PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

Cancer Screening Prevalence and Associated Factors Among US Adults

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

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PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 19, E22 APRIL 2022

EDITORIAL

Cancer Screening Prevalence and Associated Factors Among US Adults

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Accessible Version: www.cdc.gov/pcd/issues/2022/22_0063.htm

Suggested citation for this article: Ma Zq, Richardson LC. Cancer Screening Prevalence and Associated Factors Among US Adults. Prev Chronic Dis 2022;19:220063. DOI: https://doi.org/10.5888/pcd19.220063.

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Cancer is the second leading cause of death in the US, exceeded only by heart disease. In 2018, 1,708,921 people were newly diagnosed and 599,265 people died of cancer (1). Although age-adjusted cancer incidence decreased 9.5% over the past 20 years, from 481.7 per 100,000 in 2009 to 435.8 per 100,000 in 2018, the number of people diagnosed with cancer increased, from 1,292,222 in 2009 to 1,708,921 in 2018 (1,2). The estimated national expenditure for cancer care in the US rose from $190.2 billion in 2015 to $208.9 billion in 2020, a 10% increase mainly due to the aging and growth of the US population (3,4). Costs will likely increase in future years as the population grows and ages and new and often more expensive treatments are adopted as standards of care.

Approximately 30% to 50% of cancers diagnosed today could be prevented by reducing exposure to tobacco smoke and other environmental carcinogens, maintaining healthy body weight, and receiving recommended cancer screenings and vaccinations (5,6). Cancer screening, which is different from diagnostic testing, can detect cancer at early stages before symptoms occur, when it can be more successfully treated. In addition to early detection, screening can prevent colorectal and cervical cancers by identifying precancerous lesions that can be removed before they become cancer (7–9). Thus, understanding screening patterns and factors associated with screening will help public health policy makers and practitioners improve cancer prevention programs further by implementing evidence-based policies and practices (10,11). This special collection of articles from *Preventing Chronic Disease* presents research on determinants of cancer screening, public health practices that increase cancer screening uptake in specific populations, and cancer screening trends.

Screening is considered the primary factor in the steady decline in colorectal cancer incidence over the past decade (12). Richardson and colleagues used data from the Behavioral Risk Factor Surveillance System to present a GIS (geographic information system) snapshot of US states and the District of Columbia that displays the percentage of US adults who reported no screening for colorectal cancer (13). The overall percentage screened decreased from 27.4% in 2012 to 21.6% in 2020, a 5.8 percentage=point decrease that represents almost 4 million people. The average statewide percentage of adults aged 50 to 75 years who were not up to date with colorectal cancer screening in 2020 was 69.4% and ranged from 58.4% in California to 79.6% in Maine. Twenty-two states did not meet the Healthy People 2020 objective of 70.5% of population screened for colorectal cancer. And most adults not up to date with screening had never been screened. Future research on colorectal cancer screening could focus on population subgroups and on new outreach methods directed at the unscreened in those subgroups. Successful interventions could then be disseminated among other population subgroups.

Although overall age-adjusted cancer incidence has been stabilizing over the past several decades, Weir and colleagues used the age-period-cohort generalized linear model to predict that total cancer incidence in the US will increase approximately 50% from 2015 to 2050, from 1.5 million to 2.3 million (2). The largest increase in cancer incidence will occur in people aged 75 years or older; prevention and early detection do work in older populations (14). With the US population aging and age as a nonmodifiable risk factor for cancer, prevention programs can implement evidence-based risk-reduction strategies to reduce behavioral risk factors such as smoking, drinking, and exposure to environmental carcinogens and chronic conditions such as obesity and type 2 diabetes. Cancer screening could also be treated as a prevention priority to detect precancerous lesions that can be removed, thereby preventing cancer, and to detect cancers at early, treatable stages. State and local health departments could also use the age-period-cohort model to estimate their local cancer incidence in their respective state and local areas and develop actionable plans with innovative strategies to help residents change their behaviors by making healthy lifestyle choices, including increasing screening

rates. State and local health departments can also use the model to evaluate cancer prevention program outcomes by comparing the time trends and differentials of cancer incidences with or without interventions.

Screening can prevent thousands of cancer deaths. Modern mammography programs can reduce breast cancer mortality by more than 40% (15–17). The over-50% decrease in cervical cancer incidence and mortality over the past 3 decades is largely due to screening with the Papanicolaou (Pap) test, which can detect cervical cancer at an early stage as well as precancerous abnormalities (9). With appropriate evaluation, follow-up, and treatment, survival for women diagnosed with precancerous cervical lesions is almost 100% (18). Sharma and colleagues used a model-based approach in a cohort of 50-year-old participants and estimated that 10,179 deaths from breast cancer, 27,166 from cervical cancer, and 74,740 from colorectal cancer could be prevented if current screening levels were maintained. In addition, an extra 1,300 deaths from breast cancer, 3,400 from cervical cancer, and 11,000 from colorectal cancer could be averted with an increase of 10 percentage points above current screening rates (19). However, even with its proven benefits and US Preventive Services Task Force (USPSTF) recommendations, cancer screening is still suboptimal. The median prevalence of women aged 50 to 74 years who had a mammogram within the past 2 years was about 78% in 2020 and varied substantially, from 66% to 87% among states, differing by race and ethnicity, household income, access to health care, age, and education level (20). However, in 2020 approximately 20% of women aged 21 to 65 years had not been screened for cervical cancer in the past 3 years (20). Moreover, the national median prevalence of people aged 50 to 75 years who have been screened for colorectal cancer per USPSTF recommendations remains less than 70% (13). Again, screening rates differ substantially by state, age group, race and ethnicity, access to health care, health insurance, household income, and education level (20).

Many factors could affect cancer screening behavior, including sociodemographic characteristics, screening cost, health insurance, education, income, travel distance to and location of screening sites, knowledge of the disease, patient and clinician attitudes, and availability of adequate health care facilities (1,15–17,21,22). Therefore, investigating factors influencing screening participation is crucial to creating and implementing population-based cancer screening programs. One such program is the National Breast and Cervical Cancer Early Detection Program (NBCCEDP; www.cdc.gov/cancer/nbccedp/), which was authorized under the Breast and Cervical Cancer Mortality Prevention Act of 1990. The program provides breast and cervical cancer screening and diagnostic services to low-income, underinsured, and uninsured women. NBCCEDP focuses on factors at the interpersonal, organizational, community, and policy levels that influence screening and has served more than 5.9 million women with more than 15.4 million breast and cervical cancer screenings since its inception in 1991. NBCCEDP has expanded and now funds 70 award recipients — all 50 states, the District of Columbia, Puerto Rico, 5 US Pacific Island territories, and 13 American Indian and Alaska Native tribes or tribal organizations. Such programs directed at medically underserved populations should be expanded throughout the country.

Benavidez and colleagues used 2018 BRFSS data to study women who met breast, cervical, and colorectal cancer screening consistent with USPSTF recommendations and found that screening disparities persisted among socioeconomically disadvantaged groups, especially low-income women and women without health insurance (23). They also found that Hispanic women had higher breast and cervical cancer screening prevalence but lower colorectal cancer screening prevalence than non-Hispanic White women. In addition, some racial and ethnic groups and rural populations are disproportionately affected by most cancers. Kruse-Diehr and colleagues compared colorectal cancer deaths in Black populations with White populations in the historically segregated and economically distressed Mississippi Delta. They reported that segregation affected Black and White populations differently. Deaths from colorectal cancer among Black people were higher in mildly and severely segregated urban counties than in moderately segregated counties. Segregation had no effect on colorectal cancer death rates among Black populations in rural counties and was not associated with death rates among White populations (24). Bhimla and colleagues evaluated factors related to colorectal cancer screening among populations of Asian descent by neighborhood ethnic density and psychosocial factors, including knowledge about colorectal cancer, self-efficacy about screening, and perceived barriers to screening behaviors. Their study found that Vietnamese and Filipino Americans had significantly lower screening rates than Korean Americans (25). They also showed that Asian Americans who lived in neighborhoods with high Asian ethnic density were unlikely to complete the colorectal cancer screening process. These findings suggest that the people providing health education to populations with low colorectal cancer screening prevalence could benefit from a better understanding of the cultural norms and beliefs of those populations. Research on cultural characteristics is warranted to understand better why screening differences exist among different racial and ethnic populations. One successful study funded by the Centers for Disease Control and Prevention (CDC) showed that designing interventions for breast and cervical cancer for Muslim women could facilitate screening (26).

In an analysis of a large federally qualified health center in central Texas, Zhan and colleagues found that colorectal cancer screening

prevalence was low among people who lived more than 20 miles from a primary care clinic. On the other hand, they found that screening prevalence was high among people who visited their primary care provider regularly. They also used geospatial cluster analysis to identify clusters of patients not up to date with colorectal cancer screening (27).

A randomized clinical trial showed that 20% fewer lung cancer deaths occurred in a group that received an invitation to annual low-dose computed tomography (LDCT) screening compared with a group invited to receive annual chest x-rays (22). Rohatgi and colleagues completed a quantitative evaluation of geographic access to LDCT lung cancer screening in Missouri and Illinois. They reported that rural residents had significantly lower access to LDCT than urban residents (28).

Where a person lives can profoundly affect short- and long-term health (29). Much research into this relationship incorporates locality and geospatial analysis with mixed-model approaches, which can be adopted by state and local health departments by using patient data. Although some geospatial research was done at the county level because of data constraints, geospatial analysis could be further developed for small neighborhoods where homogeneity can be found at the subcounty level. To answer this need, CDC developed PLACES (www.cdc.gov/places/) with the support of the Robert Wood Johnson Foundation and the CDC Foundation. PLACES uses small area estimation methods to provide community estimates on health conditions, prevention, health risks, and health status down to the zip code tabulation area (30). The PLACES tool can help us better understand why the uptake of cancer screening did not reach Healthy People 2020 targets. These data also allow public health professionals to identify populations for implementing proven interventions.

The Community Preventive Services Task Force (*Community Guide*) provides many evidence-based findings and recommendations about cancer screening in community settings (31). These recommendations can be adopted and modified for specific localities and populations. Haverkamp and colleagues mailed a fecal immunochemical test (FIT) to the eligible population served by 3 health care facilities in Arizona operated by American Indian tribes. They found that direct mail to eligible tribe members with instructions and a follow-up telephone call and/or home visit improved the screening compliance rate significantly (32). Simply mailing the FIT test kit with instructions and a telephone call reminder to eligible patients with regular office visits increased the test kit return rate almost threefold.

CDC supports many evidence-based public health interventions. Their National Comprehensive Cancer Control Program (NCCCP; www.cdc.gov/cancer/ncccp/) funds every US state, territory, and tribe or tribal organization to develop and implement evidence-based plans to control cancer. CDC recommends that state comprehensive cancer control plans include evidence-based recommendations and guidelines, such as those from the *Community Guide* and the USPSTF. These interventions include patient reminders, reducing structural barriers, provider reminders, provider assessment and feedback, small media programs, one-on-one education for cancer screening, multicomponent interventions, and interventions that engage community health workers (31). The inclusion of evidence-based interventions in cancer control plans is an area for improvement. Soori and colleagues evaluated current comprehensive cancer control plans for 50 states and the District of Columbia for inclusion of evidence-based breast cancer control recommendations and guidelines (33). They found that only 6% to 37% of plans included USPSTF recommendations for breast cancer interventions, and only about half included mammogram prevalence in the burden statement. A previous mixed-method study done by CDC found that developers of comprehensive cancer control programs were familiar with evidence-based interventions but needed assistance in implementing them and evaluating their success (34).

Increasing cancer screening will require the collective effort of policy makers, public health practitioners, researchers, and primary care providers. Using evidence-based, multicomponent interventions can increase screening among populations with low screening rates (35). Culturally tailored strategies could be developed to address the needs of socioeconomically disadvantaged and medically underserved groups (29,36). Research and evaluations of public health programs need to focus on the roots of barriers and develop innovative strategies to increase screening. Factors that affect cancer screening behaviors are intertwined. Resolving just one will not solve the whole screening issue. For example, cancer screening rates are generally low among people with low incomes or who lack health insurance (37,38). However, offering health insurance to the uninsured may not be sufficient to increase rates. Medicaid beneficiaries have health coverage for cancer screening, but they may not be able to afford the cost of transportation or loss of a day's pay for a colonoscopy (31,39–41). The financial burden associated with transportation and loss of work should be considered and evaluated. Developing innovative cancer screening techniques that are portable, noninvasive, and low cost could also increase the uptake of cancer screening.

The ultimate goal of cancer screening is to reduce cancer incidence and mortality (36). Thus, cancer screening can be coupled with primary cancer prevention strategies to reduce cancer risks and to increase proper follow-up care and treatment, especially with the ongoing COVID pandemic in which preventive medical procedures and tests may be delayed or postponed. Public health

needs to build the infrastructure to be better prepared so that cancer education, screening, and early treatment are minimally affected by the next pandemic, thereby saving lives.

Acknowledgments

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention. No copyrighted material, surveys, instruments, or tools were used in this article.

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PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 19, E21 APRIL 2022

GIS SNAPSHOTS

Adults Who Have Never Been Screened for Colorectal Cancer, Behavioral Risk Factor Surveillance System, 2012 and 2020

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Accessible Version: www.cdc.gov/pcd/issues/2022/22_0001.htm

Suggested citation for this article: Richardson LC, King JB, Thomas CC, Richards TB, Dowling NF, Coleman King S. Adults Who Have Never Been Screened for Colorectal Cancer, Behavioral Risk Factor Surveillance System, 2012 and 2020. Prev Chronic Dis 2022; 19:220001. DOI: https://doi.org/10.5888/pcd19.220001.

