Original Study

Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis

Carla Barberan Parraga,[1,#] Roshni Singh,[2] Rachel Lin,[2] Leonardo Tamariz,[3] Ana Palacio[3]

Abstract

Colorectal cancer screening can prevent disease by early identification of precancerous polyps before they progress to cancer. Yet accessibility to CRC screening is still variable among race, geographical location, insurance status, and socioeconomic variables. We include in our analysis publicly available data for zip code-based analysis. We found that the variables that are most related to decreased screening are the social deprivation index and access to health insurance. These data may help implement interventions that target these barriers to promote CRC screenings within disadvantaged communities, which would decrease mortality rates overall.

Background: Colorectal cancer (CRC) screening can prevent disease by early identification. Existing disparities in CRC screening have been associated with factors including race, socioeconomic status, insurance, and even geography. Our study takes a deeper look into how social determinants related to zip code tabulation areas affect CRC screenings. **Materials and Methods:** We conducted a retrospective cross-sectional study of CRC screenings by race at a zip code level, evaluating for impactful social determinant factors such as the social deprivation index (SDI). We used publicly available data from CDC 500 Cities Project (2016-2019), PLACES Project (2020), and the American Community Survey (2019). We conducted multivariate and confirmatory factor analyses among race, income, health insurance, check-up visits, and SDI. **Results:** Increasing the tertile of SDI was associated with a higher likelihood of being Black or Hispanic, as well as decreased median household income ($P < .01$). Lower rates of regular checkup visits were found in the third tertile of SDI ($P < .01$). The multivariate analysis showed that being Black, Hispanic, lower income, being uninsured, lack of regular check-ups, and increased SDI were related to decreased CRC screening. In the confirmatory factor analysis, we found that SDI and access to insurance were the variables most related to decreased CRC screening. **Conclusion:** Our results reveal the top 2 factors that impact a locality's CRC screening rates are the social deprivation index and access to health care. This data may help implement interventions targeting social barriers to further promote CRC screenings within disadvantaged communities and decrease overall mortality via early screening.

Clinical Colorectal Cancer, Vol. 000, No.xxx, 1–7 © 2023 Elsevier Inc. All rights reserved.
Keywords: Social deprivation index, Social determinants of health, Public health, Colorectal Cancer, Health Disparities

Introduction

Colorectal cancer (CRC) is the third leading cause of cancer-related deaths in men and women in the United States.[1] It is estimated that in 2022 there will be approximately 150,000 new cases of CRC diagnosed and over 50,000 deaths due to CRC in the United States. Screening can prevent disease by early identification and removal of precancerous polyps before they progress to cancer, as well as detect cancer at earlier stages when treatment is more successful.[2] Many CRC screening programs have greatly improved outcomes by decreasing incidence and mortality from CRC.[3,4,5] In fact, research indicates that the stage at which CRC is diagnosed is the most significant prognostic factor that predicts survival.[6] There are multiple screening options for CRC, which include both visual and stool-based tests.

The American Gastroenterological Association recommends screening regularly begin at the age of 45.[6] However, CRC screening accessibility varies by race and ethnicity, with African Americans and Hispanics having lower rates than their non-Hispanic white counterparts. Moreover, disparities regarding CRC screening have been identified by socioeconomic factors, spoken language, and geographic location. Individuals with low socioeconomic status (SES) and those lacking insurance tend to undergo CRC screenings at lower rates.[7]

[1] Department of Medicine and Epidemiology Universidad Catolica Santiago de Guayaquil, Guayaquil, Ecuador
[2] Miller School of Medicine, University of Miami, Miami, FL
[3] Miami Veterans Affairs Medical Center, Miami, FL

Submitted: Aug 2, 2022; Accepted: Jan 24, 2023; Epub: xxx

Address for correspondence: Carla Barberan Parraga, MD, Department of Medicine and Epidemiology, Universidad Católica de Santiago de Guayaquil, Av. Carlos Julio Arosemena Km 1.5, Guayaquil 090615, Ecuador.
E-mail contact: carlabarberan0493@gmail.com

[#] Current address mailing: 88 Greenwich st. apt 527 New York, NY 10006. E-mail: carla.barberan@cu.ucsg.edu.ec

