusions given the cross-sectional data analyzed.

4.5 Conclusion

As hospitals and health systems increasingly pursue value-based care, it is commonly assumed that services and partnerships to address health related social needs will help meet cost and quality goals. Our results suggest meal delivery services may be an effective strategy for addressing health-related social needs and improving quality of care. However, the lack of association in other areas suggests that greater understanding is needed of the development and reach of hospital-based activities to address health related social needs. This additional evidence will help clarify the potential value of hospital-based activities to address health related social needs. Such evidence is especially needed as federal leadership encourages expansion health related social needs activities and in light of quality measures that will begin to hold hospitals and health systems accountable for offering such activities.

4.6 Tables

Table 7. Characteristics of hospitals in study sample

Hospital Covariate	N	%
Ownership		
Public (county, state, other gov't)	111	(13.7%)
Not-for-profit (non-gov't)	637	(78.4%)
For-profit	65	(8.0%)
Bed size (Small, Medium, Large)		
Up to 99 beds	322	(39.6%)
100 to 299 beds	283	(34.8%)
300+ beds	208	(25.6%)
Member of Larger Health System	570	(70.1%)
Teaching Hospital	63	(7.8%)
Participates in an ACO	360	(44.3%)
Participates in bundled payment	205	(25.2%)
Rurality		
Metro	550	(67.6%)
Micro	125	(15.4%)
Rural	138	(17.0%)

Table 8. Characteristics of patients in study sample, by potentially preventable admission status

	Total		Admission Not Potentially Preventable		Admission Potentially Preventable	
	N=6,003,739		N=5,207,668		N=796,071	
Sex (Female)	3,071,941	(51.2%)	2,647,539	(50.8%)	424,402	(53.3%)
Age categories						
19 to <40	789,872	(13.2%)	730,860	(14.0%)	59,012	(7.4%)
40 to < 65	2,234,405	(37.2%)	1,979,347	(38.0%)	255,058	(32.0%)
65+	2,979,462	(49.6%)	2,497,461	(48.0%)	482,001	(60.5%)
Race						
White	4,102,284	(68.3%)	3,578,229	(68.7%)	524,055	(65.8%)
Black	867,843	(14.5%)	723,943	(13.9%)	143,900	(18.1%)
Hispanic	598,180	(10.0%)	518,625	(10.0%)	79,555	(10.0%)
Asian or Pacific Islander	131,810	(2.2%)	117,086	(2.2%)	14,724	(1.8%)
Native American	28,771	(0.5%)	24,975	(0.5%)	3,796	(0.5%)
other	274,851	(4.6%)	244,810	(4.7%)	30,041	(3.8%)
Charlson Comorbidity Index						
0 comorbidities	1,729,725	(28.8%)	1,678,360	(32.2%)	51,365	(6.5%)
1 comorbidity	1,297,421	(21.6%)	1,116,442	(21.4%)	180,979	(22.7%)

	Total		Admission Not Potentially Preventable		Admission Potentially Preventable	
2 comorbidities	983,733	(16.4%)	823,487	(15.8%)	160,246	(20.1%)
3+ comorbidities	1,992,860	(33.2%)	1,589,379	(30.5%)	403,481	(50.7%)
Zip code level median household income (national quartiles)						
\$1-\$43,999	1,656,987	(27.6%)	1,403,606	(27.0%)	253,381	(31.8%)
\$44k-\$55,999	1,513,193	(25.2%)	1,307,932	(25.1%)	205,261	(25.8%)
\$56k-73,999	1,475,089	(24.6%)	1,292,841	(24.8%)	182,248	(22.9%)
74k+	1,358,470	(22.6%)	1,203,289	(23.1%)	155,181	(19.5%)
Primary Payer						
Medicare	3,244,118	(54.0%)	2,718,080	(52.2%)	526,038	(66.1%)
Medicaid	993,212	(16.5%)	873,759	(16.8%)	119,453	(15.0%)
Private Insurance	1,390,789	(23.2%)	1,280,049	(24.6%)	110,740	(13.9%)
Other (self, no charge, oth, miss)	375,620	(6.3%)	335,780	(6.4%)	39,840	(5.0%)

Table 9. Balance in patient characteristics for each health related social need activity, before and after weighting

A. Meal Delivery						
	Unweighted			Weighted		
	Mean in treated	Mean in Untreated	Standardized difference	Mean in treated	Mean in Untreated	Standardized difference
Sex: Female	0.51	0.51	0.006	0.51	0.51	0.001
Age: 19to39	0.13	0.13	-0.009	0.14	0.13	0.012
Age: 40to64	0.36	0.37	-0.028	0.37	0.37	-0.009
Age: 65plus	0.51	0.49	0.033	0.50	0.50	0.001
Race: White	0.74	0.68	0.132	0.70	0.68	0.044
Race: Black	0.12	0.15	-0.064	0.13	0.14	-0.028
Race: Hispanic	0.07	0.10	-0.133	0.09	0.10	-0.034
Race: Asian	0.02	0.02	0.004	0.02	0.02	-0.007
Race: Other	0.05	0.05	-0.001	0.05	0.05	0.003
Comorbidities: 0	0.30	0.29	0.028	0.29	0.29	0.000
Comorbidities: 1	0.22	0.22	0.002	0.22	0.22	-0.002
Comorbidities: 2	0.16	0.16	-0.003	0.16	0.16	0.002
Comorbidities: 3+	0.32	0.33	-0.026	0.33	0.33	0.000
Zip code income: low	0.20	0.28	-0.199	0.33	0.27	0.134
Zip code income: low-mid	0.18	0.26	-0.177	0.22	0.25	-0.081
Zip code income: mid-high	0.22	0.25	-0.076	0.19	0.25	-0.142
Zip code income: high	0.40	0.21	0.422	0.26	0.22	0.081
Payer: Medicare	0.55	0.54	0.017	0.54	0.54	0.007
Payer: Medicaid	0.15	0.17	-0.046	0.17	0.17	0.004
Payer: Private	0.25	0.23	0.038	0.23	0.23	-0.011
Payer: Other	0.06	0.06	-0.032	0.06	0.06	-0.001

Red text indicates standardized mean difference with absolute value greater than 0.1 (poor balance)

B. Transportation to Health Services						
	Unweighted			Weighted		
	Mean in treated	Mean in Untreated	Standardized difference	Mean in treated	Mean in Untreated	Standardized difference
Sex: Female	0.51	0.51	-0.009	0.51	0.51	-0.001
Age: 19to39	0.14	0.13	0.040	0.13	0.13	0.002
Age: 40to64	0.38	0.37	0.021	0.37	0.37	-0.003
Age: 65plus	0.48	0.50	-0.048	0.50	0.50	0.001
Race: White	0.59	0.74	-0.319	0.68	0.68	-0.002
Race: Black	0.18	0.12	0.167	0.15	0.14	0.001
Race: Hispanic	0.13	0.08	0.142	0.10	0.10	0.001
Race: Asian	0.03	0.02	0.079	0.02	0.02	0.000
Race: Other	0.07	0.03	0.162	0.05	0.04	0.022
Comorbidities: 0	0.30	0.28	0.026	0.29	0.29	0.004
Comorbidities: 1	0.21	0.22	-0.005	0.21	0.22	-0.007
Comorbidities: 2	0.16	0.16	-0.007	0.16	0.16	0.001
Comorbidities: 3+	0.33	0.33	-0.014	0.33	0.33	0.001
Zip code income: low	0.28	0.27	0.021	0.29	0.27	0.042
Zip code income: low-mid	0.23	0.26	-0.080	0.24	0.26	-0.037
Zip code income: mid-high	0.23	0.25	-0.057	0.23	0.26	-0.071
Zip code income: high	0.26	0.21	0.118	0.25	0.22	0.065
Payer: Medicare	0.52	0.55	-0.078	0.53	0.54	-0.024
Payer: Medicaid	0.18	0.16	0.075	0.17	0.16	0.018
Payer: Private	0.24	0.23	0.027	0.24	0.23	0.021
Payer: Other	0.06	0.06	-0.004	0.06	0.06	-0.015

Red text indicates standardized mean difference with absolute value greater than 0.1 (poor balance)

