Title

Examining the Association of Food Insecurity and Being Up-to-Date for Breast and Colorectal Cancer Screenings.

Journal

Cancer Epidemiology Biomarkers & Prevention, 31(5)

ISSN

1055-9965

Authors

Mendoza, Jason A
Miller, Carrie A
Martin, Kelly J
et al.

Publication Date

2022-05-04

DOI

10.1158/1055-9965.epi-21-1116

Peer reviewed

HHS Public Access

Author manuscript

Cancer Epidemiol Biomarkers Prev. Author manuscript; available in PMC 2022 November 04.

Published in final edited form as:

Cancer Epidemiol Biomarkers Prev. 2022 May 04; 31(5): 1017–1025.

doi:10.1158/1055-9965.EPI-21-1116.

Examining the Association of Food Insecurity and Being Up-To-Date for Breast and Colorectal Cancer Screenings

Jason A. Mendoza[1], **Carrie A. Miller**[2], **Kelly J. Martin**[3], **Ken Resnicow**[4], **Ronaldo Iachan**[3], **Babalola Faseru**[5], **Corinne McDaniels-Davidson**[6], **Yangyang Deng**[3], **Maria Elena Martinez**[7], **Wendy Demark-Wahnefried**[8], **Amy E. Leader**[9], **DeAnn Lazovich**[10], **Jakob D. Jensen**[11], **Katherine J. Briant**[1], **Bernard F Fuemmeler**[2]

[1]Public Health Sciences, Fred Hutchinson Cancer Research Center, Seattle, WA

[2]Health Behavior and Policy, Massey Cancer Center, Virginia Commonwealth University, Richmond, VA

[3]ICF, Rockville, Maryland

[4]University of Michigan Rogel Cancer Center and School of Public Health, Ann Arbor, MI

[5]Department of Population Health, University of Kansas Medical Center, Kansas City, KS

[6]San Diego State University Institute for Public Health, San Diego, CA

[7]Moores Cancer Center and Herbert Wertheim School of Public Health and Human Longevity Science, University of California, San Diego, La Jolla, CA

[8]Department of Nutrition Sciences, University of Alabama at Birmingham, Birmingham, AL

[9]Sidney Kimmel Cancer Center – Jefferson Health and Thomas Jefferson University

[10]Division of Epidemiology and Community Health and Masonic Cancer Center, University of Minnesota, Minneapolis, MN

[11]Department of Communication and Huntsman Cancer Institute, University of Utah, Salt Lake City, UT

Abstract

Background.—Food insecurity (FI) has been associated with poor access to healthcare. It is unclear if this association is beyond that predicted by income, education, and health insurance. FI may serve as a target for intervention given the many programs designed to ameliorate FI. We

Corresponding Author: Jason A. Mendoza, 1100 Fairview Ave N. Seattle, WA 98109; 206.667.6601; jmendoza@fredhutch.org.

AUTHOR CONTRIBUTIONS

Jason A. Mendoza, Ronaldo Iachan, Bernard F Fuemmeler, Babalola Faseru, Maria Elena Martinez contributed to the conceptualization and design of this manuscript. All authors contributed to the collection and/or assembly of data. Jason A. Mendoza, Ronaldo Iachan, Kelly Martin, Yangyang Deng, Ken Resnicow, Bernard F Fuemmeler, Babalola Faseru, Maria Elena Martinez contributed to the data analysis and interpretation. Jason A. Mendoza, Carrie A. Miller, Kelly Martin, Ken Resnicow, Ronaldo Iachan, Babalola Faseru and Bernard F Fuemmeler contributed to the writing of the manuscript. All authors contributed to the review and editing and the final approval of this manuscript.

CONFLICT OF INTEREST DISCLOSURES

The authors have no conflicts of interest to disclose.

examined the association of FI with being up-to-date to colorectal cancer (CRC) and breast cancer (BC) screening guidelines.

Methods.—Nine NCI-designated cancer centers surveyed adults in their catchment areas using demographic items and a two-item FI questionnaire. For the CRC screening sample (n=4,816), adults ages 50–75 years who reported having a stool test in the past year or a colonoscopy in the past ten years were considered up-to-date. For the BC screening sample (n=2,449), female participants ages 50–74 years who reported having a mammogram in the past two years were up-to-date. We used logistic regression to examine the association between CRC or BC screening status and FI, adjusting for race/ethnicity, income, education, health insurance, and other sociodemographic covariates.

Results.—The prevalence of FI was 18.2% and 21.6% among CRC and BC screening participants, respectively. For screenings, 25.6% of CRC and 34.1% of BC participants were not up-to-date. In two separate adjusted models, FI was significantly associated with lower odds of being up-to-date with CRC screening (OR=0.7, 95% CI [0.5, 0.99]) and BC screening (OR=0.6, 95% CI [0.4, 0.96]).

Conclusion.—FI was inversely associated with being up-to-date for CRC and BC screening.

Impact.—Future studies should combine FI and cancer screening interventions to improve screening rates.

INTRODUCTION

Cancer is the second leading cause of death in the United States (US) (1). The American Cancer Society (ACS) projects 1.9 million new cancer cases and approximately 600,000 deaths from cancer in the US in the year 2021 (2). Increased utilization of cancer screening tests can reduce the mortality of common cancer types through early detection, when removal of precancerous or early-stage lesions is possible and treatment is more often successful (3). The ACS and the US Preventive Services Task Force (USPSTF) recommend routine screenings for colorectal, breast, and cervical cancers in average-risk, asymptomatic adults (4,5). Despite these evidence-based screening guidelines, overall use of cancer screening tests in the US remains below national targets and are significantly lower among specific groups based on race/ethnicity, socioeconomic status, and health care access indicators (6).