1533-0028/$ - see front matter © 2023 Elsevier Inc. All rights reserved.
https://doi.org/10.1016/j.clcc.2023.01.001

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

CRC screening rates are much higher among English-speaking individuals; even after adjusting for SES, Spanish-speakers are 24% less likely to complete CRC screenings.[8] Additionally, disparities have also been found between residents of rural and urban communities.[9] Individuals residing in rural areas are less likely to be screened for CRC or receive follow-up testing after abnormal screening results and are more likely to present with advanced CRC than their urban counterparts[10]. Some studies looking at state-level racial disparities found that Black and Hispanic patients had lower rates of screening across most states, but it varied by region, and intraracial disparities vary within White and Black populations, based on where they live.[11]

Several studies have evaluated the individual role of SDoH (social determinants of health) and these reports have been either single center or in limited geographic areas.[12,13] Our aim is to evaluate the individual relationship between race, SES, and geography on CRC screening as well as their interrelationship. This knowledge may help develop targeted interventions that would best address CRC within specific communities in hopes of achieving more equitable screening practices and better outcomes overall.[12]

Materials and Methods

Study Design

We conducted a cross-sectional study of CRC screening among different races, evaluating the relationship with the SDI and annual income as SDoH using publicly available data sources: CDC 500 cities project, PLACES project, and the American Community Survey (ACS).

Data Sources

The *500 Cities Project* is a database created by the CDC in partnership with The Robert Wood Johnson Foundation. The aim of the project was to gather information on a large scale for cities and small areas within cities to obtain 27 measures including unhealthy behaviors, prevention practices, and health outcomes. These are useful in understanding the issues affecting the local population to identify emerging health problems and establish/monitor key health objectives to develop and implement effective and targeted prevention activities. We use the crude prevalence of health outcomes, unhealthy behaviors, and prevention data. The total population included in the project was 103,020,808 which represented 33.4% of the total United States population.[14]

The *PLACES* project is an expansion of the original 500 Cities Project. The difference between data sets is that *PLACES* provides population-level analysis and community estimates to cover the entire country, not just the 500 largest cities. This includes smaller cities and rural areas by organizing the data in a multilocal level by counties, places, census tracts, and zip codes. *PLACES* provides estimates necessary to understand the health issues affecting the residents of various regions, regardless of urban or rural status, to develop and implement effective and targeted prevention activities and identify health problems. We used the crude prevalence of health outcomes, unhealthy behaviors, and prevention data from this database as well.[15]

The *2019 American Community Survey* (ACS) is a data set collected by the United States Census Bureau that provides vital information about the US population like employment status, health insurance status, income, housing, and demographics among others. This data helps determine how federal and state funds are distributed each year. The ACS is currently the largest nationwide, continuous sample survey implemented by the US Census Bureau to produce reliable estimates for the entire country. We used median income in the past 12 months (in 2019 inflation-adjusted dollars) as well as ACS Demographic and housing estimates from this database.[16]

CRC Screening

We used CRC screening from the 500 Cities dataset. This data reports if fecal occult blood test (FOBT) within the past year, sigmoidoscopy within the past 5, and FOBT within the past 3 years or colonoscopy within the past 10 years was performed among adults who are 50 to 75 years of age. The data is reported as a continuous probability ranging from 0 to 100. Both the 500 Cities and PLACES databases use the Behavioral Risk Factor Surveillance Survey (BRFSS) which is a nationwide, state-based randomly selected telephone survey of noninstitutionalized US adult population aged >18 years. Selected participants were asked whether they had been screened for CRC, with the answer choices being yes, no, don't know/not sure, or refused [to answer].[17]

Prevalence, Crude, and Age-Adjusted With 95% CI and by Demographic Characteristics

Race. We used the 2019 ACS data to obtain demographic information. We defined race and ethnicity as Non-Hispanic White, Black, and Hispanic. We used the proportion of each race and ethnicity in each zip codes as a continuous variable. We excluded all other races and ethnicities. The validity of this approach is supported by the ACS which uses a weighting method to ensure that estimates are consistent with official Census Bureau population estimates by age, sex, race, ethnicity, as well as total housing units.[18]

Income. We used the 2019 ACS data to obtain economic information as well. The 2019 ACS sampled approximately 3.5 million housing-unit addresses in over 579,000 geographic areas. In this study, we used the 2019 ACS 5-year estimates of the percentage of the population aged 18 to 64 years [16] We used the median household income.[19]

