SONNET

Social Needs Network for Evaluation and Translation

Association of Social Risk Factors with Emergency Department and Inpatient Hospitalization Encounters Before and During the COVID-19 Pandemic

November 2022

Morgan Clennin, PhD, MPH
Mario Schootman, PhD
Liza Reifler, MPH
Heather Tavel, MPH
Lee Cromwell, MS

KAISER PERMANENTE®

Contents

Acknowledgments

Courtney Kraus, MSPH, Data Visualization
Morgan Ford, MS, Project Manager
Cheryl Kelly, PhD, MS, MPH, Mentor
Heather Feigelson, PhD, MPH, Mentor

This project was funded by the Kaiser Permanente (KP) Social Needs Network for Evaluation and Translation (SONNET). SONNET is a learning network that is committed to supporting KP leaders, clinicians, and staff as they design and evaluate effective interventions to address the social needs of our members. The Network includes researchers and evaluators from the eight KP regions, KP's Bernard J Tyson School of Medicine, KP's Office of Community Health, and from the KP and Robert Wood Johnson Foundation-supported Social Interventions Research and Evaluation Network (SIREN). SONNET is supported by KP's Office of Community Health.

Suggested citation
Clennin M, Schootman M, Reifler L, Tavel H, Cromwell L. Association of Social Risk Factors with Emergency Department and Inpatient Hospitalization Encounters Before and During the COVID-19 Pandemic. Kaiser Permanente Social Needs Network for Evaluation and Translation (SONNET). November 2022.

Learn more at sonnet.kp.org.
Contact us at sonnet@kp.org.

Executive Summary

Why we did our project

Social risks like housing instability, food insecurity, and financial strain can negatively impact health care utilization, health outcomes, and disparities in care. We did this project to better understand how social risks are linked to 'undesirable' health care utilization, i.e., emergency department (ED) visits and inpatient hospitalizations. Our project used data from the Kaiser Permanente (KP) National Social Health Survey (SHS) fielded in 2020 to help **quantify the contribution of social risk to ED and inpatient hospital encounters.**

What we did

We linked National SHS data to electronic health record (EHR) data from 7 Kaiser Permanente regions and publicly available neighborhood data to understand the relationships between members' social risks and their ED and hospital utilization. We also looked at whether these relationships varied before and after the start of the COVID-19 pandemic. Specifically, we:

- **Assessed ED and inpatient hospital utilization for 7,309 members** who met enrollment criteria and had complete data from the National SHS and other data sources
- **Examined the relationship between social risk and utilization outcomes**, using separate models for each social risk factor and comparing results pre- and during-COVID.

What we learned

- ED encounters were **33%** more likely among members with any social risk and **51%** more likely among members with any severe social risk.
- **Housing instability, food insecurity, and financial strain** were significantly linked to increased risk of an ED encounter.
- Social risk factors were **not linked to an increase in inpatient hospitalizations.**
- The relationship between social risk and utilization **did not change related to the COVID-19 pandemic**.

Sample size

10,226 members completed the KP National SHS in 2020

7,309 of those members were included in our sample

Links between social risks & ED utilization

Looking across all social risks, ED encounters were:

33% more likely for members with any social risk

51% more likely for those with any severe social risk

Looking at individual social risks, ED encounters were:

76% more likely with severe housing instability

59% more likely with severe food insecurity

44% more likely with food insecurity

34% more likely with financial strain

How we can use this work to advance social health practice at KP and beyond

Our results on the link between social risk and ED encounters can help inform health systems' prioritization of social health interventions and access to community-based resources — **specifically resources for housing instability, food insecurity, and financial strain**. Within Kaiser Permanente, these results can also serve as a historical comparison group for **examining members' social risks and the impact of social health interventions over time**.

Introduction

Why health systems are engaging in social health

Health systems are engaging with patients to assess and address their social risk factors as an essential step towards improving utilization and health outcomes.[8,16,9,12] Long-term exposure to social risk factors — such as housing instability, food insecurity, financial strain, transportation issues, and social isolation — is linked to:

- Higher risk of mortality and other poor health outcomes
- 'Undesirable' health care utilization, such as emergency department (ED) visits and hospitalizations
- Disparities in health care utilization.[15,18]

How health systems can use our findings

Our study examines **the impact of members' social risks on their ED and hospital utilization** by linking data from the Kaiser Permanente (KP) National Social Health Survey (SHS) with clinical outcomes and neighborhood data across several regional markets. **Kaiser Permanente and other health systems can use our findings to:**

1. Prioritize clinic-based initiatives to improve member outcomes
2. Identify opportunities to improve members' access to community-based resources for social risks resources.

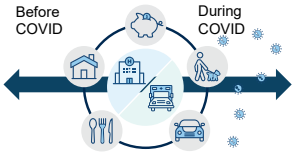
Scientific aims

Our primary aim is to examine the associations between member-reported social risks and health care utilization (ED and inpatient hospitalization encounters).

Our secondary aim is to determine the extent to which these relationships vary before and after the start of the COVID-19 pandemic.

PRIMARY AIM

SECONDARY AIM

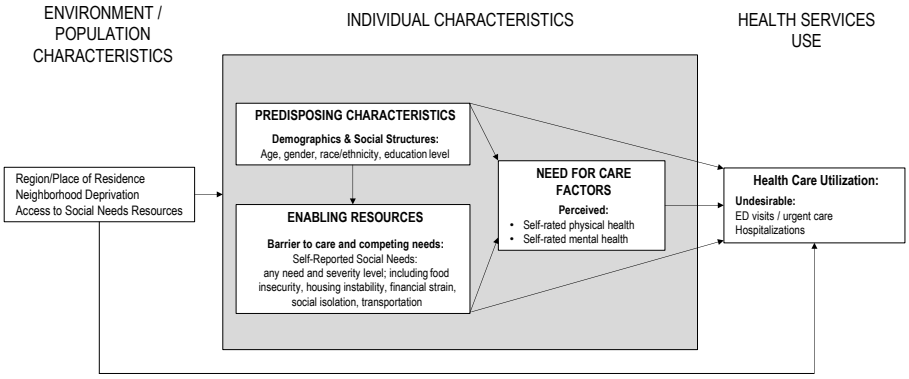


We hypothesize that members with social risks have significantly higher 'undesirable' health care utilization (i.e., ED visits, hospitalizations).

Study framework

Our study is guided by Andersen's Model for Health Services Use (see Figure 1).[2,17,3,10,13,14] We applied the model to explore social risks associated with health care utilization among the more than 10,000 Kaiser Permanente members who completed the National SHS. Our analyses looked at utilization among members with and without social risks — i.e., exposure to "specific adverse social conditions associated with poor health."[1]

Figure 1. Conceptual framework linking social risk and health care utilization*



*Adapted from Andersen's Behavioral Model for Health Services Use

Appendix A defines each component of the conceptual framework.

Methods

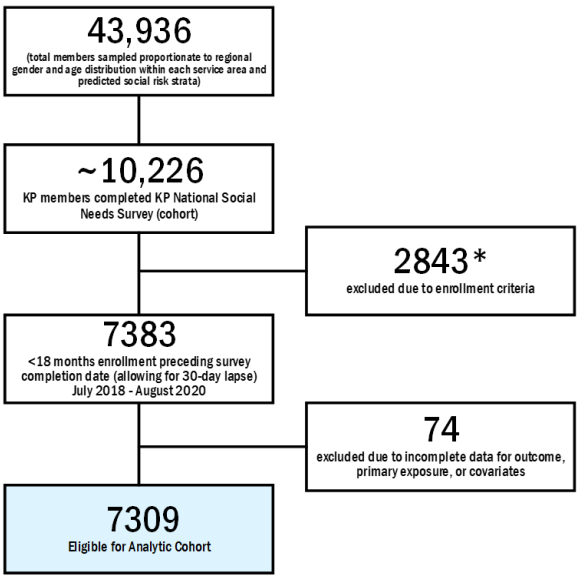
Study design, data sources, and sample

This retrospective cross-sectional study created a novel dataset by linking data from 3 sources:

- The 2020 Kaiser Permanente National Social Health Survey (SHS)
- Member clinical outcomes from electronic health record (EHR) data
- Publicly available census data and an external data repository of social health resources (i.e., Thrive Local)

Of 10,226 Kaiser Permanente members that completed the National SHS, **we included 7,309 members in our analyses**. These members had been enrolled in the health plan for at least 18 months before participating in the survey and had complete EHR data for clinical outcomes (i.e., utilization and health indicators), social risk variables, and covariates. We excluded survey respondents who: 1) had missing EHR data from one region* (n=1,151 members); 2) did not meet enrollment criteria (n=1,692); or 3) had incomplete data for primary exposure variables and covariates (n=74) (Figure 2).

Figure 2. Analytic sample, inclusion and exclusion criteria



**KPWA excluded from analytic sample due to missing data. EHR data not available from IDR (n=1,152).*

Study variables

Health care utilization

ED and inpatient hospitalization encounters were the primary outcome variables. Utilization and clinical outcomes were derived from EHR and claims data from KP's Integrated Data Repository (IDR). We analyzed utilization encounters during the 18 months before the date of survey completion. Data were extracted between July 2018-Septmber 2020. We used revenue codes from claims data or EHR encounter type identifiers to identify utilization encounters (see Appendix D Supplemental Table 1).

