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Article

Social risk factors and cancer prevention care among patients in community health-care settings

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Abstract

Background: Social risks are negatively associated with receipt of cancer preventive care. As knowledge is lacking on the pathways underlying these associations, we investigated associations between patient-reported social risks and colorectal cancer (CRC), cervical cancer, and breast cancer screening order provision and screening completion.

Methods: This study included patients eligible for CRC, cervical cancer, or breast cancer screening at 186 community-based clinics between July 1, 2015, and February 29, 2020. Outcomes included up-to-date status for indicated cancer screenings at baseline; percentage of subsequent study months in which patients were up-to-date on screenings; screening order receipt; and screening completion. Independent variables were patient-reported food insecurity, transportation barriers, and housing instability. Analyses used covariate-adjusted generalized estimating equation models, stratified by social risk.

Results: Patients with documented social risks were less likely to be up-to-date on any cancer screening at baseline and in most cases had a lower rate of total study months up-to-date on screenings. All cancer screenings were ordered less often for food-insecure patients. Cervical cancer screening was ordered less often for transportation-insecure patients. The likelihood of completing a screening test differed statistically significantly by select social risks: Cervical cancer and CRC screening rates were lower among food-insecure patients, and CRC screening rates were lower among transportation-insecure patients. The likelihood of breast cancer screening completion did not differ by social risk status.

Conclusion: Social risks affect both the ordering and the receipt of cancer screening. Research is needed on strategies to mitigate the impact of different social risks on cancer early-detection services.

Introduction

Timely cancer screening increases the likelihood of early detection and improves disease prognosis. Emerging research shows lower cancer screening rates among persons with social risks such as food insecurity, housing instability, and transportation barriers.[1-4] Research exploring how social risks impede receipt of cancer prevention services, however, is limited.[4]

To help address this knowledge gap, we investigated associations between social risks and receipt of screening for cervical cancer, colorectal cancer (CRC), and breast cancer among patients at community-based health-care organizations (eg, community health centers and federally qualified health centers). In the United States, community-based health-care organizations are a primary source of cancer screening for minoritized, low-income, rural, and immigrant populations, all of whom experience a greater burden of social risks than the general US population.[5,6]

We assessed whether patients in community-based health-care organizations screened for social risks were up-to-date on guideline-recommended breast cancer, cervical cancer, or CRC screening. Among individuals due for a given screening, we assessed receipt and completion of screening orders. We hypothesized that the presence of social risks would not be associated with cancer screening orders but would be associated with completion of screenings, especially those that require subsequent visits (eg, mammography, colonoscopy) or steps (eg, fecal immunochemical test).

Methods

Data source and study population

This study included data from adult patients seen at 186 community-based health-care organizations from 13 states

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between July 1, 2015, and February 29, 2020. The study was limited to community-based health-care organizations that offered primary care services and had any electronic health record (EHR) documentation of patient-reported social risks for food, transportation, or housing insecurity. Data on patient demographics, encounters, cancer screenings, and social risk screening were extracted from the Accelerating Data Value Across a National Community Health Center Network Clinical Research Network, a PCORnet distributed research network member,[7] which includes OCHIN (a national network of community-based health-care organizations sharing an Epic EHR system). The study period was July 2016 through February 2020. The included EHR data are either patient reported or entered by clinic staff. This study was reviewed by OCHIN Compliance and determined to be exempt from institutional review board coverage needs.

Three cohorts were studied: (1) patients due for CRC screening, (2) patients due for cervical cancer screening, and (3) patients due for breast cancer screening. Analyses were limited to patients for whom 1 year or more of observation data were available. Each patient's observation period began at their first primary care encounter 1 year or more before their end date or the date when they aged into their cohort, whichever occurred later (yielding a range of 1-3.7 observation years) and ended at their last primary care encounter before March 1, 2020, the date they aged out of the age criteria for their cohort, or the date they were diagnosed with a condition excluding them from the cohort, whichever occurred first. Analysis methods, including patient inclusion periods and assessment of social risk screening status, were based on a prior study.[8]

Inclusion criteria for each of the 3 cohorts were based on 2020 Uniform Data System reporting guidelines[9]: Patients due for CRC screening are 50 to 74 years of age, patients due for breast cancer screening are women aged 50 to 74 years, and patients due for cervical cancer screening are women aged 23 to 64 years. Patients with a medical history meeting Uniform Data System exclusion criteria for any screening were excluded. Patients were considered up-to-date for CRC screening if they had a fecal occult blood test within 1 year of first primary care encounter, a fecal immunochemical test within 3 years, flexible sigmoidoscopy or computed tomography–based colonography within 5 years, or a colonoscopy within 10 years. Patients were considered up-to-date for breast cancer screening if they had received screening mammography within 2 years. Patients aged 23 to 29 years were considered up-to-date for cervical cancer screening if they had received a Papanicolaou test within 3 years. Patients aged 30 to 64 years were considered up-to-date if they had received either a Papanicolaou test within 3 years or a Papanicolaou and human papillomavirus test within 5 years.

Measures

Outcomes examined for each cancer screening included (1) up-to-date screening status at study entry; (2) the percentage of months up-to-date for indicated screening, measured as the number of months out of the total observation period for which a patient was in concordance with guideline recommendations for each screening test; (3) receipt of an order for screening, if indicated; (4) among persons whose screening was ordered, screening completion; and (5) the rate of primary care visits per year during the observation period. We selected these outcomes to help understand receipt of guideline-recommended cancer prevention services at distinct points across the care trajectory for each cancer type.

Independent variables were any of patient-reported food insecurity or housing instability, or transportation barriers. For each social risk, patients were categorized as not screened for social risk (ie, no documentation of risk status); screened for social risk and documented as having risk; or screened for social risk and documented as not having risk. Individuals with no documentation of having been screened for a given risk were included to enable comparison of individuals who were and were not screened. Of note, the diverse study sites used varying approaches to social risk screening, including different screening tools and different domains (some clinics did not screen for all risks). Our analysis approach included screening results for a given social risk domain, regardless of how screening was conducted.

Results from the entire cohort, including patients not screened for social risk, patients screened who reported social risks, and patients screened who did not report social risks, are shown in Tables S1 through S6. Results from all patients who were screened are presented in the sections that follow.