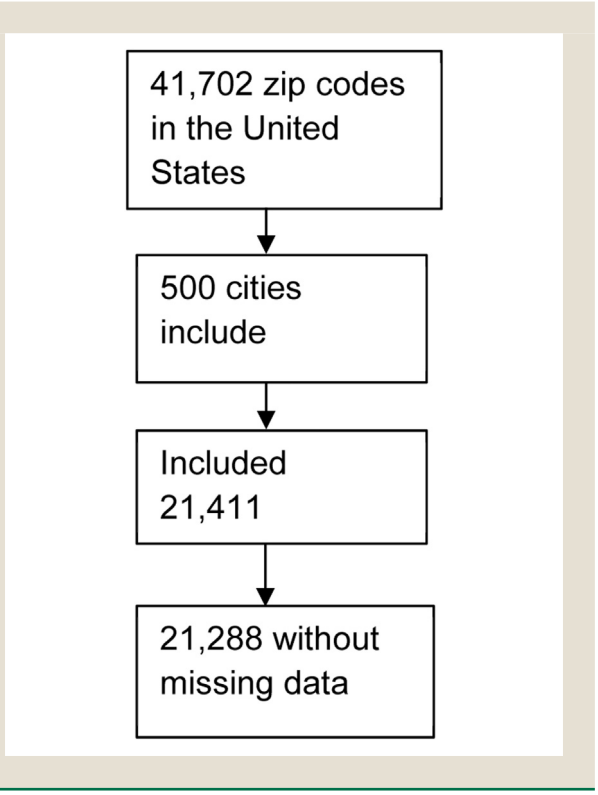
Social Deprivation Index (SDI)

We constructed county-level SDI by weighting 17 widely used measures in population health literature for employment, income, education, housing, household characteristics, and transportation.[20] The 5-year estimates of 2018 ACS data were used for calculating SDI and each of the composite measures, using an approach as described by Singh et al.[21] Higher raw SDI corresponds to more deprivation and therefore lower SES.

Database Linkage. Datasets were downloaded from publicly available databases such as the United States Census Bureau and the CDC and exported into Microsoft Excel. Files were then imported into ArcGIS. We linked all data sources via their census 5-digit ZIP code tabulation area (ZCTA5) zip codes within ArcGis. This data linking has been done in prior studies evaluating disparities.[22]

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

Figure 1 Flow chart of included zip codes



Statistical Analysis

We used percentages, means, and standard deviations to summarize the baseline characteristics of the included sample. We used ANOVA and χ^2 to compare baseline characteristics. We conducted 2 complementary analyses to accomplish the aims of our study. First, we used multivariate linear regression with CRC screening as the dependent variable to calculate the beta coefficient of each predictor and the corresponding 95% confidence interval (CI). Second, we used confirmatory factor analysis (CFA) to evaluate the effect of each variable on CRC screening and to evaluate collinearity among variables. Variables that correlated to each other and contributed together to CRC were considered a latent variable or a domain. To compare the goodness of fit we used the root-mean-squared error of approximation and comparative fit index, analyses were performed using STATA 14.0 (College Station, TX). All significance tests were 2-tailed.

Results

Baseline Characteristics

Figure 1 in the appendix shows the included and excluded zip codes in our study. We included 51% of the zip codes from the United States, the reasons for exclusion were the lack of data from the 500 Cities database on all zip codes and a small amount of missing SDI data. Table 1 presents the baseline characteristics by SDI. With increasing tertile of SDI, there is a higher likelihood of being Black and Hispanic as well as a lower median household income ($P< .01$). Lower rates of regular checkup visits were found in the third tertile of the social deprivation index ($P< .01$).

Multivariate Analysis

Table 2 shows the results of the multivariate analysis. Being Black, Hispanic, having a lower income, not having health insurance, and not having regular check-ups and SDI were related to less colon cancer screening.

Confirmatory Factor Analysis

Figure 2 in the appendix shows the structural equation model coefficients. Our latent variables included race (race and ethnicity), financial strain (SDI and income), and access to care (regular check-ups and access to health insurance). The highest R2 was for social deprivation index, income, and lack of health insurance. Table 3 shows the CFA and the R2 of variables.