Social risk factors

Social risk factors were the primary exposure variables. We assessed social risk at the individual level through a series of questions on the KP National SHS that asked about housing instability, food insecurity, financial strain, transportation issues, social isolation, and any social risk (see Table 1). Exposure to each social risk factor was categorized as follows:

1. No social risk: no exposure or experience with social risk factor
2. Social risk: some exposure or experience with social factor in past 12 mos.
3. Severe social risk: high intensity of exposure or experience with social factor in past 12 mos.

Covariates

Our covariates are based on Andersen's Behavioral Model for Health Services Use and include predisposing characteristics, need-for care-factors, and environmental factors related to health care utilization (Figure 1).

Predisposing characteristics were assessed on the National SHS and included age group, gender, race and ethnicity, education level, and insurance type.

Need-for-care factors were also assessed via the survey and included participants perceived health status, expressed as self-reported physical health and self-reported mental health.

Environmental factors were extracted from publicly available sources and included a measure of neighborhood deprivation and access to social health resources.

See Appendix D Supplemental Table 2 for additional details for study variables.

Statistical analyses

We used descriptive statistics to assess predisposing characteristics, enabling factors, need-for-care factors, environment factors, and health care utilization outcomes. We examined bivariate associations between variables of interest and health care utilization outcomes (i.e., Rao-Scott chi-square). Our model building and subsequent analyses included variables associated with the outcome ($p<.20$).[6,7,11]

To examine the relationship between social risk and **rate of ED encounters**, we used Weighted Poisson regression with jackknife replication.

To examine the relationships among social risk and **likelihood of inpatient hospitalization encounters**, we used weighted logistic regression.

To determine if the relationship between social risk and health care utilization **varied before and during the COVID-19 pandemic**, we examined an interaction term between each social risk factor and time (pre-COVID vs COVID time period). COVID-19 timing was determined by the date that pandemic specific questions were added to the survey (March 18, 2020).

We performed all analyses using the weighted sample, which allows for inferences to be made at the population level among Kaiser Permanente members. Study strengths and limitations are presented in Appendix C.

Table 1. Social risk factors defined

Social risk factors	Definition	Categorization
Housing instability	ability to pay mortgage/rent on time; number of places lived in past year; steady place to sleep or experience living in shelter; current living situation	No risk Social risk Severe social risk
Food insecurity	worried about food running out; food bought did not last and no money for more; hard to get healthy food.	
Financial strain	ability to pay for food, housing, medical care, and heating; money leftover at the end of month (e.g., more than enough, some money left, not enough, etc.)	
Transportation issues	lack of transportation kept from medical appointments/getting medications; lack of transportation kept from meetings, work, getting things needed for daily living	
Social isolation	talk on telephone with family/friends; use social media with family/friends; see family/friends; attend church/ religious services; attend club/organization meetings; get needed social and emotional support	
Any social risk	screening positive for one or more of the social risk factors	

Results

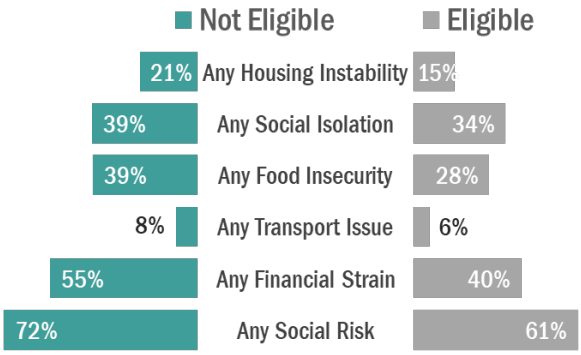
Key findings

- Members with greater social risk had significantly shorter KP enrollment.
- Members with any severe social risk were **51% more likely** to have an ED encounter.
- Members with at least one social risk were not significantly more or less likely to have an inpatient hospitalization.
- The relationship between social risk factors and utilization outcomes did not vary before and during COVID-19 pandemic.

What we learned about members and their social risks

Compared to members in our sample, a greater proportion of those who were excluded were younger (ages 18-34 years), employed, had poorer mental health, and screened positive for each social risk factor (Figure 3).

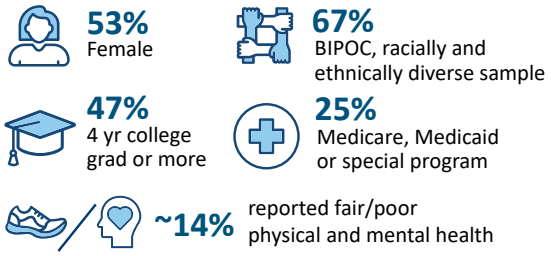
Figure 3. Proportion of members that screened positive for each social risk factor by eligibility status.



Our sample was racially and ethnically diverse with a nearly equal distribution of male and female members (Figure 4).

- About half were younger than 50.
- About half had a 4-year college degree or more.
- About 14% had fair or poor physical and mental health.

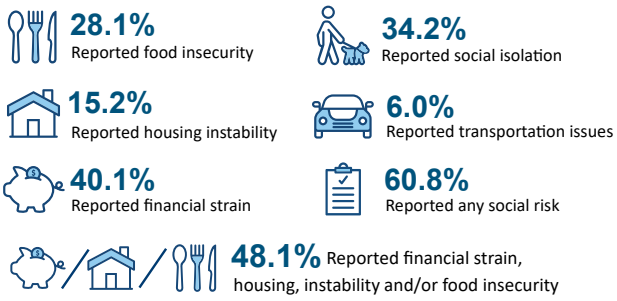
Figure 4. Predisposing & need-for-care factors



Looking at environmental data, we learned that ~66% did not have access to social health resources in their immediate neighborhood and 9% lived in the most deprived neighborhoods.

For enabling factors, more than 60% of respondents had at least one social risk factor. The most common risk factors were financial strain (~40%), social isolation (~34%), and food insecurity (~28%).

Figure 5. Enabling factors: Social risks



Looking at utilization data, we learned that ~18% of the sample had an ED encounter and 7% had an inpatient hospitalization in the 18-months prior to completing the survey.

Figure 6. Baseline health care utilization factors

Appendix D Supplemental Tables 3 and 4 present cohort descriptive statistics for the weighted overall and analytic samples.

Social risk and ED encounters

Table 2 presents full results of the adjusted relative risk (RR) of experiencing an ED encounter by social risk factor, with separate models for each factor. The adjusted RR controls for predisposing, need-for-care, and environment factors known to influence health care utilization.

Summary of results for adjust RR

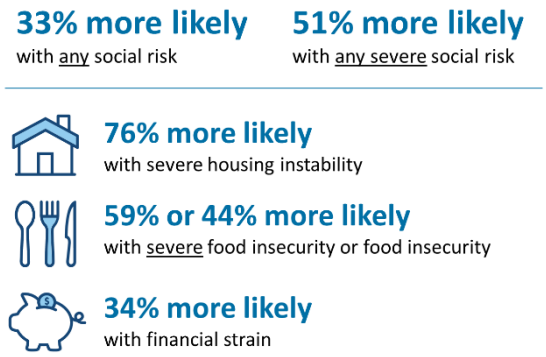
Compared to members that did not have any social risk factors, ED encounters were:

- **33%** more likely among members with any social risk
- **51%** more likely among members with any severe social risk

Members who experienced the following social risks were significantly more likely to have an ED encounter: severe housing instability (+76%), severe food insecurity (+59%), food insecurity (+44%), and financial strain (+34%).

Members with social isolation or transportation issues were not more likely to have an ED encounter.

Figure 7. Likelihood of having an ED encounter by social risk (compared to members without social risks)



Appendix D Supplemental Tables 5 and 6 present unadjusted and adjusted model results.

Figure 8. Weighted Poisson Regression: Risk of ED encounter by social risk factor