Disparities in cancer screening (as well as incidence and mortality rates) are accounted for, in large part, by social determinants of health (SDOH). The World Health Organization broadly defines SDOH as “the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life” (7). The SDOH, therefore, are considered a class of determinants beyond individual level factors such as knowledge and motivation. Leading health organizations share the goal of addressing SDOH to achieve greater health equity. To advance this goal, an organizing framework was proposed in Healthy People 2020, reflecting five domains of SDOH: economic stability, education, social and community context, health and health care, and neighborhood and built environment (8). Because socioeconomic factors are one of the most powerful determinants of health (9), reducing financial barriers to preventive services, including cancer screenings,

was a priority of the health insurance expansion under the Affordable Care Act. While health insurance coverage reform and programs providing access to free screening tests (10) may improve access to cancer screenings among low-income and traditionally medically underserved populations, these macro-level interventions may not alleviate other financial issues that affect cancer screening uptake. For example, prior studies have identified more acute, downstream characteristics of financial instability, such as housing instability (11,12) and food insecurity (FI) (12,13), as barriers to health care access.

Approximately 35 million Americans experienced FI, defined as having limited or uncertain access to adequate food supply, in 2019 (14). The FI rate is increasing among older adults (15) – those who are at higher risk for cancer and chronic diseases. The impact of FI may be profound, leading both directly to the development of cancer and other chronic diseases (e.g., lower quality nutrition), and indirectly to, poorer health outcomes among those with chronic diseases (e.g., decreased screening and health care utilization) (16–18). Although prior research has linked FI with low healthcare access (12,19,20), it is unclear to what degree FI relates to cancer prevention behaviors, like screening adherence, beyond other more commonly assessed SDOH variables, such as income and education. Assessing the relationship between FI and cancer screening, in addition to commonly assessed SDOH measures, may improve understanding of the unique and shared factors that contribute to disparities in cancer screening and help to better inform unique targets for eliminating cancer disparities where they are occurring in the population (21).

To address this gap in knowledge, we leveraged population health assessment data collected across nine National Cancer Institute (NCI)-designated cancer centers. FI and multiple other measures of socioeconomic status and SDOH were used to determine their unique influence on being “up-to-date” with colorectal cancer (CRC) and breast cancer (BC) screening guidelines.

MATERIALS AND METHODS

Study Sample

In 2019, nine NCI-designated cancer centers were awarded supplements to conduct population-based health assessments of their catchment area using a variety of probability and nonprobability methods (Table 1). Data collected included demographics, health behaviors, screening practices and various measures of SDOH, including FI. Several survey modalities were used, including web surveys, mailed paper surveys, in-person pen-and-paper surveys, and computer assisted telephone interviews. The nine cancer centers spanned the US and aimed to collect between 800 to 1,000 surveys per site. Many used a mixed mode approach (e.g., web-based and paper surveys) in order to achieve target enrollment numbers from diverse populations within their respective catchment areas. The survey study was approved by the Institutional Review Boards at each of the participating sites.

To harmonize data, we limited the nine datasets to the variables of interest for model building as well as survey weights, participant ID, and design variables. Separately, we aligned each dataset to a common set of variables naming and structure conventions and performed data cleaning to make sure no out-of-range values existed. Once all datasets were

cleaned and harmonized, the data were combined into one dataset and analytic variables were created. From the resulting harmonized dataset, we created two analytic datasets, one for each cancer screening behavior examined (CRC and BC). Within each final dataset, cancer screening variables were created to indicate whether a respondent was up-to-date (vs. not up-to-date) with cancer-specific USPSTF screening guidelines (22,23).

Measures

CRC and BC Screening: We defined the CRC screening variable based on then current USPSTF guidelines (2016), i.e., adult participants ages 50–75 years who reported having either a stool test in the past year or a colonoscopy in the past ten years (23). Similarly, we defined the BC screening variable based on being up-to-date with the USPSTF guidelines (2016), i.e., female participants ages 50–74 years who reported having a mammogram in the past two years (22).

Food Insecurity.—We included household FI due to its importance as a SDOH and as a potential intervention point. We used the Hunger Vital Signs two-item questionnaire to screen for household FI, which has acceptable validity compared to the gold standard of the 6-item Household Food Security Survey (24). The 2-items assessed within the last 30 days: 1) I worried whether my food would run out before I got money to buy more; and 2) The food I bought just didn't last, and I didn't have money to get more. Response options included often true, sometimes true, and never true (often and sometimes were considered affirmative). If participants had an affirmative response to either or both questions, they were classified as having FI.

Other SDOH and Sample Characteristics.—We used validated questionnaires from previous population-based surveys to assess a broad range of sociodemographic and behavioral factors including age (25,26), gender (25,26), race/ethnicity (25,26), rurality (using self-reported zip codes and 2013 rural-urban continuum codes 1–3 as urban and 4–9 as rural) (27), marital status (25,26), employment (25,26), education (25,26), income (25,26), financial security (25,26), health insurance (28,29), housing instability (30), and history of cancer.

Statistical Analysis

For inclusion in the CRC screening analytic group, respondents needed to be between the ages of 50 and 75 and not have reported a previous diagnosis of CRC. One site did not include questions about a CRC specific cancer diagnosis, so for that one site, we eliminated any participants who reported having any type of cancer diagnosis. The final dataset for CRC screening contained 4,816 records in the nine sites.

To be included in the BC screening analytic group, the respondent had to be female, between 50 and 74 years old, and not have reported a previous diagnosis of BC. One site did not include questions about a BC specific cancer diagnosis, so for that one site, we eliminated any respondents who reported having any type of cancer. The final dataset for the BC screening group had 2,449 participants across the nine sites.