Discussion

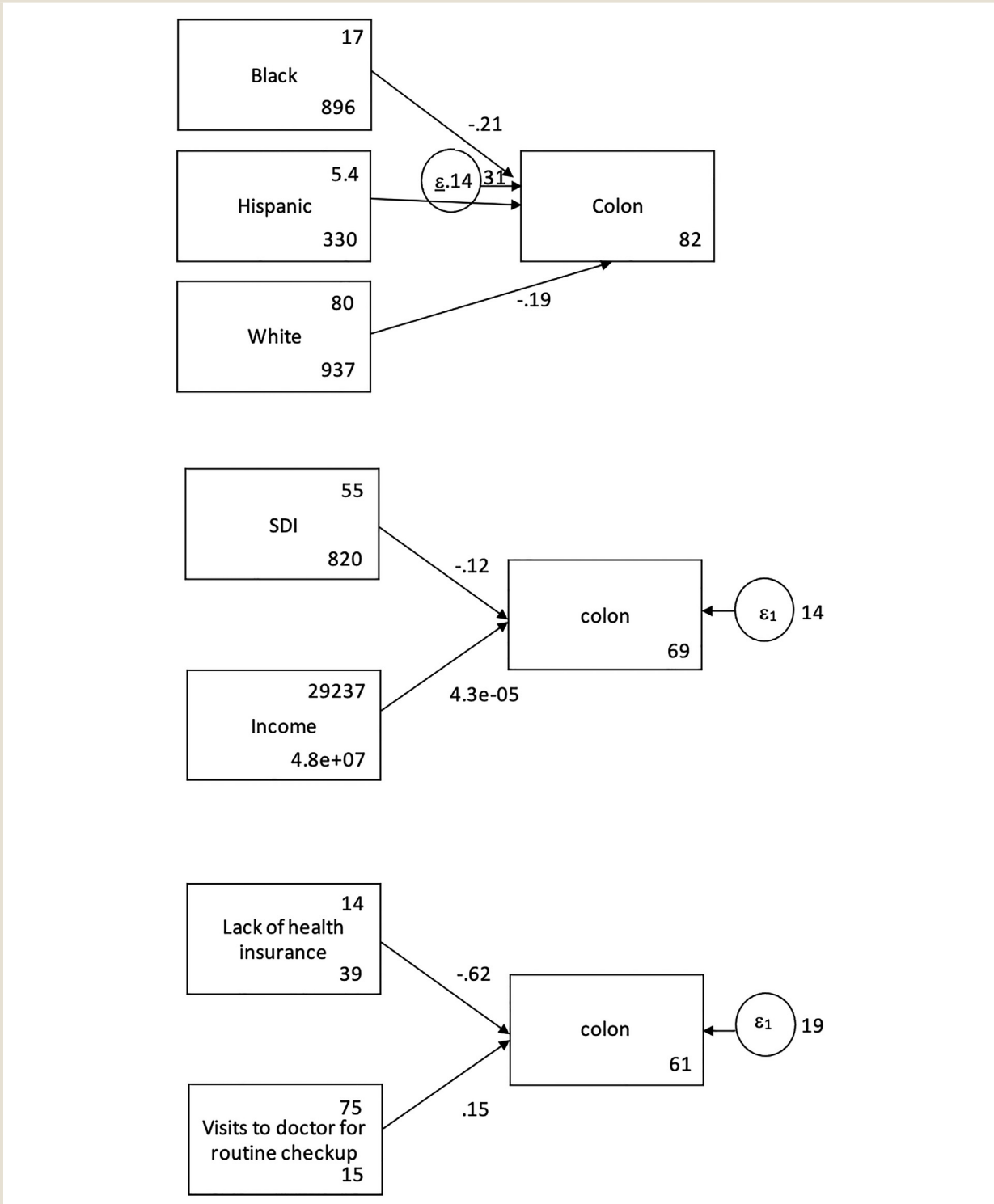
We used zip-code level data from *500 Cities* to study the intersection of race, SES, and social deprivation index on CRC screening and determined which relationship is most integral to affecting CRC screening rates. Study findings indicate an increase in SDI correlated with a decrease in CRC screening. We also observed a direct association between income and CRC screening levels, as income decreased, CRC screening decreased, and vice-versa. Both Hispanic and Black minorities studied had significantly decreased levels of CRC screening compared to their White counterparts, which aligns with past research.[23,24] Income, SDI, and access to healthcare emerged as the 3 most significant contributors to CRC screening in our CFA, and of these, lack of health insurance and social deprivation index had the greatest negative effect on CRC screening. Both contribute to CRC screenings by 46% each. Race only explained 11% of the findings and was not as significant. Rather, SDI and lack of health insurance had the greatest effect on CRC screening, which means that the main factors contributing to CRC screenings are modifiable factors. These factors should be especially considered when creating interventions that promote CRC screening among these populations.