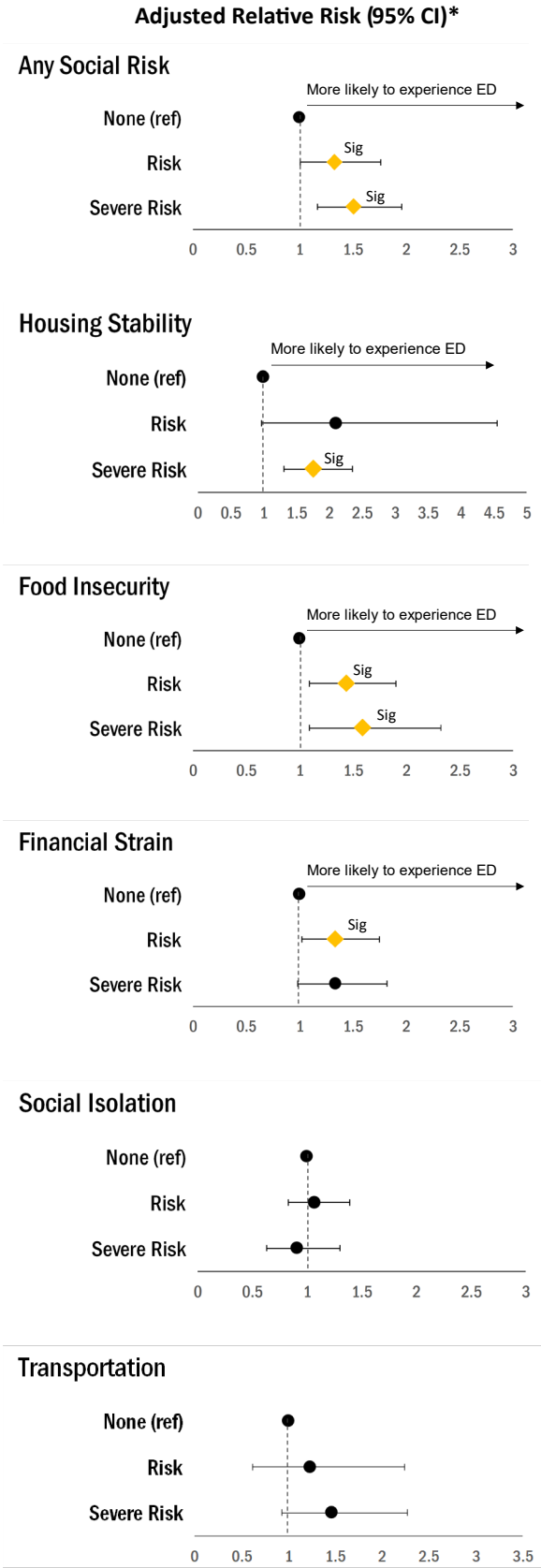


Table 2. Weighted Regression. Adjusted relative risk (RR) of emergency department encounters and adjusted odds (OR) of inpatient hospitalization encounters, by social risk factors.[1]

Social Risk Factors	Social Risk Level	Emergency Department Encounters Adjusted Risk Ratio RR (95% CI)	Inpatient Hospitalization Encounters Adjusted Odds Ratio OR (95% CI)
Housing Stability	Severe Risk	**1.76 (1.31-2.35)**	1.49 (0.92-2.41)
	Risk	2.10 (0.97-4.55)	0.39 (0.13-1.12)
	None (ref)	1.00	1.00
Food Insecurity	Severe Risk	**1.59 (1.09-2.32)**	0.94 (0.54-1.63)
	Risk	**1.44 (1.09-1.90)**	1.27 (0.86-1.89)
	None (ref)	1.00	1.00
Financial Strain	Severe Risk	1.34 (0.98-1.82)	0.98 (0.60-1.58)
	Risk	**1.34 (1.02-1.75)**	0.88 (0.60-1.30)
	None (ref)	1.00	1.00
Social Isolation	Severe Risk	0.91 (0.63-1.30)	**0.51 (0.28-0.92)**
	Risk	1.07 (0.83-1.39)	0.74 (0.47-1.15)
	None (ref)	1.00	1.00
Transportation Issues	Severe Risk	1.46 (0.93-2.27)	0.77 (0.36-1.65)
	Risk	1.23 (0.62-2.24)	0.91 (0.40-2.05)
	None (ref)	1.00	1.00
Any Social Risk Factor	Severe Risk	**1.51 (1.17-1.96)**	0.91 (0.59-1.40)
	Risk	**1.33 (1.01-1.76)**	0.83 (0.56-1.24)
	None (ref)	1.00	1.00
Financial Strain, Housing Instability, Food Insecurity	Severe Risk	**1.62 (1.25-2.12)**	1.08 (0.71-1.64)
	Risk	**1.37 (1.03-1.82)**	0.85 (0.57-1.27)
	None (ref)	1.00	1.00

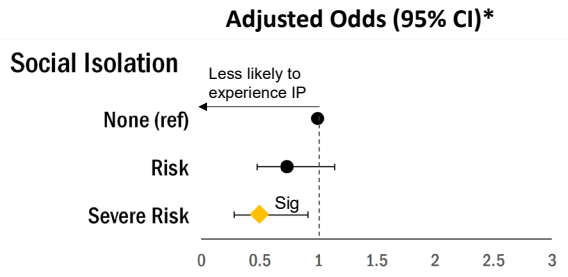
[1] Models adjusted for individual level predisposing factors (age group, gender, race and ethnicity, insurance type and education level) and need-for care factors (self-rated physical health, self-rated mental health); environmental-level factors (neighborhood deprivation index, thrive local access to resources aligning with corresponding social risk factor); and KP region.

Social risk and inpatient hospitalizations

Table 2 presents the adjusted odds of having an inpatient hospitalization by social risk factor, with separate models for each factor.

Our adjusted analyses showed a significant association between social isolation and inpatient hospitalizations. **Members reporting social isolation were 49% less likely to have a hospitalization** compared to members reporting no social isolation (Figure 9).

Figure 9. Weighted Logistic Regression: Odds of inpatient hospitalization by social isolation



Utilization before and during COVID-19

We looked at whether the effect of social risk (e.g., food insecurity) on health care utilization (i.e., ED visits) differed before and during the COVID-19 pandemic. The results were non-significant, indicating that the relationship between social risk and utilization outcomes did not change in relation to the pandemic.

Supplemental analyses

Appendix B presents supplemental analyses conducted to further examine combinations of social risk factors, influence of race and ethnicity, completeness of inpatient hospitalization data, and social isolation.

Summary, conclusions, and future directions

Summary of key findings

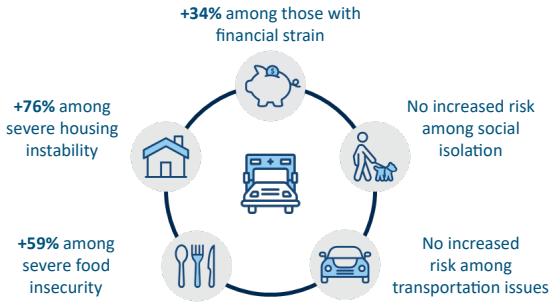
Social risks are common

6 in 10 members reported experiencing at least one social risk factor in the past 12 months. The prevalence of social risk ranged from 6.0% of members reporting transportation issues to 40.1% reporting financial strain.

Social risks are associated with ED use

Overall, members reporting at least one severe social risk were **51% more likely** to experience an ED encounter compared to members that did not have social risk. Housing instability, food insecurity, and financial strain were significantly associated with increased risk of ED encounters.

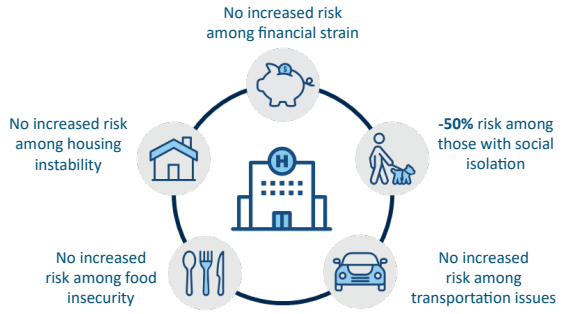
Figure 10. Key Findings: Social Risk & Emergency Department (ED) Encounters



Social risks are not associated with inpatient hospitalization encounters

Overall, members with at least one social risk were not more or less likely to have an inpatient hospitalization compared to members that did not have a social risk.

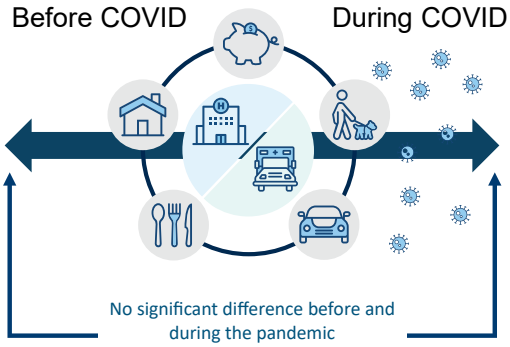
Figure 11. Key Findings: Social Risk & Inpatient (IP) Hospitalization Encounters



COVID-19 did not influence the link between social risk and utilization

The relationship between member-reported social risk factors and health care utilization outcomes did not vary significantly before and during the COVID-19 pandemic.

Figure 12. Key Findings: Before and During COVID



Conclusions

Our findings report the association of social risk factors with ED and inpatient hospitalization encounters among insured individuals with access to high-quality health care. This is the first Kaiser Permanente study to examine the association between social risk factors and health care utilization among a representative sample of KP members.

We found numerous associations between ED encounters and many social risk factors, suggesting that what happens beyond the clinic walls plays a role in influencing health.

Compared to members with no social risks:

- Members with at least one severe social risk were twice as likely to experience an ED encounter.
- Members with the following social risk were significantly more likely to experience an ED encounter: 1) housing instability, 2) food insecurity; 3) financial strain.

Importantly, we isolated the influence of social risk factors by controlling for other contributors to health (e.g., health care access, clinical care). This design can address critical gaps in the literature and our understanding of these relationships.

Study strengths and limitations are presented in Appendix C.