For each screening group, we ran weighted chi square tests for each variable in relation to FI and assessed the significance to determine which variables to include in the multivariable models. The initial models included those variables with $p<0.05$ in the bivariate relationships, but excluded some variables due to the high level of missing data. Survey sites did not necessarily include all variables needed for this analysis, so some missingness was expected.

Once the final list of independent variables was determined, we created multivariable models. Weighted logistic regression models were run using PROC SURVEYLOGISTIC in SAS 9.4. Each survey site was considered a stratum for accurate variance estimation using this software for weighted survey data which reflects the complex sampling designs. Our primary interest was in the association of FI and CRC and BC screening, above and beyond traditional SDOH variables that are commonly assessed such as income and education. To examine the impact on model fit resulting from adding food insecurity to the adjusted models for CRC and BC, we used the Akaike Information Criteria (AIC).

Results

We pooled survey data from nine cancer centers that used probability and nonprobability sampling designs (Table 1). In total, 4,816 individuals from the nine cancer centers had sufficient data to be included in the CRC screening analyses and 2,449 individuals had sufficient data to be included in the BC screening analyses.

For the CRC screening sample (Table 2a), 47.2% of respondents were female and had an average age of 62.2 years, 72.1 % were non-Hispanic white, 15.1% were non-Hispanic Black, 3.7% were Hispanic, and 9.2% were other race/ethnicity. A total of 18.2% reported FI. Compared to individuals living in food secure households, those from food insecure households had significantly ($p<0.05$) higher percentages of respondents who were female, younger, non-Hispanic Black and Hispanic, rural, not married, unemployed, less educated, lower income, not financially secure, lacking health insurance, housing unstable, and without a history of cancer (Table 2a). Covariates that were significantly associated in unadjusted bivariate analyses ($p<0.05$) with being up-to-date with CRC screening guidelines included gender, age, race/ethnicity, rurality, marital status, employment, education, income, financial security, health insurance, housing stability, and having a history of cancer. Employment and housing instability were collinear with other covariates and dropped from subsequent CRC screening analyses. The remaining covariates were retained for the adjusted models for CRC screening.

For the BC screening sample (Table 2b), respondents had an average age of 61.3 years, 69.9% were non-Hispanic white, 18.5% were non-Hispanic Black, 3.9% were Hispanic, and 7.6% were other race/ethnicity. Altogether, 21.6% reported FI. Compared to individuals living in food secure households, those from food insecure households had significantly ($p<0.05$) higher percentages of respondents who were younger, non-Hispanic Black and Hispanic, rural, not married, unemployed, lower income, less educated, housing unstable, financially insecure, and lacking health insurance. Covariates that were significantly associated in bivariate analyses (all $p<0.05$) with being up-to-date with BC screening

guidelines included race/ethnicity, rurality, marital status, employment, education, income, financial security, health insurance, housing stability, and having a history of cancer. Age category was not significantly associated with BC screening in bivariate analyses and dropped from subsequent analyses. Employment and housing instability were collinear with other covariates and dropped from subsequent BC screening analyses. The remaining covariates were retained for the adjusted models involving BC screening.

Overall, 25.6% of the CRC screening sample were not up-to-date with USPSTF CRC screening guidelines (Table 3). When stratified by FI status, 36.9% of respondents from food insecure households were not up-to-date with USPSTF CRC screening guidelines versus only 23.1% of respondents from households that were food secure ($p<0.05$). In the adjusted models for CRC screening (Table 4), n=4261, FI (OR=0.7, 95% CI [0.5, 0.99]) was significantly associated with lower odds of being up-to-date. In testing for model fit of the adjusted CRC model, the AIC significantly decreased with the addition of FI, which indicates better model fit with FI in the adjusted model.

For the BC screening sample (n=2,449), 34.1% were not up-to-date with USPSTF BC screening guidelines (Table 3). When stratified by FI status, 38.2% of respondents from food insecure households were not up-to-date versus 32.9% of participants from food secure households ($p<0.05$). In the adjusted model for BC screening (Table 4), n=2329, FI was significantly associated with lower odds of being up-to-date (OR=0.6, 95% CI [0.4, 0.96]). The AIC for the adjusted BC screening model significantly decreased with the addition of FI, which indicates that FI improves model fit.

Discussion

The primary aim of this study was to examine whether FI was associated with being up-to-date with CRC and BC screening amongst a multiethnic sample of community dwelling adults from the catchment areas of nine NCI-designated cancer centers in the US. We were particularly interested in determining whether FI remained a significant predictor of cancer screening after adjustment for other socioeconomic variables. If so, it may be useful for clinicians and public health programs to include the FI screener, in addition to other standard SDOH measures, in their intake documentation.

Our primary finding was that in both bivariate and adjusted models, FI was significantly associated with lower odds of being up-to-date with CRC and BC screening guidelines. For CRC screening those with FI had 30% lower adjusted odds of being up-to-date compared to those without FI. For BC screening, those with FI had 40% lower adjusted odds versus those without FI. Thus, the magnitude of the effect of FI was similar across both cancer screenings. Specifically, these effects were observed after adjustment for race/ethnicity, rurality, marital status, education, income, financial security, health insurance status, history of cancer, age, and gender (age and gender for CRC only as not in the final BC model).