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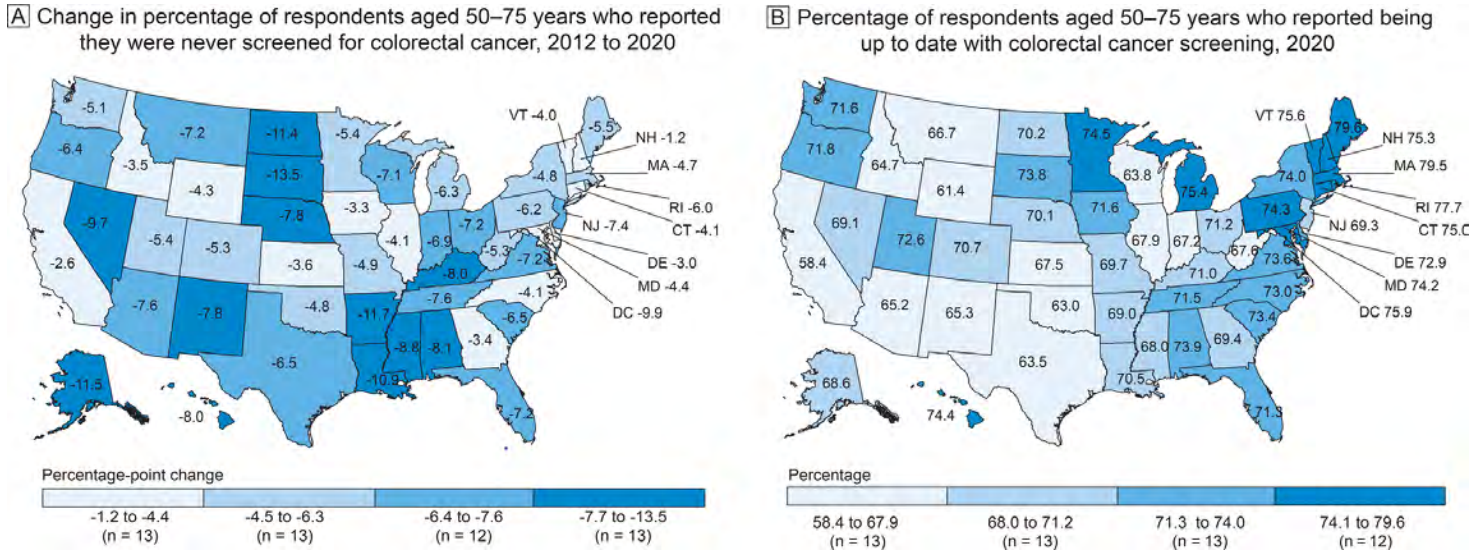

Colorectal cancer screening among US adults aged 50–75 years, Behavioral Risk Factor Surveillance System, 2012 and 2020. A, Change in percentage of US adults aged 50–75 years who reported they were never screened for colorectal cancer, 2012 to 2020. The overall decrease in never screened in the US was −5.8 percentage points. B, Percentage of US adults aged 50–75 years who reported being up to date with colorectal cancer screening in 2020. The percentage up to date in the US overall was 69.4%. Percentages were age-standardized to the 2000 US standard million population. Data source: Centers for Disease Control and Prevention, Behavioral Risk Factor Surveillance System (1,2).

Background

In 2018, colorectal cancer (CRC) was the second most diagnosed cancer and the second leading cause of cancer death among cancers that affect both men and women (3). Screening for CRC can lead to fewer cases of cancer through the removal of polyps before they become cancer, the detection of cancers at their earliest stages, and the prevention of cancer deaths (4).

Studies from the UK of screening by sigmoidoscopy and from the US of screening by colonoscopy showed that even 1-time or infrequent screening has long-term benefits (5,6). Another study showed that 83% of people who were not up to date with CRC screening had never been screened and outlined multiple barriers to getting tested (7).

We measured the change in prevalence of adults who reported no CRC screening from 2012 to 2020. We also used data on the use of CRC screening tests in 2020 to update a previous report on up-to-date screening (8).

Data and Methods

The Behavioral Risk Factor Surveillance System (BRFSS) is an annual, state-based, random-digit–dialed landline and cell phone survey of the civilian, noninstitutionalized US adult population aged 18 years or older. BRFSS collects information on demographic characteristics, health risk behaviors, preventive health practices, and health care access. We retrieved data on CRC screening from the 2012 and 2020 BRFSS (1,2). For consistency over time, we limited our analysis to respondents aged 50 to 75 years and applied the 2008 US Preventive Services Task Force (USPSTF) recommendations (9). We defined "up to date" as one of the following: 1) a home stool blood test (fecal occult blood test [FOBT] or fecal immunochemical test [FIT]) within 1 year, 2) sigmoidoscopy within 5 years with FOBT or FIT within 3 years, or 3) colonoscopy within 10 years. We analyzed the prevalence of respondents who responded yes when asked if they had ever had one of these tests and if yes, when they had the test. We defined "never screened" as respondents who answered no to being screened and respondents who had been screened but were not up to date per USPSTF 2008 recommendations. We excluded respondents who declined to answer or who reported "don't know" or "not sure." We used SAS-callable SUDAAN statistical software, version 9.4 (RTI International) for analysis. Results were age-standardized to the 2000 US standard million population to facilitate comparison with the Healthy People 2020 objective of 70.5% screened for CRC (10). We used ArcGIS Desktop version 10.8.1 (Esri) to create maps to show the absolute change in the percentage never screened between 2012 and 2020 and the percentage up to date in 2020. We used a 2-tailed Spearman rank correlation test to compare 1) the proportion of respondents by state reporting no CRC screening in 2012 with 2) the absolute difference by state in the proportion reporting no CRC screening in 2020 versus the proportion reporting no CRC screening in 2012.

Highlights

The percentage of US adults never screened for CRC decreased from 27.4% in 2012 to 21.6% in 2020, a 5.8 percentage-point reduction representing 3,917,775 fewer people screened in 2012 than in 2020. Decreases ranged from 1.2 percentage points (New Hampshire) to 13.5 percentage points (South Dakota). Decreases were 8.0 percentage points or more in 10 states and the District of Columbia (Map A). The percentage of adults never screened was higher in the northern Great Plains and the Deep South. States with the largest improvements in the proportion never screened were those with the largest proportion never screened in 2012 (Figure).

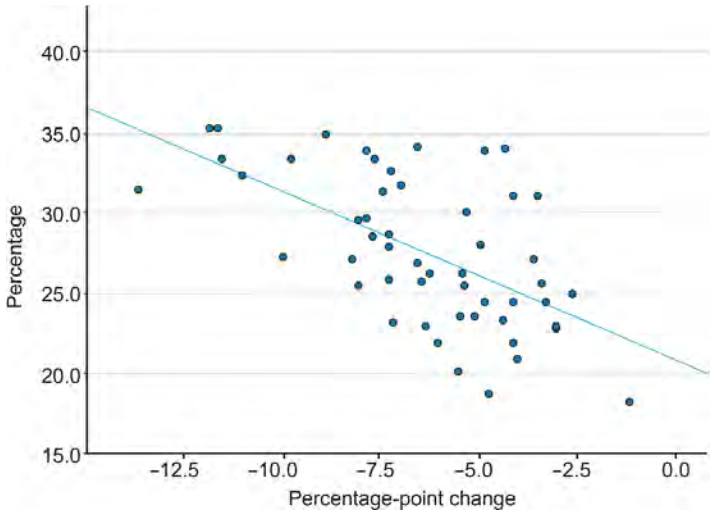

Figure. Correlation between 1) the percentage never screened for colorectal cancer in 2012 and 2) the absolute difference in the percentage never screened in 2020 minus the percentage never screened in 2012, by state. Each dot represents a state or the District of Columbia. Spearman $r = -0.58$; $P = .01$ (2-tailed). Data source: Centers for Disease Control and Prevention, Behavioral Risk Factor Surveillance System (1,2).

The percentage of adults aged 50 to 75 years who reported being up to date with CRC screening in 2020 was 69.4%, representing 62.3 million age-eligible adults, ranging from 58.4% in California to 79.6% in Maine (Map B). The percentage of up-to-date screening tended to be higher in New England. Twenty-two states did not meet the Healthy People 2020 objective of 70.5% screened for CRC.

Action

The proportion of US adults never screened for CRC decreased from 2012 to 2020 in all states and the District of Columbia. The greatest increases were in states with the highest prevalence of never screened in 2012. Even with differences in the definition of never being screened, we found improvements in the percentage screened from the approximately 29% of respondents aged 50 to 75 years never screened according to 2010 BRFSS data (5). Nevertheless, CRC screening prevalence remains lower than desired. Given the challenges of the ongoing COVID-19 pandemic, the new Healthy People 2030 target of 74.4% will likely be hard to reach.

USPSTF recommendations were updated in 2016 to include more types of screening tests (2). In 2020 for the first time, BRFSS included questions on stool DNA testing and computerized tomographic colonography (11). When we included all 5 CRC testing methods, 71.6% of respondents aged 50 to 75 years reported being up to date with CRC screening in 2020.

The National Colorectal Cancer Roundtable, in collaboration with the Centers for Disease Control and Prevention (CDC), renewed a call to action to increase CRC screening to 80% (12). This call to action must address persons aged 45 to 49 years who are now eligible for screening (2) in addition to persons aged 50 to 75 years who have never been screened. The latter group comprises most people who are not up to date.

Financial and nonfinancial barriers might explain differences in screening by state. Fedewa and colleagues noted that states that expanded Medicaid soonest after the Affordable Care Act was enacted in 2010 had the largest increases in CRC screening (13). We found a correlation between the states with the largest proportion of people never screened and improvements in screening among people never screened. States with the smallest decreases in people never screened were concentrated in the South, where Medicaid expansion still has not occurred. In contrast, South Dakota has not expanded Medicaid, but it had the largest improvement (−13.5 percentage points) among people never screened. One possible explanation is that South Dakota has been a part of CDC's Colorectal Cancer Control Program for over a decade. This program focuses on using evidence-based strategies to increase CRC screening (14). In a study that examined reasons for not being screened, people with low educational attainment, no health insurance, and no usual source of care had the highest prevalence of never being screened (5).

Nonfinancial factors also affect CRC screening. Jones and colleagues published a report of patient-reported barriers to CRC screening in 2010 (15). In their mixed-methods study, which included African American people and people with low income, barriers identified were lack of understanding about what to do when being screened and what screening involved, lack of motivation to get tested because of reservations about getting the test, and not having the means to pay for initial testing and possible follow-up testing. No similar studies have been conducted among people who reported never being screened for CRC. Reducing these barriers will require developing educational resources designed to meet the needs of people who experience these barriers

Our study has several limitations. First, CRC screening prevalence may be underestimated or overestimated because of recall bias. Second, we were unable to differentiate between a screening test and a diagnostic test, and respondents may not have been able to differentiate between types of stool tests and endoscopies. Third, social desirability bias could have affected responses to survey questions. Fourth, our analysis did not account for any sampling error. Fifth, the response rate for BRFSS was about 45%, and some respondents did not answer all the questions. Lastly, National Health Interview Survey data are used to determine Healthy People national objectives, whereas BRFSS data are used to measure state-level progress toward improving health behaviors that affect chronic diseases (16). Estimates from BRFSS tend to be higher than estimates from the National Health Interview Survey, possibly because of the survey methods (17).

If we are to reach the Healthy People 2030 objective of 74.4% of the population screened for CRC or the goal of 80% screened in every community (12), we should intensify outreach to people who have never been screened, because most of those not up to date have never been screened (5). During the COVID-19 pandemic, the backlog in CRC screening has grown to nearly 4 million people (18). We have a lot of work ahead of us. The President's Cancer Panel released new recommendations in early 2022 that will inform this work (19).

Acknowledgments

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC. No copyrighted materials or tools were used in this article.

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PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 18, E59 JUNE 2021

ORIGINAL RESEARCH

Cancer Incidence Projections in the United States Between 2015 and 2050

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Accessible Version: www.cdc.gov/pcd/issues/2021/21_0006.htm

Suggested citation for this article: Weir HK, Thompson TD, Stewart SL, White MC. Cancer Incidence Projections in the United States Between 2015 and 2050. Prev Chronic Dis 2021; 18:210006. DOI: https://doi.org/10.5888/pcd18.210006.

PEER REVIEWED

Summary

What is already known on this topic?

In the United States, the number of adults entering the age groups at greatest risk for being diagnosed with cancer is increasing.

What is added by this report?

Between 2015 and 2050, we predict the total number of cancer cases to increase by almost 50% as a result of the growth and aging of the US population. The largest increase is anticipated in adults aged ≥75 years.

What are the implications for public health practice?

Projecting cancer cases can help the public health community plan and evaluate community intervention strategies aimed at reducing the growing number of cancer cases by reducing cancer risk across the lifespan.

Abstract

Introduction

The number of adults entering the age groups at greatest risk for being diagnosed with cancer is increasing. Projecting cancer incidence can help the cancer control community plan and evaluate prevention strategies aimed at reducing the growing number of cancer cases.

Methods

We used data from the Surveillance, Epidemiology, and End Results Program and the US Census Bureau to estimate average, annual, age-standardized cancer incidence rates and case counts (for all sites combined and top 22 invasive cancers) in the US for 2015 and to project cancer rates and counts to 2050. We used age, period, and cohort models to inform projections.

Results

Between 2015 and 2050, we predict the overall age-standardized incidence rate (proxy for population risk for being diagnosed with cancer) to stabilize in women (1%) and decrease in men (−9%). Cancers with the largest change in risk include a 34% reduction for lung and bronchus and a 32% increase for corpus uterine (32%). Because of the growth and aging of the US population, we predict that the annual number of cancer cases will increase 49%, from 1,534,500 in 2015 to 2,286,300 in 2050, with the largest percentage increase among adults aged ≥75 years. Cancers with the largest projected absolute increase include female breast, colon and rectum, and prostate.

Discussion

By 2050, we predict the total number of incident cases to increase by almost 50% as a result of the growth and aging of the US population. A greater emphasis on cancer risk reduction is needed to counter these trends.

Introduction

In the US, cancer is the leading cause of death in midlife and may soon become the leading cause of death overall as the number of people diagnosed with and dying from cancer continues to increase (1,2). Paradoxically, over the past several decades the overall age-standardized cancer incidence rates have stabilized and death rates have declined steadily. The age-standardized rate can be used as a proxy for the population's risk of being diagnosed with or dying from cancer and is useful for comparing risk between populations or over time within a population. However, the age-standardized rate effectively removes the underlying influence of demographic changes in the population. The risk of being diagnosed with cancer generally increases with age, and over this period the US population has grown, particularly in the older age groups (2,3). Thus, the increase in the number of incident cases and deaths reflects, to a large extent, the impact of a growing and aging population. This demographic trend is expected to continue as a larger proportion of the Baby Boom and Gen X cohorts sur-

vive to older ages compared with earlier generations and enter the age groups most at risk for a cancer diagnosis.

Trends in cancer incidence rates (population risk) and projections of population growth and age structure have been used to predict cancer incidence including in the US (4), Canada (5), England (6), the Nordic countries (7), and for world regions broadly (8). Predicting the growth in the number of incident cases in the US can help health planners and policy makers anticipate the resources needed to diagnose, treat, and care for future cancer patients and cancer survivors. Cancer-specific projections can also help the public health community to plan and evaluate risk reduction strategies and alert researchers to early changes in population risk.

In this study, we used data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program to estimate nationwide, age-standardized, 5-year average annual cancer incidence rates and case counts (all sites and top 22 cancers) for the US population for 2015 and to project rates and counts to 2050.

Methods

Data sources

We obtained data for patients diagnosed with invasive cancer from 1996 through 2015 from the SEER Program, which covered approximately 14% of the US population (9). The file included in situ bladder cancer cases because these cancers are considered invasive for the purpose of incidence reporting (10). Population estimates used as rate denominators were a modification of annual county age- and sex-specific population estimates produced by the US Census Bureau's Population Estimates Program, in collaboration with the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics and with support from the National Cancer Institute (11). We obtained population projections of the resident population (Middle Series) by age and sex from 2016 through 2050 from the US Census Bureau's Population Projections Program (12).