Short-term recommendations

Our results on the linkage between social risk factors and ED encounters can be used to:

- Prioritize social health interventions to address social risk and social needs – **specifically housing instability, food insecurity, and financial strain**
- Serve as a historical comparison group for **examining social risks among members over time** as well as the impact of social health interventions

Improving health outcomes and addressing disparities will require continued investment in social health initiatives and interventions to:

- **Identify** vulnerable members (e.g., screening and referral workflows, frequency of screening, types of encounters implementing screening, etc.)
- **Connect** them with essential social health resources (e.g., Thrive Local, healthy food programs, etc.)
- **Ensure** social needs are consistently met over time

Long-term recommendations

The pathways explaining how social risk factors influence health care utilization and health outcomes are complex and warrant further examination. To intervene effectively, we need a deeper understanding of the multilevel social risk factors influencing utilization.

Future research should aim to:

1. Expand our understanding of the relationship between neighborhood-level and individual-level social risk with health care utilization.
2. Identify the emergence of this relationship over the life course.
3. Examine the underlying mechanisms that help to explain how social risk influences health and health care utilization.

A comprehensive understanding of this relationship will help to identify key leverage points for community-based and clinic-based interventions. It will also inform the development of effective upstream policy and practice strategies to promote health among Kaiser Permanente members who have social health risk factors and may benefit from social health interventions.

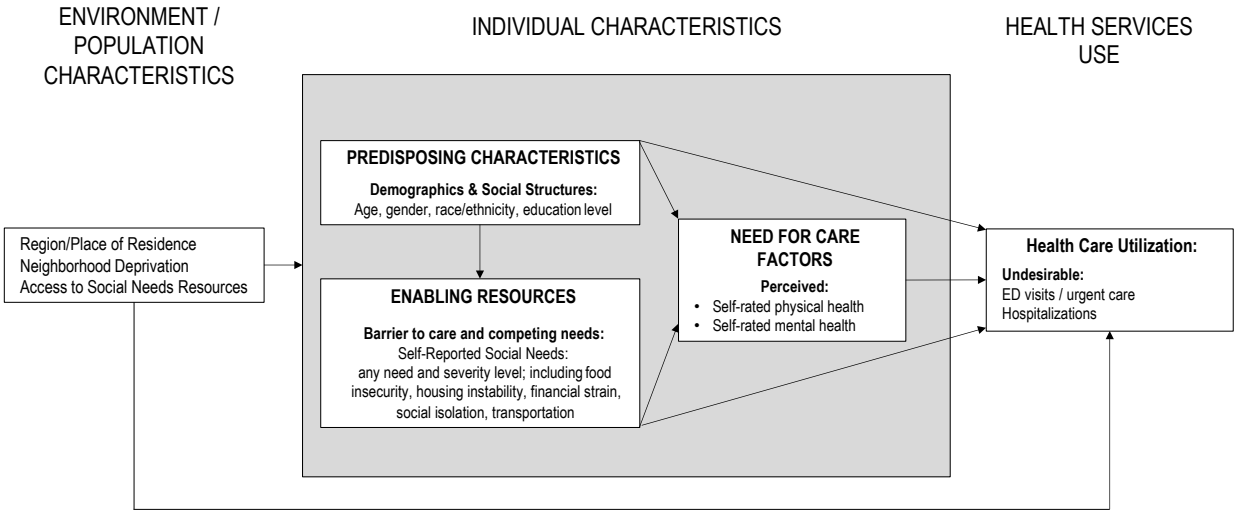
References

1. Alderwick H, Gottlieb LM. Meanings and misunderstandings: a social determinants of health lexicon for health care systems. The Milbank Quarterly. 2019;97:407-419.
2. Andersen RM. National health surveys and the behavioral model of health services use. Med Care. 2008 Jul;46(7):647–653. doi: 10.1097/MLR.0b013e31817a835d.
3. Babitsch B, Gohl D, Von Lengerke T. Re-visiting Anderson's behavioral model of health services use: A systematic review of studies from 1998 to 2011. GMS Psycho-Social. 2012 Medicine 9, Doc. 11.
4. Beckett MK, Martino SC, Agniel D, Mathews M, Hudson Scholle S, James C, Wilson-Frederick S, Orr N, Darabidian B, Elliott MN. Distinguishing neighborhood and individual social risk factors in health care. *Health Serv Res.* 2022; 57(3): 458- 471.
5. Berkowitz SA, Meigs JB, DeWalt D, Seligman HK, Barnard LS, Bright OJ, Schow M, Atlas SJ, Wexler DJ. Material need insecurities, control of diabetes mellitus, and use of health care resources: results of the Measuring Economic Insecurity in Diabetes study. JAMA Intern Med. 2015 Feb;175(2):257-65.
6. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source code for biology and medicine. 2008 Dec;3(1):1-8.
7. Chowdhury MZ, Turin TC. Variable selection strategies and its importance in clinical prediction modelling. Family medicine and community health. 2020;8(1).
8. De Marchis EH, Brown E, Aceves B, et al. State of the Science of Screening in Healthcare Settings. Social Interventions Research & Evaluation Network (SIREN), 2022. Available online: https://sirenetwork.ucsf.edu/tools-resources/resources/screen-report-state-science-social-screening-healthcare-settings
9. Doran KM, Kunzler NM, Mijanovich T, Lang SW, Rubin A, Testa PA, Shelley D. Homelessness and other social determinants of health among emergency department patients. Journal of Social Distress and the Homeless. 2016 Jul 2;25(2):71-7.
10. Gurewich, D., Garg, A. & Kressin, N.R. Addressing Social Determinants of Health Within Healthcare Delivery Systems: a Framework to Ground and Inform Health Outcomes. J GEN INTERN MED 35, 1571–1575 (2020).
11. Heinze G, Wallisch C, Dunkler D. Variable selection–a review and recommendations for the practicing statistician. Biometrical journal. 2018 May;60(3):431-49.
12. Hatef E, Ma X, Rouhizadeh M, Singh G, Weiner JP, Kharrazi H. Assessing the impact of social needs and social determinants of health on health care utilization: using patient-and community-level data. Population health management. 2021 Apr 1;24(2):222-30.
13. Hirshfield S, Downing Jr MJ, Horvath KJ, Swartz JA, Chiasson MA. Adapting Andersen's behavioral model of health service use to examine risk factors for hypertension among US MSM. American journal of men's health. 2018 Jul;12(4):788-97.
14. Messi M, Mueller Y, Haller DM, Zeller A, Neuner-Jehle S, Streit S, Burnand B, Herzig L. A cross-sectional study of Swiss ambulatory care services use by multimorbid patients in primary care in the light of the Andersen model. BMC family practice. 2020 Dec;21(1):1-0.
15. Post WS, Watson KE, Hansen S, Folsom AR, Szklo M, Shea S, Barr RG, Burke G, Bertoni AG, Allen N, Pankow JS. Racial and ethnic differences in all-cause and cardiovascular disease mortality: the MESA study. Circulation. 2022 Jul 19;146(3):229-39.
16. Radic M, Parlier-Ahmad AB, Wills B, Martin CE. Social Determinants of Health and Emergency Department Utilization Among Adults Receiving Buprenorphine for Opioid Use Disorder. Drug and Alcohol Dependence Reports. 2022 May 14:100062.
17. Ricketts TC, Goldsmith LJ. Access in health services research: the battle of the frameworks. Nurs Outlook. 2005 Nov-Dec;53(6):274–280. doi: 10.1016/j.outlook.2005.06.007.
18. Rui P, Kang K, Ashman JJ. National Hospital Ambulatory Medical Care Survey: 2016 emergency department summary tables. 2016. Available from: https://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2016_ed_web_tables.pdf.
19. Walker RJ, Strom Williams J, Egede LE. Influence of Race, Ethnicity and Social Determinants of Health on Diabetes Outcomes. Am J Med Sci. 2016 Apr;351(4):366-73.

Appendices

Appendix A. Anderson's Behavioral Model for Health Services Use; Components and Definitions

Variables were linked to Andersen's model components:



- Enabling resources include those traditionally available to individuals or a community that enable access to health (e.g., health insurance coverage; financial resources). Member-reported social risk factors are the primary exposure of interest and include housing instability, food insecurity, financial strain, transportation issues, and social isolation.
- Predisposing factors include sociodemographic characteristics, social structural variables, and beliefs and behaviors related to health and care utilization.
- Need-for-care factors include individual-level perceived health status (i.e., a member's self-evaluation of their physical and mental health status); and evaluated health statuses (i.e., indicators of a member's health assessed during health care encounters and documented in EHRs); both are associated with health service utilization (i.e., illness, chronic disease).
- Population and environment characteristics include community and neighborhood-level attributes that are associated with health service utilization, such as population health indicators, access to essential resources, and neighborhood environment characteristics (Beckett et al., 2021).
- Health care utilization includes desirable and undesirable utilization of healthcare services. Based on data availability, the current study examined the following utilization outcomes: 1) emergency department (ED) encounters; and 2) inpatient hospitalization encounters.

Appendix B. Supplemental Analyses

Combinations of Social Risk Exposures (Appendix D. Supplemental Table 7)

Supplemental analyses also explore the unadjusted relationship between utilization outcomes and social risk variables by type, severity, and combinations of member-reported social risk. In general, members that experienced more social risk and more severe social risk (i.e., none vs. 1-2 risks vs. 3-4 risks) had an increased risk of ED encounters during the 18-months preceding survey completion. However, the number and severity of social risk factors reported was not significantly associated with increased odds of experiencing an inpatient hospitalization encounter. When examining combinations of social risk factors, no significant associations were observed for inpatient hospitalizations.