The intersection of FI and cancer screening deserves further exploration. Previous studies have shown that cancer patients and survivors are more likely to experience FI (31,32), however less is known about the relationship between FI and cancer screening. Connections

have been made between other social determinants of health and adherence to cancer screening (33), as well as neighborhood-level factors and adherence to cancer screening (34). Financial hardship and reduced adherence to cancer screening among cancer survivors has also been observed (35). Yet, to our knowledge, this is the first study to document a direct relationship between FI and adherence to cancer screening in a general population above that of income, insurance, and education. Based on these initial findings, we hypothesize that FI may divert people's resources and attention from obtaining cancer screening services to obtaining food for their next meal(s). Moreover, we speculate that greater severity and frequency of FI may potentially lead to greater symptoms of depression and/or anxiety, which may impair people's ability to access health care services such as cancer screenings. These relationships of FI with poorer health care outcomes have been proposed and demonstrated previously in populations with chronic diseases such as HIV (36), diabetes (37), and cancer (32). Given that FI leads to increased levels of stress (38) and poor dietary food choices (39), both considered to be risk factors for cancer, it is imperative that this relationship be investigated as a possible driver of cancer disparities. Indeed, the ACS recently called for increased attention on the role of the social determinants of health on cancer equity in the US (40). Since there are already programs at the population- and individual-levels to alleviate food insecurity, including medically tailored meal delivery (41) the US Department of Agriculture's Supplemental Nutrition Assistance Program (42) and related incentive programs for fruits and vegetables, more research is needed to understand how these and similar programs that address FI could be better used or combined with existing programs, such as the Center for Disease Control and Prevention's National Breast and Cervical Cancer Early Detection Program, to encourage cancer screening.

The prevalence of FI in our sample, 18.2% for the CRC sample and 21.6% for the BC sample (site range 11.2% to 43.6%) was higher than the 2013 prevalence of 14% reported by Gundersen et al (43) and similar to the prevalence of 23% reported by Haber (44), based on subjects surveyed between 1998 and 2008, both using the same measure as our study. Using a more comprehensive measure of FI, in 2019 the U.S. Department of Agriculture reported that around 10.5% of US households were classified as food insecure at least part of the year (14).

The screening prevalence for both CRC and BC observed here are somewhat higher than national data. Specifically, 74% of our sample were up-to-date with CRC screening compared to 66% nationally in the 2018 National Health Interview Survey (45). For BC screening, 66% of our sample were up-to-date compared to 63% nationally in 2018 (46). The higher prevalence of screening in our sample are unlikely due to differences in overall insurance coverage as the rate in our sample, 92% overall (56.9% private and 43.1% public), is identical to the 92% overall rate (67.3% private and 34.4% public) nationally (47). It is possible that the higher prevalence of public insurance in our sample, 43% vs nationally, 34%, might have influenced the higher screening prevalences. Whether the higher cancer screening prevalences in our sample impacted the association of screening with FI is difficult to determine.

The study has some limitations. First, cancer screening status was based on self-report rather than verified through health records. Self-reported screening, however, has generally been

shown to be strongly correlated with verified screening, so relying on self-report may not have substantially impacted our findings (48–51). Second, study participants at some sites were not randomly selected or based on population probability. Therefore, generalizability of these results may be limited. Third, one site asked about a history of cancer but did not query about the type of cancer—we excluded those participants from the adjusted models due to cancer patients having different surveillance requirements than the general population. While this pertains to only 93 participants from the adjusted CRC model and 47 participants from the adjusted BC model, it is unclear how this would impact results, if at all. Fourth, there was a wide range of response rates across sites and those who responded to the survey may be more health conscious than the general population, which could lead to selection bias. Finally, we were unable to examine FI and cervical cancer screening (also recommended by the USPSTF) because survey sites inconsistently queried this examination. Future research, therefore, examining how FI may relate to cervical cancer screening and other health behaviors appears warranted.

In conclusion, this study demonstrates that a brief measure of FI is associated with lower odds of cancer screening, after adjustment for standard SES variables. This suggests that it may be useful to include assessment of FI to help identify individuals whose need for assistance obtaining adequate food for their households may be impeding their willingness or ability to access important health services, such as cancer screening. Importantly, our findings suggest that assessing income and health insurance status may not fully capture unmet social needs such as FI, which is also predictive of screening. Assessing FI along with other SDOH in clinical practice could be useful in identifying individuals who could benefit from programs to promote screening. In sum, efforts to promote cancer screening may be more effective if they also assess and attempt to address FI.

ACKNOWLEDGEMENTS

Supported by the National Institutes of Health: P30CA015704-43S4, PI: G.D. Gilliland (Fred Hutch/University of Washington Cancer Consortium); P30CA016059-30, PI: Robert Winn and T32CA093423, MPI: V. Sheppard & B. Fuemmeler (VCU Massey Cancer Center); P30CA046592, PI: E. Fearon (University of Michigan Rogel Cancer Center); P30 CA168524-07S2, PI: R. Jensen and CTSA Award # UL1TR002366, PI: M. Castro (University of Kansas Cancer Center and University of Kansas Medical Center), P30CA023100-32S5, PI: S.M. Lippman (UC San Diego Moores Cancer Center) and U54CA132384, PI: H. Madanat & U54CA132379, PI: M.E. Martinez (SDSU/UCSD Cancer Partnership); 3P30CA013148-46S5, PI: M. Birrer (O'Neal Comprehensive Cancer Center at the University of Alabama at Birmingham); P30CA077598, PI: D. Yee (University of Minnesota); 3P30CA056036-19S1, PI: K.E. Knudsen (Thomas Jefferson University); P30CA082709-17S6, PI: M.C. Beckerle (University of Utah).