C. Mobile Clinic Services						
	Unweighted			Weighted		
	Mean in treated	Mean in Untreated	Standardized difference	Mean in treated	Mean in Untreated	Standardized difference
Sex: Female	0.50	0.52	-0.029	0.51	0.51	0.000
Age: 19to39	0.15	0.12	0.072	0.13	0.13	-0.006
Age: 40to64	0.39	0.36	0.058	0.38	0.37	0.011
Age: 65plus	0.46	0.51	-0.106	0.49	0.50	-0.006
Race: White	0.59	0.73	-0.284	0.68	0.68	-0.003
Race: Black	0.18	0.13	0.136	0.15	0.14	0.002
Race: Hispanic	0.13	0.08	0.163	0.10	0.10	0.001
Race: Asian	0.02	0.02	0.010	0.02	0.02	0.000
Race: Other	0.07	0.04	0.153	0.05	0.04	0.018
Comorbidities: 0	0.29	0.29	0.014	0.29	0.29	0.008
Comorbidities: 1	0.21	0.22	-0.021	0.21	0.22	-0.013
Comorbidities: 2	0.16	0.16	-0.006	0.16	0.16	0.000
Comorbidities: 3+	0.33	0.33	0.009	0.33	0.33	0.003
Zip code income: low	0.29	0.27	0.055	0.28	0.27	0.035
Zip code income: low-mid	0.23	0.26	-0.073	0.24	0.26	-0.046
Zip code income: mid-high	0.23	0.25	-0.058	0.23	0.25	-0.057
Zip code income: high	0.25	0.22	0.075	0.25	0.22	0.067
Payer: Medicare	0.50	0.56	-0.109	0.53	0.54	-0.025
Payer: Medicaid	0.19	0.16	0.086	0.17	0.16	0.009
Payer: Private	0.24	0.23	0.018	0.23	0.23	0.002
Payer: Other	0.07	0.06	0.056	0.07	0.06	0.034

Red text indicates standardized mean difference with absolute value greater than 0.1 (poor balance)

D. Community-Oriented Violence Prevention Programs						
	Unweighted			Weighted		
	Mean in treated	Mean in Untreated	Standardized difference	Mean in treated	Mean in Untreated	Standardized difference
Sex: Female	0.51	0.51	-0.013	0.51	0.51	-0.002
Age: 19to39	0.14	0.13	0.050	0.13	0.13	0.000
Age: 40to64	0.39	0.37	0.040	0.38	0.37	0.013
Age: 65plus	0.47	0.51	-0.073	0.49	0.50	-0.012
Race: White	0.60	0.72	-0.243	0.68	0.68	-0.011
Race: Black	0.17	0.13	0.095	0.15	0.15	0.008
Race: Hispanic	0.12	0.09	0.114	0.10	0.10	0.005
Race: Asian	0.03	0.02	0.034	0.02	0.02	0.004
Race: Other	0.08	0.03	0.185	0.05	0.04	0.021
Comorbidities: 0	0.29	0.29	0.002	0.29	0.29	0.010
Comorbidities: 1	0.21	0.22	-0.023	0.21	0.22	-0.012
Comorbidities: 2	0.16	0.16	0.000	0.16	0.16	0.001
Comorbidities: 3+	0.34	0.33	0.018	0.33	0.33	0.001
Zip code income: low	0.28	0.28	0.000	0.30	0.26	0.089
Zip code income: low-mid	0.20	0.27	-0.163	0.22	0.26	-0.110
Zip code income: mid-high	0.23	0.25	-0.049	0.22	0.26	-0.081
Zip code income: high	0.29	0.20	0.211	0.26	0.22	0.096
Payer: Medicare	0.51	0.55	-0.084	0.53	0.54	-0.026
Payer: Medicaid	0.19	0.16	0.083	0.18	0.16	0.041
Payer: Private	0.25	0.23	0.048	0.24	0.23	0.021
Payer: Other	0.06	0.07	-0.040	0.05	0.07	-0.049

Red text indicates standardized mean difference with absolute value greater than 0.1 (poor balance)

E. Extensive Partnerships for Population Health						
	Unweighted			Weighted		
	Mean in treated	Mean in Untreated	Standardized difference	Mean in treated	Mean in Untreated	Standardized difference
Sex: Female	0.51	0.51	-0.008	0.51	0.51	0.002
Age: 19to39	0.13	0.13	0.023	0.13	0.13	-0.010
Age: 40to64	0.37	0.37	0.019	0.37	0.37	0.004
Age: 65plus	0.49	0.51	-0.034	0.50	0.49	0.003
Race: White	0.66	0.73	-0.152	0.68	0.68	0.016
Race: Black	0.15	0.12	0.094	0.14	0.15	-0.007
Race: Hispanic	0.11	0.09	0.069	0.10	0.10	-0.007
Race: Asian	0.02	0.02	0.044	0.02	0.02	0.000
Race: Other	0.05	0.04	0.052	0.05	0.05	-0.010
Comorbidities: 0	0.29	0.29	-0.016	0.29	0.29	-0.003
Comorbidities: 1	0.21	0.22	-0.015	0.22	0.22	0.000
Comorbidities: 2	0.16	0.16	0.001	0.16	0.16	0.001
Comorbidities: 3+	0.34	0.32	0.028	0.33	0.33	0.001
Zip code income: low	0.26	0.32	-0.128	0.28	0.26	0.052
Zip code income: low-mid	0.24	0.29	-0.119	0.25	0.27	-0.049
Zip code income: mid-high	0.25	0.24	0.021	0.24	0.27	-0.064
Zip code income: high	0.26	0.15	0.252	0.23	0.21	0.064
Payer: Medicare	0.53	0.56	-0.055	0.54	0.54	-0.015
Payer: Medicaid	0.17	0.15	0.059	0.17	0.16	0.040
Payer: Private	0.24	0.22	0.050	0.23	0.23	0.020
Payer: Other	0.06	0.07	-0.063	0.06	0.07	-0.062

Red text indicates standardized mean difference with absolute value greater than 0.1 (poor balance)

Table 10. Marginal effect for each activity to address health related social needs (percentage point change in probability of potentially preventable admission when activity is present)

GLM Models	Overall			Medicaid			Medicare		
	Marginal Effect	95% CI LL	95% CI UL	Marginal Effect	95% CI LL	95% CI UL	Marginal Effect	95% CI LL	95% CI UL
Meal Delivery	-1.1	-2.1	-0.1	-2.3	-3.5	-1.0	-0.9	-2.1	0.2
Transportation to Medical Appointments	0.3	-0.4	0.9	-0.3	-1.0	0.4	0.4	-0.3	1.1
Community-Oriented Violence Prevention Programs	-0.5	-0.2	0.2	-0.4	-1.1	0.3	-0.3	-1.1	0.5
Mobile Health Clinic	-0.1	-0.8	0.6	0.0	-0.7	0.7	-0.1	-0.9	0.7
Extensive Partnerships	0.1	-0.5	0.6	0.0	-0.7	0.8	0.0	-0.7	0.7

*All models control for gender, age category, race, zip code level income, comorbidities, payer, ownership, beds, system, teaching, accountable care organization participation, bundled payment participation, and rurality.

CI = confidence interval, LL = lower limit; UL = upper limit

Table 11. Associations between potentially preventable hospitalizations and each hospital-based activity to address health related social needs (with odds ratios for all covariates modeled)

A. Meal Delivery						
	Full sample		Medicaid Only		Medicare Only	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Meal Delivery	0.905*	[0.825,0.993]	0.794***	[0.697,0.904]	0.931	[0.851,1.019]
Sex: Female	1.129***	[1.118,1.140]	1.133***	[1.103,1.165]	1.146***	[1.135,1.157]
Age: 19to39	1	[1,1]	1	[1,1]	1	[1,1]
Age: 40to64	0.994	[0.962,1.026]	1.005	[0.967,1.045]	1.264***	[1.208,1.323]
Age: 65+	1.124***	[1.081,1.169]	1.279***	[1.202,1.361]	1.315***	[1.251,1.383]
Race: White	1	[1,1]	1	[1,1]	1	[1,1]
Race: Black	1.424***	[1.378,1.471]	1.461***	[1.394,1.530]	1.277***	[1.237,1.319]
Race: Hispanic	1.174***	[1.123,1.227]	1.115***	[1.048,1.186]	1.178***	[1.127,1.233]
Race: Asian	0.957	[0.855,1.072]	0.963	[0.833,1.112]	0.949	[0.845,1.067]
Race: Other	0.975	[0.931,1.021]	0.99	[0.928,1.055]	0.966	[0.916,1.019]
Zip code income: low	1	[1,1]	1	[1,1]	1	[1,1]
Zip code income: low-mid	0.925***	[0.897,0.953]	0.923***	[0.885,0.963]	0.941***	[0.913,0.970]
Zip code income: mid-high	0.878***	[0.849,0.907]	0.875***	[0.836,0.917]	0.902***	[0.873,0.933]
Zip code income: high	0.865***	[0.823,0.910]	0.843***	[0.787,0.902]	0.912***	[0.869,0.957]
Comorbidities: 0	1	[1,1]	1	[1,1]	1	[1,1]
Comorbidities: 1	4.974***	[4.837,5.115]	7.148***	[6.764,7.553]	3.727***	[3.630,3.827]
Comorbidities: 2	5.929***	[5.717,6.149]	9.913***	[9.261,10.61]	4.483***	[4.341,4.630]
Comorbidities: 3+	7.547***	[7.259,7.847]	9.949***	[9.252,10.70]	6.087***	[5.869,6.313]
Payer: Medicare	1	[1,1]				
Payer: Medicaid	1.002	[0.977,1.028]				
Payer: Private	0.715***	[0.695,0.735]				