Inpatient Hospitalization and Social Isolation

Supplemental analyses were conducted to examine the significant and protective association between members that reported social isolation and experienced an inpatient hospitalization. Specifically, the following interaction terms were added separately to the final adjusted model: 1) age group x social isolation; 2) race and ethnicity x social isolation; 3) COVID time period x social isolation. All three interactions were non-significant and did not significantly add to explaining the outcomes (Type 3 Values: $p=0.06$; $p=0.32$; $p=0.67$, respectively). The association between social isolation and inpatient hospitalization did not vary significantly by age groups, race and ethnicity groups, or COVID time period.

Inpatient Hospitalization Definition (Appendix D. Supplemental Table 8)

Sensitivity analyses were performed on inpatient hospitalization encounters before and after removing non-emergent encounters from the definition – specifically planned hospitalizations including newborn labor and delivery. Excluding those cases did not change the findings or the odds of inpatient hospitalization by each social risk factor when outcome variable was refined.

Controlling for Race and Ethnicity (Appendix D. Supplemental Table 9)

Emerging research has suggested that social risk factors may be better predictors for health-related outcomes than race and ethnicity; recommendations to use social risk factors instead of race and ethnicity in predictor models have increased.[19] In the current analysis, race and ethnicity was not a significant predictor of ED and inpatient hospitalization encounters in the adjusted regression models ($p>.05$). Exploratory analyses removed race and ethnicity from the adjusted models; findings remained consistent with no significant change in estimates.

Appendix C. Strengths and Limitations

The present study has several strengths that should be noted. The multistage stratified sampling framework was designed to produce generalizable findings across KP regions. The established cohort allows researchers to explore the prevalence of social risks amongst KP members and their influence on health services utilization outcomes. These findings are generalizable and can help to inform the development of targeted interventions within and across regions. They can also serve as a comparison group for testing future social health interventions.

However, there are some limitations that warrant discussion.

1. Members reporting social risk in the past 12 months were less likely to be enrolled in the health plan for a duration equal to or greater than 18-months.
2. A potential gap in external utilization encounter data may exist among Medicaid members. Specifically, Medicaid encounter data may be missing in KP markets that do not own their own hospitals.
3. Not all ED and hospitalization encounters are 'undesirable' or inappropriate. The current analyses examined all ED and hospitalization encounters.

Finally, statistical estimates may have decreased precision in weighted analyses; however, weighted analyses were appropriate for representativeness and the sample design and allow for inferences in the broader KP populations. As an example, decreased precision may result in wider confidence intervals and thus may explain why financial strain was significantly linked to higher ED utilization, but severe financial strain was not.

Appendix D. Supplemental Tables

Supplemental Table 1. Revenue Codes Used to Extract Utilization Outcomes from Claims and EHR Data Sources

Source table	VARIABLE NAME	Description	Permissible values	Comments	Revenue Code; IDR mapping (KFH and NonKFH)
IE	ENCOUNTER_ID	A UNIQUE ID TO IDENTIFY A UNIQUE APPOINTMENT			ENCTR_SK
IE	VISIT_DATE	Date of encounter or Visit or admit (for inpatient stays)	MMDDYY10.		ENCTR_STRT_TS
IE	DISCHARGE_DATE	Date of Discharge	MMDDYY10.	missing allowed for outpatient visit or same day discharge	ENCTR_END_TS
IE	DISCHARGE_DISPOSITION	The disposition of the patient at discharge for events with discharge.	A' = Alive		KFH:KPHC_DSCHRG_DISP_IK
			'E' = Expired		NonKFH:DSCHRG_DISP_IK
			'U' = Unknown		Use look up table to derive A, E, and U
					NonKFH
IE	LOS	Length of Stay (in days)	greater than or equal to 0	MAX((DISCHARGE_DATE-VISIT_DATE)+1,1)	TTL_LOS_DAY_CT only populated for discharged cases, exclude HOV
IE	ED_STRT_TS				ED_STRT_TS
IE	ED_END_TS				ED_END_TS
IE	INPAT_STRT_TS				INPAT_STRT_TS
IE	INPAT_END_TS				INPAT_END_TS
IE	UTLZTN_TYP_CD		CLAIMS, KFH, REFERRALS		UTLZTN_TYP_CD
IE	ENCTR_SVC_CD				
IE	ENCTR_SVC_DS_TX				
IE	ED_IN_CD	Evidence of ER use	Y/N		
Derived	NON_UC_ER_FLAG	Indicator of an ER charge attached to the encounter	Y/N	If ER (non-urgent care) revenue code is present on claim then set to 'Y'	450 EMERG ROOM
					451 ER MEDICAL SCREENING SERVICES
					452 ER BEYOND EMTALA SCREENING
					459 OTHER EMER ROOM
Derived	ER_UC_FLAG	Indicator of urgent care level ER charges attached to the encounter		If ER Urgent Care revenue code is present, then set to 'Y'	456 EMERG ROOM: URGENT CARE
Derived	UC_FLAG	Indicator of urgent care clinic charges attached to the encounter		If urgent care clinic revenue code is present then set to 'Y'	516 URGENT CARE CLINIC
					526 URGENT CARE CLINIC
Derived	HH_FLAG	Indicator of Home Health Charges attached to the encounter	Y/N	If home health revenue code is present on claim then set to 'Y'	570 AIDE/HOME HEALTH
					571 AIDE/HOME HLTH/VISIT

					572 AIDE/HOME HLTH/HOUR
					579 AIDE/HOME HLTH/OTHER
					580 VISIT/HOME HEALTH
					581 VISIT/HOME HLTH/VISIT
					582 VISIT/HOME HLTH/HOUR
					589 VISIT/HOME HLTH/OTHER
					590 UNIT/HOME HEALTH
					599 UNIT/HOME HLTH/OTHER
					600 O2/HOME HEALTH
Derived	HSPC_FLAG	Indicator of Hospice Charges attached to the encounter	Y/N	If hospice revenue code is present on claim then set to 'Y'	115 HOSPICE/PVT
					125 HOSPICE/2BED
					135 HOSPICE/3&4BED
					145 HOSPICE/DLX
					155 HOSPICE/WARD
					235 NUR INCR/HOSPICE
					650 HOSPICE GENERAL CLASSIFICATION
					651 HOSPICE/RTN HOME
					652 HOSPICE/CTNS HOME
					653 HOSPICE
					655 HOSPICE/IP RESPITE
					656 HOSPICE/IP NON-RESPITE
					657 HOSPICE/PHYSICIAN
					659 HOSPICE/OTHER
					658 HOSPICE/SNF
Derived	ICU_FLAG	Indicator of Intensive Care Unit Charges attached to the encounter	Y/N	If ICU revenue code is present on claim then set to 'Y'	201 ICU/SURGICAL
					202 ICU/MEDICAL
					203 ICU/PEDS
					204 ICU/PSYCH
					206 POST ICU
					207 ICU/BURN CARE
					208 ICU/TRAUMA
					209 ICU/OTHER
Derived	NB_FLAG	Indicator of labor/delivery/new born charges attached to the encounter	Y/N	If labor, delivery, or newborn revenue code is present on claim then set to 'Y'	170 NURSERY
					171 NURSERY/NEWBORN
					172 NURSERY/PREMIE
					173 NEWBORN-LEVEL III
					174 NEWVBORN - LEVEL IV

					179 NURSERY/OTHER
					231 NUR INCR/NURSERY
					720 DELIVEROOM/LABOR
					721 LABOR
					722 DELIVERY ROOM
					723 CIRCUMCISION
					724 BIRTHING CENTER
					729 OTHER/DELIVER-LABOR
Derived	OBS_FLAG	Indicator of observation bed charges attached to the encounter	Y/N	If observation bed revenue code is present on claim then set to 'Y'	760 TREATMENT/OBSERVATION RM
					761 TREATMENT ROOM
					762 OBSERVATION ROOM
					769 OTHER TREATMENT/OBSERVATION RM
Derived	SNF_FLAG	Indicator of skilled nursing charges attached to the encounter		If skilled nursing revenue code is present on claim then set to 'Y'	550 SKILLED NURSING
					551 SKILLED NURS/VISIT
					552 SKILLED NURS/HOUR
Derived	SURG_FLAG	Indicator of surgery charges attached to the encounter		If surgery or operating room revenue code is present on claim then set to 'Y'	360 OR SERVICES
					361 OR/MINOR
					362 OR/ORGAN TRANS
					367 OR/KIDNEY TRANS
					369 OR/OTHER
					490 AMBULATORY SURG
					499 OTHER AMBULATORY SURG