Statistical analyses

Descriptive statistics of patient characteristics overall and by social risk factor were estimated and reported. Outcomes were analyzed through generalized estimating equation models, stratified by risk factor, with separate models for food, transportation, and housing insecurity. Binary variables used a logit link function, the count variable (months up-to-date for screening) used a log link, specifying a Poisson distribution and using the number of months the patients were observed as the offset. Models controlled for sex, race and ethnicity, preferred language, age and insurance status at index encounter, federal poverty level on or after the index encounter, and the number of primary care visits per year during the individual's observation period (this variable was not included in the model for primary care visit rate). Race and ethnicity were categorized into Hispanic, Non-Hispanic Black, Non-Hispanic White, Non-Hispanic Other (which included American Indian or Alaska Native, Asian, Multiple race, Native Hawaiian, or Other Pacific Islander), and No data. All analyses were conducted using SAS Enterprise Guide, version 8.3.8.206, software (SAS Institute Inc), and all statistical testing was 2 sided, with a type I error set to 5%.

Results

Analysis cohorts

Study sample characteristics are provided in Tables 1, 2, and 3. In the breast cancer screening cohort (n = 83 993), 27% of patients were Hispanic and 19% were non-Hispanic Black; 84% were aged 50 to 64 years; 42% had Medicaid; and 54% had a household income of 100% or less of the federal poverty level. In the cervical cancer screening cohort (n = 202 895), 36% of patients were Hispanic and 19% were non-Hispanic Black; 45% were aged 23 to 39 years; 53% had Medicaid; and 56% had a household income of 100% or less of the federal poverty level. In the CRC screening cohort (n = 171 724), 24% of patients were Hispanic and 19% were non-Hispanic Black, 74% were aged 50 to 64 years; approximately 38% had Medicaid; and 54% had a household income 100% or less of the federal poverty level. In each cohort there were some differences between individuals screened for a given social risk and individuals not screened (Tables S1-S3). These differences were adjusted for in the regression analyses in Tables 4, 5, and 6.

Table 1. Breast cancer screening cohort

Characteristic	Total[a] (column %)	Food insecurity		Housing instability		Transportation barriers	
		Need	No need	Need	No need	Need	No need
Patients, No.	83 993 (100)	3605	7608	1666	8924	1689	7330
Female sex, %	83 993 (100)	100.0	100.0	100.0	100.0	100.0	100.0
Race and ethnicity,[b] %							
Hispanic	23 011 (27.4)	20.3	16.6	14.7	15.7	15.4	17.1
Non-Hispanic Black	15 913 (18.9)	29.5	25.6	34.2	34.3	31.7	31.0
Non-Hispanic White	5773 (41.8)	40.5	39.4	40.8	30.8	41.9	32.6
Non-Hispanic Other	35 072 (6.9)	5.8	10.7	6.2	11.4	7.1	11.6
No data	4224 (5.0)	3.9	7.7	4.2	7.8	3.9	7.7
Preferred language, %							
English	56 258 (67.0)	77.0	67.7	79.3	65.3	80.0	66.8
Non-English	27 735(33.0)	23.0	32.4	20.7	34.7	20.0	33.2
Age at index visit							
Median (range), y	58 (50-73)	57 (50-73)	59 (50-73)	57 (50-73)	59 (50-73)	57 (50-73)	59 (50-73)
Age group, %							
50-64 y	70 143 (83.5)	89.5	81.7	91.6	81.6	91.4	82.3
65-73 y	13 850 (16.5)	10.5	18.3	8.4	18.4	8.6	17.7
Payer at index visit, %							
Medicaid	35 633 (42.4)	50.3	35.7	50.8	38.1	53.6	37.7
Medicare	19 543 (23.3)	26.3	21.7	23.4	22.8	25.5	22.7
Other public	4270 (5.1)	2.1	2.8	2.1	3.0	1.7	3.0
Private	17 631 (21.0)	12.7	33.7	15.4	32.1	10.7	32.1
Uninsured	6916 (8.2)	8.7	6.1	8.3	4.0	8.5	4.5
Federal poverty level, %							
≤100	45 666 (54.4)	63.8	44.0	63.4	50.2	66.6	47.5
101-200	16 327 (19.4)	18.0	19.4	18.8	16.9	16.8	17.4
>200	8958 (10.7)	5.2	15.0	6.2	10.6	4.1	10.6
No data	13 042 (15.5)	13.1	21.7	11.6	22.3	12.5	24.5
Primary care visits in the first year after index, %							
1-2	17 721 21.1)	12.6	20.7	10.7	17.6	10.2	17.1
3-4	28 694 (34.2)	28.9	35.7	29.3	34.7	29.8	34.4
5-6	19 490(23.2)	25.7	23.4	26.1	24.7	25.9	24.8
≥7	18 088 (21.5)	32.8	20.3	33.9	23.0	34.0	23.7
Years of observation,[c,] %							
<2	79 623 (94.8)	95.5	94.8	95.4	95.4	95.8	95.4
2-3.7	4370 (5.2)	4.5	5.2	4.6	4.6	4.2	4.6
Breast cancer screening status at index,[c] %							
Due	23 047 (27.4)	29.3	23.1	32.5	21.2	32.7	22.4
Up-to-date	60 946 (72.6)	70.7	76.9	67.5	78.8	67.3	77.6
Ever due during observation period, %							
Not due during observation period	42 022 (50.0)	50.1	53.3	47.6	56.8	47.9	54.5
Due during observation period	41 971 (50.0)	49.9	46.7	52.4	43.2	52.1	45.5

[a] These data were representative of 186 clinics spanning 13 US states categorized by region: Midwest (Indiana, Minnesota, Ohio, and Wisconsin), Northeast (Massachusetts), South (Georgia, North Carolina, and Texas), and West (Alaska, California, Montana, Oregon, and Washington). Social determinants of health risk group was determined during the observation period. Pearson χ^2 tests were performed. In the regression models, federal poverty level categories were collapsed to ≤100, >200, and unknown. Race and ethnicity categories were collapsed to Hispanic, Non-Hispanic Black, Non-Hispanic White, and Non-Hispanic Other/Unknown. Comparing characteristics by the patient's social determinants of health needs category, all tests were statistically significant at $P < .05$, except for years of observation and food Insecurity.

[b] Race and ethnicity were categorized into Hispanic, Non-Hispanic Black, Non-Hispanic White, Non-Hispanic Other (included American Indian or Alaska Native, Asian, Multiple race, Native Hawaiian, or Other Pacific Islander), and No data.