Analytic methods

We used SEER*stat to calculate age-specific and age-standardized rates for cancer patients of all ages who were diagnosed with invasive cancer (other than nonmelanoma skin cancer) from 1996 through 2015. All invasive cancers were selected and grouped according to the top 22 cancers and all other remaining sites combined among men and women. We estimated nationwide, annual incident counts for 2015 by applying 5-year age-specific incidence rates (2011–2015) to the 2011–2015 US population estimates and dividing by 5. Similarly, projections for 2050 were calculated by annualizing rates and population projections for the 2046–2050 period. Methods for projecting cancer incident cases in the US have been published previously (4,5). Briefly, to project cancer incidence rates from 2016 through 2050, we used NORDPRED software, available from the Cancer Registry of Norway website (www.kreftregisteret.no/en/Research/Projects/Nordpred/Nordpred-software/) (7). The program used age–period–cohort regression models with input data aggregated into four 5-year calendar periods (1996–2000, 2001–2005, 2006–2010, 2011–2015) and 15 age groups (15–19 years through ≥85 years). Separate models were fit for each cancer site by sex and all races combined: $R_{ap} = (A_a + D \bullet p + P_p + C_c)^5$ in which the dependent variable R_{ap} is the incidence rate in age group a in calendar period p. A_a is the age component for age group a, D is the drift parameter (the common linear effect of both calendar period and birth cohort), P_p is the nonlinear period component of period p, and C_c is the nonlinear cohort component of cohort c. When using the regression models as the basis for projected rates for each cancer site and sex group, the starting age criterion was that each age group contain 10 or more cases. Projections for age groups below that starting criterion were based on the average rates from the past 10 years. Separate models were fit for each cancer site by sex. To offset exponential increases or decreases in incidence rates, we used the power-5 link function. Assuming that trends are not likely to continue indefinitely, the drift component in the model was reduced by 25% in the second calendar period, by 50% in the third calendar period, and by 75% in the fourth and fifth periods. These modifications have been shown empirically to improve predictions (7).

We based projections on 20 years of data (1996–2015) unless significant curvature in the trend was found over time. When curvature occurred, the linear drift component was based on the most recent 10-year period. Projections for all sites combined were summed estimates for the cancer sites categories, including other cancer sites combined. For thyroid cancer, we used a modified approach to account for recent concerns that overdiagnosis may inflate projections (13). We based projections for thyroid cancers on age-specific rates for thyroid cancer diagnosed from 2011 through 2015 because recent thyroid incidence rates are no longer increasing (14). For female breast and prostate cancer, we used a modified approach to account for breast cancer incidence decreases in the early 2000s attributed to a reduction in the use of hormone replacement therapy and fluctuations in prostate cancer incidence related to the use of the prostate-specific antigen test (15,16). For these cancers, we had the trends taper off sooner by applying 25%, 50%, and 75% reductions in the first 3 calendar periods and truncating the trends (ie, 100% reduction) in the fourth and fifth periods.

NordPred provides projections for up to five 5-year periods; thus, age-specific incidence rates were projected for the 5-year calendar periods 2016–2020, 2021–2025, 2026–2030, 2031–2035, and 2036–2040. Projections for 2041–2045 and 2046–2050 were generated by applying the 2036–2040 age-specific incidence rates to corresponding population projections because the greatest driver in overall cancer incident cases has been the growth and aging of the US population (4).

We calculated the absolute and relative difference between estimated 2015 and projected 2050 age-standardized incidence rates and case counts. Annual estimated and projected incident cases and absolute differences were rounded to the nearest 100th for presentation in tables.

Results

Table 1 shows the distribution of estimated and projected annual counts of all cancer incident cases for 2015 and 2050, respectively, by age. The total number of cases is predicted to increase by 49% from 1,534,500 (2015) to 2,286,300 annual cases (2050). In each age group, the total number of cases is predicted to increase. The largest percent increase was projected for adults aged ≥85 years followed by adults aged 75–84 years (Figure 1). In 2015, it is estimated that 842,200 (55%) of cancer patients were diagnosed at aged ≥65 years. In 2050, we predict that 1,446,000 (63%) of all patients diagnosed with cancer will be aged ≥65 years, an increase of 603,800 annual cases from 2015.

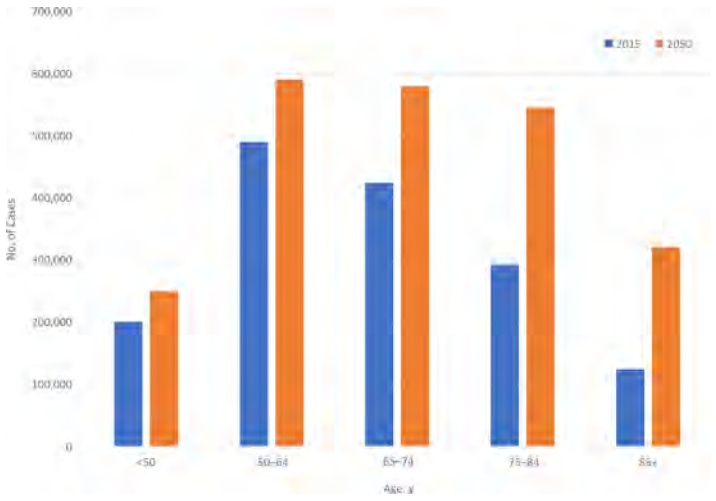

Figure 1. Distribution of estimated 2015 and projected 2050 average annual cancer cases (all sites combined), by age group, United States. Numbers may not sum to total because of rounding.

Table 2 shows estimated 2015 and projected 2050 average annual age-standardized incidence rates and case counts. The top 4 cancers (female breast, prostate, lung and bronchus, and colon and rectum) accounted for 49% of all incident cases in 2015 and are projected to account for 46% of all incident cases in 2050. Cancer sites in which there is projected to be a relative percentage increase of 10% or more in age-standardized rates include female breast, kidney and renal pelvis, corpus and uterus, liver and intrahepatic bile duct, and myeloma. The largest absolute and relative increases in incident cases are expected in female breast (123,900; 52%), prostate (82,300; 43%), colon and rectum (67,900; 50%), and melanoma of the skin (48,000; 63%).

Cancer sites projected to have fewer than an additional 10,000 annual incident cases between 2015 and 2050 are cancers of the ovary, brain and nervous system, esophagus, cervix uteri, and larynx. No increase in additional incident cases for Hodgkin lymphoma is predicted. Cancer sites with a predicted relative decrease of 10% or more are lung and bronchus, non-Hodgkin lymphoma, urinary bladder, esophagus, cervix uteri, larynx, and Hodgkin lymphoma.

Figure 2 shows the rank order of average annual incident cases estimated to be diagnosed in 2015 and the additional number of annual cases predicted to be diagnosed in 2050. Female breast, prostate, colon and rectum, and lung and bronchus are projected to remain the 4 leading cancers in 2050. In 2015, cancers of the lung and bronchus were estimated to be the third leading cancer diagnosed in men and women followed by colorectal cancers. By 2050, the number of colorectal cancers is predicted to exceed the number of cancers of the lung and bronchus.

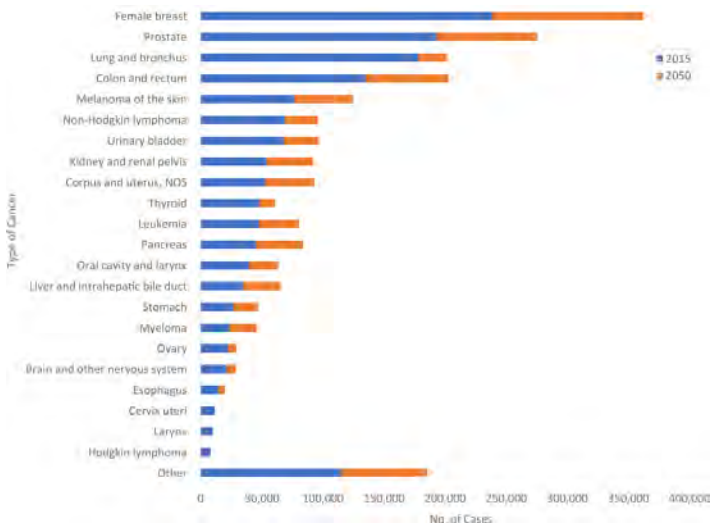

Figure 2. Estimated (2015) cancer cases and projected additional cases (2050) by cancer site, United States. Numbers may not sum to total because of rounding. Abbreviation: NOS, not otherwise specified.

Discussion

Over the next several decades, we predict the total number of cancer incident cases (excluding nonmelanoma skin cancer) to increase by nearly 50%, from 1,534,500 in 2015 to 2,286,300 in 2050. As the size of the US population increases, incident cases are expected to increase in all age groups, but the largest percentage increases will occur among adults aged ≥75 years. Over this period, overall cancer risk is predicted to stabilize in women (1%) and decline slightly (−9%) among men. Thus, the increase in the total number of incident cases will reflect primarily demographic changes related to a growing and aging population.

The demographic components underlying the increase in incident cases are being driven initially by adults born between 1946 and 1964 (the Baby Boom cohort). In 2011, adults in this generation began turning 65 years of age and by 2029, all will be aged 65 years or older. In addition to the increase in the number of incident cases, the number of people living with a history of cancer (cancer survivors) also is expected to increase. Improvements in early detection and cancer treatment of some common cancers resulted in an overall increase in 5-year cancer survival for all cancers combined, from 49% for patients diagnosed in the 1970s to 70% for patients diagnosed in the 2010s (14). An increase in the number of people who receive a cancer diagnosis and high 5-year survival for common cancers like cancers of the female breast and prostate have resulted in an increase in the number of cancer survivors. In 2019, the number of cancer survivors was estimated to be 16.9 million and is projected to reach 22.1 million by 2030 (17). Cancer survivors require ongoing care and surveillance because they are at increased risk for additional cancer diagnoses, as well as other chronic diseases (18). The increase in number of cancer survivors has profound implications for health care and cancer surveillance resource needs in the US, including the need for oncology specialists and certified tumor registrars (19,20). In addition, the costs of cancer care are substantial, increasing, and not sustainable (21,22).

The projections in this study assume that cancer incidence patterns will continue largely unchanged for the next few decades with the 4 leading cancers (female breast, prostate, colon and rectum, and lung and bronchus) accounting for just under 50% of all cancer cases. If the prevalence of causal factors associated with higher cancer risk declined in the population, so too could cancer incidence. Multiple opportunities exist to disrupt the initiation or promotion of different cancers in adults by reducing exposures to carcinogens, promoting social and physical environments that support healthy behaviors, and preventing chronic conditions such as obesity and diabetes (23,24). The Community Guide (www.thecommunityguide.org/) provides recommended community-based strategies to reduce the prevalence of several common behavioral risk factors. Expanded research on environmental cancer and on interventions to reduce inequities in cancer risk could provide additional opportunities to lower cancer incidence in the future (25,26).

A comprehensive cancer control plan can provide a roadmap for public health action to reduce the burden of cancer. Individual state, tribal, and territorial cancer plans in 66 jurisdictions across the US are developed by participants in CDC's National Comprehensive Cancer Control Program (NCCCP) (27). Program participants can use these findings to prioritize Community Guide and other evidence-based interventions in their plans to help reduce the expected increases in particular cancers, either through the reduction of cancer risk factors or the medical treatment of precancerous conditions, such as the removal of polyps during screening colonoscopy or treatment of cervical lesions detected by Papanicolaou (Pap) tests (27). The NCCCP has historically focused on many of the cancers that are expected to increase in total numbers (female breast, colon and rectum, melanoma, lung and bronchus [through tobacco control], and liver and hepatic duct cancers). In addition to the continued prioritization of these cancers, our data suggest that an expansion of NCCCP's focus may be warranted in the near term to include reduction and control of cancers of the kidney and renal pelvis and the corpus and uterus. In California, efforts focused on the primary prevention of breast cancer offered an innovative model for integrating scientific evidence on multiple risk factors with community perspectives to develop an action plan (28).

Our analysis has strengths and limitations. Age–period–cohort models identify trends in younger birth cohorts and extrapolate these trends to future older cohorts. These models have been used in many population-based studies, and the methods have been validated using long-term cancer incidence data (7). However, these predictions should be viewed with caution. First, the SEER data covered 14% of the US population, which tended to be more urban and have more foreign-born individuals compared with other parts of the US. As a result, incidence rates based on data from SEER found that 14 areas differed somewhat from data based on National Program of Cancer Registries (NPCR) areas, with prostate incidence higher and lung cancer incidence lower (29). Second, changes in risk factor exposures, screening recommendations, and advances in medical techniques are likely to occur between now and 2050. Finally, population projections are themselves forecasts based on assumptions regarding future births, deaths, and migration and can therefore affect projections of incident counts and rates. Therefore, although our predictions are based on the best available information, they should be updated periodic-

ally in consultation with cancer surveillance subject matter experts when combined long-term data from SEER and NPCR become available and as revised population projections become available.

Our projections make it clear that, to mitigate the impact of a growing and aging population, a substantial, robust, and coordinated focus on primary prevention is needed. If these efforts are to have any significant impact on the number of future cancer cases, they must be implemented immediately, owing to the long latency period for many cancers.

Acknowledgments

This work was supported by CDC. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC. No copyrighted materials or tools were used in this research.

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Tables

Table 1. Distribution of Estimated (2015) and Projected (2050) Average[a] Annual Counts of Cancer Cases (All Sites Combined) and Percentage Change, by Age, United States

Age, y	2013	2048	2013–2048
	No. (%)	No. (%)	No. Change (% Change)
<50	201,500 (13)	249,500 (11)	48,000 (24)
50–64	490,700 (32)	590,700 (26)	100,000 (20)
65–74	425,000 (28)	579,500 (25)	154,500 (36)
75–84	293,200 (19)	545,400 (24)	252,200 (86)
≥85	124,000 (8)	321,100 (14)	197,100 (159)
Total	1,534,500 (100)	2,286,300 (100)	751,900 (49)

[a] 2015 Estimated counts are average annual counts of cancer incident cases diagnosed 2011–2015. 2050 Projected counts are average annual counts of cancer incident cases projected to be diagnosed 2045–2050.