References

1. Heron M. Deaths: Leading Causes for 2017. National vital statistics reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System 2019;68(6):1–77.
2. American Cancer Society. Cancer Facts & Figures 2021. Atlanta, GA: American Cancer Society; 2021.
3. Sharma KP, Grosse SD, Maciosek MV, Joseph D, Roy K, Richardson LC, et al. Preventing Breast, Cervical, and Colorectal Cancer Deaths: Assessing the Impact of Increased Screening. Preventing chronic disease 2020;17:E123 doi 10.5888/pcd17.200039. [PubMed: 33034556]

4. Smith RA, Andrews KS, Brooks D, Fedewa SA, Manassaram-Baptiste D, Saslow D, et al. Cancer screening in the United States, 2019: A review of current American Cancer Society guidelines and current issues in cancer screening. 2019;69(3):184–210.
5. US Preventive Services Task Force. 2020 Sept 14. A and B Recommendations. <https://www.uspreventiveservicestaskforce.org/uspstf/recommendation-topics/uspstf-and-b-recommendations>. Accessed 2020 Sept 14.
6. White A, Thompson TD, White MC, Sabatino SA, de Moor J, Doria-Rose PV, et al. Cancer screening test use—United States, 2015. 2017;66(8):201.
7. World Health Organization. 2020 Sept 14. Social Determinants of Health. <https://www.who.int/social_determinants/en/>. Accessed 2020 Sept 14.
8. Office of Disease Prevention and Health Promotion. 2020 Sept 14. Social Determinants of Health. <https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health>. Accessed 2020 Sept 14.
9. Braveman P, Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. Public health reports 2014;129(1_suppl2):19–31.
10. Centers for Disease Control and Prevention. 2020 Sept 14. National Breast and Cervical Cancer Early Detection Program (NBCCEDP). <https://www.cdc.gov/cancer/nbccedp/index.htm>. Accessed 2020 Sept 14.
11. Hughes AE, Tiro JA, Balasubramanian BA, Skinner CS, Pruitt SLJCE, Biomarkers P. Social disadvantage, healthcare utilization, and colorectal cancer screening: leveraging longitudinal patient address and health records data. 2018;27(12):1424–32.
12. Kushel MB, Gupta R, Gee L, Haas JSJJogim. Housing instability and food insecurity as barriers to health care among low-income Americans. 2006;21(1):71–7.
13. Cole MB, Nguyen KHJHSR. Unmet social needs among low-income adults in the United States: Associations with health care access and quality.
14. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Household Food Security in the United States in 2019, ERR-275. Washington, DC: U.S. Department of Agriculture, Economic Research Service; 2020.
15. Barrett CB. Measuring food insecurity. Science 2010;327(5967):825–8. [PubMed: 20150491]
16. Gregory CA, Coleman-Jensen A. Food insecurity, chronic disease, and health among working-age adults. 2017.
17. Garcia SP, Haddix A, Barnett KJPcd. Peer Reviewed: Incremental Health Care Costs Associated With Food Insecurity and Chronic Conditions Among Older Adults. 2018;15.
18. Mendoza JA, Haaland W, D'Agostino RB, Martini L, Pihoker C, Frongillo EA, et al. Food insecurity is associated with high risk glycemic control and higher health care utilization among youth and young adults with type 1 diabetes. 2018;138:128–37.
19. Janio EA, Sorkin DH. Food insecurity and healthcare access, utilization, and quality among middle and later life adults in California. Journal of aging and health 2021;33(3–4):171–86 doi 10.1177/0898264320967563. [PubMed: 33131379]
20. Jia J, Fung V, Meigs JB, Thorndike AN. Food Insecurity, Dietary Quality, and Health Care Utilization in Lower-Income Adults: A Cross-Sectional Study. J Acad Nutr Diet 2021;121(11):2177–86.e3 doi 10.1016/j.jand.2021.06.001.
21. Patel KG, Borno HT, Seligman HK. Food insecurity screening: A missing piece in cancer management. Cancer 2019;125(20):3494–501 doi 10.1002/cncr.32291. [PubMed: 31287159]
22. Siu AL US Preventive Services Task Force. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med 2016;164(4):279–96 doi 10.7326/m15-2886. [PubMed: 26757170]
23. Bibbins-Domingo K, Grossman DC, Curry SJ, Davidson KW, Epling JW Jr, García FAR, et al. Screening for Colorectal Cancer: US Preventive Services Task Force Recommendation Statement. Jama 2016;315(23):2564–75 doi 10.1001/jama.2016.5989. [PubMed: 27304597]
24. Makelarski JA, Abramsohn E, Benjamin JH, Du S, Lindau ST. Diagnostic Accuracy of Two Food Insecurity Screeners Recommended for Use in Health Care Settings. Am J Public Health 2017;107(11):1812–7 doi 10.2105/ajph.2017.304033. [PubMed: 28933929]