[c] Study duration was determined at the patient level and defined by patient's last primary care encounter date at which they met the criteria for breast cancer screening guidelines and their first primary care encounter date that occurred at least 1 year before their last primary care encounter. Primary care encounters were defined as a face-to-face visit with an medical doctor, osteopath, physician assistant, or nurse practitioner. The study followed Uniform Data System guidelines for breast cancer screening and considered patients to have met the criteria for screening if they had received a mammography within 2 years.

Prevalence of social risks

In the breast cancer screening cohort, among patients screened for a given social risk, 32% (3605/11 213) reported food insecurity, 16% (1666/10 590) reported housing instability, and 19% (1689/9019) reported transportation barriers. In the cervical cancer screening cohort, among patients screened for a given social risk, 32% (8233/25 864) reported food insecurity, 16% (3824/24 612) reported housing instability, and 17% (3461/20 433) reported transportation barriers. In the CRC screening cohort, among patients screened for a given social risk, 31% (4196/22 899) reported food insecurity, 16% (3480/21 314) reported housing instability, and 19% (3434/18 005) reported transportation barriers.

Up-to-date at index visit

Patients with food insecurity, housing instability, or transportation barriers were statistically significantly less likely to be up-to-date on breast cancer screening at their index visit compared with individuals reporting not having those risks (Table 4). Specifically, persons with food insecurity were 3% less likely to be up-to-date at index (relative risk [RR] = 0.97, 95% CI = 0.94 to 0.99), persons with housing instability were 6% less likely (RR = 0.94, 95% CI = 0.90 to 0.97), and persons with transportation barriers were 6% less likely (RR = 0.94, 95% CI = 0.90 to 0.98).

The associations between having social risks and being up-to-date on cervical cancer screening at the index visit were also statistically significant (Table 5). Persons reporting food insecurity

Table 2. Cervical cancer screening cohort

Characteristic	Total[a] (column %)	Food insecurity		Housing instability		Transportation barriers	
		Need	No need	Need	No need	Need	No need
Patients, No.	202 895 (100)	8233	17 631	3824	20 788	3461	16 972
Female sex, %	202 895 (100)	100.0	100.0	100.0	100.0	100.0	100.0
Race and ethnicity, %							
Hispanic	72 698 (35.6)	24.4	22.0	19.4	19.0	17.7	20.8
Non-Hispanic Black	37 444 (18.5)	29.2	25.1	32.9	34.6	31.1	31.1
Non-Hispanic White	70 360 (34.8)	37.6	34.0	38.0	27.1	41.1	28.9
Non-Hispanic Other	12 365 (6.1)	5.1	9.9	5.6	10.3	6.1	10.4
No data	9758 (4.8)	3.8	8.9	4.1	9.0	3.9	8.9
Preferred language, %							
English	113 560 (65.8)	77.3	71.6	78.7	71.2	81.2	72.2
Non-English	69 315 (34.2)	22.7	28.4	21.3	28.8	18.8	27.8
Age at index visit, y							
Median (range)	42 (23-63)	43 (23-63)	41 (23-63)	43 (23-63)	41 (23-63)	45 (23-63)	41 (23-63)
Age group, %							
23-39 y	91 180 (44.9)	41.1	47.1	42.0	46.0	38.2	46.4
40-49 y	48 388 (23.8)	25.4	21.8	23.5	22.5	23.4	22.4
50-63 y	63 327 (31.2)	33.6	31.1	34.5	31.5	38.4	31.2
Payer at index visit, %							
Medicaid	107 625 (53.0)	61.5	44.2	62.1	47.6	66.4	46.9
Medicare	13 210 (6.5)	10.7	5.0	10.3	6.0	11.8	5.9
Other public	10 923 (5.4)	2.9	3.6	2.6	3.9	2.2	3.9
Private	44 811 (22.1)	13.2	38.7	15.3	37.1	9.1	37.3
Uninsured	26 296 (13.0)	11.7	8.6	9.8	5.5	10.6	6.0
Federal poverty level, %							
≤100	114 234 (56.3)	63.1	43.1	63.8	47.9	69.0	45.5
101-200	42 608 (21.0)	18.4	19.1	17.6	17.3	15.5	17.3
>200	19 282 (9.5)	5.8	15.5	5.3	12.1	4.1	12.2
No data	26 771 (13.2)	12.7	22.3	13.3	22.8	11.4	25.0
Primary care visits in first year after index, %							
1-2	59 885 (29.5)	20.2	28.4	16.7	25.8	16.7	25.3
3-4	67 258 (33.1)	29.7	34.7	30.2	33.9	29.5	33.9
5-6	38 484 (19.0)	21.9	18.6	22.3	19.9	22.7	20.0
≥7	37 268 (18.4)	28.3	18.2	30.8	20.4	31.1	20.8
Years of observation,[b] %							
<2	185 415 (91.4)	91.8	91.2	92.4	91.8	92.3	91.7
2-3.7	17 480 (8.6)	8.2	8.8	7.6	8.2	7.7	8.3
Cervical cancer screening status[c] at index, %							
Due	76 710 (37.8)	36.1	31.8	38.1	31.9	38.8	29.8
Up-to-date[d]	126 185 (62.2)	63.9	68.2	61.9	68.1	61.2	70.3
Ever due for screening during observation, %							
Not due during observation	97 301 (48.0)	49.3	51.8	48.1	52.8	48.3	53.8
Due during observation	105 594 (52.0)	50.8	48.2	51.9	47.2	51.7	46.5

[a] These data were representative of 186 clinics spanning 13 US states categorized by region: Midwest (Indiana, Minnesota, Ohio, and Wisconsin), Northeast (Massachusetts), South (Georgia, North Carolina, and Texas), and West (Alaska, California, Montana, Oregon, and Washington). Social determinants of health risk group was determined during the observation period. Pearson χ^2 tests were performed. In the regression modeling, federal poverty level categories were collapsed to ≤100, >200, and Unknown. Race and ethnicity categories were collapsed into Hispanic, Non-Hispanic Black, Non-Hispanic White, and Non-Hispanic Other/Unknown. Comparing characteristics by the patient's Social determinants of health needs category, all tests were statistically significant at $P = .05$, except for years of observation and food insecurity.

[b] Study duration was determined at the patient level and defined by patients' last primary care encounter date at which they met the criteria for cervical cancer screening guidelines and their first primary care encounter date that occurred at least 1 year before their last primary care encounter. Primary care encounters were defined as a face-to-face visit with a medical doctor, osteopath, physician assistant, or nurse practitioner.