This study's findings are consistent with several studies that have shown minority status, SDI, SES, and rurality all impact CRC screening.[7,9,25] To our knowledge, there is only 1 published report examining zip-code level data association between CRC, area deprivation, and rurality, but this was a study from an integrated health care delivery system in 3 Midwestern states.[13,25] Another study confirmed the effect of neighborhood and individual-level socioeconomic factors on CRC but was limited by a sample size of 526 participants.[26] Our study showed that income, social deprivation index, and access to healthcare are the 3 most significant contributors to CRC screening, but access to healthcare and financial strain had the greatest effect on CRC screening.

One cross-sectional study found that the screening rate for CRC was 53.4% for Hispanics, compared to 70.4% for non-Hispanic whites.[23] CRC screening rates among Blacks are also lower than among whites (55.5% vs. 61.5%).[24] Another cross-sectional analysis of average-risk adults found that although rates of CRC screening have increased overall between 2008 and 2016, they have increased

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

Figure 2 Structural equation models coefficients



Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

Table 1 Baseline Characteristics by Social Deprivation Index

Characteristic	Tertile 1	Tertile 2	Tertile 3	*P*-Value
Number	9003	6224	5971	
Mean social deprivation index	19.9 ± 11.1	55.3 ± 9.7	86.2 ± 8.3	<.01
% Black	4	10	30	<.01
% Hispanic	1	8	9	<.01
% White	89	87	68	<.01
Income	57,873 ± 2460	36,252 ± 1294	28,367± 2021	<.01
Lack of health insurance	10	14	18	<.01
Visited a healthcare provider for a checkup in the past year	76	75	71	<.01
Obesity	31	35	36	<.01

Table 2 Multivariate Analysis

Characteristic	Beta Coefficient	*P*-Value
Social deprivation index	-0.12 (-0.13 to -0.10)	<.01
Income	0.00 (0.00-0.00)	<.01
Black	-0.01 (-0.18 to -0.012)	<.01
Hispanic	-0.09 (-0.09 to -0.08)	<001
White	0.01 (0.15-0.02)	<.01
Lack of health insurance	-0.64 (-0.65 to -0.63)	<.01
Check-up visits	0.36 (0.34-0.38)	<.01

Table 3 Confirmatory Factor Analysis

Latent Variable	Variables	Coefficient	R2
Race/Ethnicity	Black Hispanic White	-0.20 -0.14 -0.19	11%
Financial strain	Social deprivation index Income	-0.12 0.004	46%
Access to care	Access to health insurance Regular checkups	-0.62 0.14	46%

disproportionately in each racial and ethnic group, with disparities in screening uptake persisting.[27]

Our study has several strengths. It is one of the first of its kind to use nationwide zip code data. Our study includes 51% of the zip codes from the United States and only excluded zip codes with missing data, making the results generalizable to the entire country. Although early studies have examined the impact of the geographic location and SES on CRC screening, specifically urban versus rural disparities regarding access to care, none of them have studied SDoH at the zip-code level. To our knowledge, our study was one of the first of its kind to analyze how social determinants related to geographic location and specifically zip codes affect CRC screenings using a multivariate analysis and CFA.