Table 2. Estimated (2015) and Projected (2050) Age-Standardized Incidence Rates, Average Annual Case Counts and Percentage Change by Cancer Site

Cancer Site	Sex	Age-Standardized Rates			Average Annual Case Counts			
		2015	2050	% Change	2015	2050	Difference, No.	% Change
All cancer sites	Both	428.9	412.6	−4	1,534,500	2,286,300	751,800	49
All cancer sites	Male	467.1	425.0	−9	766,700	1,149,600	382,900	50
All cancer sites	Female	404.3	407.2	1	767,800	1,136,700	368,900	48
Breast	Female	127.0	139.5	10	238,800	362,700	123,900	52
Prostate	Male	110.9	101.9	−8	193,200	275,500	82,300	43
Lung and bronchus	Both	49.7	32.5	−34	178,100	201,700	23,600	13
Lung and bronchus	Male	57.5	37.1	−35	91,500	106,200	14,700	16
Lung and bronchus	Female	43.9	28.6	−35	86,600	95,500	8,900	10
Colon and rectum	Both	37.9	38.8	3	135,100	203,000	67,900	50
Colon and rectum	Male	43.3	44.5	3	70,200	111,700	41,500	59
Colon and rectum	Female	33.3	33.6	1	64,900	91,300	26,400	41
Melanoma of the skin	Both	21.9	20.9	−5	76,700	124,700	48,000	63
Non-Hodgkin lymphoma	Both	19.5	16.3	−16	68,900	96,100	27,200	39
Urinary bladder	Both	19.0	14.4	−24	68,000	96,700	28,700	42
Kidney and renal pelvis	Both	15.1	17.0	13	54,000	92,100	38,100	71
Corpus and uterus, NOS	Female	26.9	35.5	32	52,800	93,100	40,300	76
Thyroid	Both	14.5	14.4	−1	48,100	60,700	12,600	26
Leukemia	Both	13.8	14.3	4	47,700	80,500	32,800	69
Pancreas	Both	12.5	13.4	7	45,200	84,100	38,900	86
Oral cavity and pharynx	Both	10.9	11.6	7	39,700	63,600	23,900	60
Liver and intrahepatic bile duct	Both	9.2	10.4	14	34,500	65,400	30,900	90
Stomach	Both	7.5	8.0	7	26,700	47,000	20,300	76
Myeloma	Both	6.7	7.6	14	23,900	46,100	22,200	93
Ovary	Female	11.9	11.3	−5	22,500	29,100	6,600	29
Brain and other nervous system	Both	6.2	6.2	−1	21,200	29,000	7,800	37
Esophagus	Both	4.0	3.3	−19	14,700	19,900	5,200	35
Cervix uteri	Female	6.9	5.4	−21	11,400	11,600	200	1
Larynx	Both	2.6	1.8	−31	9,700	10,200	500	6
Hodgkin lymphoma	Both	2.5	2.0	−23	8,200	7,800	−400	−5
Other	Both	33.2	32.6	−2	115,400	185,500	70,100	61

Abbreviation: NOS, not otherwise specified.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 17, E123 OCTOBER 2020

ORIGINAL RESEARCH

Preventing Breast, Cervical, and Colorectal Cancer Deaths: Assessing the Impact of Increased Screening

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Accessible Version: www.cdc.gov/pcd/issues/2020/20_0039.htm

Suggested citation for this article: 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. Prev Chronic Dis 2020;17:200039. DOI: https://doi.org/10.5888/pcd17.200039.

PEER REVIEWED

Summary

What is already known on this topic?

Screening for colorectal cancer and for female breast and cervical cancers can effectively reduce deaths from these cancers. Yet many preventive services, including cancer screening, remain underutilized in the United States.

What is added by this report?

Increased use of screening from current levels to 100% would prevent an additional 2,821 deaths from breast cancer, 6,834 deaths from cervical cancer, and 35,530 deaths from colorectal cancer over a lifetime of the respective single-year cohort. Increasing use of colorectal cancer screening would prevent more deaths than an equivalent increase in breast and cervical cancer screening.

What are the implications for public health practice?

Public health programs incorporating strategies shown to be effective can help increase screening rates. Organized screening approaches leveraging partnerships between public health and primary health care to implement such strategies could be used to reduce the prevalence of these cancers.

Abstract

Introduction

The US Preventive Services Task Force (USPSTF) recommends select preventive clinical services, including cancer screening. However, screening for cancers remains underutilized in the United States. The Centers for Disease Control and Prevention leads initiatives to increase breast, cervical, and colorectal cancer (CRC) screening. We assessed the number of avoidable deaths from increased screening, according to USPSTF recommendations, for CRC and female breast and cervical cancers.

Methods

We used model-based estimates of avoidable deaths for the lifetime of single-year age cohorts under the current and increased use of screening scenarios (data year 2016; analysis, 2018). We calculated prevented cancer deaths for each 1% increase in screening uptake and extrapolated to current level of screening (2016), current level plus 10 percentage points, and increasing screening to 90% and 100% of the eligible population.

Results

Increased use of screening from current levels to 100% would prevent an additional 2,821 deaths from breast cancer, 6,834 deaths from cervical cancer, and 35,530 deaths from CRC over a lifetime of the respective single-year cohort. Increasing use of CRC screening would prevent approximately 8.5 times as many deaths as the equivalent increase in use of breast cancer screening (women only), although twice as many people (men and women) would have to be screened for CRC.

Conclusions

A large number of deaths could be avoided by increasing breast, cervical, and CRC screening. Public health programs incorporating strategies shown to be effective can help increase screening rates.

Introduction

The US Preventive Services Task Force (USPSTF) recommends select clinical preventive services with "A" and "B" recommendation grades for the eligible population. A grade "A" recommendation reflects high certainty of substantial net benefit from a ser-

vice; grade "B" reflects high certainty of moderate benefit or moderate certainty of substantial benefit. USPSTF recommendations include routine screening for female breast cancer in women aged 50 to 74 years, cervical cancer in women aged 21 to 65 years, and colorectal cancer (CRC) in men and women aged 50 to 75 years (1). Most private health plans cover these services without copays or deductibles. However, insurance coverage does not ensure uptake of recommended services, and many preventive services remain underutilized (2).

To increase the use of these services, the US Department of Health and Human Services supports various programs and initiatives (3). For example, 2 cancer control programs at the Centers for Disease Control and Prevention (CDC), the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) and the Colorectal Cancer Control Program (CRCCP), seek to increase screening use among low-income, medically underserved populations (4,5). Despite the availability of screening services and better treatment outcomes, a large number of patients still die of these cancers. In 2016, the number of deaths from female breast cancer was 41,487; from cervical cancer, 4,188; and from CRC, 52,286 (6). In 2016, the self-reported screening rates for female breast and cervical cancers were 78.3% and 79.9%, respectively, and the self-reported screening rate for CRC was 67.7% (7).

In this article, we assess the number of potential deaths that could be prevented by increasing screening for female breast and cervical cancers and for CRC according to USPSTF recommendations. The report is motivated by the need to increase the use of evidence-based interventions that reduce the rates of illness and death from cancer.

Methods

We simulated and compared the number of deaths that could be prevented by increasing screening from current rates to defined targets by using previously reported model-based estimates. We compared the cumulative numbers of cancer deaths for a single-year age cohort under different scenarios: current level of screening (2016), current level plus 10 percentage points, and increasing screening to 90% and 100% of the eligible population. We also calculated the numbers of adults currently screened and expected to be screened under different scenarios of increased screening. Table 1 provides a summary of key analysis assumptions and model inputs. Current screening estimates are based on 2016 survey data from the Behavioral Risk Factor Surveillance System (BRFSS) (7).

Each of the simulation models on which our calculations are based followed a synthetic cohort from the USPSTF-recommended starting age of screening: 50-year-old women for breast cancer screening, 21-year-old women for cervical cancer screening, and 50-year-old men and women for CRC screening. The simulations followed each cohort through their lifetimes. Screening modalities included mammography for breast cancer and cytology or Pap test for cervical cancer. For CRC, the model assumed a mix of annual fecal occult blood test (FOBT), flexible sigmoidoscopy every 5 years plus FOBT every 3 years, or colonoscopy every 10 years (Table 1).

The estimates of avoidable burden were prepared in 2018 by Health Partners Institute researchers using models that were previously used in peer-reviewed studies to inform the National Commission on Prevention Priorities (NCPP) ranking of clinical preventive services (8). Specifically, the estimates for avoidable deaths from breast cancer screening (9) were based on results of 5 Cancer Information Surveillance Modeling Network screening models (10) plus an estimate from a sixth model (11). Estimates for cervical cancer screening and CRC screening were based on results from models to inform the same NCPP ranking (12,13). These reports provide estimates of cancer deaths that would be prevented either by screening 100% of the target population compared with no screening (8,9) or by screening a portion of the target population who would accept and follow up with screening if recommended by a physician (10,11,14). Each model estimated cancer deaths prevented by first constructing a natural history of cancer based on progression of lesions through cancer stages and then simulating the potential for screening to interrupt cancer progression and prevent death. Using the estimates from models, we calculated the deaths prevented from each 1% increase in screening uptake in the US eligible population and linearly scaled that estimate from current screening rates up to the screening rates in the scenarios just described. Linear extrapolation should provide a reasonable estimate of the impact of increasing screening rates when capacity exists or is developed to provide additional screening and follow-up of quality equal to existing screening and follow-up, and when the currently screened and unscreened populations have similar risks of lesion development and cancer progression.

Results

If the current level of screening use were maintained, 10,179 deaths from breast cancer would be prevented among the cohort of 50-year-old women over their lifetime; 27,166 deaths from cervical cancer would be prevented among the cohort of 21-year-old women; and 74,470 deaths from CRC would be prevented among the cohort of 50-year-old men and women (Table 2).

Using a linear relation between screening use and avoided deaths indicated a similar pattern of relative incremental deaths preven-

ted through increased screening. Increases of 10 percentage points would prevent an additional 1,300 deaths from breast cancer; 3,400 deaths from cervical cancer; and 11,000 deaths from CRC over the lifetime of each cohort. In terms of the 2016 general population, those reductions would require additional screenings of 4.9 million women for breast cancer, 9.7 million women for cervical cancer, and 9.6 million men and women for CRC (Table 1).

The impact of increasing the screening rate to 100% sets the upper limit on the number of potentially avoidable deaths (Figure). Screening of 100% age-appropriate adults could prevent 2,821 additional deaths from breast cancer over the lifetime of a cohort of 50-year-old women; 6,834 additional deaths from cervical cancer over the lifetime of 21-year-old women; and 35,530 additional deaths from CRC over the lifetime of 50-year-old men and women. Increasing use of CRC screening would prevent approximately 8.5 times as many deaths as the equivalent increase in use of breast cancer screening (women only), although twice as many people (men and women) would have to be screened for CRC (Table 1).

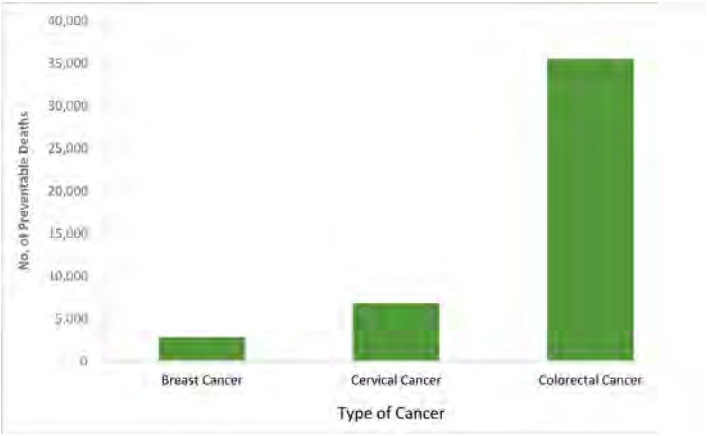

Figure. Estimates of maximum number of preventable deaths in a single-year cohort with increased use of screening under US Preventive Services Task Force guidelines (study year 2018). Preventable deaths over a lifetime for breast cancer are among women aged 50, for cervical cancer among women aged 21, and for colorectal cancer among men and women aged 50.

Discussion

The estimated deaths from breast cancer, cervical cancer, and CRC prevented under different scenarios, comparing the impact of incremental screening rates, may be useful for setting goals and making resource allocation decisions on prevention. For example, one of the goals of Healthy People 2020, the US government's 10-year national health objectives, is to reduce female breast and cervical cancer mortality by 10% and CRC mortality by 15% (15).

Our estimates suggest that large numbers of deaths from cancer could be prevented through increased use of evidence-based screenings. The greatest impact could be realized for increased CRC screening. The magnitude of potential impact of universal CRC screening is attributed to the fact that CRC screening has a current rate that is lower than breast and cervical cancer screening, includes both men and women, and has a larger proportionate decrease in mortality associated with it. Although we recognize that 100% screening is not an achievable goal, we included it as a target to illustrate the maximum benefit that could be achieved by increased screening.

The Community Preventive Services Task Force (CPSTF) recommends evidence-based strategies, such as patient and provider reminders, to increase screening rates for all 3 cancers (16–18). CDC's CRCCP aims to increase screening rates among priority populations through implementation of these strategies in health system clinic settings. The NBCCEDP is a long-standing CDC initiative that screened over 1.4 million low-income, uninsured and underinsured women over the 5 years ending in 2017 alone (19). These public health programs, along with other state and local efforts, are critical to increasing cancer screening. For example, early results of CRCCP suggested a 4.4 percentage-point annual increase in screening rates among the participating clinics (5). By the second and third year of the CRCCP, the rate increased by 8.3 and 10.1 percentage points, respectively. An increase of 10.1 percentage points implied more than 82,000 additional CRC screenings under CRCCP (20).

Increasing cancer screening rates would require additional resources for the delivery of clinical services, as well as strategies to promote uptake of screening in population groups with lower use of screening. Previous studies that examined the cost of public provision of programs to increase screening found that such programs include not only cost of screening services but also substantial cost of administering and promoting the programs (21,22). The incremental costs associated with additional screenings may be offset by early detection of cancer or precancerous abnormalities through routine screening. In particular, use of colonoscopy for CRC screening or as follow-up to abnormal fecal screening can significantly reduce the onset of CRC through removal of precancerous polyps in addition to allowing early detection of tumors. Consequently, economic analyses have concluded that screening for CRC might be cost-saving to health care systems, with the magnitude of cost savings greater for colonoscopy-based screening (23,24). A CPSTF systematic review found that multicomponent interventions to promote CRC might also be cost-saving, a finding that was based on a small study in a disadvantaged population in south Texas and a modeling study from South Korea (25).

However, those analyses did not factor in competing risks or future medical costs, although taking those into account may still render CRC screening to be considered cost-effective even if not cost-saving (26).

Our estimates of the relative contributions of recommended screenings align with previous estimates, although methods differ (27). In particular, the results of Farley et al reflect annual impact in a US cross-section, while our estimates reflect the lifetimes of a US birth cohort. These different methods could produce the same number of life-years at risk of cancer and the same results if, among other things, the successive birth cohorts represented in the cross-section were all the same size. However, because the older cohorts in a cross-section came from smaller, pre-1946 birth cohorts, annual estimates tend to be smaller than lifetime estimates from a birth cohort. Our estimate of 68% (35,530) CRC deaths prevented, associated with increasing screening from 68% to 100%, is higher than the Meester et al estimate (28) of 58% CRC deaths prevented in 2020, even with an increase in screening rate from 60% to 100%.