[c] The study followed Uniform Data System guidelines for cervical cancer screening and considered patients to have met the criteria for screening if they had had a Papanicolaou test within the past 3 years and were 21 years of age or older at the time of the test or if they were older than 30 years of age and had a Papanicolaou–human papillomavirus co-test within the past 5 years.

[d] Papanicolaou test or Papanicolaou–human papillomavirus co-test.

were 3% less likely to be up-to-date with cervical cancer screening at index (RR = 0.97, 95% CI = 0.95 to 0.99), persons with housing instability were 6% less likely (RR = 0.94, 95% CI = 0.92 to 0.97), and persons with transportation barriers were 7% less likely (RR = 0.93, 95% CI = 0.89 to 0.96).

Persons reporting food insecurity were 6% less likely to be up-to-date with CRC screening at index than individuals reporting no food insecurity (RR = 0.94, 95% CI = 0.92 to 0.97), persons reporting housing instability were 8% less likely (RR = 0.92, 95% CI = 0.88 to 0.97), and persons reporting transportation barriers were 13% less likely (RR = 0.87, 95% CI = 0.83 to 0.90) (Table 6). Overall, each social risk was associated with a statistically significantly lower likelihood of being up-to-date on cancer screenings at the index visit (Table 7).

Percentage of study months up-to-date

Patients with food insecurity or housing instability did not have statistically significant different rates of study months up-to-date with breast cancer screening compared with persons not reporting food insecurity or housing instability (food insecurity RR = 0.99, 95% CI = 0.96 to 1.03; housing instability RR = 0.97, 95% CI = 0.93 to 1.02) (Table 4). In all other analyses, patients with social risks had a statistically significant lower rate of months up-to-date on screenings than persons without those risks.

Table 3. Colorectal cancer screening cohort

		Food insecurity		Housing instability		Transportation barriers	
Characteristic	**Total[a] (column %)**	**Need**	**No need**	**Need**	**No need**	**Need**	**No need**
Patients, No.	171 724 (100)	7141	15 758	3480	17 834	3434	14 571
Sex, %							
Female	95 590 (55.7)	56.8	56.5	53.3	58.4	55.9	58.3
Male	78 418 (44.3)	43.2	43.5	46.7	41.6	44.1	41.7
Race and ethnicity, %							
Hispanic	41 940 (24.4)	19.0	15.0	13.9	14.3	14.4	15.7
Non-Hispanic Black	31 737 (18.5)	29.9	23.1	34.7	31.2	31.0	28.5
Non-Hispanic White	77 269 (45.0)	40.6	43.1	40.5	34.3	43.2	35.7
Non-Hispanic Other	11 434 (6.7)	6.1	10.5	5.7	11.7	7.3	11.9
No data	9344 (5.4)	4.4	8.3	5.1	8.6	4.2	8.3
Preferred language, %							
English	121 173 (70.6)	78.0	69.8	80.5	66.8	81.0	68.0
Non-English	121 173 (29.4)	22.0	30.2	19.5	33.2	19.0	32.0
Age at index visit, y							
Median (range)	59 (50-73)	58 (50-73)	60 (50-73)	58 (50-73)	60 (50-73)	58 (50-73)	60 (50-73)
Age group, %							
50-64	126 825 (73.9)	79.8	69.8	82.3	69.7	80.8	70.7
65-73	44 899 (26.1)	20.2	30.2	17.7	30.3	19.2	29.4
Payer at index visit, %							
Medicaid	65 231 (38.0)	44.5	30.7	46.8	32.7	48.9	32.4
Medicare	53 129 (31.0)	31.8	30.7	28.5	31.1	31.8	30.8
Other public	7057 (4.1)	1.9	2.2	1.8	2.6	1.5	2.5
Private	32 689 (19.0)	11.2	30.7	13.3	30.0	8.8	30.0
Uninsured	13 588 (7.9)	10.6	5.8	9.6	3.7	9.0	4.3
Federal poverty level, %							
≤100	92 059 (53.6)	64.8	44.3	64.5	49.7	67.1	47.3
101-200	33 080 (19.3)	17.4	18.8	17.0	17.2	16.4	17.5
>200	19 824 (11.5)	5.6	16.4	6.8	11.6	4.8	11.6
No data	26 761 (15.6)	12.2	20.5	11.8	21.5	11.7	23.6
Primary care visits in the first year after index, %							
1-2	37 958 (22.1)	14.5	21.2	12.6	18.2	12.3	17.5
3-4	58 848 (34.3)	28.9	35.2	28.5	34.3	29.3	33.9
5-6	39 001 (22.7)	24.7	23.1	25.9	24.5	24.8	24.9
≥7	35 917 (20.)9	31.9	20.5	33.1	23.0	33.6	23.7
Years of observation,[b] %							
<2	162 076 (94.4)	94.5	94.4	94.4	95.1	94.7	95.0
2-3.7	9648 (5.6)	5.5	5.6	5.6	4.9	5.3	5.0
Fecal immunochemistry test/fecal occult blood test screen before index, %							
No test before index	96 142 (56.0)	57.9	55.7	58.0	57.2	58.4	54.8
Test before index	75 582 (44.0)	42.0	44.3	42.0	42.8	41.6	45.2
Imaging screen before index, %							
No	111 951 (65.2)	62.6	55.4	65.0	53.8	64.4	53.8
Yes	59 773 (34.8)	37.4	44.6	35.0	46.2	35.6	46.2
CRC screening status[c] at index, %							
Due	95 013 (56.0)	55.5	51.0	56.4	51.6	57.1	49.9
Up-to-date[d]	76 711 (44.0)	44.5	49.0	43.6	48.4	42.9	50.1
Ever due during observation period, %							
Not due during observation	42 494 (24.7)	26.1	28.9	24.4	28.4	24.9	29.2
Due during observation	129 230 (75.3)	73.9	71.1	75.6	71.6	75.1	70.8

Abbreviation: CRC = colorectal cancer.

[a] These data were representative of 186 clinics spanning 13 US states categorized by region: Midwest (Indiana, Minnesota, Ohio, and Wisconsin), Northeast (Massachusetts), South (Georgia, North Carolina, and Texas), and West (Alaska, California, Montana, Oregon, and Washington). Social determinants of health risk group was determined during the observation period. Pearson χ^2 tests were performed. Note that in the modeling, federal poverty level categories were collapsed into ≤100. >200, and Unknown. Race and ethnicity categories were collapsed into Hispanic, Non-Hispanic Black, Non-Hispanic White, and Non-Hispanic Other/Unknown. Comparing characteristics by the patient's Social determinants of health needs category, all tests were statistically significant at $P = .05$, except for years of observation and food insecurity.