However, our study has some limitations. Since it is a cross-sectional study, it can only reveal correlations rather than establish a true cause-and-effect relationship. One of the limitations of the use of US census tract-level data includes the use of estimates and missing data and both random and nonrandom errors. Zip codes are large geographic units that are grouped together and generalized. CRC numbers are reported by zip codes and not by block groups or census tracts; this could lead to misclassification. Additionally, the use of geographical location is an estimate for patient-reported measures that reflect socioeconomic indicators and may not be accurate as both someone with a high SES and low SES may live in the same zip code. This measure is merely an approximation and may be subject to mistakes. Another limitation is that Hispanics frequently identify as White race in the census-based question, which may lead to misclassification. One advantage is that both race and ethnicity data were gathered in this census (Hispanic vs. Non-Hispanic), which might have reduced the chance of misclassification. However, our study tries to overcome some of the limitations of census tract data by using GIS mapping and spatial analysis.[28]

Many studies have investigated how SDoH and race impact CRC screening rates.[7,29] Race, SDI, insurance status, and SES, all have known effects on access to CRC screenings, treatment rate, and survival rate. Moreover, the impact of geography and rurality on

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

CRC screening has also been studied.[9,29] Our study not only recognizes the SDoH that impacts CRC screenings among people of different races, SDIs, and SES, but also identifies which factors are most indicative of impacting CRC screenings.

There are many theories as to why certain groups do not undergo CRC screenings at the same rate as other groups.[25,30] While racial disparities exist, they may only be partially explained by SES and access to care.[8] For minority groups, there may be less access to care due to language barriers, lack of education and medical literacy, lack of insurance, or mistrust for the medical system considering historic past events with mistreatment.[31] One study surveyed Black patients at a community center regarding attitudes about CRC screening; fear, denial, fatalism, perceptions of the procedure, and lack of self-efficacy all contributed to the CRC screening gap.[32] Among African Americans, Kiviniemi et al. showed that SES was related to both screening compliance and decision-making regarding screening.[33]

Conclusion

Significant progress is being made in our understanding of factors that contribute to racial/ethnic disparities in cancer screening, incidence, and outcomes. Our results add to the current literature and help pinpoint which factors in particular have the largest impact on patients undergoing CRC screenings. With these data, interventions may be implemented that specifically target these identified barriers in our study of social deprivation index, income, and lack of health insurance, to promote CRC screenings and catch colorectal cancer early within disadvantaged communities.

Future Studies

We need to use this information to develop culturally and linguistically tailored CRC screening programs focused on cancer awareness, education, and navigation, as well as interventions that address changes in modifiable risk behaviors in groups known to be at higher risk.[34] The availability of multiple screening options which currently exist for CRC screening allows a patient-centered approach to using the test that works for each person.[35] However, these need to be accompanied by system-level changes in insurance, access, and equity. More studies are needed to corroborate these findings and to evaluate the impact of race, SDoH, and SDI on CRC screening. We also need to take a closer look at structural racism and racial discrimination as the underlying cause behind the lower CRC screening. Interventions using multipronged targeted approaches are needed within each community in hopes of achieving more equitable CRC screening and having better overall health outcomes.

Clinical Practice Points

• Colorectal cancer is the third cause of cancer-related death in the US. Screening can prevent disease through early identification and removal of precancerous polyps before they progress to cancer. It's well known that screening accessibility varies by race and ethnicity but there are other factors to take in consideration like socioeconomic factors, spoken language, and geographic location.

• Our aim is to evaluate the individual relationship between race, SES, and geography on CRC screening as well as their interrelationship because usually, this variable tends to measure the same we performed a multivariate analysis and a confirmatory factor analysis to look at which variable is most significant among the others.

• With increasing the Social Deprivation Index there is a higher likelihood of being Black and Hispanic as well as a lower median household income and Lower rates of regular checkup visits were found in the third tertile of the social deprivation index.

• We found that the variables that are most related to decreased screening are the social deprivation index and access to health insurance.

• These data may help implement interventions that specifically target these barriers to promote CRC screenings within disadvantaged communities, which would decrease mortality rates overall.

Acknowledgment

We thank Dr. Leonardo Tamariz and Dr. Ana Palacio for their contributions to this paper, especially for sharing our passion for health disparities and social determinants of health.

Disclosure

The authors have stated that they have no conflicts of interest.