Limitations

The current rates of screening used in this study were based on self-reported BRFSS survey data, but actual rates could be substantially less. Past studies have suggested that self-reports of screening overestimated screening rates by as much as 15 to 25 percentage points (29,30). We did not account for the potential contribution from the use of human papillomavirus (HPV) vaccination to reduce incidence of cervical cancer; neither did we include HPV testing for cervical cancer screening in women aged 30 or older. The estimates for CRC deaths prevented were based on 3 screening strategies: FOBT alone, flexible sigmoidoscopy combined with FOBT, and colonoscopy alone; other currently available or recommended strategies or test methods (eg, fecal immunochemical test, fecal DNA, Cologuard) were not included. Furthermore, our approach assumes proportional effects of screening and does not account for population heterogeneity in screening frequencies and risk of death. Also, the validity of our approach to extrapolate outside the observed range of data is not known, although this is often the only approach available.

Conclusions

Increasing screening for CRC and breast and cervical cancers could prevent a substantial number of deaths attributed to these cancers. Organized screening approaches that leverage partnerships between public health and primary health care to implement evidence-based strategies could be used to reduce the prevalence of these cancers.

Acknowledgments

The authors thank Martin Meltzer and Phoebe Thorpe for their contributions. No financial disclosures were reported by the authors of this article, and no external financial support was received for this work. No copyrighted instruments or tools were used for this study. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC.

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Tables

Table 1. Summary of Key Analysis Assumptions Used to Estimate the Effects of Colorectal Cancer and Women's Breast and Cervical Cancers in the United States

Analysis Assumption	Breast Cancer	Cervical Cancer	Colorectal Cancer
Study cohort	50-year-old women	21-year-old women	50-year-old men and women
Screening age[a]	50–74 y	21–65 y	50–75 y
Eligible US population for the test (million)[b]	48.7	96.7	95.9
Follow-up period	Lifetime or until death by any cause		
Screening tests included[a]	Mammogram	Cytology or pap smear	High-sensitivity FOBT, flexible sigmoidoscopy, or colonoscopy
Screening intervals[a]	Every 2 years	Every 3 years	Annual screening with high-sensitivity FOBT Sigmoidoscopy every 5 years, with high-sensitivity FOBT every 3 years Screening colonoscopy every 10 years
Baseline screening rate (%)[c]	78.3	79.9	67.7
Age eligible US population screened in baseline (millions)[b]	37.4	76.8	63.5
Other screening scenarios (number of additional people needed to be screened to reach the goal [in millions] by cancer type[b])	Increase in baseline rate by 10 percentage points (breast, 4.8; cervical, 9.6; colorectal, 9.4) Screening rate of 90% (breast, 5.6; cervical, 9.7; colorectal, 20.9) Screening rate of 100% (breast, 10.4; cervical, 19.3; colorectal, 30.3)		

Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; FOBT, fecal occult blood test.
[a] Based on US Preventive Services Task Force recommendations, 2008.
[b] Author calculations based on annual estimates of the resident population by sex, race, and Hispanic origin for 2016 from the US Census.
[c] Based on BRFSS 2016 data (7).

Table 2. Estimates of Current and Increased Use of US Preventive Services Task Force–Recommended Cancer Screenings Over the Lifetime of Study Cohort, United States, 2018

Preventive Service	Current Use, %[a]	Current Impact (Deaths Prevented)[b]	Incremental Impact (Deaths Prevented) With Increased Screening	
			Increase Screening by 10 Percentage Points[b]	Increase Screening to 90%[b]
Breast cancer screening of 50-year-old women until the age of 74	78.3	10,179	1,300	1,521
Cervical cancer screening of 21-year-old women until the age of 65	79.9	27,166	3,400	3,434
Colorectal cancer screening of 50-year-old adults until the age of 75	67.7	74,470	11,000	24,530

[a] Source: Behavioral Risk Factor Surveillance System Prevalence and Trends Data (7).
[b] Model-based estimates by authors.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 18, E37 APRIL 2021

ORIGINAL RESEARCH

Disparities in Meeting USPSTF Breast, Cervical, and Colorectal Cancer Screening Guidelines Among Women in the United States

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Accessible Version: www.cdc.gov/pcd/issues/2021/20_0315.htm

Suggested citation for this article: Benavidez GA, Zgodic A, Zahnd WE, Eberth JM. Disparities in Meeting USPSTF Breast, Cervical, and Colorectal Cancer Screening Guidelines Among Women in the United States. Prev Chronic Dis 2021;18:200315. DOI: https://doi.org/10.5888/pcd18.200315.

PEER REVIEWED

Summary

What is already known on this topic?

Early cancer detection and early treatment initiation increase the chances of survival. Social and environmental context often influences the ability of women to obtain preventive health services such as cancer screening.

What is added by this report?

We highlighted the consistently strong association between financial and economic barriers and not meeting cancer screening guidelines among socioeconomically disadvantaged women.

What are the implications for public health practice?

Interventions to promote cancer screening should target uninsured women and either provide free screening services or connect them with resources/services that may reduce the cost of screening.

Abstract

Introduction

Many sociodemographic factors affect women's ability to meet cancer screening guidelines. Our objective was to examine which sociodemographic characteristics were associated with women meeting US Preventive Services Task Force (USPSTF) guidelines for breast, cervical, and colorectal cancer screening.

Methods

We used 2018 Behavioral Risk Factor Surveillance System data to examine the association between sociodemographic variables, such as race/ethnicity, rurality, education, and insurance status, and self-reported cancer screening for breast, cervical, and colorectal cancer. We used multivariable log-binomial regression models to estimate adjusted prevalence ratios and 95% CIs.

Results

Overall, the proportion of women meeting USPSTF guidelines for breast, cervical, and colorectal cancer screening was more than 70%. The prevalence of meeting screening guidelines was 6% to 10% greater among non-Hispanic Black women than among non-Hispanic White women across all 3 types of cancer screening. Women who lacked health insurance had a 26% to 39% lower screening prevalence across screening types than women with health insurance. Compared with women with $50,000 or more in annual household income, women with less than $50,000 in annual household income had a 3% to 8% lower screening prevalence across all 3 screening types. For colorectal cancer, the prevalence of screening was 7% less among women who lived in rural counties than among women in metropolitan counties.

Conclusion

Many women still do not meet current USPSTF guidelines for breast, cervical, and colorectal cancer screening. Screening disparities are persistent among socioeconomically disadvantaged groups, especially women with low incomes and without health insurance. To increase the prevalence of cancer screening and reduce disparities, interventions must focus on reducing economic barriers and improving access to care.

Introduction

Approximately 40% of new cancer diagnoses and 25% of cancer deaths among women each year are attributed to 3 types of cancer, all of which are amenable to early detection through screening: breast, colorectal, and cervical cancer (1). These cancers have 5-year survival rates at or greater than 90% if diagnosed at a localized stage (1). Because of high survival rates for breast, cervical, and colorectal cancers when detected early, programs such as the

National Breast and Cervical Cancer Early Detection Program (2) and the Colorectal Cancer Control Program (3), which provide screening to low-income, uninsured, and underinsured populations, were developed to increase uptake of screening and subsequent follow-up. Although colorectal cancer screening rates increased from 2000 to 2015 as a result in part of increased use of noninvasive screening methods, the proportion of eligible women being screened for cervical and breast cancer decreased nationally by 4.3% and 3.0%, respectively (4).

Racial/ethnic minority populations, women of low socioeconomic status, and women residing in rural areas have had worse cancer survival outcomes than their counterparts (5). From 2013 to 2017, non-Hispanic Black women died of cervical cancer (3.4 per 100,000), breast cancer (27.6 per 100,000), and colorectal cancer (18.5 per 100,000) at higher rates than any other racial/ethnic group (6). Higher mortality among socioeconomically disadvantaged groups is partly due to receiving a diagnosis at a later stage of disease (5). Rural disparities in screening uptake are often attributed to lack of access to screening services and longer travel distances for care (7). The national declines in breast and cervical cancer screening (4) are likely exacerbated among groups that are already socioeconomically disadvantaged and medically underserved, and this exacerbation further widens mortality gaps (8).

Identifying characteristics associated with not meeting cancer screening guidelines could enhance surveillance of possible disparities among groups of people who have historically been economically or socially marginalized. Understanding these factors, whether modifiable or nonmodifiable, will help guide public health efforts, resource allocation, and policies. The objective of our study was to describe the sociodemographic characteristics associated with women meeting US Preventive Services Task Force (USPSTF) guidelines for breast, cervical, and colorectal cancer screening.

Methods

We used data from the 2018 Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is the largest annual nationally representative telephone survey of the noninstitutionalized US population on health-related risk behaviors, health conditions, and use of preventive health services (9). A full description of BRFSS survey methodologies is published elsewhere (9). In 2018, BRFSS surveyed 437,436 people across all 50 states, the District of Columbia, Guam, and Puerto Rico, with a 53.3% response rate among landline users and a 43.4% response rate among cellular telephone users (10). BRFSS includes core modules that ask questions about screening examinations for breast and cervical cancer, prostate cancer, and colorectal cancer. For this analysis, we used only records for breast, cervical, and colorectal cancer screening among women who identified as residing in any of the 50 US states or the District of Columbia.

Dependent and independent variables

We examined 3 dependent variables: 1) meeting current breast cancer screening guidelines, 2) meeting current cervical cancer screening guidelines, 3) meeting current colorectal cancer screening guidelines. The USPSTF guidelines recommend that women aged 50 to 74 at average risk be screened for breast cancer by biennial mammography (11). For colorectal cancer, USPSTF guidelines recommend that people aged 50 to 75 at average risk of colorectal cancer be screened by using any of the following methods and frequencies: colonoscopy every 10 years, flexible sigmoidoscopy every 5 years, or yearly stool-based tests (11). USPSTF recommends screening for cervical cancer every 3 years with cervical cytology alone in women aged 21 to 29. For women aged 30 to 65, the USPSTF recommends screening every 3 years with cervical cytology alone, every 5 years with high-risk human papillomavirus testing alone, or every 5 years with high-risk human papillomavirus testing in combination with cytology (11). On the basis of questions on age, types of screenings performed, and when screenings took place, BRFSS computes variables that categorize women's status for meeting each USPSTF guideline (12).

The Healthy People 2020 framework categorizes the social determinants of health in 5 areas: 1) economic stability, 2) education, 3) social and community context, 4) health and health care, and 5) neighborhood and built environment (13). On the basis of this framework, we used the following sociodemographic variables: annual household income, based on previous BRFSS-generated categories (<$25,000, $25,000 to <$35,000, $35,000 to <$50,000, or ≥$50,000), education (<high school diploma, high school diploma, some college, or college degree), location of residence (metropolitan county, micropolitan county, or rural county as determined by the National Center for Health Statistics' Urban–Rural Classification Scheme for Counties [14]), health insurance coverage (some form of health insurance or no form of health insurance), employment status (employed, unemployed, or retired), avoidance of medical care because of cost in the past year (yes or no), and race/ethnicity (Hispanic, non-Hispanic Black, non-Hispanic White, or "other" (Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native). We categorized age according to USPSTF screening guidelines: for cervical cancer, 3 age groups (21–39, 40–49, and 50–65); for breast cancer and colorectal cancer, 2 groups (50–64 and 65–75).

Statistical analysis

We produced weighted frequencies for all sociodemographic factors. We then used weighted Wald χ^2 tests to compare differences in breast, cervical, and colorectal cancer screening by study factors. Accounting for survey weights and nesting (patients nested within states), we constructed mixed-effect log-binomial regression models for each cancer screening subtype. We used log-binomial regression to produce prevalence ratios (PR) and adjusted PRs instead of odds ratios because of the high prevalence of our outcome variables (15). We ran univariate followed by multivariable log-binomial regression models, treating sociodemographic factors as fixed effects and including a random intercept to account for state-to-state variation. We considered the complex survey design structure in our model building. As outlined by Carle (16) and Rabe-Hesketh and Skrondal (17), we rescaled the weights provided by BRFSS at the participant level to reduce the risk of biased estimates in our multilevel model. As described by Goldstein (18) and West et al (19), we created new state-level weights. The use of weights at each level of our mixed-effects model helps generalize our findings beyond our BRFSS sample (19). We generated 95% CIs and used a significance level of .05 throughout our analysis. We used SAS version 9.4 (SAS Institute, Inc) for all statistical analyses.

Results

Of the women who responded to the question on breast cancer screening, 56.6% were aged 65 to 75, 72.1% were non-Hispanic White, and 83.3% lived in metropolitan counties (Table 1). Of the women who responded to the question on cervical cancer screening, 48.0% were aged 21 to 39, 60.2% were non-Hispanic White, and 86.7% lived in metropolitan counties. Of the women who responded to the question on colorectal cancer, 56.4% were aged 65 to 75, 72.8% were non-Hispanic White, and 83.2% lived in metropolitan counties. Overall, 78.8%, 80.0%, and 71.3% of eligible women reported meeting USPSTF breast, cervical, and colorectal cancer screening guidelines, respectively (Table 2). For all 3 screening types, in unadjusted analyses, we found significant differences in the proportion of women meeting guidelines by race/ethnicity, annual household income, education, employment status, health insurance status, and reporting medical cost as a barrier to seeking health care (Table 2).

Breast cancer screening

In the adjusted mixed-effects log-binomial models, we found significant differences in meeting breast cancer screening guidelines by sociodemographic factors (Table 3). Compared with women aged 50 to 64, women aged 65 to 75 had a 3% (adjusted PR = 1.03; 95% CI, 1.02–1.05) higher prevalence. The prevalence was higher among non-Hispanic Black (adjusted PR = 1.10; 95% CI, 1.07–1.13) and Hispanic (adjusted PR = 1.08; 95% CI, 1.04–1.13) women than among non-Hispanic White women. The prevalence was 7% (adjusted PR = 0.93; 95% CI, 0.90–0.96) lower among women with an annual household income of less than $25,000 than among women with an annual household income of $50,000 or more. The prevalence among retired women was 3% less (adjusted PR = 0.97; 95% CI, 0.95–0.99) than that of employed women. Women reporting having no form of health insurance coverage had a 26% lower prevalence (adjusted PR = 0.74; 95% CI, 0.68–0.79) than those with some form of health insurance. Women who reported avoiding medical care because of cost had a 15% lower prevalence (adjusted PR = 0.85; 95% CI, 0.81–0.89) than women not avoiding medical care. The prevalence in micropolitan (adjusted PR = 0.99; 95% CI, 0.96–1.01) and rural counties (adjusted PR = 0.98; 95% CI, 0.94–1.01), however, did not differ significantly from the prevalence in metropolitan counties, and the prevalence was no different between women with less than a college degree and women with a college degree.