Supplemental Table 2. Study Variables

Domain	Variable	Collapsed Variables /Levels of Expression	Data Source	Role in Analysis	Dates
Health Care Utilization	In Patient Hospitalization	Yes/No	EHR, IDR	Primary outcome (DV)	Variables assessed retrospectively, 18 months preceding survey completion
	Emergency Department	Count			
Enabling Resources – Social Risk	Social risk: food insecurity	No Social Risk; Social Risk; Severe Social Risk	Survey	Primary exposure (IV)	Variables assessed at time of survey completion, 1/2020-9/2020; Social risk questions asking 'in the past 12 months')
	Social risk: housing instability				
	Social risk: financial strain				
	Social risk: social isolation				
	Social risk: transportation				
	Social risk: any need				
Predisposing Characteristics – Demographics	Age Group	18-34 years; 35-50 years; 51-64 years; 65+ years	Survey	Controlling for (Covariate)	Accessed at survey completion date
	Gender	Male; Female			
	Race and Ethnicity (collapsed for analyses)	White (Non-Hispanic); Black (Non-Hispanic); Asian/Pacific Islander (Non-Hispanic); Multi-racial, Other including Native American (Non-Hispanic); Hispanic			
	Education	Less than High School; High school graduate or GED; Some college or 2-year degree; 4-year college graduate or more			
	Insurance Type	Medicare, Medicaid, Special Programs; Commercial			
Need for Care Factors	Perceived Self-rated physical health	Excellent/Very Good; Good; Fair/Poor	Survey	Controlling for (Covariate)	Accessed during 18-months prior to survey completion date
	Perceived Self-rated mental health	Excellent/Very Good; Good; Fair/Poor	Survey		
Environment / Population Characteristics	KP Region	8 regions	EHR	Controlling for (Covariate)	Assessed at time of data extraction
	Neighborhood Deprivation Index (NDI)		EHR (GEMS)		
	Access to Social Needs Resources		Thrive Local Resource Directory		

Supplemental Table 3. Comparison of Eligible and Non-Eligible Populations from SONNET Social Needs Survey Cohort, Weighted Data

Trait	Value	Not Eligible**	Eligible* (Analytic Sample)	Total Sample (Survey Cohort)	Weighted Rao Scott chisq p-values
KP Region	KPCO	81091 (4.1%)	339740 (5.5%)	420831 (5.2%)	<.0001
	KPGA	58661 (3.0%)	145381 (2.4%)	204042 (2.5%)	
	KPHI	45970 (2.3%)	124830 (2.0%)	170799 (2.1%)	
	KPMA	119152 (6.1%)	368924 (6.0%)	488076 (6.0%)	
	KPNC	535704 (27.2%)	2372339 (38.5%)	2908043 (35.8%)	
	KPNW	119544 (6.1%)	355837 (5.8%)	475381 (5.9%)	
	KPSC	560936 (28.5%)	2450336 (39.8%)	3011272 (37.1%)	
	KPWA	445861 (22.7%)	0 (0.0%)	445861 (5.5%)	
Sociodemographic Characteristics					
High Risk	N	1196634 (60.8%)	4438191 (72.1%)	5634824 (69.4%)	<.0001
	Y	770285 (39.2%)	1719195 (27.9%)	2489480 (30.6%)	
Age Group	18-34 years	819868 (41.7%)	1558081 (25.3%)	2377949 (29.3%)	<.0001
	35-49 years	500917 (25.5%)	1479687 (24.0%)	1980604 (24.4%)	
	50-64 years	400315 (20.4%)	1725644 (28.0%)	2125959 (26.2%)	
	65+ years	245819 (12.5%)	1393974 (22.6%)	1639793 (20.2%)	
Gender	F	1124955 (57.2%)	3264088 (53.0%)	4389043 (54.0%)	0.03
	M	841963 (42.8%)	2893298 (47.0%)	3735261 (46.0%)	
Race & Ethnicity (survey, collapsed)	Missing	13662 (0.7%)	0 (0.0%)	13662 (0.2%)	0.59
	White, Non-Hispanic (NH)	828545 (42.1%)	2688792 (43.7%)	3517337 (43.3%)	
	African American, NH	152346 (7.7%)	529168 (8.6%)	681514 (8.4%)	
	Asian and Pacific Islander , NH	324587 (16.5%)	1114902 (18.1%)	1439489 (17.7%)	
	Native American, NH	10689 (0.5%)	27315 (0.4%)	38005 (0.5%)	
	Multi-racial and other NH	60597 (3.1%)	164206 (2.7%)	224803 (2.8%)	
	Hispanic	576493 (29.3%)	1633002 (26.5%)	2209495 (27.2%)	
Race and Ethnicity Analysis (uncollapsed and hardcoded)	African American (Non-Hispanic)	150685 (7.7%)	526892 (8.6%)	677577 (8.3%)	0.01
	AIAN (Non-Hispanic)	10689 (0.5%)	27423 (0.4%)	38112 (0.5%)	
	Asian (Non-Hispanic)	270344 (13.7%)	916333 (14.9%)	1186676 (14.6%)	
	Hispanic	576493 (29.3%)	1632865 (26.5%)	2209358 (27.2%)	
	Multi-racial (Non-Hispanic)	60714 (3.1%)	236528 (3.8%)	297241 (3.7%)	
	Other (Non-Hispanic)	20826 (1.1%)	46931 (0.8%)	67757 (0.8%)	
	Pacific Islander (Non-Hispanic)	30685 (1.6%)	105866 (1.7%)	136551 (1.7%)	
	White (Non-Hispanic)	816504 (41.5%)	2649394 (43.0%)	3465898 (42.7%)	
	Unknown	29980 (1.5%)	15154 (0.2%)	45134 (0.6%)	
Insurance Type (UCDAs simplified product or insurance type category)	Medicaid, Medicare, Special Programs	396503 (20.2%)	1507149 (24.5%)	1903652 (23.4%)	0.005
	Commercial	1570416 (79.8%)	4650237 (75.5%)	6220653 (76.6%)	
Employment status	Missing	29139 (1.5%)	17263 (0.3%)	46402 (0.6%)	<.0001
	Employed	1400174 (71.2%)	3992645 (64.8%)	5392820 (66.4%)	
	Unemployed	326290 (16.6%)	854864 (13.9%)	1181154 (14.5%)	
	Retired	211315 (10.7%)	1292614 (21.0%)	1503929 (18.5%)	
Education	Missing	63025 (3.2%)	0 (0.0%)	63025 (0.8%)	0.18
	Less than High School Degree	118692 (6.0%)	358394 (5.8%)	477086 (5.9%)	

	High school graduate or GED	334751 (17.0%)	973763 (15.8%)	1308514 (16.1%)	
	Some college or 2-year degree	596997 (30.4%)	1934532 (31.4%)	2531530 (31.2%)	
	4-year college graduate	499768 (25.4%)	1512415 (24.6%)	2012183 (24.8%)	
	More than a 4-year college degree	353686 (18.0%)	1378281 (22.4%)	1731967 (21.3%)	
Marital Status	Missing	30507 (1.6%)	16241 (0.3%)	46748 (0.6%)	<.0001
	Married/Living with a Partner	1178870 (59.9%)	4050569 (65.8%)	5229439 (64.4%)	
	Widowed	46743 (2.4%)	291096 (4.7%)	337840 (4.2%)	
	Separated/Divorced	207390 (10.5%)	586179 (9.5%)	793569 (9.8%)	
	Never married	503408 (25.6%)	1213302 (19.7%)	1716710 (21.1%)	
Health Indicators					
Physical Heath	Missing	2612 (0.1%)	0 (0.0%)	2612 (0.0%)	0.28
	Excellent	244528 (12.4%)	643940 (10.5%)	888468 (10.9%)	
	Very good	684932 (34.8%)	2326554 (37.8%)	3011485 (37.1%)	
	Good	740737 (37.7%)	2322652 (37.7%)	3063389 (37.7%)	
	Fair	259956 (13.2%)	737791 (12.0%)	997747 (12.3%)	
	Poor	34154 (1.7%)	126449 (2.1%)	160603 (2.0%)	
Mental Health	Missing	13374 (0.7%)	0 (0.0%)	13374 (0.2%)	<.05
	Excellent	345272 (17.6%)	1093446 (17.8%)	1438718 (17.7%)	
	Very good	656544 (33.4%)	2405911 (39.1%)	3062455 (37.7%)	
	Good	606472 (30.8%)	1807274 (29.4%)	2413746 (29.7%)	
	Fair	276500 (14.1%)	698118 (11.3%)	974618 (12.0%)	
	Poor	68757 (3.5%)	152637 (2.5%)	221394 (2.7%)	
Charlson Score using data 18 months prior	Missing	1588306 (80.8%)	4346765 (70.6%)	5935071 (73.1%)	<.0001
	0	239045 (12.2%)	691809 (11.2%)	930854 (11.5%)	
	1-2	86712 (4.4%)	541017 (8.8%)	627729 (7.7%)	
	3-4	26753 (1.4%)	264894 (4.3%)	291648 (3.6%)	
	5-6	9805 (0.5%)	99938 (1.6%)	109743 (1.4%)	
	7+	16297 (0.8%)	212963 (3.5%)	229261 (2.8%)	
Social Risk					
Any Social Risk	Yes	1421079 (72.2%)	3745890 (60.8%)	5166969 (63.6%)	<0.0001
Any Financial Strain	Yes	1075365 (54.7%)	2486679 (40.4%)	3562043 (43.8%)	<0.0001
Any Transport Issue	Yes	160807 (8.2%)	365131 (5.9%)	525938 (6.5%)	<0.05
Any Food Insecurity	Yes	759894 (38.6%)	1728952 (28.1%)	2488846 (30.6%)	<0.0001
Any Social Isolation	Yes	764144 (38.8%)	2105642 (34.2%)	2869786 (35.3%)	<0.05
Any Housing Instability	Yes	412484 (21.0%)	936095 (15.2%)	1348579 (16.6%)	<0.0001
Social Need					
Desire for assistance	No	802748 (40.8%)	3252504 (52.8%)	4055252 (49.9%)	<0.0001
	Yes	1164170 (59.2%)	2904882 (47.2%)	4069052 (50.1%)	

Notes. *Eligible = Member enrolled for at least 18 months prior to survey completion date; **Not Eligible = Member enrolled for less than 18 months prior to survey date

Supplemental Table 4. Cohort Descriptives by Andersen's Behavioral Model for Health Care Use: Predisposing Characteristics, Enabling Factors, and Need-for-Care Factors; Weighted Sample.