Payer: Other	0.98	[0.941,1.020]				
Ownership: Public	1	[1,1]	1	[1,1]	1	[1,1]
Ownership: Non-profit	1.012	[0.935,1.096]	1.063	[0.945,1.196]	0.979	[0.907,1.056]
Ownership: For-profit	1.011	[0.905,1.130]	1.134	[0.978,1.316]	0.98	[0.878,1.093]
Size: 0-99 beds	1	[1,1]	1	[1,1]	1	[1,1]
Size: 100-299 beds	0.795***	[0.727,0.869]	0.771***	[0.681,0.872]	0.808***	[0.740,0.882]
Size: 300+ beds	0.714***	[0.652,0.782]	0.684***	[0.601,0.780]	0.734***	[0.672,0.802]
Part of a system	1.032	[0.970,1.098]	1.089	[0.995,1.191]	1.012	[0.951,1.076]
Teaching hospital	0.805***	[0.741,0.876]	0.804***	[0.739,0.874]	0.832***	[0.769,0.901]
ACO participant	0.981	[0.933,1.033]	0.995	[0.934,1.061]	0.966	[0.920,1.015]
Bundled payment participant	0.997	[0.942,1.057]	1.017	[0.952,1.085]	0.989	[0.937,1.044]
Rurality: Metropolitan	1	[1,1]	1	[1,1]	1	[1,1]
Rurality: Micropolitan	1.175***	[1.069,1.292]	1.162*	[1.029,1.312]	1.159**	[1.060,1.267]
Rurality: Rural	1.736***	[1.422,2.118]	1.462**	[1.116,1.915]	1.754***	[1.452,2.119]

* = $p < 0.05$; ** = $p < 0.01$ *** = $p < 0.001$

B. Transportation to Medical Appointments						
	Full sample		Medicaid Only		Medicare Only	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Transportation	1.024	[0.966,1.087]	0.969	[0.900,1.043]	1.031	[0.974,1.091]
Sex: Female	1.128***	[1.117,1.139]	1.130***	[1.100,1.161]	1.146***	[1.135,1.157]
Age: 19to39	1	[1,1]	1	[1,1]	1	[1,1]
Age: 40to64	0.991	[0.960,1.023]	1.002	[0.965,1.041]	1.256***	[1.200,1.315]
Age: 65+	1.120***	[1.077,1.164]	1.272***	[1.192,1.357]	1.306***	[1.242,1.374]
Race: White	1	[1,1]	1	[1,1]	1	[1,1]
Race: Black	1.418***	[1.373,1.464]	1.472***	[1.408,1.538]	1.270***	[1.230,1.310]
Race: Hispanic	1.168***	[1.115,1.224]	1.117***	[1.053,1.185]	1.170***	[1.115,1.228]

Race: Asian	0.933	[0.851,1.023]	0.941	[0.823,1.077]	0.924	[0.843,1.014]
Race: Other	0.958*	[0.918,0.999]	0.976	[0.916,1.039]	0.951*	[0.906,0.998]
Zip code income: low	1	[1,1]	1	[1,1]	1	[1,1]
Zip code income: low-mid	0.924***	[0.897,0.952]	0.920***	[0.882,0.958]	0.939***	[0.912,0.968]
Zip code income: mid-high	0.876***	[0.848,0.905]	0.867***	[0.829,0.907]	0.900***	[0.871,0.931]
Zip code income: high	0.863***	[0.822,0.907]	0.826***	[0.772,0.885]	0.912***	[0.869,0.956]
Comorbidities: 0	1	[1,1]	1	[1,1]	1	[1,1]
Comorbidities: 1	4.998***	[4.863,5.136]	7.234***	[6.864,7.624]	3.741***	[3.646,3.838]
Comorbidities: 2	5.965***	[5.752,6.186]	10.06***	[9.418,10.75]	4.504***	[4.362,4.650]
Comorbidities: 3+	7.586***	[7.295,7.889]	10.09***	[9.399,10.84]	6.112***	[5.895,6.338]
Payer: Medicare	1	[1,1]				
Payer: Medicaid	1.004	[0.980,1.029]				
Payer: Private	0.714***	[0.694,0.734]				
Payer: Other	0.984	[0.943,1.026]				
Ownership: Public	1	[1,1]	1	[1,1]	1	[1,1]
Ownership: Non-profit	1.002	[0.927,1.084]	1.062	[0.945,1.193]	0.969	[0.899,1.044]
Ownership: For-profit	1.004	[0.899,1.122]	1.134	[0.976,1.317]	0.973	[0.870,1.087]
Size: 0-99 beds	1	[1,1]	1	[1,1]	1	[1,1]
Size: 100-299 beds	0.804***	[0.740,0.874]	0.779***	[0.692,0.878]	0.817***	[0.753,0.888]
Size: 300+ beds	0.723***	[0.663,0.788]	0.699***	[0.617,0.792]	0.743***	[0.682,0.808]
Part of a system	1.027	[0.967,1.092]	1.065	[0.977,1.162]	1.01	[0.950,1.074]
Teaching hospital	0.800***	[0.732,0.873]	0.801***	[0.734,0.875]	0.825***	[0.760,0.896]
ACO participant	0.982	[0.930,1.036]	1.004	[0.941,1.071]	0.965	[0.917,1.016]
Bundled payment participant	0.995	[0.938,1.055]	1.01	[0.945,1.079]	0.99	[0.937,1.046]
Rurality: Metropolitan	1	[1,1]	1	[1,1]	1	[1,1]
Rurality: Micropolitan	1.156**	[1.055,1.266]	1.145*	[1.022,1.282]	1.143**	[1.047,1.248]
Rurality: Rural	1.774***	[1.489,2.114]	1.475**	[1.132,1.922]	1.799***	[1.526,2.119]

* = p < 0.05; ** = p < 0.01 *** = p < 0.001

C. Mobile Clinics						
	Full sample		Medicaid Only		Medicare Only	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Mobile Clinics	0.991	[0.931,1.055]	0.998	[0.928,1.073]	0.992	[0.934,1.054]
Sex: Female	1.129***	[1.118,1.140]	1.134***	[1.103,1.165]	1.146***	[1.135,1.158]
Age: 19to39	1	[1,1]	1	[1,1]	1	[1,1]
Age: 40to64	0.991	[0.960,1.023]	1.002	[0.964,1.041]	1.257***	[1.201,1.316]
Age: 65+	1.119***	[1.077,1.164]	1.271***	[1.195,1.352]	1.307***	[1.243,1.374]
Race: White	1	[1,1]	1	[1,1]	1	[1,1]
Race: Black	1.421***	[1.376,1.468]	1.462***	[1.394,1.532]	1.274***	[1.235,1.315]
Race: Hispanic	1.173***	[1.125,1.224]	1.113***	[1.050,1.180]	1.178***	[1.127,1.231]
Race: Asian	0.956	[0.854,1.072]	0.963	[0.829,1.119]	0.947	[0.843,1.063]
Race: Other	0.965	[0.924,1.008]	0.972	[0.913,1.035]	0.955	[0.910,1.003]
Zip code income: low	1	[1,1]	1	[1,1]	1	[1,1]
Zip code income: low-mid	0.926***	[0.898,0.954]	0.924***	[0.886,0.963]	0.942***	[0.914,0.970]
Zip code income: mid-high	0.878***	[0.849,0.907]	0.872***	[0.834,0.913]	0.903***	[0.874,0.933]
Zip code income: high	0.867***	[0.826,0.911]	0.839***	[0.784,0.899]	0.915***	[0.873,0.959]
Comorbidities: 0	1	[1,1]	1	[1,1]	1	[1,1]
Comorbidities: 1	4.986***	[4.848,5.127]	7.191***	[6.810,7.593]	3.735***	[3.637,3.836]
Comorbidities: 2	5.959***	[5.745,6.181]	10.03***	[9.370,10.75]	4.500***	[4.358,4.646]
Comorbidities: 3+	7.581***	[7.289,7.885]	10.10***	[9.387,10.86]	6.108***	[5.890,6.334]
Payer: Medicare	1	[1,1]				
Payer: Medicaid	1.004	[0.979,1.029]				
Payer: Private	0.715***	[0.695,0.735]				