Cervical cancer screening

We found significant differences in meeting cervical cancer screening guidelines by sociodemographic factors in the adjusted weighted mixed-effects log-binomial models (Table 3). We found no difference in prevalence among women aged 40 to 49, compared with women aged 21 to 39, but we found a 2% (adjusted PR = 0.98; 95% CI, 0.96–0.99) lower prevalence among women aged 50 to 65. Compared with non-Hispanic White women, non-Hispanic Black (adjusted PR = 1.06; 95% CI, 1.04–1.08) and Hispanic (adjusted PR = 1.05; 95% CI, 1.03–1.07) women had a higher prevalence. Women at any annual household income level lower than $50,000 had a lower prevalence ranging from 3% to 6%. Compared with women with a college degree, women with some college (adjusted PR = 0.97; 95% CI, 0.94–0.99) and women with a high school diploma (adjusted PR = 0.95; 95% CI, 0.92–0.97) had a lower prevalence. Retired women (adjusted PR = 0.96; 95% CI, 0.94–0.98) had a lower prevalence compared with employed women, but we observed no difference between unemployed women and employed women. Women reporting having no form of health insurance had a 17% lower prevalence (adjusted PR = 0.83; 95% CI, 0.79–0.88) compared with women with some form of health insurance. Women who reported avoiding medical care because of cost had a 6% lower prevalence (adjusted PR = 0.94; 95% CI, 0.92–0.97) than those not avoiding medical care. We observed no significant difference in the adjusted model for women residing in micropolitan (adjusted PR = 0.98; 95% CI, 0.95–1.02) or rural counties (adjusted PR = 0.97; 95% CI, 0.94–1.00) compared with metropolitan counties.

Colorectal cancer screening

We found significant differences in meeting colorectal cancer screening guidelines by sociodemographic factors in the adjusted weighted mixed-effects log-binomial models (Table 3). Compared with women aged 50–64, women aged 65 to 75 had a 23% (adjusted PR = 1.23; 95% CI, 1.19–1.28) higher prevalence. Non-Hispanic Black (adjusted PR = 1.07; 95% CI, 1.03–1.12) women had higher prevalence than non-Hispanic White women. In contrast, Hispanic women had a 3% (adjusted PR = 0.97; 95% CI, 0.92–0.99) lower prevalence than non-Hispanic White women. Women in rural counties had a 7% lower prevalence (adjusted PR = 0.93; 95% CI, 0.88–0.98) than women in metropolitan counties; we found no significant difference between women in micropolitan counties and women in metropolitan counties. Women in the lowest income level had an 8% (adjusted PR = 0.92; 95% CI, 0.89–0.96) lower prevalence than women at the highest income level. Compared with women with a college degree, women with less than a college degree had a lower prevalence ranging from 4% to 12%. We found no significant difference between women who were unemployed or retired and women who were employed. Women who reported having no form of health insurance had a 39% lower prevalence (adjusted PR = 0.61; 95% CI, 0.56–0.66) than women with some form of health insurance. Women who reported avoiding medical care because of cost had a 9% lower prevalence (adjusted PR = 0.91; 95% CI, 0.87–0.96) than women not avoiding medical care.

Discussion

This study examined sociodemographic factors and their association with meeting USPSTF guidelines for breast, cervical, and colorectal cancer screening. Our findings suggest that women currently not meeting screening guidelines share many characteristics. Women who have an annual household income less than $50,000, have less than a college education, live in rural counties, and lack ability to pay for medical care because of cost or lack of health insurance have a lower prevalence of meeting USPSTF guidelines for breast, cervical, and/or colorectal cancer screening than their more socioeconomically advantaged counterparts and women living in metropolitan counties.

Although most of our results demonstrate a lower prevalence of meeting guidelines among people who historically have been medically underserved, the prevalence of meeting guidelines for all screening types was higher among non-Hispanic Black women than among non-Hispanic White women in adjusted models. Analyses of similar nationally representative data sets have produced similar results (4,6). The prevalence of some screenings has been consistently higher among non-Hispanic Black women than among non-Hispanic White women since 1987 (6). In our analysis, Hispanic women also had a higher prevalence of breast and cervical cancer screening than their non-Hispanic White counterparts. However, they had a lower prevalence of colorectal cancer screening, consistent with previous research (6). Reasons for this trend among Hispanic populations are not well understood. Research on culturally specific characteristics among the various Hispanic nationalities is needed to better understand why Hispanic people fall behind other racial/ethnic groups in colorectal cancer screening. Previous data highlight disparities in cancer mortality between racial/ethnic minority groups, especially non-Hispanic Black women and their white counterparts. Our analysis confirms that higher cancer mortality among racial/ethnic minority groups will not be reduced solely by increasing rates of cancer screening. Although preventive screenings and timely diagnosis are important elements of prognosis, they are just 2 elements of many along the cancer care continuum that need to be addressed to eliminate disparities in cancer mortality.

We found that women in rural counties had a lower prevalence of meeting colorectal cancer screenings guidelines than women in metropolitan counties, even after accounting for other sociodemographic characteristics. Health care professionals with specialized training most often perform colorectal cancer screenings by colonoscopy or sigmoidoscopy. Women in rural areas may have a lower prevalence of meeting colorectal cancer screening guidelines because rural areas often have limited access to specialized health care services (20). Additionally, the limited access to health care services in rural areas often means that people living in rural areas must travel long distances to reach areas where advanced health care services are provided (21). These disadvantages in the early detection and treatment of cancer are compounded by the fact that rural residents, on average, have lower incomes than their nonrural counterparts and lower rates of health insurance coverage (22).

We found disparities in meeting USPSTF screening guidelines among economically disadvantaged women, defined in our study as having an annual household income less than $50,000, not having health insurance, or reporting avoiding medical care because of cost. In the past 2 decades, women with an income less than 200% of the federal poverty level have had consistently lower cancer screening rates than women with incomes above 200% of the federal poverty level (6). Women with low incomes, for numerous reasons, are less likely to have a usual source of primary care — where preventive screenings and measures are often discussed and performed. National programs such as the Centers for Disease Control and Prevention–funded Colorectal Cancer Control Program and National Breast and Cervical Cancer Early Detection Program were developed with the primary aim of eliminating cost

as a barrier for breast, cervical, and colorectal cancer screening and follow-up. These programs distribute funding to health care centers to provide eligible low-income, underinsured, and uninsured women access to screening, diagnostic, and cancer treatment services. Further work is needed to ensure that these programs are used and expanded. Of women eligible for the National Breast and Cervical Cancer Early Detection Program during 2015–2017, only 6.7% received cervical cancer screening and 15% breast cancer screening services. Furthermore, not all states receive funding from the Colorectal Cancer Control Program. Targeted outreach and awareness of these Centers for Disease Control and Prevention programs and similar programs are needed: our results and the results of previous studies demonstrate a consistently strong association between economic barriers and lack of meeting screening guidelines. Increased use of these programs may reduce cancer mortality among women with persistent economic barriers to care (23).

Overall, sustainable solutions to cancer screening disparities will require large-scale policy changes and smaller-scale health education and awareness campaigns on the importance of cancer screening. Shifting to a single-payer health care system in the US may save an estimated 68,000 lives annually by removing economic barriers to preventive health care such as cancer screening and routine checkups (24). Hendryx and Luo showed an increase in the proportion of low-income women being screened in states that expanded Medicaid under the Affordable Care Act (25). The expansion of Medicaid is likely to have the largest effect in states that have large rural and low-income populations and consistently demonstrate poor health outcomes, such as states in the Southeast (26). Additionally, evidence supports the efficacy of small-scale interventions to increase screening rates in some locations and populations (27). A meta-analysis of randomized controlled interventions designed to increase colorectal cancer screening rates demonstrated that in diverse health care populations, the use of patient navigators, a type of barrier-focused intervention in which trained specialists assist patients in navigating logistical barriers of the cancer screening process, increased screening rates by approximately 20 percentage points (27).

Our study has several strengths. One strength is our mixed-effects modeling approach, which allowed us to account for state-to-state variation in the data. Economic and social structure varies from state to state, and accounting for this variation allowed us to generate less biased PRs. Second, our adjusted models accounted for several potentially confounding variables, but residual confounding may still be present in our PR estimates. Future studies may benefit from incorporating and merging state and county-level variables with BRFSS data to provide better area-level context for more representative estimates. Third, because BRFSS is nationally representative sample, the results of our study are generalizable to women in the general US population.

Our study also has potential limitations. First, although BRFSS is the nation's premier surveillance mechanism for health behaviors, BRFSS data are self-reported. Our estimates depend on respondents providing accurate information with minimal recall bias or social desirability bias. However, studies have found these biases not to be associated with self-reported cancer screening adherence (28). Second, BRFSS is a telephone-based survey that limits responses to people with access to a telephone and only people who answer and are willing to participate. However, a new weighting methodology known as raking now allows BRFSS to consider telephone ownership in the weighting process, potentially minimizing bias resulting from telephone-based data collection. Third, our screening prevalence estimates may be overestimated. Comparisons of data from BRFSS and the National Health Interview Survey (NHIS) found that screening prevalence estimates were consistently higher in BRFSS (29). One reason BRFSS screening estimates are higher is that the survey is designed to produce estimates at the state level whereas NHIS is designed to produce estimates at the national level. The aggregation of state-level BRFSS data to generate a national estimate likely biases the estimates upwards. Despite these potential limitations, the absolute difference in estimates between BRFSS and other nationally representative surveys in most cases is small from a surveillance perspective (30).

Efforts have been made to increase the proportion of women who meet cancer prevention screening guidelines. Most women in the US meet USPSTF guidelines, but continued attention needs to be directed toward women who do not. Across all 3 cancer screening types, women facing economic barriers had a consistently lower prevalence of meeting preventive screening guidelines. Interventions and policy changes to reduce economic barriers are expected to increase cancer screening uptake to meet benchmarks such as Healthy People 2030 goals (31).

Acknowledgments

This study was supported by the Federal Office of Rural Health Policy, the Health Resources and Services Administration, and the US Department of Health and Human Services under cooperative agreement no. U1CRH30539. The publication was also made possible in part by grant no. T32-GM081740 from the National Institute of General Medical Sciences. The information, conclusions,

and opinions expressed in this article are those of the authors, and no endorsement by any of the aforementioned entities is intended or should be inferred. No copyrighted materials were used in this article.

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Tables

Table 1. Selected Sociodemographic Characteristics of Women Who Responded to Behavioral Risk Factor Surveillance System Screening Module, by Cancer Type, 2018[a]

Variable	Breast Cancer (n = 108,746)	Cervical Cancer (n = 105,096)	Colorectal Cancer (n = 109,940)
Age, y[b]			
21–39	—	48.0	—
40–49	—	21.3	—
50–65	—	30.7	—
Age, y[b]			
50–64	43.4	—	43.6
65–75	56.6	—	56.4
Race/ethnicity			
Non-Hispanic White	72.1	60.2	72.8
Non-Hispanic Black	11.2	12.7	11.0
Hispanic	10.4	18.1	10.0
Other[c]	6.3	9.0	6.2
County type			
Metropolitan	83.3	86.7	83.2
Micropolitan	9.1	7.7	9.2
Rural	7.5	5.5	7.6
Annual household income, $			
<25,000	26.8	26.5	26.8
25,000 to <35,000	9.6	9.4	9.8
35,000 to <50,000	12.6	11.8	12.6
≥50,000	51.0	52.3	50.8
Education			
<High school diploma	11.9	10.8	11.7
High school diploma	26.2	22.3	26.4
Some college	33.2	32.1	33.1
College degree	28.7	34.8	28.7
Current employment status			
Employed	53.0	60.0	53.1
Unemployed	10.6	8.6	11.7
Retired	36.4	41.4	36.2
Have some form of health insurance			
Yes	93.7	86.9	93.9

Abbreviation: — , not applicable.
[a] Source: Centers for Disease Control and Prevention (9). Cancer screening groups are not mutually exclusive. All values are percentages.
[b] Age categories were created according to screening eligibility criteria defined by the US Preventive Services Task Force.
[c] Consists of Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native.

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Table 1. Selected Sociodemographic Characteristics of Women Who Responded to Behavioral Risk Factor Surveillance System Screening Module, by Cancer Type, 2018[a]

Variable	Breast Cancer (n = 108,746)	Cervical Cancer (n = 105,096)	Colorectal Cancer (n = 109,940)
No	6.3	13.1	6.1
Avoided medical care because of cost in past year			
Yes	11.7	16.6	11.4
No	88.3	83.4	88.6

Abbreviation: — , not applicable.
[a] Source: Centers for Disease Control and Prevention (9). Cancer screening groups are not mutually exclusive. All values are percentages.
[b] Age categories were created according to screening eligibility criteria defined by the US Preventive Services Task Force.
[c] Consists of Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native.

Table 2. Proportion of Women Meeting USPSTF Guidelines by Selected Sociodemographic Factors, Behavioral Risk Factor Surveillance System, 2018[a]

Variable	Breast Cancer Screening	*P* Value[b]	Cervical Cancer Screening	*P* Value[b]	Colorectal Cancer Screening	*P* Value[b]
Meet screening guidelines	78.8	—	80.0	—	71.3	—
Age, y[c]						
21–39	—	—	79.2	<.001	—	—
40–49	—		83.0		—	
50–65	—		79.3		—	
Age, y[c]						
50–64	76.0	<.001	—	—	61.0	<.001
65–75	81.0		—		78.6	
Race/ethnicity						
Non-Hispanic White	78.1	<.001	80.0	<.001	72.8	<.001
Non-Hispanic Black	83.9		84.8		73.1	
Hispanic	78.9		80.3		60.8	
Other[d]	77.5		71.2		67.1	
County type						
Metropolitan	79.5	<.001	80.4	<.001	71.9	<.001
Micropolitan	76.1		76.9		70.0	
Rural	74.6		75.9		67.1	
Annual household income, $						
<25,000	72.3	<.001	74.3	<.001	64.1	<.001
25,000 to <35,000	75.1		76.7		70.8	
35,000 to <50,000	78.1		80.3		72.2	
≥50,000	83.0		84.9		75.4	
Education						
<High school diploma	73.1	<.001	74.5	<.001	59.2	<.001
High school diploma	76.9		75.1		69.0	
Some college	78.6		79.2		72.7	
College degree	83.3		85.4		76.8	
Employment status						
Employed	80.1	<.001	82.9	<.001	67.7	.005
Unemployed	74.8		77.5		64.9	
Retired	72.5		75.2		64.8	
Have some form of health insurance						
Yes	80.5	<.001	82.2	<.001	73.4	<.001

Abbreviations: — , not applicable; USPSTF, US Preventive Services Task Force.
[a] Source: Centers for Disease Control and Prevention (9). All values are percentages unless otherwise indicated.
[b] All *P* values derived by using weighted Wald χ^2 tests; significance set at $P < .05$.
[c] Age categories were created according to screening eligibility criteria defined by USPSTF.
[d] Consists of Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native.