Characteristics	**Response Options**			**Weighted % or Mean (SD)**
Predisposing Characteristics				
Age Group	18-34 years			25.3%
	35-49 years			24.0%
	50-64 years			28.0%
	65 + years			22.6%
Gender	Female			53.0%
	Male			47.0%
Race and Ethnicity[1]	Hispanic, Latino/a or Spanish origin			26.5%
	White/Caucasian (non-Hispanic)			43.0%
	Black or African American (non-Hispanic)			8.6%
	Asian (non-Hispanic)			14.9%
	Pacific Islander (non-Hispanic)			1.7%
	American Indian or Alaska Native (non-Hispanic)			0.4%
	Other race selected (non-Hispanic)			0.8%
	Multi-racial, two or more groups selected (non-Hispanic)			3.8%
Education Level	Less than High School			5.8%
	High school graduate or GED			15.8%
	Some college or 2-year degree			31.4%
	4-year college graduate or more			47.0%
Insurance Type	Medicare, Medicaid, Special Program			24.5%
	Commercial			75.5%
Enabling Factors	*Severe Risk*		*Risk*	*No Risk*
Food Insecurity	6.1%		22.0%	71.9%
Housing Instability	11.8%		3.4%	84.8%
Financial Strain	14.3%		26.1%	59.6%
Social Isolation	12.1%		22.1%	65.8%
Transportation	2.6%		3.4%	94.1%
Any Financial strain, Housing instability, and/or food insecurity	23.2%		24.9%	51.9%
Any social risk reported	30.1%		30.7%	39.2%
Need-For-Care Factors	*Excellent / Very Good*		*Good*	*Fair / Poor*
Self-rated physical health	48.3%		37.7%	14.1%
Self-rated mental health	56.9%		29.4%	13.8%
Environmental Factors				
Neighborhood Deprivation Index (NDI), *Percentiles*	*≤10th*		*11th-89th*	*≥90th (ref)*
	11.9%		79.0%	9.0%
Material Deprivation (Access to Social Needs Resources), *Count*	*None, 0*	*One, 1*	*Some, 2-10*	*Many, 11-50*
	65.7%	10.6%	20.2%	3.5%
Health Service Utilization	*None, 0*	*One, 1*	*2-5*	*6 or more*
Emergency Department Encounter, *Count* (Range 0-19)	82.1%	12.1%	5.6%	0.2%
Inpatient Hospitalization Encounter, *Count* (Range 0-13)	93.3%	5.0%	1.7%	<.01

Note: Weighted Sample = 6,221,873; Unweighted Sample = 7,309

[1]Race and ethnicity was collapsed for analyses due to small sample size and power.

Supplemental Table 5. Weighted Poisson Regression. Unadjusted and adjusted relative risk of emergency room (ED) encounters by social risk (enabling) factors.

Social Risk Factors	Social Risk Level	Emergency Room Encounters		
		Model 1 Unadjusted Model	Model 2 Adjusted Model: Individual-Level Factors[1]	Model 3 Adjusted Model: Individual & Environment Factors[2]
		RR (95% CI)	RR (95% CI)	RR (95% CI)
Housing Stability	Severe Risk	**1.80 (1.38-2.35)**	**1.76 (1.31-2.35)**	**1.76 (1.31-2.35)**
	Risk	**2.24 (1.08-4.65)**	2.10 (0.97-0.45)	2.10 (0.97-4.55)
	None (ref)	1.00	1.00	1.00
Food Insecurity	Severe Risk	**1.85 (1.31-2.59)**	**1.59 (1.09-2.32)**	**1.59 (1.09-2.32)**
	Risk	**1.60 (1.24-2.06)**	**1.43 (1.08-1.88)**	**1.44 (1.09-1.90)**
	None (ref)	1.00	1.00	1.00
Financial Strain	Severe Risk	**1.66 (1.28-2.17)**	1.33 (0.98-1.18)	1.34 (0.98-1.82)
	Risk	**1.50 (1.17-1.92)**	**1.34 (1.03-1.76)**	**1.34 (1.02-1.75)**
	None (ref)	1.00	1.00	1.00
Social Isolation	Severe Risk	1.10 (0.79-1.52)	0.93 (0.65-1.33)	0.91 (0.63-1.30)
	Risk	1.22 (0.96-1.55)	1.10 (0.84-1.43)	1.07 (0.83-1.39)
	None (ref)	1.00	1.00	1.00
Transportation Issues	Severe Risk	**1.94 (1.23-3.07)**	1.43 (0.92-2.24)	1.46 (0.93-2.27)
	Risk	1.50 (0.78-2.89)	1.22 (0.62-2.42)	1.23 (0.62-2.24)
	None (ref)	1.00	1.00	1.00
Any Social Risk Factor	Severe Risk	**1.70 (1.35-2.15)**	**1.53 (1.18-1.97)**	**1.51 (1.17-1.96)**
	Risk	**1.39 (1.07-1.81)**	**1.35 (1.02-1.79)**	**1.33 (1.01-1.76)**
	None (ref)	1.00	1.00	1.00
Financial Strain, Housing Instability, Food Insecurity	Severe Risk	**1.82 (1.45-2.29)**	**1.62 (1.24-2.11)**	**1.62 (1.25-2.12)**
	Risk	**1.47 (1.13-1.93)**	**1.38 (1.04-1.82)**	**1.37 (1.03-1.82)**
	None (ref)	1.00	1.00	1.00

[1] Model adjusted for individual level predisposing factors (age group, gender, race and ethnicity, insurance type and education level) and need-for care factors (self-rated physical health, self-rated mental health); and region.

[2] Model 2+ adjusted for environmental-level factors (neighborhood deprivation index, thrive local access to resources aligning with corresponding social risk factor)

Supplemental Table 6. Weighted Logistic Regression. Unadjusted and adjusted odds of inpatient hospitalization by social risk (enabling) factors.

Social Risk Factors	Social Risk Level	Inpatient Hospitalization Encounters		
		Model 1 Unadjusted Model	**Model 2 Adjusted Model: Individual-Level Factors[1]**	**Model 3 Adjusted Model: Individual & Environment Factors[2]**
		OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Housing Stability	Severe Risk	**1.59 (1.03-2.44)**	1.51 (0.93-2.46)	1.49 (0.92-2.41)
	Risk	0.39 (0.14-1.10)	0.40 (0.14-1.15)	0.39 (0.13-1.12)
	None (ref)	1.00	1.00	1.00
Food Insecurity	Severe Risk	1.10 (0.67-1.81)	0.92 (0.53-1.63)	0.94 (0.54-1.63)
	Risk	1.39 (0.96-2.02)	1.27 (0.86-1.86)	1.27 (0.86-1.89)
	None (ref)	1.00	1.00	1.00
Financial Strain	Severe Risk	1.21 (0.79-1.86)	0.99 (0.61-1.61)	0.98 (0.60-1.58)
	Risk	0.98 (0.68-1.42)	0.89 (0.60-1.31)	0.88 (0.60-1.30)
	None (ref)	1.00	1.00	1.00
Social Isolation	Severe Risk	**0.58 (0.35-0.97)**	**0.50 (0.28-0.91)**	**0.51 (0.28-0.92)**
	Risk	0.79 (0.52-1.19)	0.74 (0.48-1.14)	0.74 (0.47-1.15)
	None (ref)	1.00	1.00	1.00
Transportation	Severe Risk	1.18 (0.55-2.54)	0.78 (0.36-1.67)	0.77 (0.36-1.65)
	Risk	1.21 (0.59-2.48)	0.87 (0.38-1.98)	0.91 (0.40-2.05)
	None (ref)	1.00	1.00	1.00
Any Social Risk Factor	Severe Risk	1.04 (0.72-1.50)	0.92 (0.60-1.42)	0.91 (0.59-1.40)
	Risk	0.86 (0.58-1.27)	0.83 (0.56-1.24)	0.83 (0.56-1.24)
	None (ref)	1.00	1.00	1.00
Financial Strain, Housing Instability, Food Insecurity	Severe Risk	1.27 (0.88-1.84)	1.09 (0.72-1.66)	1.08 (0.71-1.64)
	Risk	0.92 (0.62-1.37)	0.84 (0.56-1.27)	0.85 (0.57-1.27)
	None (ref)	1.00	1.00	1.00

[1] Model 2 adjusted for individual level predisposing factors (age group, gender, race and ethnicity, insurance type and education level) and need-for care factors (self-rated physical health, self-rated mental health); and region.