[b] Study duration was determined at the patient level and defined by patients' last primary care encounter date at which they met the criteria for CRC screening guidelines and their first primary care encounter date that occurred at least 1 year before their last primary care encounter.

[c] The study followed Uniform Data System guidelines for CRC screening and considered patients to have met the criteria for screening if they were 50 to 74 years of age with no history of CRC, colectomy, or referral to hospice. Up-to-date was defined as a completed fecal occult blood test within 1 year, fecal immunochemical test within 3 years, flexible sigmoidoscopy or colonography within 5 years, or colonoscopy within 10 years.

[d] Flexible sigmoidoscopy, colonography, or colonoscopy.

Patients with transportation barriers had a lower rate of months up-to-date with breast cancer screening than persons not reporting transportation barriers (RR = 0.94, 95% CI = 0.89 to 0.99). Individuals reporting food, housing, or transportation insecurity had a lower rate of study months up-to-date with cervical cancer screening than persons not reporting those risks (food insecurity RR = 0.96, 95% CI = 0.95 to 0.98; housing instability RR = 0.95, 95% CI = 0.93 to 0.98; transportation barriers RR = 0.94, 95% CI = 0.91 to 0.97). Individuals with food, housing, or transportation insecurity had a lower rate of study months up-to-date with CRC

Table 4. Association between reported social risks and breast cancer screening[a]

	Patient sample, No.	Estimated rate, % (95% CI)	Relative risk, (95% CI)	P
Food insecurity				
Up-to-date breast cancer status at index[b,c]				
Food insecurity	3805	69.5 (66.6 to 72.6)	0.97 (0.94 to 0.99)	.0078*
No food insecurity	7608	72.0 (69.6 to 74.5)	(Referent)	
Percentage of months up-to-date[c]				
Food insecurity	3805	61.6 (58.6 to 64.7)	0.99 (0.96 to 1.03)	.6196
No food insecurity	7608	62.1 (59.6 to 64.7)	(Referent)	
Documented order within 1 y of due date[d]				
Food insecurity	1150	31.7 (28.2 to 35.6)	0.90 (0.82 to 0.99)	.0281*
No food insecurity	2023	35.3 (32.0 to 38.8)	(Referent)	
Completed mammogram[e]				
Food insecurity	417	59.9 (54.7 to 65.6)	0.95 (0.88 to 1.03)	.2129
No food insecurity	808	63.0 (58.4 to 67.9)	(Referent)	
Primary care visits[f] in year after index (rate)				
Food insecurity	3535	5.0 (4.8 to 5.3)	1.15 (1.10 to 1.20)	<.0001*
No food insecurity	7574	4.4 (4.2 to 4.6)	(Referent)	
Housing instability				
Up-to-date breast cancer status at index[b,c]				
Housing instability	1666	67.8 (64.8 to 71.1)	0.94 (0.90 to 0.97)	.0004*
No housing instability	8924	72.5 (69.8 to 70.3)	(Referent)	
Percentage of months up-to-date[c]				
Housing instability	1666	60.7 (57.4 to 64.2)	0.97 (0.93 to 1.02)	.2043
No housing instability	8924	62.5 (60.0 to 65.2)	(Referent)	
Documented order within 1 y of due date[d]				
Housing instability	582	31.6 (27.6 to 36.0)	0.92 (0.81 to 1.03)	.1556
No housing instability	2100	34.5 (31.2 to 38.2)	(Referent)	
Completed mammogram[e]				
Housing instability	213	62.6 (56.8 to 69.0)	1.04 (0.94 to 1.14)	.458
No housing instability	866	60.4 (56.3 to 64.8)	(Referent)	
Primary care visits[f] in year after index (rate)				
Housing instability	1666	5.2 (4.8 to 5.7)	1.15 (1.09 to 1.22)	<.0001*
No housing instability	8924	4.5 (4.3 to 4.7)	(Referent)	
Transportation barriers				
Up-to-date breast cancer status at index[b,c]				
Transportation barriers	1689	67.9 (64.2 to 71.7)	0.94 (0.90 to 0.98)	.0040*
No transportation barriers	7330	72.1 (69.5 to 74.8)	(Referent)	
Percentage of months up-to-date[c]				
Transportation barriers	1689	59.4 (55.6 to 63.4)	0.94 (0.89 to 0.99)	.0301*
No transportation barriers	7330	63.0 (60.5 to 65.7)	(Referent)	
Documented order within 1 y of due date[d]				
Transportation barriers	589	31.9 (27.7 to 36.7)	0.91 (0.80 to 1.04)	.1734
No transportation barriers	1875	35.0 (31.8 to 38.6)	(Referent)	
Completed mammogram[e]				
Transportation barriers	219	60.3 (53.5 to 67.9)	0.97 (0.86 to 1.10)	.6782
No transportation barriers	772	61.8 (57.3 to 66.8)	(Referent)	
Primary care visits[f] in year after index (rate)				
Transportation barriers	1689	5.2 (4.8 to 5.5)	1.13 (1.07 to 1.19)	<.0001*
No transportation barriers	7330	4.6 (4.4 to 4.8)	(Referent)	

* $P < .05$.

[a] Estimates were derived using general estimating equation log binomial (binary outcomes) or negative binomial (rates outcome) regression models with robust sandwich variance estimation for clustering of patients within clinics. For all analyses, regression adjustment was made for race and ethnicity, preferred language, age, and insurance status at the index visit, first known federal poverty level, and yearly rate of primary care visits (except in estimating the visit rate outcome). Rates were estimated at marginal frequencies of the covariates in the model.

[b] Index visit was defined as the first primary care visit at least 1 year before patients' last eligible visit in the electronic health record.

[c] The study followed Uniform Data System guidelines for breast cancer screening and considered patients to have met the criteria for screening if they had received a mammogram within 2 years of the index date.

[d] Estimates based on population of patients with 1 year of observation after first date due for mammogram (n = 25 948).

[e] Estimates based on population of patients with a documented order for a mammogram in the 1 year of observation after the first date due (n = 8955).

[f] Primary care encounters were defined as face-to-face visits with a medical doctor, osteopath, physician assistant, or nurse practitioner.

screening than persons without those risks (food insecurity RR = 0.91, 95% CI = 0.89 to 0.94; housing instability RR = 0.92, 95% CI = 0.88 to 0.95; transportation barriers RR = 0.87, 95% CI = 0.83 to 0.91).