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Table 2. Proportion of Women Meeting USPSTF Guidelines by Selected Sociodemographic Factors, Behavioral Risk Factor Surveillance System, 2018[a]

Variable	Breast Cancer Screening	*P* Value[b]	Cervical Cancer Screening	*P* Value[b]	Colorectal Cancer Screening	*P* Value[b]
No	54.5		65.0		39.4	
Avoided medical care because of cost in past year						
Yes	64.0	<.001	71.7	<.001	56.4	<.001
No	80.8		81.6		73.3	

Abbreviations: — , not applicable; USPSTF, US Preventive Services Task Force.
[a] Source: Centers for Disease Control and Prevention (9). All values are percentages unless otherwise indicated.
[b] All *P* values derived by using weighted Wald χ^2 tests; significance set at $P < .05$.
[c] Age categories were created according to screening eligibility criteria defined by USPSTF.
[d] Consists of Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native.

Table 3. Unadjusted and Adjusted Prevalence Ratios (PRs), of Meeting Current USPSTF Screening Guidelines, Behavioral Risk Factor Surveillance System, 2018[a]

Variables	Breast Cancer		Cervical Cancer		Colorectal Cancer	
	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]
Age, y[c]						
21–39	—	—	1 [Reference]	1 [Reference]	—	—
40–49	—	—	1.05 (1.02–1.07)	1.02 (1.00–1.04)	—	—
50–65	—	—	1.00 (0.98–1.02)	0.98 (0.96–0.99)	—	—
Age, y[c]						
50–64	1 [Reference]	1 [Reference]	—	—	1 [Reference]	1 [Reference]
65–75	1.29 (1.24–1.34)	1.03 (1.02–1.05)	—	—	1.06 (1.05–1.08)	1.23 (1.19–1.28)
Race/ethnicity						
Non-Hispanic White	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Non-Hispanic Black	1.07 (1.04–1.10)	1.10 (1.07–1.13)	1.06 (1.03–1.08)	1.06 (1.04–1.08)	1.01 (0.97–1.04)	1.07 (1.03–1.12)
Hispanic	1.01 (0.97–1.06)	1.08 (1.04–1.13)	1.01 (0.99–1.03)	1.05 (1.03–1.07)	0.83 (0.77–0.88)	0.97 (0.92–0.99)
Other[d]	0.98 (0.95–1.01)	1.01 (0.95–1.06)	0.89 (0.86–0.92)	0.90 (0.87–0.93)	0.90 (0.88–0.93)	0.95 (0.91–1.00)
County type						
Metropolitan	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Micropolitan	0.97 (0.94–0.99)	0.99 (0.96–1.01)	0.96 (0.91–1.00)	0.98 (0.95–1.02)	0.97 (0.95–1.00)	0.98 (0.94–1.02)
Rural	0.95 (0.92–0.98)	0.98 (0.94–1.01)	0.93 (0.91–0.96)	0.97 (0.94–1.00)	0.93 (0.90–0.95)	0.93 (0.88–0.98)
Annual household income, $						
<25,000	0.87 (0.85–0.89)	0.93 (0.90–0.96)	0.87 (0.85–0.89)	0.94 (0.91–0.96)	0.85 (0.81–0.89)	0.92 (0.89–0.96)
25,000 to <35,000	0.91 (0.89–0.93)	0.92 (0.89–0.95)	0.90 (0.88–0.93)	0.95 (0.92–0.98)	0.94 (0.91–0.97)	0.96 (0.91–0.99)
35,000 to <50,000	0.94 (0.93–0.96)	0.95 (0.92–0.97)	0.94 (0.93–0.95)	0.97 (0.96–0.99)	0.96 (0.93–0.99)	0.95 (0.92–0.99)
≥50,000	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Education						
<High school diploma	0.88 (0.85–0.92)	0.98 (0.94–1.01)	0.87 (0.80–0.95)	0.97 (0.90–1.04)	0.77 (0.73–0.82)	0.88 (0.83–0.94)
High school diploma	0.93 (0.92–0.94)	0.99 (0.96–1.01)	0.88 (0.86–0.90)	0.95 (0.92–0.97)	0.90 (0.89–0.92)	0.92 (0.89–0.95)
Some college	0.95 (0.93–0.96)	0.97 (0.95–1.00)	0.93 (0.91–0.95)	0.97 (0.94–0.99)	0.95 (0.93–0.97)	0.96 (0.92–0.99)
College degree	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Employment status						
Employed	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Unemployed	0.94 (0.92–0.96)	0.98 (0.95–1.00)	0.94 (0.92–0.95)	0.97 (0.95–1.00)	0.96 (0.93–0.99)	0.97 (0.94–1.01)
Retired	0.91 (0.89–0.94)	0.97 (0.95–0.99)	0.91 (0.89–0.93)	0.96 (0.94–0.98)	0.96 (0.94–0.99)	1.02 (1.00–1.05)

Abbreviations: — , not applicable; USPSTF, US Preventive Services Task Force.
[a] Source: Centers for Disease Control and Prevention (9). Log-binomial regression was used to estimate prevalence ratios instead of odds ratios to produce less biased measures of association due to the high frequency of the outcome variable (meeting screening guidelines) in this analysis.
[b] Adjusted log-binomial regression models include age, race/ethnicity, county type, annual household income, education, employment status, health insurance status, and whether the respondent avoided medical care because of cost in the past year.
[c] Age categories were created according to screening eligibility criteria defined by USPSTF.
[d] Consists of Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native.

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Table 3. Unadjusted and Adjusted Prevalence Ratios (PRs), of Meeting Current USPSTF Screening Guidelines, Behavioral Risk Factor Surveillance System, 2018[a]

Variables	Breast Cancer		Cervical Cancer		Colorectal Cancer	
	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]	Unadjusted PR (95% CI)	Adjusted PR (95% CI)[b]
Have some form of health insurance						
Yes	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
No	0.68 (0.64–0.72)	0.74 (0.68–0.79)	0.79 (0.75–0.83)	0.83 (0.79–0.88)	0.54 (0.49–0.59)	0.61 (0.56–0.66)
Avoided medical care because of cost in past year						
Yes	0.80 (0.77–0.82)	0.85 (0.81–0.89)	0.88 (0.86–0.89)	0.94 (0.92–0.97)	0.77 (0.73–0.81)	0.91 (0.87–0.96)
No	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]

Abbreviations: — , not applicable; USPSTF, US Preventive Services Task Force.
[a] Source: Centers for Disease Control and Prevention (9). Log-binomial regression was used to estimate prevalence ratios instead of odds ratios to produce less biased measures of association due to the high frequency of the outcome variable (meeting screening guidelines) in this analysis.
[b] Adjusted log-binomial regression models include age, race/ethnicity, county type, annual household income, education, employment status, health insurance status, and whether the respondent avoided medical care because of cost in the past year.
[c] Age categories were created according to screening eligibility criteria defined by USPSTF.
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PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 18, E14 FEBRUARY 2021

ORIGINAL RESEARCH

Racial Residential Segregation and Colorectal Cancer Mortality in the Mississippi Delta Region

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Accessible Version: www.cdc.gov/pcd/issues/2021/20_0483.htm

Suggested citation for this article: Kruse-Diehr AJ, McDaniel JT, Lewis-Thames MW, James AS, Yahaya M. Racial Residential Segregation and Colorectal Cancer Mortality in the Mississippi Delta Region. Prev Chronic Dis 2021;18:200483. DOI: https://doi.org/10.5888/pcd18.200483.

PEER REVIEWED

Summary

What is already known on this topic?

Colorectal cancer mortality rates are higher than the national average among rural residents of the Mississippi Delta Region. Little is known about the interaction between rurality and racial segregation.

What is added by this report?

We found that colorectal cancer mortality was higher among Black residents in urban Delta Region counties with low and high levels of racial segregation, but this relationship was less evident among Black residents in rural Delta Region counties.

What are the implications for public health practice?

Further research should be conducted in segregated rural communities to better understand protective factors for Black residents against colorectal cancer mortality. Practitioners should partner with existing organizations to leverage social networks when developing and implementing colorectal cancer interventions.

Abstract

Introduction

Few studies have examined the effects of racial segregation on colorectal cancer (CRC) outcomes, and none has determined whether rurality moderates the effect of racial segregation on CRC mortality. We examined whether the effect of segregation on CRC mortality varied by rurality in the Mississippi Delta Region, an economically distressed and historically segregated region of the United States.

Methods

We used data from the US Census Bureau and the 1999–2018 Surveillance, Epidemiology, and End Results (SEER) program to estimate mixed linear regression models in which CRC mortality rates among Black and White residents in Delta Region counties (N = 252) were stratified by rurality and regressed on White–Black residential segregation indices and 4 socioeconomic control variables.

Results

Among Black residents, CRC mortality rates in urban counties were a function of a squared segregation term (b = 162.78, P = .01), indicating that the relationship between segregation and CRC mortality was U-shaped. Among White residents, main effects of annual household income (b = 29.01, P = .04) and educational attainment (b = 34.58, P = .03) were associated with CRC mortality rates in urban counties, whereas only annual household income (b = 19.44, P = .04) was associated with CRC mortality rates in rural counties. Racial segregation was not associated with CRC mortality rates among White residents.

Conclusion

Our county-level analysis suggests that health outcomes related to racial segregation vary by racial, contextual, and community factors. Segregated rural Black communities may feature stronger social bonds among residents than urban communities, thus increasing interpersonal support for cancer prevention and control. Future research should explore the effect of individual-level factors on colorectal cancer mortality.

Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed cancer and the second leading cause of cancer-related deaths among adults in the United States (1). Although CRC mortality rates decreased from 28.6 per 100,000 population in 1976 to 14.1 in 2014, higher mortality rates persist in the lower Mississippi Delta Region, which includes parts of Arkansas, Tennessee,

Louisiana, Mississippi, Kentucky, Missouri, and Illinois (2). Because colorectal cancer mortality was approximately 40% higher in the Delta Region than in the rest of the United States from 2009–2011, a cluster of 94 Delta counties has been designated as the nation's largest hotspot for CRC mortality (2). Additionally, many of these counties have also been found to be hotspots for early-onset CRC (3). Compared with their non-Delta counterparts, Delta counties have a greater proportion of low-income Black residents, lower median household income, lower educational attainment, higher rates of obesity, less access to exercise opportunities, higher smoking rates, and a less nutritious food environment (4). These factors, among others, contribute to higher mortality in the Delta Region.

The largely rural Delta Region is heavily segregated by race, with poorer health outcomes concentrated in census blocks with predominantly Black residents (5), and although urban residential segregation has decreased in the United States, the opposite trend has occurred in rural areas (6). Residential segregation has been linked to poorer quality education, reduced access to employment, more concentrated poverty, higher infant mortality rates, and reduced access to both primary and specialty health care, among other negative outcomes (7). These disparities may be even more pronounced in segregated rural areas, where factors such as poverty and travel distance make it difficult to access resources.

Although the association between rurality and increased cancer mortality is clear (8), the confounding effect of race and residential segregation is blurry. A systematic review of segregation and racial cancer disparities noted that 70% of included studies found that segregation contributed in some way to cancer mortality, though not always negatively (9). In highly segregated areas, studies reported lower breast cancer mortality among Black women but not White women (10), higher breast cancer mortality among Black women but not White women (11), and no associations between segregation and breast cancer mortality among Black women (12). For lung cancer, segregation has been linked to higher mortality rates among Black residents, but among White residents living in segregated areas, the association between lung cancer mortality rates is either weaker (13) or nonexistent (14). Further complicating the interpretation of these associations, studies routinely operationalize racial segregation in multiple ways — ranging from the percentage of Black people living in a given area (9) to measuring dissimilarity (ie, unevenness and clustering) of racial distribution (13) — and at different levels, including the census block group (10,13) and the metropolitan/micropolitan statistical area (11). Given that evidence of the effect of racial segregation on cancer outcomes is inconclusive, additional investigation is needed to better understand these associations to assess allocation of resources and education for underserved and disparate populations in racially segregated areas.

For Delta Region residents, accounting for racial residential segregation is an important, but less investigated, structural and social determinant of health (5,15). Previous studies investigated relationships between segregation and CRC outcomes throughout the continuum, including early-stage CRC diagnosis (16), late-stage CRC diagnosis (17), and treatment (15). To date, few studies have examined the effects of racial segregation on CRC outcomes, and none has determined if the effect of racial segregation on CRC mortality among Black and White residents varies by rurality. Given that the Delta Region 1) encompasses the largest hotspot for CRC mortality, 2) comprises both rural and urban counties (as classified by rural–urban continuum codes), and 3) includes regions that have been historically racially segregated, it provides a unique context within which to achieve the objective of this study: to describe relationships between racial residential segregation and CRC mortality and determine whether effects of segregation differ by race and between rural and urban Delta Region residents.

Methods

Study design and outcome variable

We used an ecologic study design, with counties in the Delta Region as the unit of analysis (N = 252), to determine whether the relationship between racial residential segregation and CRC mortality rates — our main outcome variable — among Black and White Delta residents varied by rurality. We calculated age-standardized CRC mortality rates per 100,000 for White and Black residents separately in each Delta county for the period 1999–2018 using the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) SEER*Stat (version 8.3.5) software, which collects data from both SEER cancer registries and the National Center for Health Statistics (18).

Independent variables

We measured racial residential segregation for White and Black residents in each Delta county by using the multilevel index of dissimilarity (MLID), which measures the spatial clustering of segregation (19). We calculated the MLID for each Delta county using population count data from the 2011–2015 US Census Bureau for White and Black residents in 3 nested within-county census geographies: block groups, tracts, and county subdivisions (20). We used the Missouri Census Data Center Geographic Correspondence Engine (Geocorr) to map tracts onto county subdivisions, because some census tracts overlapped county subdivision

boundaries (21). The MLID can range from 0 (no segregation) to 1 (total segregation) (19). We calculated the MLID for each county by using the MLID package in RStudio version 3.6.1.

We determined county rurality using 2013 rural–urban continuum codes (RUCCs) from the US Department of Agriculture (22). RUCCs range from 1 (counties in metropolitan areas with populations >1,000,000) to 9 (completely rural or an urban population <2,500, not adjacent to a metropolitan area). Similar to the approach used by Zahnd and colleagues (23), we dichotomized all RUCCs to indicate whether a county was urban (RUCCs 1 to 3) or rural (RUCCs 4 to 9).

Control variables

We included several control variables in our analysis to isolate the effects of rurality and racial residential segregation on CRC mortality rates. Manser and Bauerfeind's (24) systematic review indicated that CRC mortality was strongly associated with socioeconomic factors, such as low income, low levels of education, and overcrowding. We included these factors as direct measures of socioeconomic status.