[2] Model 3+ adjusted for environmental-level factors (neighborhood deprivation index, thrive local access to resources aligning with corresponding social risk factor)

Supplemental Table 7. Combinations of Social Risk. Unadjusted relationship between emergency department (ED) and inpatient (IP) hospitalization encounters, by type and severity of member-reported social risks, individual risk and combinations of risk.

Member-Reported Social Risk		Emergency Department RR (95% CI)	Inpatient Hospitalization OR (95% CI)
Individual Social Risk Domains			
Housing Instability	Severe Social Risk	**1.80 (1.38-2.35)**	**1.59 (1.03-2.44)**
	Social Risk	**2.24 (1.08-4.65)**	0.39 (0.14-1.10)
	None (ref)	1.00	1.00
Food Insecurity	Severe Social Risk	**1.85 (1.31-2.59)**	1.10 (0.67-1.81)
	Social Risk	**1.60 (1.24-2.06)**	1.39 (0.96-2.02)
	None (ref)	1.00	1.00
Financial Strain	Severe Social Risk	**1.66 (1.28-2.17)**	1.21 (0.79-1.86)
	Social Risk	**1.50 (1.17-1.92)**	0.98 (0.68-1.42)
	None (ref)	1.00	1.00
Social Isolation	Severe Social Risk	1.10 (0.79-1.52)	**0.58 (0.35-0.97)**
	Social Risk	1.22 (0.96-1.55)	0.79 (0.52-1.19)
	None (ref)	1.00	1.00
Transportation	Severe Social Risk	**1.94 (1.23-3.07)**	1.18 (0.55-2.54)
	Social Risk	**1.50 (0.78-2.89)**	1.21 (0.59-2.48)
	None (ref)	1.00	1.00
Number and Severity of Social Risks			
Social Risk (Count)	5	**1.86 (1.08-3.19)**	0.97 (0.40-2.33)
	3-4	**2.08 (1.56-2.77)**	1.19 (0.78-1.82)
	1-2	**1.30 (1.04-1.63)**	0.84 (0.59-1.21)
	None, 0 (ref)	1.00	1.00
Severe Social Risk (Count)	5	1.51 (0.15-14.75)	0.90 (0.14-5.98)
	3-4	**1.70 (1.16-2.49)**	1.00 (0.55-1.81)
	1-2	**1.41 (1.12-1.77)**	1.13 (0.79-1.61)
	None, 0 (ref)	1.00	1.00
Combinations			
Any Social Risk	Any Severe Social Risk	**1.70 (1.35-2.15)**	1.04 (0.72-1.50)
	Any Social Risk	**1.39 (1.07-1.81)**	0.86 (0.58-1.27)
	None (ref)	1.00	1.00
Financial Strain, Housing Instability, & Food Insecurity	Severe Social Risk	**1.82 (1.45-2.29)**	1.27 (0.88-1.84)
	Social Risk	**1.47 (1.13-1.93)**	0.92 (0.62-1.37)
	None (ref)	1.00	1.00

Note. Bivariate associations between inpatient hospitalization encounters (Utilization), predisposing characteristics, enabling factors (social risk factors), need-for-care factors examined, weighted sample [saved here – see link]

Supplemental Table 8. Sensitivity analysis. Adjusted odds of inpatient hospitalization by enabling factors (removing non-emergent, newborn and labor/delivery encounters from inpatient hospitalization definition).[1]

		Adjusted Odds Ratios (OR)s (Table 4)			Adjusted Odds Ratios (OR)s Removing newborn and labor/delivery encounter from IP outcome definition		
Enabling Factors	**Response Options**	**OR**	**OR LCL**	**OR UCL**	**OR**	**OR LCL**	**OR UCL**
Any Social Risk	Severe Risk	0.920	0.598	1.417	0.838	0.540	1.302
	Risk	0.834	0.561	1.238	0.770	0.510	1.164
	None (ref)	1.00			1.00		
Food Insecurity	Severe Risk	0.924	0.525	1.626	0.947	0.529	1.698
	Risk	1.272	0.855	1.893	1.276	0.844	1.930
	None (ref)	1.00			1.00		
Housing Stability	Severe Risk	1.510	0.928	2.456	1.414	0.858	2.333
	Risk	0.396	0.137	1.145	0.367	0.118	1.147
	None (ref)	1.00			1.00		
Financial Strain	Severe Risk	0.989	0.607	1.612	1.015	0.614	1.680
	Risk	0.887	0.599	1.314	0.874	0.579	1.321
	None (ref)	1.00			1.00		
Social Isolation	Severe Risk	**0.500**	**0.276**	**0.905**	**0.491**	**0.266**	**0.907**
	Risk	0.737	0.476	1.141	0.749	0.478	1.174
	None (ref)	1.00			1.00		
Transportation	Severe Risk	0.778	0.363	1.666	0.778	0.358	1.692
	Risk	0.872	0.384	1.977	0.880	0.380	2.037
	None (ref)	1.00			1.00		
Financial Strain, Housing Instability, Food Insecurity	Severe Risk	1.091	0.716	1.662	1.032	0.672	1.585
	Risk	0.844	0.563	1.265	0.781	0.509	1.198
	None (ref)	1.00			1.00		

[1] Models adjusted for individual level predisposing factors (age group, gender, race and ethnicity, insurance type and education level) and need-for care factors (self-rated physical health, self-rated mental health); and region.

Supplemental Table 9. Weighted Logistic Regression. Unadjusted and adjusted odds of inpatient hospitalization among patients with and without social risk of housing stability.

Characteristics	Response Options	Inpatient Hospitalization Encounter (Y/N)		
		Model 1 Unadjusted Model	Model 2 Adjusted Model: Individual-Level Factors[1]	Model 3 Adjusted Model: Individual & Environment Factors[2]
Enabling Factors		OR (95% CI)	OR (95% CI)	OR (95% CI)
Housing Stability	Severe Housing Instability	**1.59 (1.03-2.44)**	1.51 (0.93-2.46)	1.49 (0.92-2.41)
	Housing Instability	0.39 (0.14-1.10)	0.40 (0.14-1.15)	0.39 (0.13-1.12)
	No Housing Instability (ref)	1.00	1.00	1.00
Predisposing Factors				
Age Group	18-34 years (ref)		1.00	1.00
	35-49 years		0.63 (0.38-1.04)	0.63 (0.38-1.04)
	50-64 years		**0.37 (0.21-0.64)**	**0.37 (0.22-0.65)**
	65 + years		0.74 (0.41-1.34)	0.74 (0.41-1.33)
Gender	Male		**0.58 (0.41-0.81)**	**0.57 (0.40-0.80)**
	Female (ref)		1.00	1.00
Race and Ethnicity	Hispanic		0.85 (0.52-1.41)	0.83 (0.50-1.40)
	Black (Non-Hispanic)		1.25 (0.73-2.15)	0.17 (0.68-2.02)
	Asian/Pacific Islander (Non-Hispanic)		0.63 (0.36-1.12)	0.64 (0.36-1.14)
	Multi-racial & Other including Native American (Non-Hispanic)		1.40 (0.57-3.45)	1.47 (0.60-3.61)
	White (Non-Hispanic) (ref)		1.00	1.00
Insurance Type	Medicare, Medicaid, Special Program		1.62 (0.98-2.65)	**1.65 (1.01-2.71)**
	Commercial (ref)		1.00	1.00
Education Level	Less than High School		1.00 (0.49-2.05)	0.97 (0.48-1.94)
	High School graduate or GED		0.92 (0.56-1.49)	0.86 (0.53-1.40)
	Some College or 2-year degree		1.02 (0.70-1.50)	0.98 (0.67-1.44)
	4-year degree or more (ref)		1.00	1.00
Need-For-Care Factors				
Self-Rated Physical Health	Excellent/Very Good (ref)		1.00	1.00
	Good		1.85 (1.24-2.75)	1.84 (1.24-2.75)
	Fair/Poor		**2.98 (1.83-4.88)**	**2.97 (1.82 (4.86)**
Self-Rated Mental Health	Excellent/Very Good (ref)		1.00	1.00
	Good		**0.49 (0.33-0.72)**	**0.48 (0.33-0.72)**
	Fair/Poor		0.65 (0.40-1.08)	0.66 (0.40-1.09)
Environment Factors				
Neighborhood Deprivation Index	≤10th Percentile			1.00
	11th-89th Percentile			1.78 (0.88-3.58)
	≥90th Percentile (ref)			1.98 (0.82-4.77)
Access to Resources, Count (Housing)	0			1.00
	1			0.70 (0.43-1.13)
	2-10			0.75 (0.45-1.27)
	11-50			0.88 (0.27-3.39)

[1] Model adjusted for individual level predisposing factors (age group, gender, race and ethnicity, insurance type and education level) and need-for care factors (self-rated physical health, self-rated mental health); and region.

[2] Model 2 plus adjusted for environmental-level factors (neighborhood deprivation index, thrive local access to resources aligning with corresponding social risk factor)

Note: Supplemental analyses examined: 1) interaction between COVID and social risk (non-significant); 2) removing race and ethnicity from adjusted model (no change in results), results not presented.