Primary care visits

In all cases, patients with social risks had statistically significantly higher primary care visit rates than persons without those risks (Tables 4-6). In the breast cancer cohort, visit rates were higher among patients with food insecurity (RR = 1.15, 95% CI = 1.10 to 1.20), housing instability (RR = 1.15, 95% CI = 1.09 to 1.22), and transportation barriers (RR = 1.13, 95% CI = 1.07 to 1.19). In the cervical cancer cohort, visit rates were higher among patients with food insecurity (RR = 1.16, 95% CI = 1.12 to 1.20), housing instability (RR = 1.20, 95% CI = 1.13 to 1.27), and transportation barriers (RR = 1.16, 95% CI = 1.10 to 1.22). In the CRC cohort, visit rates were higher among patients with food insecurity (RR = 1.15, 95% CI = 1.11 to 1.20), housing instability (RR = 1.17, 95% CI = 1.10 to 1.25), and transportation barrier status (RR = 1.11, 95% CI = 1.04 to 1.19).

Table 5. Association between reported social risks and cervical cancer screening[a]

	Patient sample, No.	Estimated rate, % (95% CI)	Relative risk (95% CI)	P
Food insecurity				
Up-to-date cervical cancer status at index[b,c]				
Food insecurity	8233	60.3 (58.0 to 62.6)	0.97 (0.95 to 0.99)	.0123*
No food insecurity	17 831	61.9 (59.8 to 64.1)	(Referent)	
Percentage of months up-to-date[c]				
Food insecurity	8233	63.6 (61.3 to 66.0)	0.96 (0.95 to 0.98)	<.0001*
No food insecurity	17 831	66.0 (63.8 to 68.3)	(Referent)	
Documented order within 1 y of due date[d]				
Food insecurity	3210	28.8 (26.4 to 31.5)	0.87 (0.81 to 0.94)	.0002*
No food insecurity	6105	33.0 (30.7 to 35.4)	(Referent)	
Completed cervical cancer screening[e]				
Food insecurity	945	92.2 (89.6 to 94.8)	0.97 (0.96 to 0.99)	.0041*
No food insecurity	2257	94.6 (93.0 to 96.3)	(Referent)	
Primary care visits[f] in year after index (rate)				
Food insecurity	8233	4.5 (4.3 to 4.8)	1.16 (1.12 to 1.20)	<.0001*
No food insecurity	17 831	3.9 (3.7 to 4.1)	(Referent)	
Housing instability				
Up-to-date cervical cancer status at index[b,c]				
Housing instability	3824	58.5 (56.2 to 60.9)	0.94 (0.92 to 0.97)	<.0001*
No housing instability	20 788	62.1 (59.9 to 64.3)	(Referent)	
Percentage of months up-to-date[c]				
Housing instability	3824	62.6 (60.2 to 65.2)	0.95 (0.93 to 0.98)	<.0001*
No housing instability	20 788	65.8 (63.4 to 68.2)	(Referent)	
Documented order within 1 y of due date[d]				
Housing instability	3210	29.9 (27.2 to 33.0)	0.93 (0.85 to 1.02)	.1406
No housing instability	6105	32.1 (29.5 to 34.9)	(Referent)	
Completed cervical cancer screening[e]				
Housing instability	489	93.7 (91.4 to 96.1)	0.99 (0.97 to 1.02)	.6583
No housing instability	2666	94.2 (92.2 to 96.2)	(Referent)	
Primary care visits[f] in year after index (rate)				
Housing instability	3824	4.8 (4.5 to 5.3)	1.20 (1.13 to 1.27)	<.0001*
No housing instability	20 788	4.0 (3.9 to 4.2)	(Referent)	
Transportation barriers				
Up-to-date cervical cancer status at index[b,c]				
Transportation barriers	3461	58.0 (55.4 to 60.8)	0.93 (0.89 to 0.96)	<.0001*
No transportation barriers	16 972	62.6 (60.5 to 64.8)	(Referent)	
Percentage of months up-to-date[c]				
Transportation barriers	3461	61.7 (59.0 to 64.6)	0.94 (0.91 to 0.97)	<.0001*
No transportation barriers	16 972	65.9 (63.7 to 68.3)	(Referent)	
Documented order within 1 y of due date[d]				
Transportation barriers	3210	28.3 (25.6 to 31.4)	0.88 (0.81 to 0.95)	.0017*
No transportation barriers	6105	32.2 (30.1 to 34.5)	(Referent)	
Completed cervical cancer screening[e]				
Transportation barriers	412	92.3 (88.9 to 95.8)	0.98 (0.95 to 1.00)	.0741
No transportation barriers	2099	94.6 (92.8 to 96.5)	(Referent)	
Primary care visits[f] in year after index (rate)				
Transportation barriers	3461	4.7 (4.4 to 5.0)	1.16 (1.10 to 1.22)	<.0001*
No transportation barriers	16 972	4.1 (3.9 to 4.3)	(Referent)	

* $P < .05$.

[a] Estimates were derived using general estimating equation log binomial (binary outcomes) or negative binomial (rates outcome) regression models with robust sandwich variance estimation for clustering of patients within clinics. For all analyses, regression adjustment was made for race and ethnicity, preferred language, age, and insurance status at the index visit; first known federal poverty level; and yearly rate of primary care visits (except in estimating the visit rate outcome). Rates were estimated at marginal frequencies of the covariates in the model.

[b] Index visit was defined as the first primary care visit at least 1 year before patients' last eligible visit in the electronic health record.

[c] The study followed Uniform Data System guidelines for cervical cancer screening and considered patients to have met the criteria for screening if they had had a Papanicolaou test within the past 3 years and were 21 years of age or older at the time of the test or if they were older than 30 years of age and were Papanicolaou–human papillomavirus co-tested within the past 5 years.

[d] Estimates based on population of patients with 1 year of observation after the first date due for Papanicolaou tests (n = 82 145).

[e] Estimates based on population of patients with documented orders for Papanicolaou tests in the 1 year of observation after first date due (n = 24 582).

[f] Primary care encounters were defined as face-to-face visits with a medical doctor, osteopath, physician assistant, or nurse practitioner.

Cancer screening orders

Breast cancer screening orders (RR = 0.90, 95% CI = 0.82 to 0.99), cervical cancer screening orders (RR = 0.87, 95% CI = 0.81 to 0.94), and CRC screening orders (RR = 0.91, 95% CI = 0.85 to 0.96) were all less likely to be placed for patients with food insecurity than for patients without food insecurity. Cervical cancer screening orders were also less likely to be placed for patients with transportation barriers than for patients without (RR = 0.88, 95% CI = 0.81 to 0.95). No other statistically significant differences in screening orders were associated with social risk status.