Payer: Other	0.977	[0.940,1.017]				
Ownership: Public	1	[1,1]	1	[1,1]	1	[1,1]
Ownership: Non-profit	1.006	[0.929,1.089]	1.056	[0.941,1.185]	0.976	[0.904,1.055]
Ownership: For-profit	1.005	[0.899,1.123]	1.131	[0.976,1.311]	0.976	[0.873,1.091]
Size: 0-99 beds	1	[1,1]	1	[1,1]	1	[1,1]
Size: 100-299 beds	0.807***	[0.742,0.877]	0.782***	[0.690,0.887]	0.820***	[0.756,0.890]
Size: 300+ beds	0.724***	[0.664,0.789]	0.697***	[0.609,0.797]	0.745***	[0.684,0.810]
Part of a system	1.032	[0.971,1.097]	1.076	[0.982,1.179]	1.015	[0.955,1.078]
Teaching hospital	0.805***	[0.740,0.876]	0.798***	[0.732,0.871]	0.835***	[0.771,0.904]
ACO participant	0.986	[0.936,1.039]	1.003	[0.941,1.070]	0.97	[0.921,1.021]
Bundled payment participant	0.993	[0.938,1.052]	1.011	[0.946,1.079]	0.988	[0.935,1.044]
Rurality: Metropolitan	1	[1,1]	1	[1,1]	1	[1,1]
Rurality: Micropolitan	1.158**	[1.061,1.265]	1.148*	[1.023,1.289]	1.146**	[1.053,1.248]
Rurality: Rural	1.763***	[1.476,2.105]	1.467**	[1.121,1.919]	1.791***	[1.518,2.113]

* = p < 0.05; ** = p < 0.01 *** = p < 0.001

D. Community-Oriented Violence Prevention Programs						
	Full sample		Medicaid Only		Medicare Only	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Violence Prevention	0.958	[0.898,1.022]	0.962	[0.895,1.034]	0.978	[0.918,1.041]
Sex: Female	1.129***	[1.118,1.140]	1.134***	[1.103,1.165]	1.146***	[1.135,1.158]
Age: 19to39	1	[1,1]	1	[1,1]	1	[1,1]
Age: 40to64	0.991	[0.960,1.023]	1.002	[0.964,1.041]	1.257***	[1.201,1.316]
Age: 65+	1.119***	[1.077,1.164]	1.271***	[1.195,1.352]	1.307***	[1.243,1.374]
Race: White	1	[1,1]	1	[1,1]	1	[1,1]
Race: Black	1.421***	[1.376,1.468]	1.462***	[1.394,1.532]	1.274***	[1.235,1.315]
Race: Hispanic	1.173***	[1.125,1.224]	1.113***	[1.050,1.180]	1.178***	[1.127,1.231]

Race: Asian	0.956	[0.854,1.072]	0.963	[0.829,1.119]	0.947	[0.843,1.063]
Race: Other	0.965	[0.924,1.008]	0.972	[0.913,1.035]	0.955	[0.910,1.003]
Zip code income: low	1	[1,1]	1	[1,1]	1	[1,1]
Zip code income: low-mid	0.926***	[0.898,0.954]	0.924***	[0.886,0.963]	0.942***	[0.914,0.970]
Zip code income: mid-high	0.878***	[0.849,0.907]	0.872***	[0.834,0.913]	0.903***	[0.874,0.933]
Zip code income: high	0.867***	[0.826,0.911]	0.839***	[0.784,0.899]	0.915***	[0.873,0.959]
Comorbidities: 0	1	[1,1]	1	[1,1]	1	[1,1]
Comorbidities: 1	4.986***	[4.848,5.127]	7.191***	[6.810,7.593]	3.735***	[3.637,3.836]
Comorbidities: 2	5.959***	[5.745,6.181]	10.03***	[9.370,10.75]	4.500***	[4.358,4.646]
Comorbidities: 3+	7.581***	[7.289,7.885]	10.10***	[9.387,10.86]	6.108***	[5.890,6.334]
Payer: Medicare	1	[1,1]				
Payer: Medicaid	1.004	[0.979,1.029]				
Payer: Private	0.715***	[0.695,0.735]				
Payer: Other	0.977	[0.940,1.017]				
Ownership: Public	1	[1,1]	1	[1,1]	1	[1,1]
Ownership: Non-profit	1.006	[0.929,1.089]	1.056	[0.941,1.185]	0.976	[0.904,1.055]
Ownership: For-profit	1.005	[0.899,1.123]	1.131	[0.976,1.311]	0.976	[0.873,1.091]
Size: 0-99 beds	1	[1,1]	1	[1,1]	1	[1,1]
Size: 100-299 beds	0.807***	[0.742,0.877]	0.782***	[0.690,0.887]	0.820***	[0.756,0.890]
Size: 300+ beds	0.724***	[0.664,0.789]	0.697***	[0.609,0.797]	0.745***	[0.684,0.810]
Part of a system	1.032	[0.971,1.097]	1.076	[0.982,1.179]	1.015	[0.955,1.078]
Teaching hospital	0.805***	[0.740,0.876]	0.798***	[0.732,0.871]	0.835***	[0.771,0.904]
ACO participant	0.986	[0.936,1.039]	1.003	[0.941,1.070]	0.97	[0.921,1.021]
Bundled payment participant	0.993	[0.938,1.052]	1.011	[0.946,1.079]	0.988	[0.935,1.044]
Rurality: Metropolitan	1	[1,1]	1	[1,1]	1	[1,1]
Rurality: Micropolitan	1.158**	[1.061,1.265]	1.148*	[1.023,1.289]	1.146**	[1.053,1.248]
Rurality: Rural	1.763***	[1.476,2.105]	1.467**	[1.121,1.919]	1.791***	[1.518,2.113]

* = p < 0.05; ** = p < 0.01 *** = p < 0.001

E. Extensive Partnerships for Population Health Improvement						
	Full sample		Medicaid Only		Medicare Only	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Extensive Partnerships	1.006	[0.954,1.061]	1.003	[0.929,1.084]	1.001	[0.949,1.055]
Sex: Female	1.129***	[1.118,1.141]	1.132***	[1.101,1.163]	1.147***	[1.136,1.158]
Age: 19to39	1	[1,1]	1	[1,1]	1	[1,1]
Age: 40to64	0.994	[0.963,1.026]	1.005	[0.967,1.045]	1.264***	[1.207,1.325]
Age: 65+	1.126***	[1.082,1.172]	1.291***	[1.210,1.376]	1.319***	[1.253,1.388]
Race: White	1	[1,1]	1	[1,1]	1	[1,1]
Race: Black	1.424***	[1.378,1.472]	1.466***	[1.397,1.537]	1.278***	[1.237,1.320]
Race: Hispanic	1.176***	[1.123,1.230]	1.117***	[1.048,1.191]	1.180***	[1.126,1.236]
Race: Asian	0.948	[0.853,1.054]	0.947	[0.823,1.090]	0.938	[0.841,1.047]
Race: Other	0.979	[0.934,1.025]	0.994	[0.927,1.066]	0.969	[0.920,1.020]
Zip code income: low	1	[1,1]	1	[1,1]	1	[1,1]
Zip code income: low-mid	0.926***	[0.898,0.954]	0.924***	[0.885,0.964]	0.941***	[0.913,0.970]
Zip code income: mid-high	0.878***	[0.849,0.908]	0.871***	[0.831,0.913]	0.903***	[0.873,0.934]
Zip code income: high	0.859***	[0.818,0.903]	0.822***	[0.766,0.881]	0.910***	[0.867,0.954]
Comorbidities: 0	1	[1,1]	1	[1,1]	1	[1,1]
Comorbidities: 1	5.007***	[4.867,5.151]	7.204***	[6.805,7.627]	3.744***	[3.646,3.843]
Comorbidities: 2	5.973***	[5.755,6.198]	10.02***	[9.328,10.76]	4.503***	[4.359,4.652]
Comorbidities: 3+	7.602***	[7.306,7.909]	10.02***	[9.290,10.82]	6.129***	[5.907,6.358]
Payer: Medicare	1	[1,1]				
Payer: Medicaid	1.005	[0.979,1.031]				
Payer: Private	0.715***	[0.696,0.735]				
Payer: Other	0.981	[0.941,1.021]				
Ownership: Public	1	[1,1]	1	[1,1]	1	[1,1]

Ownership: Non-profit	1.003	[0.925,1.088]	1.053	[0.932,1.189]	0.971	[0.899,1.050]
Ownership: For-profit	0.995	[0.886,1.117]	1.12	[0.955,1.314]	0.964	[0.860,1.082]
Size: 0-99 beds	1	[1,1]	1	[1,1]	1	[1,1]
Size: 100-299 beds	0.805***	[0.743,0.874]	0.774***	[0.682,0.878]	0.820***	[0.757,0.888]
Size: 300+ beds	0.718***	[0.660,0.781]	0.685***	[0.599,0.783]	0.740***	[0.681,0.803]
Part of a system	1.03	[0.970,1.095]	1.08	[0.986,1.182]	1.011	[0.951,1.073]
Teaching hospital	0.806***	[0.740,0.876]	0.802***	[0.734,0.877]	0.834***	[0.770,0.903]
ACO participant	0.987	[0.936,1.040]	1.008	[0.946,1.074]	0.97	[0.921,1.021]
Bundled payment participant	0.996	[0.940,1.055]	1.012	[0.947,1.082]	0.99	[0.937,1.045]
Rurality: Metropolitan	1	[1,1]	1	[1,1]	1	[1,1]
Rurality: Micropolitan	1.156**	[1.058,1.264]	1.140*	[1.011,1.285]	1.146**	[1.052,1.249]
Rurality: Rural	1.782***	[1.510,2.103]	1.485**	[1.148,1.922]	1.807***	[1.547,2.111]