25. Hesse BW, Greenberg AJ, Peterson EB, Chou WS. The Health Information National Trends Survey (HINTS): A Resource for Consumer Engagement and Health Communication Research. Studies in health technology and informatics 2017;240:330–46. [PubMed: 28972526]
26. Wigfall LT, Friedman DB. Cancer Information Seeking and Cancer-Related Health Outcomes: A Scoping Review of the Health Information National Trends Survey Literature. Journal of health communication 2016;21(9):989–1005 doi 10.1080/10810730.2016.1184358. [PubMed: 27466828]
27. United States Department of Agriculture. 2019 08–01-2020. Rural-urban continuum codes. <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/>. 08–01-2020.
28. Mokdad AH. The Behavioral Risk Factors Surveillance System: Past, Present, and Future. Annual Review of Public Health 2009;30(1):43–54 doi 10.1146/annurev.publhealth.031308.100226.
29. Pierannunzi C, Hu SS, Balluz L. A systematic review of publications assessing reliability and validity of the Behavioral Risk Factor Surveillance System (BRFSS), 2004–2011. BMC Med Res Methodol 2013;13:49 doi 10.1186/1471-2288-13-49. [PubMed: 23522349]
30. Montgomery AE, Fargo JD, Kane V, Culhane DP. Development and validation of an instrument to assess imminent risk of homelessness among veterans. Public health reports (Washington, DC : 1974) 2014;129(5):428–36 doi 10.1177/003335491412900506.
31. Gany F, Melnic I, Ramirez J, Wu M, Li Y, Paolantonio L, et al. The association between housing and food insecurity among medically underserved cancer patients. Support Care Cancer 2021:1–10 doi 10.1007/s00520-021-06254-1.
32. McDougall JA, Anderson J, Adler Jaffe S, Guest DD, Sussman AL, Meisner ALW, et al. Food Insecurity and Forgone Medical Care Among Cancer Survivors. JCO oncology practice 2020;16(9):e922–e32 doi 10.1200/jop.19.00736. [PubMed: 32384017]
33. Katz A, Chateau D, Enns JE, Valdivia J, Taylor C, Walld R, et al. Association of the Social Determinants of Health With Quality of Primary Care. Annals of family medicine 2018;16(3):217–24 doi 10.1370/afm.2236. [PubMed: 29760025]
34. Kurani SS, McCoy RG, Lampman MA, Doubeni CA, Finney Rutten LJ, Inselman JW, et al. Association of Neighborhood Measures of Social Determinants of Health With Breast, Cervical, and Colorectal Cancer Screening Rates in the US Midwest. JAMA network open 2020;3(3):e200618 doi 10.1001/jamanetworkopen.2020.0618.
35. Zheng Z, Han X, Zhao J, Banegas MP, Tucker-Seeley R, Rai A, et al. Financial Hardship, Healthcare Utilization, and Health Among U.S. Cancer Survivors. Am J Prev Med 2020;59(1):68–78 doi 10.1016/j.amepre.2020.02.016. [PubMed: 32564805]
36. Weiser SD, Young SL, Cohen CR, Kushel MB, Tsai AC, Tien PC, et al. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. The American Journal of Clinical Nutrition 2011;94(6):1729S-39S doi 10.3945/ajcn.111.012070.
37. Mendoza JA, Haaland W, D'Agostino RB, Martini L, Pihoker C, Frongillo EA, et al. Food insecurity is associated with high risk glycemic control and higher health care utilization among youth and young adults with type 1 diabetes. Diabetes Res Clin Pract 2018;138:128–37 doi 10.1016/j.diabres.2018.01.035. [PubMed: 29427695]
38. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: a systematic review and meta-analysis. Public Health Nutr 2020;23(10):1778–90 doi 10.1017/s136898001900435x. [PubMed: 32174292]
39. Lombe M, Nebbitt VE, Sinha A, Reynolds A. Examining effects of food insecurity and food choices on health outcomes in households in poverty. Social work in health care 2016;55(6):440–60 doi 10.1080/00981389.2015.1133469. [PubMed: 27045462]
40. Alcaraz KI, Wiedt TL, Daniels EC, Yabroff KR, Guerra CE, Wender RC. Understanding and addressing social determinants to advance cancer health equity in the United States: A blueprint for practice, research, and policy. CA: a cancer journal for clinicians 2020;70(1):31–46 doi 10.3322/caac.21586. [PubMed: 31661164]
41. Berkowitz SA, Delahanty LM, Terranova J, Steiner B, Ruazol MP, Singh R, et al. Medically Tailored Meal Delivery for Diabetes Patients with Food Insecurity: a Randomized Cross-over Trial. J Gen Intern Med 2019;34(3):396–404 doi 10.1007/s11606-018-4716-z. [PubMed: 30421335]

42. Gregory CA, Deb P. Does SNAP improve your health? Food Policy 2015;50:11–9 doi 10.1016/j.foodpol.2014.09.010.
43. Gundersen C, Engelhard EE, Crumbaugh AS, Seligman HK. Brief assessment of food insecurity accurately identifies high-risk US adults. Public Health Nutr 2017;20(8):1367–71 doi 10.1017/s1368980017000180. [PubMed: 28215190]
44. Hager ER, Quigg AM, Black MM, Coleman SM, Heeren T, Rose-Jacobs R, et al. Development and Validity of a 2-Item Screen to Identify Families at Risk for Food Insecurity. Pediatrics 2010;126(1):e26–32 doi 10.1542/peds.2009-3146. [PubMed: 20595453]
45. Siegel RL, Miller KD, Goding Sauer A, Fedewa SA, Butterly LF, Anderson JC, et al. Colorectal cancer statistics, 2020. CA: a cancer journal for clinicians 2020;70(3):145–64 doi 10.3322/caac.21601. [PubMed: 32133645]
46. American Cancer Society. Breast Cancer Facts & Figures 2019–2020. Atlanta, GA: American Cancer Society, Inc.; 2019.
47. Berchick ER, Jessica C. Barnett, and Upton Rachel D. Current Population Reports, Health Insurance Coverage in the United States: 2018. Washington, DC US Census, U.S. Government Printing Office; 2019.
48. Tiro JA, Sanders JM, Shay LA, Murphy CC, H AH, Bartholomew LK, et al. Validation of self-reported post-treatment mammography surveillance among breast cancer survivors by electronic medical record extraction method. Breast Cancer Res Treat 2015;151(2):427–34 doi 10.1007/s10549-015-3387-2. [PubMed: 25922083]
49. Baier M, Calonge N, Cutter G, McClatchey M, Schoentgen S, Hines S, et al. Validity of self-reported colorectal cancer screening behavior. Cancer Epidemiol Biomarkers Prev 2000;9(2):229–32. [PubMed: 10698488]
50. Khoja S, McGregor SE, Hilsden RJ. Validation of self-reported history of colorectal cancer screening. Can Fam Physician 2007;53(7):1192–7. [PubMed: 17872816]
51. Dodou D, de Winter JC. Agreement between self-reported and registered colorectal cancer screening: a meta-analysis. Eur J Cancer Care (Engl) 2015;24(3):286–98 doi 10.1111/ecc.12204. [PubMed: 24754544]

Table 1.