References

1. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer statistics, 2021 [published correction appears in CA Cancer J Clin. 2021 Jul;71(4):359]. *CA Cancer J Clin*. 2021;71(1):7–33. doi:10.3322/caac.21654.
2. American Cancer Society. *Colorectal Cancer Facts & Figures 2020-2022*. Atlanta, GA: American Cancer Society; 2020.
3. Rex DK, Boland CR, Dominitz JA, et al. Colorectal cancer screening: recommendations for physicians and patients from the U.S. multi-society task force on colorectal cancer. *Am J Gastroenterol*. 2017;112(7):1016–1030. doi:10.1038/ajg.2017.174.
4. Brenner H, Stock C, Hoffmeister M. Effect of screening sigmoidoscopy and screening colonoscopy on colorectal cancer incidence and mortality: systematic review and meta-analysis of randomised controlled trials and observational studies. *BMJ*. 2014;348:g2467. doi:10.1136/bmj.g2467.
5. Sieg Siegel RL, Miller KD, Goding Sauer A, et al. Colorectal cancer statistics, 2020. *CA Cancer J Clin*. 2020;70(3):145–164. doi:10.3322/caac.21601.
6. Patel SG, May FP, Anderson JC, et al. Updates on age to start and stop colorectal cancer screening: recommendations from the U.S. multi-society task force on colorectal cancer. *Gastroenterology*. 2022;162(1):285–299. doi:10.1053/j.gastro.2021.10.007.
7. Warren Andersen S, Blot WJ, Lipworth L, Steinwandel M, Murff HJ, Zheng W. Association of race and socioeconomic status with colorectal cancer screening, colorectal cancer risk, and mortality in Southern US adults. *JAMA Netw Open*. 2019;2(12). doi:10.1001/jamanetworkopen.2019.17995.
8. Liss DT, Baker DW. Understanding current racial/ethnic disparities in colorectal cancer screening in the United States: the contribution of socioeconomic status and access to care. *Am J Prev Med*. 2014;46(3):228–236. doi:10.1016/j.amepre.2013.10.023.
9. Cole AM, Jackson JE, Doescher M. Colorectal cancer screening disparities for rural minorities in the United States. *J Prim Care Community Health*. 2013;4(2):106–111. doi:10.1177/2150131912463244.
10. Hirko KA, Lennon SA, Lucas T, et al. Improving colorectal cancer screening in a rural setting: a randomized study. *Am J Prev Med*. 2020;59(3):404–411. doi:10.1016/j.amepre.2020.03.019.
11. Abualkhair WH, Zhou M, Ochoa CO, et al. Geographic and intra-racial disparities in early-onset colorectal cancer in the SEER 18 registries of the United States. *Cancer Med*. 2020;9(23):9150–9159. doi:10.1002/cam4.3488.
12. Faruque FS, Zhang X, Nichols EN, et al. The impact of preventive screening resource distribution on geographic and population-based disparities in colorectal cancer in Mississippi. *BMC Res Notes*. 2015;8:423. doi:10.1186/s13104-015-1352-0.
13. Kurani SS, McCoy RG, Lampman MA, et al. Association of neighborhood measures of social determinants of health with breast, cervical, and colorectal cancer screening rates in the US Midwest. *JAMA Netw Open*. 2020;3(3). doi:10.1001/jamanetworkopen.2020.0618.
14. 500 Cities project. Centers for disease control and prevention. Accessed April 12, 2022. Available at: https://www.cdc.gov/500cities.
15. PLACES Project. Centers for disease control and prevention. Accessed April 12, 2022. Available at: https://www.cdc.gov/places
16. United States Census Bureau. American Community Survey 2019 median income in the past 12 months (in 2019 inflation-adjusted dollars). 2022.Accessed April 12,