* = p < 0.05; ** = p < 0.01 *** = p < 0.001

Table 12. Mean number of activities to address health related social needs when each activity is present

Activity that is present	Mean # Activities (Range: 1-5)	95% Confidence Interval
Meal delivery	3.24	3.236-3.243
Transportation to medical appointments	2.82	2.817-2.820
Mobile clinic	2.82	2.823-2.826
Community-oriented violence prevention	2.94	2.941-2.945
Extensive partnerships	2.17	2.170-2.172

5 Conclusion

This dissertation contributes new evidence on health system efforts to address health related social needs for several key outcomes. Specifically, the first paper examined Covid-19 vaccination among people offered case management for health and social needs. The second paper leverages the same case management program to compare changes in healthcare services use among people who received a housing deposit with case management services versus case management services alone. Last, the third paper examined five different hospital-based activities to support health related social needs and their associations with potentially preventable hospitalizations.

These studies yield promising results. The first paper identified that people offered case management during the first year of the Covid-19 pandemic received Covid-19 vaccination at higher rates compared to those not offered case management. Results highlight how case management program infrastructure played a vital role in a time of public health crisis, drawing on case managers' existing experience in building trust and navigating healthcare and social services systems. The finding of spillover public health effects adds to earlier research, which identified significantly fewer hospitalizations among the intervention group.²⁶ The second paper found that receiving a housing deposit in addition to case management was associated with greater decreases in primary care relative to a comparison group that received case management alone. Given high pre-intervention levels of primary care use among deposit recipients, the decrease suggests that deposit recipients experienced meaningful health improvements. Last, in the third paper, hospital-provided meal delivery was associated with fewer potentially preventable hospital admissions based on a large sample of geographically diverse hospitalizations, adding to existing positive evidence for meal delivery programs.¹¹²⁻¹¹⁶

Although promising, study results also point to a need for caution about what health related social needs interventions can realistically achieve. For example, analysis of case management and Covid-19 vaccination suggests that case management operations may need to be supplemented with focused outreach strategies to boost vaccination among disadvantaged subpopulations. In addition, analysis of housing deposits did not identify changes in acute care use, which would be necessary to achieve common expectations of cost-neutrality or cost-savings. Last, several hospital-based social needs activities were not associated with potentially preventable hospitalizations, indicating a need to clarify intervention designs and reach.

Findings from this work provide timely evidence for policy makers and health system leaders who may be considering further investments and program development to address health related social needs. In particular, the Centers for Medicare and Medicaid Services' section 1115 demonstration waivers establish unique opportunities for states to offer new Medicaid benefits for services not traditionally considered medical care. In addition, new quality measures will begin to track the extent to which health systems inquire about health related social needs and offer assistance.

As noted in the conceptual model, future work in this area should also consider the external environment, patient demographics, and organizational traits in addition to the direct relationship between health related social needs interventions and key outcomes. Conditions in the external environment including state-level policies and local factors like housing supply may have heavy influences intervention design and effectiveness. Meanwhile certain patient demographics such as Medicaid eligibility may help identify patients for whom some interventions may be more impactful, as observed for hospital meal delivery. In contrast, patients with other demographics like comorbid behavioral health conditions may require more intensive services, as observed in the housing deposit population. Last, organizational characteristics including slack resources, data integration, and an underlying culture or strategy of addressing health related social needs can also support intervention effectiveness.

In summary, this dissertation has examined interventions to address health related social needs from three different angles. Collectively, these papers indicate that health system efforts to address health related social needs hold promise. Nevertheless, opportunities remain to better understand the factors that enable implementation effectiveness. Interventions may require continued tailoring to meet the needs of specific patient populations and local communities.

6 References

1. Corburn J. “Chapter 2: The City in the Field”. *Toward the Healthy City*. MIT Press; 2009:39-43.
2. Bensken WP, Alberti PM, Koroukian SM. Health-Related Social Needs and Increased Readmission Rates: Findings from the Nationwide Readmissions Database. *Journal of General Internal Medicine*. 2021/05/01 2021;36(5):1173-1180. doi:10.1007/s11606-021-06646-3
3. Holcomb J, Highfield L, Ferguson GM, Morgan RO. Association of Social Needs and Healthcare Utilization Among Medicare and Medicaid Beneficiaries in the Accountable Health Communities Model. *Journal of General Internal Medicine*. 2022/11/01 2022;37(14):3692-3699. doi:10.1007/s11606-022-07403-w
4. Cole MB, Nguyen KH. Unmet social needs among low-income adults in the United States: Associations with health care access and quality. *Health Serv Res*. Oct 2020;55 Suppl 2(Suppl 2):873-882. doi:10.1111/1475-6773.13555
5. Heller CG, Rehm CD, Parsons AH, Chambers EC, Hollingsworth NH, Fiori KP. The association between social needs and chronic conditions in a large, urban primary care population. *Preventive Medicine*. 2021/12/01/ 2021;153:106752. doi:<https://doi.org/10.1016/j.ypmed.2021.106752>
6. De Lew N, Sommers BD. Addressing Social Determinants of Health in Federal Programs. *JAMA Health Forum*. 2022;3(3):e221064-e221064. doi:10.1001/jamahealthforum.2022.1064
7. National Association of Community Health Centers. *Section 1115 Waiver Transparency Process*. 2013. <http://www.nachc.org/wp-content/uploads/2015/11/WAIVERTransparency.pdf>
8. Centers for Medicare & Medicaid Services. About Section 1115 Demonstrations. Accessed 4 Dec 2019, 2019. <https://www.medicaid.gov/medicaid/section-1115-demo/about-1115/index.html>
9. Kaiser Family Foundation. Medicaid Waiver Tracker: Approved and Pending Section 1115 Waivers by State. Updated 23 June 2023. Accessed 7 July, 2023 <https://www.kff.org/medicaid/issue-brief/medicaid-waiver-tracker-approved-and-pending-section-1115-waivers-by-state/>
10. CMS Quality Payment Program. Quality ID #487: Screening for Social Drivers of Health, Version 7.0. Updated November 2022. Accessed 22 June, 2022. https://qpp.cms.gov/docs/QPP_quality_measure_specifications/CQM-Measures/2023_Measure_487_MIPSCQM.pdf
11. National Committee for Quality Assurance (NCQA). Social Need: New HEDIS Measure Uses Electronic Data to Look at Screening, Intervention. . Updated 02 November 2022. Accessed 22 June, 2023. <https://www.ncqa.org/blog/social-need-new-hedis-measure-uses-electronic-data-to-look-at-screening-intervention/>

12. DiMaggio PJ, Powell WW. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American sociological review*. 1983;147-160.
13. Centers for Medicare & Medicaid Services. HHS Offers States Flexibility to Better Address Medicaid Enrollees' Needs. Updated 04 Jan 2023. Accessed 24 May, 2023. <https://www.cms.gov/newsroom/press-releases/hhs-offers-states-flexibility-better-address-medicare-enrollees-needs>
14. Gusoff G, Fichtenberg C, Gottlieb LM. Professional medical association policy statements on social health assessments and interventions. *The Permanente journal*. 2018;22
15. Byhoff E, Kangovi S, Berkowitz SA, et al. A Society of General Internal Medicine Position Statement on the Internists' Role in Social Determinants of Health. *Journal of General Internal Medicine*. 2020/09/01 2020;35(9):2721-2727. doi:10.1007/s11606-020-05934-8
16. Monegain B. Social determinants of health gain traction as UnitedHealthcare and Intermountain build new programs. *Healthcare IT News*. 2018. Accessed 7 July 2023. <https://www.healthcareitnews.com/news/social-determinants-health-gain-traction-unitedhealthcare-and-intermountain-build-new-programs>
17. Pfeffer J, Salancik G. *External Control of Organizations—Resource Dependence Perspective*. Harper & Row; 1978.
18. Williamson O. The economics of organization: the transaction cost approach. *American Journal of Sociology*; 1981. p. 548-77.
19. Frazee TK, Beidler LB, Savitz LA. "It's Not Just the Right Thing... It's a Survival Tactic": Disentangling Leaders' Motivations and Worries on Social Care. *Medical Care Research and Review*. 2021;10775587211057673.
20. Gottlieb LM, Wing H, Adler NE. A systematic review of interventions on patients' social and economic needs. *American Journal of Preventive Medicine*. 2017;53(5):719-729.
21. Tsega M, Lewis C, McCarthy D, Shah Ta, Coutts K. *Review of Evidence for Health-Related Social Needs Interventions*. 2019. https://www.commonwealthfund.org/sites/default/files/2019-07/COMBINED_ROI_EVIDENCE_REVIEW_7.15.19.pdf
22. Hopman P, De Bruin SR, Forjaz MJ, et al. Effectiveness of comprehensive care programs for patients with multiple chronic conditions or frailty: a systematic literature review. *Health policy*. 2016;120(7):818-832.
23. McGregor J, Mercer SW, Harris FM. Health benefits of primary care social work for adults with complex health and social needs: a systematic review. *Health & Social Care in the Community*. 2018;26(1):1-13.