Summary of survey designs implemented by the nine cancer centers

Survey site	Probability methods	Non-Probability	Sample Size (N)	Response Rate (%)
UC San Diego Health Moores Cancer Center	ABS mail survey with two sampling frames: one including all residences in San Diego County and another focused on zip codes along the US-Mexican border. Sampling frames provided by Marketing Systems Group.	N/A	720	14.4%
Fred Hutch/UW Cancer Consortium	ABS mail survey: stratified random sample representative of the Western Washington catchment area's demographics (race/ethnicity, urban/rural), stratified by county groupings based on being more urban or more rural. Sampling frames provided by Data Axle.	N/A	1052	3.6%
O'Neal Comprehensive Cancer Center at UAB	ABS mail survey with sampling frames provided by Caldwell List Company designed to provide a probability sample representative of Alabama's demographics (race/ethnicity, sex). Double sampling of 34 of 67 counties where cancer incidence is higher than state averages.	N/A	768	15.2%
University of Michigan Rogel Cancer Center	Simple random sample (n=501) of adults via landlines and cell numbers from 40 counties in Michigan obtained from SSI, with oversampling of African Americans.	Convenience sample 1* (n=1122) from SSI panel from 40 counties in Michigan, with oversampling of African American to comprise 20% of sample. Convenience sample 2* (n=206) from community intercepts with relatively high proportions of Middle Eastern and North African populations in 3 Michigan counties.	1829	9.0%
The University of Kansas Cancer Center	Stratified random sample via mail from three health systems and simple random sample from one health system files	Convenience sample	1364	17.1%
Masonic Cancer Center at the University of Minnesota	ABS mail survey with sampling frames provided by SSI to produce a random sample for the state of Minnesota stratified by region of state	N/A	717	47.0%
Sidney Kimmel Cancer Center – Jefferson Health	Simple random sample from 3 sources: a survey of their catchment area in southeastern Pennsylvania via email, a SurveyGizmo standing panel in Pennsylvania and another in New Jersey.	N/A	1557	*
Huntsman Cancer Institute at the University of Utah	ABS mail survey using sampling frames provided by Utah Population Database designed to produce a simple random sample for Utah, stratified by rurality with oversampling of more rural counties	N/A	1196	24.0%
VCU Massey Cancer Center	ABS mail survey of their catchment area in Central, Eastern, and Southern Virginia. Sampling frames provided by Marketing Systems Group.	N/A	895	17.0%

ABS= Address-based sampling; SSI= Survey Sampling International; UC=University of California; UW=University of Washington; UAB=University of Alabama Birmingham; VCU=Virginia Commonwealth University

*Data unavailable to calculate the response rate (incomplete denominator data)

Table 2a.

Characteristics of the colorectal cancer (CRC) screening sample overall and stratified by food insecurity status.

Characteristics	Total CRC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
GENDER								
Male	2066	52.8%	268	44.9%	0.0014	1786	54.6%	0.0014
Female	2719	47.2%	560	55.1%		2140	45.4%	
missing	31		12			14		
AGE								
50–59	1830	47.5%	423	60.2%	<.0001	1391	44.6%	<.0001
60–69	2072	39.0%	305	31.0%		1750	40.7%	
70+	914	13.6%	112	8.8%		799	14.8%	
missing	0		0			0		
RACE/ETHNICITY								
Non-Hispanic White	3579	72.1%	479	55.4%	<.0001	3088	76.0%	<.0001
Non-Hispanic Black	627	15.1%	214	26.7%		407	12.4%	
Hispanic	112	3.7%	38	8.8%		74	2.6%	
Asian	355	1.7%	9	1.7%		49	1.5%	
Other	414	9.2%	96	9.2%		314	9.1%	
missing	84		13			57		
RURALITY								
Rural	1226	13.8%	240	18.0%	0.0135	981	13.0%	0.0135
Urban	3550	86.2%	588	82.0%		2932	87.0%	
missing	40		12			27		
MARITAL STATUS								
Married/Living as Married	3039	62.9%	318	36.6%	<.0001	2707	68.8%	<.0001
Not Married	1733	37.1%	515	63.4%		1210	31.2%	
missing	44		7			23		
EMPLOYMENT								
Employed	1810	47.8%	256	33.4%	<.0001	1547	51.3%	<.0001
Unemployed	805	18.6%	340	42.3%		463	12.9%	

Cancer Epidemiol Biomarkers Prev. Author manuscript; available in PMC 2022 November 04.

Characteristics	Total CRC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
Retired	1608	33.6%	193	24.3%		1403	35.8%	
missing	593		51			527		
HIGHEST LEVEL of EDUCATION								
Less than baccalaureate college degree	2483	54.6%	630	78.9%	<.0001	1842	49.3%	<.0001
Baccalaureate college or graduate degree	2281	45.4%	198	21.1%		2073	50.7%	
missing	52		12			25		
INCOME								
Less than $20,000	734	17.5%	390	48.8%	<.0001	342	10.4%	<.0001
$20,000 - $49,999	1051	21.6%	267	33.3%		782	19.1%	
$50,000 - $99,999	1452	31.9%	110	12.7%		1338	36.2%	
$100,000+	1225	29.0%	32	5.2%		1189	34.3%	
missing	354		41			289		
FINANCIAL SECURITY								
Yes	3699	76.8%	306	36.2%	<.0001	3388	90.7%	<.0001
No	808	16.8%	484	63.8%		323	9.3%	
missing	309		50			229		
HEALTH INSURANCE								
Yes	4541	94.3%	750	89.3%	<.0001	3765	95.6%	<.0001
No	228	4.7%	81	9.6%		146	3.7%	
missing	47		9			29		
HOUSING INSTABILITY								
Housing instability	154	6.5%	91	21.1%	<.0001	62	3.1%	<.0001
Housing stability	3182	93.5%	479	78.9%		2692	96.9%	
missing	1480		270			1186		
HISTORY OF CANCER								
Previously diagnosed with cancer	1090	19.8%	147	14.6%	0.0026	938	21.1%	0.0026
No cancer diagnosis	3683	80.2%	687	85.4%		2971	78.9%	
missing	43		6			31		
FOOD INSECURITY								
Food insecure	840	18.2%						

Cancer Epidemiol Biomarkers Prev. Author manuscript; available in PMC 2022 November 04.