Completion of cancer screening

Patients with food insecurity were less likely to complete cervical cancer screening (RR = 0.97, 95% CI = 0.96 to 0.99) than patients not reporting food insecurity. Patients with food insecurity were statistically significantly less likely to complete CRC screening (RR = 0.95, 95% CI = 0.91 to 0.99), as were patients with transportation barriers (RR = 0.90, 95% CI = 0.82 to 0.99) compared with patients without these risks. No other statistically significant differences in screening completion were associated with social risk status.

Table 6. Association between reported social risks and CRC screening[a]

	Patient sample, No.	Estimated rate, % (95% CI)	Relative risk (95% CI)	P
Food insecurity				
Up-to-date CRC status at index[b,c]				
Food insecurity	7141	43.4 (40.9 to 46.0)	0.94 (0.92 to 0.97)	<.0001*
No food insecurity	15 758	46.0 (43.9 to 48.2)	(Referent)	
Percentage of months up-to-date[c]				
Food insecurity	7141	44.3 (41.9 to 46.9)	0.91 (0.89 to 0.94)	<.0001*
No food insecurity	15 758	48.6 (46.3 to 50.9)	(Referent)	
Documented order within 1 y of due date[d]				
Food insecurity	4196	33.3 (31.1 to 35.5)	0.91 (0.85 to 0.96)	.0009
No food insecurity	8643	36.7 (34.3 to 39.3)	(Referent)	
Completed CRC screening[e]				
Food insecurity	1485	58.7 (54.6 to 63.0)	0.95 (0.91 to 0.99)	.0195*
No food insecurity	3412	61.8 (57.7 to 66.2)	(Referent)	
Primary care visits[f] in year after index (rate)				
Food insecurity	7141	4.9 (4.7 to 5.2)	1.15 (1.11 to 1.20)	<.0001
No food insecurity	157 58	2.9 (2.7 to 3.1)	(Referent)	
Housing instability				
Up-to-date CRC status at index[b,c]				
Housing instability	3480	42.2 (39.3 to 45.2)	0.92 (0.88 to 0.97)	.001
No housing instability	17 834	45.6 (43.4 to 47.9)	(Referent)	
Percentage of months up-to-date[c]				
Housing instability	3480	44.1 (41.5 to 46.9)	0.92 (0.88 to 0.95)	<.0001
No housing instability	17 834	48.2 (45.9 to 50.6)	(Referent)	
Documented order within 1 y of due date[d]				
Housing instability	2085	34.5 (32.0 to 37.1)	0.96 (0.91 to 1.01)	.0852
No housing instability	9831	36.1 (33.9 to 38.5)	(Referent)	
Completed CRC screening[e]				
Housing instability	777	60.3 (55.5 to 65.5)	0.99 (0.93 to 1.05)	.7255
No housing instability	3828	61.0 (56.9 to 65.4)	(Referent)	
Primary care visits[f] in year after index (rate)				
Housing instability	3480	4.1 (3.8 to 4.4)	1.17 (1.10 to 1.25)	<.0001
No housing instability	17 834	3.4 (3.2 to 3.6)	(Referent)	
Transportation barriers				
Up-to-date CRC status at index[b,c]				
Transportation barriers	3434	40.5 (37.8 to 43.5)	0.87 (0.83 to 0.90)	<.0001*
No transportation barriers	14 571	46.8 (44.7 to 49.1)	(Referent)	
Percentage of months up-to-date[c]				
Transportation barriers	3434	42.4 (39.5 to 45.4)	0.87 (0.83 to 0.91)	<.0001*
No transportation barriers	14 571	48.7 (46.5 to 51.0)	(Referent)	
Documented order within 1 y of due date[d]				
Transportation barriers	2059	35.0 (32.5 to 37.7)	0.99 (0.93 to 1.05)	.6579
No transportation barriers	7 823	35.5 (33.3 to 37.8)	(Referent)	
Completed CRC screening[e]				
Transportation barriers	788	56.0 (50.6 to 62.0)	0.90 (0.82 to 0.99)	.0338*
No transportation barriers	3066	62.3 (57.8 to 67.0)	(Referent)	
Primary care visits[f] in year after index (rate)				
Transportation barriers	3434	3.9 (3.6 to 4.4)	1.11 (1.04 to 1.19)	.0027*
No transportation barriers	14 571	3.5 (3.3 to 3.7)	(Referent)	

Abbreviation: CRC = colorectal cancer.

* $P < .05$.

[a] Estimates were derived using general estimating equation log binomial (binary outcomes) or negative binomial (rates outcome) regression models with robust sandwich variance estimation for clustering of patients within clinics. For all analyses, regression adjustment was made for race and ethnicity, preferred language, age, and insurance status at the index visit; first known federal poverty level; and yearly rate of primary care visits (except in estimating the visit rate outcome). Rates were estimated at marginal frequencies of the covariates in the model.

[b] Index visit was defined as the first primary care visit at least 1 year before patients' last eligible visit in the electronic health record.

[c] The study followed Uniform Data System guidelines for CRC screening and considered patients to have met the criteria for screening if they were 50 to 74 years of age with no history of CRC, colectomy, or referral to hospice. Up-to-date was defined as a completed fecal occult blood test within 1 year, fecal immunochemical test within 3 years, flexible sigmoidoscopy or colonography within 5 years, or colonoscopy within 10 years.

[d] Estimates based on population of patients with 1 year of observation after the first date due for the test (n = 101 724).

[e] Estimates based on population of patients with documented orders for the test in 1 year of observation after the first date due (n = 34 506).

[f] Primary care encounters were defined as face-to-face visits with a medical doctor, osteopath, physician assistant, or nurse practitioner.

Discussion

We investigated associations between food insecurity, housing instability, and transportation barriers and cancer preventive care outcomes among patients in community-based health-care organizations. We sought to identify the pathways through which social risks affect cancer screening and early detection by studying patients with access to care and considering whether cancer screening gaps are the result of differences in primary care visits, screening orders, or screening completion rates.