24. Iovan S, Lantz PM, Allan K, Abir M. Interventions to decrease use in prehospital and emergency care settings among super-utilizers in the United States: a systematic review. *Medical Care Research and Review*. 2020;77(2):99-111.
25. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ*. 2008;337:a1655. doi:10.1136/bmj.a1655
26. Brown DM, Hernandez EA, Levin S, et al. Effect of Social Needs Case Management on Hospital Use Among Adult Medicaid Beneficiaries: A Randomized Study. *Annals of Internal Medicine*. 2022;
27. Kangovi S, Mitra N, Grande D, Long JA, Asch DA. Evidence-Based Community Health Worker Program Addresses Unmet Social Needs And Generates Positive Return On Investment: A return on investment analysis of a randomized controlled trial of a standardized community health worker program that addresses unmet social needs for disadvantaged individuals. *Health Affairs*. 2020;39(2):207-213.
28. Finkelstein A, Zhou A, Taubman S, Doyle J. Health care hotspotting—a randomized, controlled trial. *NEJM*. 2020;382(2):152-162.
29. Hwang SW, Henderson MJ. *Health Care Utilization in Homeless People: Translating Research into Policy and Practice: Agency for Healthcare Research and Quality Working Paper No. 10002*. October 2010. <http://gold.ahrq.gov>
30. Aubry T, Bloch G, Bric V, et al. Effectiveness of permanent supportive housing and income assistance interventions for homeless individuals in high-income countries: a systematic review. *The Lancet Public Health*. 2020;5(6):e342-e360.
31. National Academies of Sciences E, Medicine. Integrating social care into the delivery of health care: Moving upstream to improve the nation's health. 2019;
32. Mosen DM, Banegas MP, Benuzillo JG, Hu WR, Brooks NB, Ertz-Berger BL. Association between social and economic needs with future healthcare utilization. *Am J Prev Med*. 2020;58(3):457-460.
33. Cole MB, Nguyen KH. Unmet social needs among low-income adults in the United States: Associations with health care access and quality. *Health Services Research*. 2020;55(S2):873-882. doi:10.1111/1475-6773.13555
34. Joynt Maddox KE, Reidhead M, Hu J, et al. Adjusting for social risk factors impacts performance and penalties in the hospital readmissions reduction program. *Health Services Research*. 2019;54(2):327-336. doi:10.1111/1475-6773.13133
35. Fichtenberg CM, Alley DE, Mistry KB. Improving social needs intervention research: key questions for advancing the field. *Am J Prev Med*. 2019;57(6):S47-S54.
36. Baker M, Nelson S, Krsnak J. Case Management on the Front Lines of COVID-19: The Importance of the Individualized Care Plan Across Care Settings.

- Professional Case Management*. 2021;26(2):62-69.
doi:10.1097/ncm.0000000000000484
37. Stadnick NA, Cain KL, Oswald W, et al. Co-creating a Theory of Change to advance COVID-19 testing and vaccine uptake in underserved communities. *Health Services Research*. 2022;57(S1):149-157.
doi:<https://doi.org/10.1111/1475-6773.13910>
 38. Nawaz S, Moon KJ, Vazquez R, et al. Evaluation of the Community Health Worker Model for COVID-19 Response and Recovery. *J Community Health*. Jan 6 2023;1-16. doi:10.1007/s10900-022-01183-4
 39. Tai-Seale M, Cheung MW, Kwak J, et al. Unmet needs for food, medicine, and mental health services among vulnerable older adults during the COVID-19 pandemic. *Health Services Research*. n/a(n/a)doi:<https://doi.org/10.1111/1475-6773.14084>
 40. Azar KMJ, Shen Z, Romanelli RJ, et al. Disparities In Outcomes Among COVID-19 Patients In A Large Health Care System In California. *Health Affairs*. 2020;39(7):1253-1262. doi:10.1377/hlthaff.2020.00598
 41. Feyman Y, Avila CJ, Auty S, et al. Racial and ethnic disparities in excess mortality among U.S. veterans during the COVID-19 pandemic. *Health Services Research*. n/a(n/a)doi:<https://doi.org/10.1111/1475-6773.14112>
 42. Bibbins-Domingo K. This time must be different: disparities during the COVID-19 pandemic. *Annals of Internal Medicine*. 2020;
 43. Alsan M, Chandra A, Simon K. The Great Unequalizer: Initial Health Effects of COVID-19 in the United States. *Journal of Economic Perspectives*. 2021;35(3):25-46. doi:10.1257/jep.35.3.25
 44. Stern RJ, Rafferty HF, Robert AC, et al. Concentrating Vaccines in Neighborhoods with High Covid-19 Burden. *NEJM Catalyst Innovations in Care Delivery*. 2021;2(2)
 45. Pingali C, Meghani M, Razzaghi H, et al. COVID-19 Vaccination Coverage Among Insured Persons Aged ≥ 16 Years, by Race/Ethnicity and Other Selected Characteristics - Eight Integrated Health Care Organizations, United States, December 14, 2020-May 15, 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(28):985-990. doi:10.15585/mmwr.mm7028a1
 46. Berkowitz RL, Gao X, Michaels EK, Mujahid MS. Structurally vulnerable neighbourhood environments and racial/ethnic COVID-19 inequities. *Cities & Health*. 2020:1-4.
 47. Metzl JM, Maybank A, De Maio F. Responding to the COVID-19 Pandemic: The Need for a Structurally Competent Health Care System. *JAMA*. 2020;324(3):231-232. doi:10.1001/jama.2020.9289
 48. Simon GE, Shortreed SM, DeBar LL. Zelen design clinical trials: why, when, and how. *Trials*. 2021/08/17 2021;22(1):541. doi:10.1186/s13063-021-05517-w

49. Latimer NR, Abrams K, Lambert P, et al. Adjusting for treatment switching in randomised controlled trials—a simulation study and a simplified two-stage method. *Statistical methods in medical research*. 2017;26(2):724-751.
50. Adler AI, Latimer NR. Adjusting for Nonadherence or Stopping Treatments in Randomized Clinical Trials. *JAMA*. 2021;325(20):2110-2111. doi:10.1001/jama.2021.2433
51. Zwarenstein M, Treweek S, Gagnier JJ, et al. Improving the reporting of pragmatic trials: an extension of the CONSORT statement. *BMJ*. 2008;337
52. Hosmer DW, Lemeshow S. *Applied survival analysis: regression modelling of time to event data*. Wiley; 2002.
53. Lingsma H, Rozenbeek B, Steyerberg E. Covariate adjustment increases statistical power in randomized controlled trials. *Journal of clinical epidemiology*. 2010;63(12):1391.
54. Quadri NS, Knowlton G, Vazquez Benitez G, et al. Evaluation of Preferred Language and Timing of COVID-19 Vaccine Uptake and Disease Outcomes. *JAMA Netw Open*. Apr 3 2023;6(4):e237877. doi:10.1001/jamanetworkopen.2023.7877
55. *Stata: Release 17. Statistical Software*. StataCorp LP; 2021.
56. Press VG, Huisingh-Scheetz M, Arora VM. Inequities in technology contribute to disparities in COVID-19 vaccine distribution. American Medical Association; 2021:e210264-e210264.
57. Knox M, Esteban EE, Hernandez EA, Fleming MD, Safaeinilli N, Brewster AL. Defining case management success: a qualitative study of case manager perspectives from a large-scale health and social needs support program. *BMJ Open Quality*. 2022;11(2):e001807.
58. Vaidya V, Partha G, Karmakar M. Gender Differences in Utilization of Preventive Care Services in the United States. *J Women's Health*. 2012;21(2):140-145. doi:10.1089/jwh.2011.2876
59. Luquis RR, Kensinger WS. Perceptions of Health Care and Access to Preventive Services Among Young Adults. *Journal of Community Health*. 2017/12/01 2017;42(6):1204-1212. doi:10.1007/s10900-017-0371-2
60. Abdul-Mutakabbir JC, Casey S, Jews V, et al. A three-tiered approach to address barriers to COVID-19 vaccine delivery in the Black community. *The Lancet Global Health*. 2021;9(6):e749-e750. doi:10.1016/S2214-109X(21)00099-1
61. Kamal A, Hodson A, Pearce JM. A Rapid Systematic Review of Factors Influencing COVID-19 Vaccination Uptake in Minority Ethnic Groups in the UK. *Vaccines*. 2021;9(10):1121.
62. Hernandez I, Dickson S, Tang S, Gabriel N, Berenbrok LA, Guo J. Disparities in distribution of COVID-19 vaccines across US counties: A geographic information