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001

2022 Available at: https://data.census.gov/cedsci/tableq=income&g=0100000US.860000&tid=ACSST5Y2019.S1903.
17. Centers for Disease Control and Prevention. Behavioral risk factor surveillance system overview: BRFSS 2019. Available at: https://www.cdc.gov/brfss/annual_data/annual_2019.html. Accessed April 12, 2022.
18. United States Census Bureau. American Community Survey 2019 demographic and housing estimates. 2022. Available at: https://data.census.gov/cedsci/tableg=0100000US.860000&tid=ACSDP5Y2019.DP05.
19. Zhang X, Holt JB, Yun S, Lu H, Greenlund KJ, Croft JB. Validation of multilevel regression and poststratification methodology for small area estimation of health indicators from the behavioral risk factor surveillance system. *Am J Epidemiol*. 2015;182(2):127–137. doi:10.1093/aje/kwv002.
20. Butler DC, Petterson S, Phillips RL, Bazemore AW. Measures of social deprivation that predict health care access and need within a rational area of primary care service delivery. *Health Serv Res*. 2013;48(2 Pt 1):539–559. doi:10.1111/j.1475-6773.2012.01449.x.
21. Singh GK, Daus GP, Allender M, et al. Social determinants of health in the United States: addressing major health inequality trends for the nation, 1935-2016. *Int J MCH AIDS*. 2017;6(2):139–164. doi:10.21106/ijma.236.
22. Tamariz L, Medina H, Suarez M, Seo D, Palacio A. Linking census data with electronic medical records for clinical research: a systematic review. *J Econ Soc Meas*. 2018;43(1-2):105–118. doi:10.3233/JEM-180454.
23. Viramontes O, Bastani R, Yang L, Glenn BA, Herrmann AK, May FP. Colorectal cancer screening among Hispanics in the United States: disparities, modalities, predictors, and regional variation. *Prev Med*. 2020;138. doi:10.1016/j.ypmed.2020.106146.
24. DeSantis CE, Siegel RL, Sauer AG, et al. Cancer statistics for African Americans, 2016: progress and opportunities in reducing racial disparities. *CA Cancer J Clin*. 2016;66(4):290–308. doi:10.3322/caac.21340.
25. Zahnd WE, Murphy C, Knoll M, et al. The intersection of rural residence and minority race/ethnicity in cancer disparities in the United States. *Int J Environ Res Public Health*. 2021;18(4):1384. doi:10.3390/ijerph18041384.
26. Mayhand KN, Handorf EA, Ortiz AG, et al. Effect of neighborhood and individual-level socioeconomic factors on colorectal cancer screening adherence. *Int J Environ Res Public Health*. 2021;18(9):4398. doi:10.3390/ijerph18094398.
27. May FP, Yang L, Corona E, Glenn BA, Bastani R. Disparities in colorectal cancer screening in the United States before and after implementation of the Affordable Care Act. *Clin Gastroenterol Hepatol*. 2020;18(8):1796–1804.e2. doi:10.1016/j.cgh.2019.09.008.
28. Logan JR. Relying on the census in urban social science. *City Community*. 2018;17(3):540–549. doi:10.1111/cico.12331.
29. Davis MM, Renfro S, Pham R, et al. Geographic and population-level disparities in colorectal cancer testing: a multilevel analysis of Medicaid and commercial claims data. *Prev Med*. 2017;101:44–52. doi:10.1016/j.ypmed.2017.05.001.
30. Carethers JM, Doubeni CA. Causes of socioeconomic disparities in colorectal cancer and intervention framework and strategies. *Gastroenterology*. 2020;158(2):354–367. doi:10.1053/j.gastro.2019.10.029.
31. Adams LB, Richmond J, Corbie-Smith G, Powell W. Medical mistrust and colorectal cancer screening among African Americans. *J Community Health*. 2017;42(5):1044–1061. doi:10.1007/s10900-017-0339-2.
32. Greiner KA, Born W, Nollen N, Ahluwalia JS. Knowledge and perceptions of colorectal cancer screening among urban African Americans. *J Gen Intern Med*. 2005;20(11):977–983. doi:10.1111/j.1525-1497.2005.00165.x.
33. Kiviniemi MT, Klasko-Foster LB, Erwin DO, Jandorf L. Decision-making and socioeconomic disparities in colonoscopy screening in African Americans. *Health Psychol*. 2018;37(5):481–490. doi:10.1037/hea0000603.
34. Zavala VA, Bracci PM, Carethers JM, et al. Cancer health disparities in racial/ethnic minorities in the United States. *Br J Cancer*. 2021;124(2):315–332. doi:10.1038/s41416-020-01038-6.
35. Issa IA, Noureddine M. Colorectal cancer screening: an updated review of the available options. *World J Gastroenterol*. 2017;23(28):5086–5096. doi:10.3748/wjg.v23.i28.5086.

Please cite this article as: Carla Barberan Parraga et al, Colorectal Cancer Screening Disparities Among Race: A Zip Code Level Analysis, Clinical Colorectal Cancer, https://doi.org/10.1016/j.clcc.2023.01.001