Characteristics	Total CRC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
Food secure	3940	81.8%						
missing	36							

Rao-Scott Chi-Square Test was performed.

Table 2b.

Characteristics of the breast cancer (BC) screening sample overall and stratified by food insecurity status.

Characteristics	Total BC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
GENDER								
Male	0	N/A	0	N/A	N/A	0	N/A	N/A
Female	2449	100.0%	522	21.6%		1908	78.4%	
missing	0		0			0		
AGE								
50–59	1027	49.5%	268	59.7%	0.0031	751	47.0%	0.0031
60–69	1065	39.5%	197	30.7%		859	41.6%	
70+	357	10.9%	57	9.6%		298	11.4%	
missing	0		0			0		
RACE/ETHNICITY								
Non-Hispanic White	1777	69.9%	302	56.5%	<.0001	1467	74.0%	<.0001
Non-Hispanic Black	373	18.5%	137	27.4%		231	15.9%	
Hispanic	67	3.9%	24	8.3%		43	2.8%	
Other	203	7.6%	55	7.8%		146	7.3%	
missing	29		4			21		
RURALITY								
Rural	627	12.8%	145	18.5%	0.0045	478	11.3%	0.0045
Urban	1800	87.2%	369	81.5%		1416	88.8%	
missing	22		8			14		
MARITAL STATUS								
Married/Living as Married	1357	53.2%	179	36.2%	<.0001	1170	57.9%	<.0001
Not Married	1073	46.8%	339	63.8%		728	42.1%	
missing	19		4			10		
EMPLOYMENT								
Employed	953	45.9%	161	35.1%	<.0001	786	49.0%	<.0001
Unemployed	512	22.3%	222	40.5%		288	17.0%	
Retired	781	31.7%	112	24.4%		663	33.9%	

Characteristics	Total BC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
missing	203		27			171		
HIGHEST LEVEL of EDUCATION								
Less than baccalaureate college degree	1314	45.5%	400	80.2%	<.0001	908	47.5%	<.0001
Baccalaureate college or graduate degree	1114	54.5%	116	19.8%		990	52.5%	
missing	21		6			10		
INCOME								
Less than $20,000	459	21.9%	255	47.9%	<.0001	202	14.6%	<.0001
$20,000 - $49,999	578	23.8%	164	33.1%		413	21.4%	
$50,000 - $99,999	723	31.1%	70	14.0%		651	35.9%	
$100,000+	523	23.2%	16	5.1%		503	28.1%	
missing	166		17			139		
FINANCIAL SECURITY								
Yes	1829	79.6%	206	41.2%	<.0001	1623	90.3%	<.0001
No	468	20.4%	294	58.8%		174	9.7%	
missing	152		22			111		
HEALTH INSURANCE								
Yes	2297	95.0%	473	91.3%	0.0335	1824	96.0%	0.0335
No	120	5.0%	45	8.7%		75	4.0%	
missing	32		4			9		
HOUSING INSTABILITY								
Housing instability	82	6.7%	51	18.1%	<.0001	30	3.3%	<.0001
Housing stability	1529	93.3%	299	81.9%		1222	96.7%	
missing	838		172			656		
HISTORY OF CANCER								
Previously diagnosed with cancer	390	13.5%	80	13.1%	0.7681	307	13.8%	0.7681
No cancer diagnosis	2035	86.5%	438	86.9%		1581	86.2%	
missing	24		4			20		
FOOD INSECURITY								
Food insecure	522	21.6%						
Food secure	1908	78.4%						

Characteristics	Total BC Sample		Food insecure			Food secure		
	Frequency	Weighted %	Frequency	Weighted %	p-value	Frequency	Weighted %	p-value
missing	19							

Rao-Scott Chi-Square Test was performed.

Table 3.

Cancer screening status per United States Preventive Services Task Force (USPSTF) guidelines from 2016: unadjusted bivariate estimates overall and stratified by food insecurity status

	Total N (%)		Food insecurity status N (%)			
			Food insecure		Food secure	
Colorectal cancer screening status						
Not up-to-date	1255	25.6%	305	36.9%	950	23.1%
Up-to-date	3525	74.4%	535	63.1%	2990	76.9%
Total N (%)			840	18.2%	3940	81.8%
Missing	36		0		0	
Breast cancer screening status						
Not up-to-date	619	34.1%	179	38.2%	440	32.9%
Up-to-date	1811	65.9%	343	61.8%	1468	67.1%
Total N (%)			522	21.6%	1908	78.4%
Missing	19		0		0	

Table 4.

Multiple logistic regression models and associations for being up to date with United States Preventive Services Task Force cancer screening guidelines from 2016 ([a] colorectal cancer screening model: n=4261, 555 missing were excluded and [b] breast cancer screening model: n=2329, 120 missing were excluded).

	Odds Ratio	95% Confidence Interval	
Up to date with colorectal cancer screening *			
FOOD INSECURITY			
Food insecure	0.7	0.5	0.99
Food secure	Reference		
Up to date with breast cancer screening **			
FOOD INSECURITY			
Food insecure	0.6	0.4	0.96
Food secure	Reference		

* Model adjusts for gender, age, race/ethnicity, rurality, marital status, highest level of education, income, financial security, health insurance, and history of cancer.

** Model adjusts for race/ethnicity, rurality, marital status, highest level of education, income, financial security, health insurance, and history of cancer.