- system-based cross-sectional study. *PLoS Med.* Jul 2022;19(7):e1004069.
doi:10.1371/journal.pmed.1004069
63. Williams AM, Clayton HB, Singleton JA. Racial and Ethnic Disparities in COVID-19 Vaccination Coverage: The Contribution of Socioeconomic and Demographic Factors. *Am J Prev Med.* Apr 2022;62(4):473-482.
doi:10.1016/j.amepre.2021.10.008
 64. California State Government. Vaccination Data: Vaccination status by Vaccine Equity Metric and other groups. Updated 06 September 2022. Accessed 07 September, 2022. <https://covid19.ca.gov/vaccination-progress-data/#equity-metric>
 65. Barber A, West J. Conditional cash lotteries increase COVID-19 vaccination rates. *Journal of Health Economics.* 2022/01/01/ 2022;81:102578.
doi:<https://doi.org/10.1016/j.jhealeco.2021.102578>
 66. Sehgal NK. Impact of Vax-a-Million lottery on COVID-19 vaccination rates in Ohio. *The American journal of medicine.* 2021;134(11):1424-1426.
 67. Mallow PJ, Enis A, Wackler M, Hooker EA. COVID-19 financial lottery effect on vaccine hesitant areas: Results from Ohio's Vax-a-million program. *The American Journal of Emergency Medicine.* 2022;56:316-317.
 68. Acharya B, Dhakal C. Implementation of state vaccine incentive lottery programs and uptake of COVID-19 vaccinations in the United States. *JAMA Network Open.* 2021;4(12):e2138238-e2138238.
 69. Robertson C, Schaefer KA, Scheitrum D. Are vaccine lotteries worth the money? *Economics Letters.* 2021/12/01/ 2021;209:110097.
doi:<https://doi.org/10.1016/j.econlet.2021.110097>
 70. Campos-Mercade P, Meier AN, Schneider FH, Meier S, Pope D, Wengström E. Monetary incentives increase COVID-19 vaccinations. *Science.* 2021;374(6569):879-882.
 71. Wong CA, Pilkington W, Doherty IA, et al. Guaranteed financial incentives for COVID-19 vaccination: a pilot program in North Carolina. *JAMA Internal Medicine.* 2022;182(1):78-80.
 72. Thirumurthy H, Milkman KL, Volpp KG, Buttenheim AM, Pope DG. Association between statewide financial incentive programs and COVID-19 vaccination rates. *PLOS ONE.* 2022;17(3):e0263425. doi:10.1371/journal.pone.0263425
 73. Noonan K. Two Years After A Disappointing RCT in Camden: Reassessing Value and Builing Ecosystem of Care. *Health Affairs Forefront.* 2022;(August 29, 2022)doi:10.1377/forefront.20220825.285684
 74. De Marchis EH, Alderwick H, Gottlieb LM. Do patients want help addressing social risks? *The Journal of the American Board of Family Medicine.* 2020;33(2):170-175.
 75. Rosenbaum S, Gunsalus R, Velasquez M, Jones S, Rothenberg S, Beckerman JZ. Medicaid Payment and Delivery Reform: Insights from Managed Care Plan

- Leaders in Medicaid Expansion States. *The Commonwealth Fund Issue Brief*. 2018;
76. Lewis CC, Jones SMW, Wellman R, et al. Social risks and social needs in a health insurance exchange sample: a longitudinal evaluation of utilization. *BMC Health Services Research*. 2022/11/28 2022;22(1):1430. doi:10.1186/s12913-022-08740-6
 77. Centers for Medicare & Medicaid Services. Addressing Health-Related Social Needs in Section 1115 Demonstrations. Updated 12 December 2022. Accessed 24 July, 2023. <https://www.medicaid.gov/health-related-social-needs/index.html>
 78. Kertesz SG, Weiner SJ. Housing the Chronically Homeless: High Hopes, Complex Realities. *JAMA*. 2009;301(17):1822-1824. doi:10.1001/jama.2009.596
 79. Fleming MD, Evans JL, Graham-Squire D, et al. Association of shelter-in-place hotels with health services use among people experiencing homelessness during the COVID-19 pandemic. *JAMA network open*. 2022;5(7):e2223891-e2223891.
 80. Wright BJ, Vartanian KB, Li H-F, Royal N, Matson JK. Formerly homeless people had lower overall health care expenditures after moving into supportive housing. *Health Affairs*. 2016;35(1):20-27.
 81. Keene DE, Niccolai L, Rosenberg A, Schlesinger P, Blankenship KM. Rental assistance and adult self-rated health. *Journal of Health Care for the Poor and Underserved*. 2020;31(1):325-339.
 82. Denary W, Fenelon A, Schlesinger P, Purtle J, Blankenship KM, Keene DE. Does rental assistance improve mental health? Insights from a longitudinal cohort study. *Social Science & Medicine*. 2021/08/01/ 2021;282:114100. doi:<https://doi.org/10.1016/j.socscimed.2021.114100>
 83. Simon AE, Fenelon A, Helms V, Lloyd PC, Rossen LM. HUD Housing Assistance Associated With Lower Uninsurance Rates And Unmet Medical Need. *Health Affairs*. 2017;36(6):1016-1023. doi:10.1377/hlthaff.2016.1152
 84. Pfeiffer D. Rental Housing Assistance and Health: Evidence From the Survey of Income and Program Participation. *Housing Policy Debate*. 2018/07/04 2018;28(4):515-533. doi:10.1080/10511482.2017.1404480
 85. U.S. Census Bureau. Contra Costa County. Accessed 21 June, 2023. <https://datacommons.org/place/geoId/06013#>
 86. Tiutin O, Branning N. Contra Costa Health Plan Population Needs Assessment Report. Accessed July 07, 2023. <https://cchealth.org/healthplan/pdf/PNA-Report-2022.pdf>
 87. Pourat N CE, O'Masta B, Haley LA, Chen X, Zhou W, Haile M,. *Final Evaluation of California's Whole Person Care (WPC) Program*. UCLA Center for Health Policy Research; December 2022.
 88. Fleming MD, Safaeinili N, Knox M, et al. Conceptualizing the effective mechanisms of a social needs case management program shown to reduce

- hospital use: a qualitative study. *BMC Health Services Research*. 2022/12/26 2022;22(1):1585. doi:10.1186/s12913-022-08979-z
89. Fleming MD, Guo C, Knox M, Brown DM, Hernandez EA, Brewster AL. Impact of Social Needs Case Management on Use of Medical and Behavioral Health Services: Secondary Analysis of a Randomized Controlled Trial. *Annals of Internal Medicine*. 2023;176(8)doi:doi:10.7326/M23-0876
 90. Dimick JB, Ryan AM. Methods for Evaluating Changes in Health Care Policy: The Difference-in-Differences Approach. *JAMA*. 2014;312(22):2401-2402. doi:10.1001/jama.2014.16153
 91. Daw JR, Hatfield LA. Matching in Difference-in-Differences: between a Rock and a Hard Place. *Health Services Research*. 2018;53(6):4111-4117. doi:<https://doi.org/10.1111/1475-6773.13017>
 92. Daw JR, Hatfield LA. Matching and Regression to the Mean in Difference-in-Differences Analysis. *Health Services Research*. 2018;53(6):4138-4156. doi:<https://doi.org/10.1111/1475-6773.12993>
 93. Chhabra M, Spector E, Demuyneck S, Wiest D, Buckley L, Shea JA. Assessing the relationship between housing and health among medically complex, chronically homeless individuals experiencing frequent hospital use in the United States. *Health & Social Care in the Community*. 2020;28(1):91-99.
 94. Swope CB, Hernández D. Housing as a determinant of health equity: A conceptual model. *Social Science & Medicine*. 2019/12/01/ 2019;243:112571. doi:<https://doi.org/10.1016/j.socscimed.2019.112571>
 95. Taylor LA. Housing and Health: An Overview of the Literature. *Health Affairs Policy Brief*. 2018;June 7, 2018doi:10.1377/hpb20180313.396577
 96. Thomson H, Thomas S. Developing empirically supported theories of change for housing investment and health. *Social Science & Medicine*. 2015;124:205-214.
 97. Polvere L, Macnaughton, E., & Piat, M. . Participant perspectives on housing first and recovery: Early findings from the At Home/Chez Soi project. . *Psychiatric Rehabilitation Journal*. 2013;36(2):110-112. doi:<https://doi.org/10.1037/h0094979>
 98. Jaworsky D, Gadermann A, Duhoux A, et al. Residential stability reduces unmet health care needs and emergency department utilization among a cohort of homeless and vulnerably housed persons in Canada. *Journal of Urban Health*. 2016;93:666-681.
 99. Kushel MB, Vittinghoff E, Haas JS. Factors Associated With the Health Care Utilization of Homeless Persons. *JAMA*. 2001;285(2):200-206. doi:10.1001/jama.285.2.200
 100. Aubry T, Tsemberis S, Adair CE, et al. One-year outcomes of a randomized controlled trial of housing first with ACT in five Canadian cities. *Psychiatric Services*. 2015;66(5):463-469.