Patients reporting any social risks were less likely to be up-to-date with cancer screenings at their index visit, aligning with prior research showing adverse associations between social risks and cancer screening receipt.[2,10-17] Patients reporting food insecurity, housing instability, or transportation barriers also had

Table 7. Summary of the associations between breast, cervical, and colorectal cancer screenings and social risk status[a]

Cohort	Outcome	Food insecure vs food secure	Housing unstable vs housing stable	Transportation barriers vs no transportation barriers
Breast cancer screening	Up-to-date at index	**Less likely**	**Less likely**	**Less likely**
	Months up-to-date	No difference	No difference	**Fewer**
	Screening order received	**Less likely**	No difference	No difference
	Screening completed	No difference	No difference	No difference
	Primary care visits	**More**	**More**	**More**
Cervical cancer screening	Up-to-date at index	**Less likely**	**Less likely**	**Less likely**
	Months up-to-date	**Fewer**	**Fewer**	**Fewer**
	Screening order received	**Less likely**	No difference	**Less likely**
	Screening completed	**Less likely**	No difference	No difference
	Primary care visits	**More**	**More**	**More**
Colorectal cancer screening	Up-to-date at index	**Less likely**	**Less likely**	**Less likely**
	Months up-to-date	**Fewer**	**Fewer**	**Fewer**
	Screening order received	**Less likely**	**Less likely**	No difference
	Screening completed	**Less likely**	No difference	**Less likely**
	Primary care visits	**More**	**More**	**More**

[a] Table provides summary results based on the estimates in Tables 2, 3, and 4. Text in bold indicates a statistically significant association, with a 2-sided $\alpha < .05$. "No difference" means that there was no statistically significant difference found at an $\alpha < .05$ level between patients with and without documented social risk.

statistically significantly lower rates of total study months up-to-date for cervical cancer and CRC screening than patients without each social risk. Patients with transportation barriers also had a statistically significant lower rate of total months up-to-date for breast cancer screening. This finding suggests that compared with patients without each social risk, patients reporting food insecurity, housing instability, or transportation difficulties had a lower proportion of months during their observation period during which all the guideline-recommended screening services were complete. Interestingly, we also found that patients with social risks had higher rates of primary care visits during the study period, a finding that aligns with prior research showing that such patients have higher chronic disease burden and health care utilization than patients without such risks.[18] These findings suggest that differences in study months up-to-date for cancer screening do not reflect a lack of access to primary care in this population.

We also explored whether patients experiencing social risks receive orders for indicated cancer screenings or complete screenings for which an order was received at the same rate as patients who are not experiencing social risks. We did not find consistent associations between having a given social risk and the likelihood of cancer screening orders, with 1 notable exception: Orders for all 3 cancer screenings were less likely in patients reporting food insecurity. One explanation could be that the urgency of food insecurity may shift the focus of the encounter and result in delays in routine preventive care. Research suggests that reform of the primary care delivery system to include multidisciplinary teams caring for patients through multiple modalities may help change this pattern.[19]

In contrast, housing and transportation barriers had different associations with the studied outcomes, depending on the type of cancer screening. For instance, neither of these social risks was associated with breast cancer screening, possibly because mammograms are relatively easy for patients to complete, in part because outreach programs such as mobile mammography clinics support mammogram access.[20-22]

Other cancer screenings were associated with these social risks, however. For instance, patients with transportation barriers were less likely to have cervical cancer screening orders placed or to complete CRC screening. Papanicolaou screenings (still the most common form of cervical cancer screening) are often completed at the health-care visit at which the screening order is issued, but it is possible that patients with transportation insecurity face barriers to staying at the clinic long enough to complete a Papanicolaou test or may prioritize other needs during their clinical encounters. Lower rates of CRC screening orders in patients with housing instability may be because clinicians assume that patients do not have the resources needed to prepare for colonoscopy (eg, bathroom access) or because patients do not have a stable address to which to mail a fecal immunochemical test.

Study findings underscore the need to better understand the barriers to guideline-concordant cancer screening for patients with social risks. The heterogeneous relationships among social risks, screening orders, and screening completion rates illuminate the complex pathways leading to equitable cancer care. Future research should explore patient and clinician decision making about cancer screening and the barriers social risks pose to obtaining these services.

Our findings should be interpreted in light of several study limitations. During the study period, social risk screening was not conducted by all OCHIN network clinics. Our analysis represents the 53% of OCHIN member organizations that document social risk screening in the EHR. Results are also limited to patients with access to primary care services at these clinics; access is obviously another barrier to receipt of cancer screening. Further, we considered patients reporting food, housing, and transportation barriers. These social risks may not be the sole drivers of receipt of cancer preventive services; they also may serve as proxies for other barriers to care. In addition, not all patients in these clinics were screened for all 3 of the social risks we examined. Clinic staff may have screened some patients for certain risks more than others; thus, results are generalizable to patients who have been screened. Our analysis focused on screening for breast, cervical, and colorectal cancers, which were included in the 2020 Uniform Data System reporting requirements for health centers. Inclusion of other cancer screening services (eg, prostate-specific antigen testing for prostate cancer) is important for future research. We did not include information about patient nativity or preferred spoken language, although these elements also may affect cancer screening decisions and should be included in future analyses. Potential bias was addressed by including all eligible patients (including those

without documented social risk screening) (Tables S4-S6) and analyses adjusting for demographic, socioeconomic, and health care utilization characteristics.

Patients with social risks are less likely to be up-to-date with cancer screening guidelines than patients without social risks; social risks are associated with screening order and completion rates. Future research should assess both how clinicians make decisions about cancer preventive care and how patients prioritize cancer screening in the context of social risks. As novel strategies and policies to mitigate social risks proliferate, it will be important to assess how these programs mitigate the complex pathways between social risks and cancer early detection services.

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Author contributions

Matthew P. Banegas, PhD, MPH, MS (Conceptualization; Writing—original draft; Writing—review & editing), Jean O'Malley, MPH (Data curation; Formal analysis; Writing—review & editing), Jorge Kaufmann, ND, MS (Methodology; Writing—review & editing), Miguel Marino, PhD (Methodology; Writing—review & editing), Laura Gottlieb, MD, MPH (Writing—review & editing), Nathalie Huguet, PhD (Writing—review & editing), Adjoa Anyane-Yeboa, MD, MPH (Writing—review & editing), Rachel Gold, PhD, MPH (Conceptualization; Project administration; Supervision; Writing—original draft; Writing—review & editing).

Supplementary material

Supplementary material is available at *JNCI Cancer Spectrum* online.

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Conflicts of interest

The authors declare no conflicts of interest.

Data availability

The raw data underlying this article were generated from multiple health systems across the OCHIN network; restrictions apply to the availability and re-release of data under organizational agreements. Please make any requests to the corresponding author.

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