101. Frazee TK, Brewster AL, Lewis VA, Beidler LB, Murray GF, Colla CH. Prevalence of screening for food insecurity, housing instability, utility needs, transportation needs, and interpersonal violence by US physician practices and hospitals. *JAMA network open*. 2019;2(9):e1911514-e1911514.
102. Chhabra M, Sorrentino AE, Cusack M, Dichter ME, Montgomery AE, True G. Screening for Housing Instability: Providers' Reflections on Addressing a Social Determinant of Health. *Journal of General Internal Medicine*. 2019/07/01 2019;34(7):1213-1219. doi:10.1007/s11606-019-04895-x
103. Cordray DS, Pion GM. What's behind the numbers? Definitional issues in counting the homeless. *Housing Policy Debate*. 1991/01/01 1991;2(3):585-616. doi:10.1080/10511482.1991.9521065
104. McGough M, Krutika A, Cox C. How has healthcare utilization changed since the pandemic. Peterson-Kaiser Family Foundation Health System Tracker. Updated 24 Jan 2023. Accessed 25 July, 2023. <https://www.healthsystemtracker.org/chart-collection/how-has-healthcare-utilization-changed-since-the-pandemic/>
105. Jones KG, Roth SE, Vartanian KB. Health and Health Care Use Strongly Associated with Cumulative Burden of Social Determinants of Health. *Population health management*. 2022;25(2):218-226.
106. Rogers A, Hu YR, Schickedanz A, Gottlieb L, Sharp A. Understanding High-Utilizing Patients Based on Social Risk Profiles: a Latent Class Analysis Within an Integrated Health System. *Journal of General Internal Medicine*. 2020/07/01 2020;35(7):2214-2216. doi:10.1007/s11606-019-05510-9
107. National Academies of Sciences Engineering and Medicine. *Investing in Interventions That Address Non-Medical, Health-Related Social Needs: Proceedings of a Workshop*. 2019.
108. Schickedanz A, Sharp A, Hu YR, et al. Impact of social needs navigation on utilization among high utilizers in a large integrated health system: a quasi-experimental study. *Journal of general internal medicine*. 2019;34(11):2382-2389.
109. Rosenbaum S. Hospital Community Benefit Spending: Leaning In on the Social Determinants of Health. *The Milbank quarterly*. Jun 2016;94(2):251-4. doi:10.1111/1468-0009.12191
110. Young GJ, Chou C-H, Alexander J, Lee S-YD, Raver E. Provision of community benefits by tax-exempt US hospitals. *New England Journal of Medicine*. 2013;368(16):1519-1527.
111. Agency for Healthcare Research and Quality. *AHRQ Quality Indicators — Guide to Prevention Quality Indicators: Hospital Admission for Ambulatory Care Sensitive Conditions*. Vol. AHRQ Pub. No. 02-R0203. 2001.
112. Shan M, Gutman R, Dosa D, et al. A New Data Resource to Examine Meals on Wheels Clients' Health Care Utilization and Costs. *Medical Care*. 2019;57(3):e15-e21. doi:10.1097/mlr.0000000000000951

113. Cho J, Thorud JL, Marishak-Simon S, Hammack L, Stevens AB. Frequency of Hospital Use Before and After Home-Delivery Meal by Meals On Wheels, of Tarrant County, Texas. *J Nutr Health Aging*. 2018;22(4):519-525. doi:10.1007/s12603-017-0973-5
114. Nguyen HQ, Duan L, Lee JS, et al. Association of a Medicare Advantage Posthospitalization Home Meal Delivery Benefit With Rehospitalization and Death. *American Medical Association*; 2023:e231678-e231678.
115. Galiatsatos P, Ajayi A, Maygers J, et al. Together in Care: An Enhanced Meals on Wheels Intervention Designed to Reduce Rehospitalizations among Older Adults with Cardiopulmonary Disease-Preliminary Findings. *Int J Environ Res Public Health*. Jan 1 2022;19(1)doi:10.3390/ijerph19010458
116. Berkowitz SA, Terranova J, Hill C, et al. Meal Delivery Programs Reduce The Use Of Costly Health Care In Dually Eligible Medicare And Medicaid Beneficiaries. *Health Affairs*. 2018;37(4):535-542. doi:10.1377/hlthaff.2017.0999
117. Solomon EM, Wing H, Steiner JF, Gottlieb LM. Impact of Transportation Interventions on Health Care Outcomes: A Systematic Review. *Med Care*. Apr 2020;58(4):384-391. doi:10.1097/mlr.0000000000001292
118. Coaston A, Lee S-J, Johnson J, Hardy-Peterson M, Weiss S, Stephens C. Mobile Medical Clinics in the United States Post-Affordable Care Act: An Integrative Review. *Population Health Management*. 2022;25(2):264-279. doi:10.1089/pop.2021.0289
119. Strong B, Shipper A, Downton K, Lane W. The effects of health care-based violence intervention programs on injury recidivism and costs: A systematic review. *J Trauma Acute Care Surg*. Nov 2016;81(5):961-970. doi:10.1097/ta.0000000000001222
120. Hilts KE, Yeager VA, Gibson PJ, Halverson PK, Blackburn J, Menachemi N. Hospital Partnerships for Population Health: A Systematic Review of the Literature. *Journal of Healthcare Management*. 2021;66(3):170-198. doi:10.1097/jhm-d-20-00172
121. American Hospital Association. AHA Annual Survey Database (2017 Edition). Accessed 4 November, 2021. <https://www.ahadata.com/aha-annual-survey-database-asdb/>.
122. Barrett M, Lopez-Gonzalez L, Hines A, Andrews R, Jiang J. *An Examination of Expected Payer Coding in HCUP Databases*. 2014:13. *HCUP Methods Series Report #2014-03 ONLINE*. <https://hcup-us.ahrq.gov/reports/methods/2014-03.pdf>
123. James J. Medicare hospital readmissions reduction program. *Health affairs*. 2013;34(2):1-5.
124. Berkowitz SA, Delahanty LM, Terranova J, et al. Medically Tailored Meal Delivery for Diabetes Patients with Food Insecurity: a Randomized Cross-over Trial. *J Gen Intern Med*. Mar 2019;34(3):396-404. doi:10.1007/s11606-018-4716-z

125. Westphal JD, Gulati R, Shortell SM. Customization or conformity? An institutional and network perspective on the content and consequences of TQM adoption. *Administrative science quarterly*. 1997;366-394.
126. Crook HL, Zheng J, Bleser WK, Whitaker RG, Masand J, Saunders RS. How are payment reforms addressing social determinants of health. *Milbank Memorial Fund Issue Brief*. 2021;
127. Chaiyachati KH, Hubbard RA, Yeager A, et al. Association of Rideshare-Based Transportation Services and Missed Primary Care Appointments: A Clinical Trial. *JAMA Intern Med*. Mar 1 2018;178(3):383-389. doi:10.1001/jamainternmed.2017.8336
128. Razon N, Gottlieb L. Content Analysis of Transportation Screening Questions in Social Risk Assessment Tools: Are We Capturing Transportation Insecurity? *The Journal of the American Board of Family Medicine*. 2022;35(2):400-405. doi:10.3122/jabfm.2022.02.210256
129. Fichtenberg CM, De Marchis EH, Gottlieb LM. Understanding patients' interest in healthcare-based social assistance programs. *American Journal of Preventive Medicine*. 2022;63(3):S109-S115.
130. Gorman E, Coles Z, Baker N, et al. Beyond Recidivism: Hospital-Based Violence Intervention and Early Health and Social Outcomes. *J Am Coll Surg*. Dec 1 2022;235(6):927-939. doi:10.1097/xcs.0000000000000409
131. Castrucci BC, Auerbach J. Meeting Individual Needs Falls Short of Addressing Social Determinants of Health. *Health Affairs Blog*. 2019;
132. Brewster AL, Frazee TK, Gottlieb LM, Frehn J, Murray GF, Lewis VA. The role of value-based payment in promoting innovation to address social risks: A cross-sectional study of social risk screening by us physicians. *The Milbank quarterly*. 2020;98(4):1114-1133.