First, using the same data we used to calculate county MLIDs, we calculated the proportion of each county's population that was Black and the proportion of each county's population that was White. Second, we determined the proportion of Black and White residents, separately, in each county, who reported an annual household income of less than $20,000 using 2011–2015 data from the US Census Bureau (20). Third, we determined the proportion of Black and White residents, separately, in each county, who reported having never completed high school using 2011–2015 data from the US Census Bureau (20). Fourth, we determined the proportion of Black and White residents, separately, in each county, who reported living arrangements with more than 1 occupant per room in the house (ie, overcrowding) using 2011–2015 data from the US Census Bureau (20).

Data analysis

Because counties with fewer than 10 deaths caused by CRC were suppressed to ensure confidentiality, we analyzed 169 Delta Region counties with data on CRC mortality rates among Black residents and 248 counties with data on CRC mortality rates among White residents. That is, we conducted complete case analysis because the data missing were not missing at random; data on CRC mortality among Black residents had 67% missingness, which is 27 percentage points greater than current guidance for the use of imputation (25). We estimated 4 mixed linear regression models to address our research questions. In the first and second models, which were stratified by rural or urban status, we regressed CRC mortality rates among Black residents on MLIDs while controlling for county-level socioeconomic factors among Black residents. These models also included a quadratic term for MLID. In the third and fourth models, which were also stratified by rural and urban status, we regressed CRC mortality rates among White residents on MLIDs while controlling for county-level socioeconomic factors among White residents. These models included a quadratic term for MLID as well. All 4 models included a random intercept for the nesting of counties within states. Because we obtained all data from de-identified public use data sets, institutional review board approval was not required for this study. We used Stata version 16 (StataCorp LLC) to estimate models, and all figures were produced using ESRI ArcGIS version 10.5.1.

Results

Although county-level CRC mortality rates were higher on average among White residents than among Black residents (Table 1), we observed greater variability in rates among Black residents. For example, we observed the highest (45.77 per 100,000) and the lowest (7.54 per 100,000) CRC mortality rates in urban counties among Black residents. CRC mortality rates among Black residents were highest in Crockett County, Tennessee (45.77 per 100,000), and Sharkey County, Mississippi (44.18 per 100,000), whereas CRC mortality rates among White residents were highest in Holmes County, Mississippi (44.80 per 100,000), and Dallas County, Arkansas (42.35 per 100,000) (Figure 1).

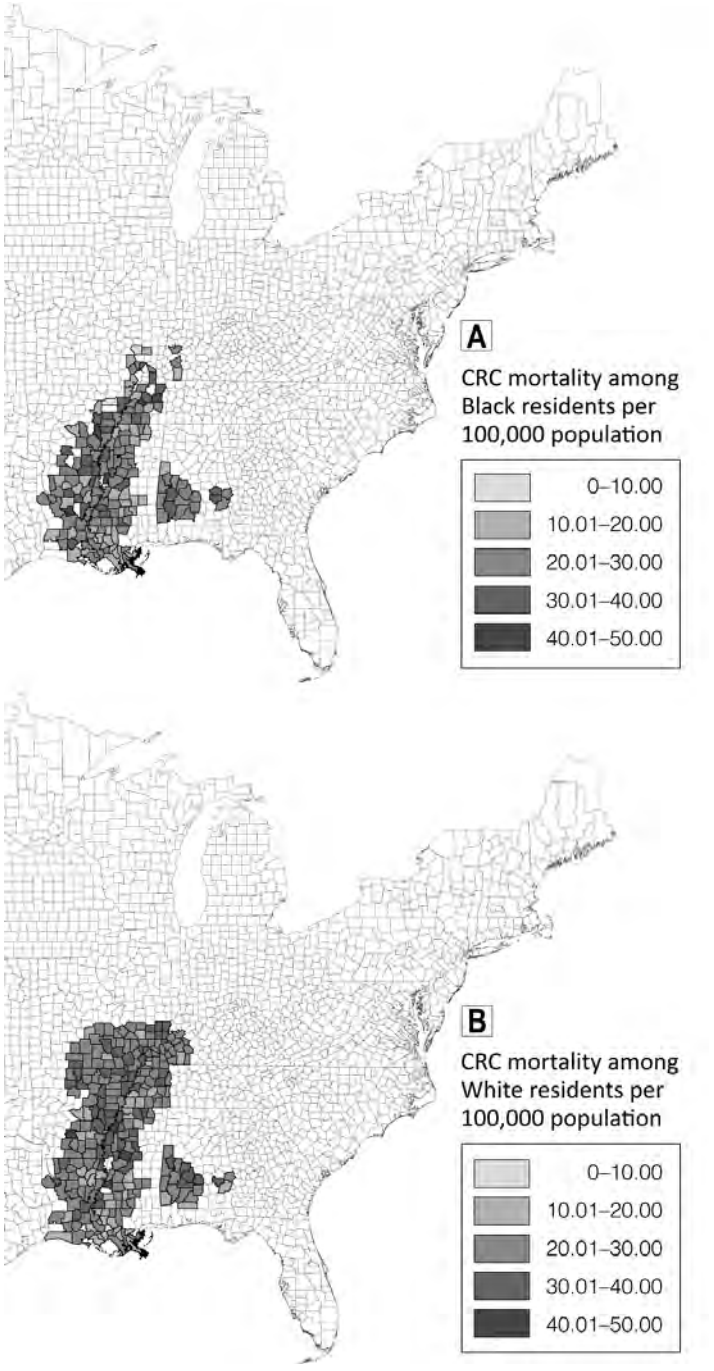

Figure 1. Colorectal cancer mortality rates per 100,000 population among A, Black residents and B, White residents in counties in the Mississippi Delta Region, 1999–2018. Map created using ESRI ArcGIS version 10.5.1. Abbreviation: CRC, colorectal cancer.

The mixed linear regression model for CRC mortality among Black residents in rural counties ($\chi^2 = 6.2$, $P = .40$) showed that racial segregation — including a quadratic form of segregation (ie, a U-shaped relationship) — was not significantly associated with CRC mortality (Table 2). However, the model for CRC mortality among Black residents in urban counties ($\chi^2 = 17.6$, $P = .008$) showed that a quadratic term for racial segregation was significantly associated with CRC mortality (b = 162.78, $P = .01$). As such, starting with counties that had an MLID of 0, the slope is such that CRC mortality among Black residents would decrease by 158.99 per 100,000 for each additional unit of the MLID — that is, if the slope remained unchanged; however, our model discredits the idea of an unchanged slope. Each unit added to the MLID increased the slope of the CRC mortality rate among Black residents by 162.78 per 100,000. In this model, the coefficient of the square term was positive, indicating that the relationship between the MLID and CRC mortality among Black residents was convex (Figure 2).

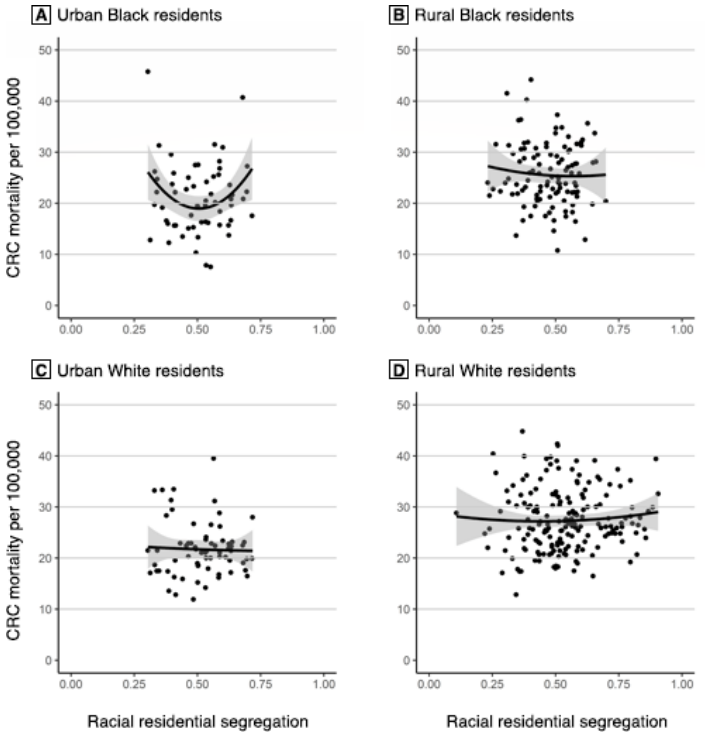

Figure 2. The effects of county urbanity and rurality on the relationship between Black–White residential segregation, as measured by the multilevel index of dissimilarity (MLID), which measures the spatial clustering of segregation (19), and colorectal cancer mortality rates among Black and White residents in Mississippi Delta region counties. A, Urban Black residents; B, Rural Black residents; C, Urban White residents; D, Rural White residents. Shading indicates 95% CIs.

The model for CRC mortality among White residents in rural counties ($\chi^2 = 72.2$, $P < .001$) showed that racial segregation — including a quadratic form of segregation — was not significantly

associated with CRC mortality. The model for CRC mortality among White residents in urban counties ($\chi^2 = 36.1$, $P < .001$) also showed that racial segregation was not significantly associated with CRC mortality; however, the models for CRC mortality among White residents showed that educational attainment and annual income were more important than racial segregation as predictors of CRC mortality. Specifically, in rural counties, a 1 percentage-point increase in the county percentage of White residents with less than $20,000 in annual household income was associated with an increase of 19.44 per 100,000 in CRC mortality. In urban counties, a 1 percentage-point increase in the county percentage of White residents with less than $20,000 in annual household income was associated with an increase of 29.01 per 100,000 in CRC mortality. Additionally, in urban counties, a 1 percentage-point increase in the county percentage of White residents with less than a high school education was associated with an increase of 34.58 per 100,000 in CRC mortality.

Discussion

Our models suggested that urban Delta Region counties with low and high, but not moderate, levels of racial segregation had higher CRC mortality rates among Black residents, a finding aligned with other research on CRC disparities (15,26). However, this relationship was less evident in rural Delta Region counties. Although this finding may seem surprising, the relationship between residential segregation and cancer outcomes among Black people remains unclear. Some studies found poor cancer outcomes (as we did for urban counties) (13,14), while others showed protective effects (10,17) and others reported no association (11,12,27). Our discovery that moderately segregated urban Delta Region counties had lower CRC mortality among Black residents than counties with low or high levels of segregation is, to our knowledge, a novel finding. Clearly, the pathways by which the interaction of urbanity/rurality and race affect CRC outcomes deserves additional exploration in health research, particularly given varying levels of county-level segregation. A few hypotheses might provide insight into our novel findings.

One potential explanation for our findings is that segregated rural communities may have unique features that do not exist in their segregated rural analogs. Racial or ethnic enclaves — geographic areas marked by large concentrations of people of similar races or ethnicities that often feature organizations led by members of these communities — have been shown to impart health benefits via different pathways, such as smaller and more racially concordant social networks (10), increased social capital and support (9,10), and less exposure to racism-related stress (27). However, other highly segregated areas may be cut off from resources, access, and knowledge (7), thus perpetuating unequal balances of power or resources and leaving communities of color with smaller social networks and less support (10). These disparities may be more pronounced in urban areas and social bonds may be stronger in segregated rural communities, thus contributing to urban–rural differences in cancer outcomes. Perhaps, too, social bonds in Black rural communities yield stronger or more effective interpersonal support to promote screening for preventable cancers such as colorectal cancer, a hypothesis echoed by Moss and colleagues (28), who found higher CRC screening rates in highly segregated counties than in those with less segregation.

Despite these possible differences, it is critical to remember that racial residential segregation is a system of oppression that comprises multiple factors that affect long-term health outcomes. Because of segregation, Black communities have historically entrenched and socially and politically enforced barriers to economic, educational, and health resources, implications of which continue to be felt today. Although our study identified a stronger relationship between CRC mortality and Black segregation in urban Delta Region counties than in rural Delta Region counties, it is important to acknowledge that multiple factors likely drive this relationship, thus underscoring the necessity for continued research dedicated to understanding the long-term effects of segregation on health outcomes and how these effects might produce different outcomes in both urban and rural residents in different geographic regions of the country.

Our county-level data do not fully capture data on individual-level factors — such as comorbidities, screening data, median age of death, or other risk factors — that might partly explain our findings. Data from the 2012–2015 Behavioral Risk Factor Surveillance System show that rural Black residents self-report lower levels of health-related quality of life, higher cost-related barriers to seeking treatment, lower CRC screening rates, and more comorbidities than rural White residents (29). Furthermore, precancerous polyps, many of which have little or no symptoms, can take upwards of a decade to progress to CRC (30). Perhaps, then, rural Black residents in the Delta Region are dying prematurely from complications of other causes (ie, multiple chronic conditions) *before* dying from the slower developing consequences of CRC. Given that the Delta Region as a whole has one of the lowest life expectancies in the country (4), our findings might not fully show the entire picture on trends in CRC mortality among Black people in the Delta Region.

Our study has several limitations. First, we examined only 1 geographic area of the United States, the Mississippi Delta Region. Although we selected this region purposely because of its large burden of CRC mortality (2), researchers should investigate other

rural areas to determine whether they differ from the Delta. Second, data on CRC mortality among Black residents were suppressed in many counties. The averages computed in our study may not reflect the region as a whole.

Third, our study was limited by the snapshot of health represented from 1999–2018, and general implications about the effects of a socially and legislatively enforced historical phenomenon like segregation on health outcomes. Fourth, given that the county was the unit of analysis in this study, we were unable to control for individual-level covariates (eg, stage at diagnosis, median age, comorbidity scores, and individual insurance coverage) that may have partly explained our findings. Fifth, no publicly available data set breaks down CRC screening at the county level by race; it is possible that screening differences account for a proportion of our findings. Finally, our study is correlational in nature and, as such, no causal effects can be inferred based on our findings.

To date, few studies have examined the effects of racial residential segregation on CRC outcomes, and to the best of our knowledge, none has determined whether the effect of segregation on CRC mortality among Black and White residents varies by rurality. Here, we used the Mississippi Delta Region as a frame of reference, given its history of racial segregation, combination of rural and urban counties, and highest incidence of CRC mortality of any hotspot in the United States (2). We found that urban counties with low and high levels of racial segregation had higher rates of CRC mortality among Black residents than moderately segregated urban counties. This relationship was less pronounced in rural counties. Furthermore, segregation was not a significant factor in CRC mortality among White residents in urban or rural counties. Our findings suggest that segregation affects White and Black residents differently, especially in rural areas. Future research should examine individual-level factors that may help explain this rural–urban disparity. Collectively, these findings can help inform community-engaged evidence-based practices to reduce CRC cancer burden in rural segregated areas.

Acknowledgments

Dr Lewis-Thames is supported by a Northwestern University Clinical and Translational Sciences Institute grant (UL1TR001422) and the Respiratory Health Association of Metropolitan Chicago (RHA2020-01). Dr. James receives support from the Siteman Cancer Center and the Foundation for Barnes Jewish Hospital. No copyrighted materials were used in this article.

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Tables

Table 1. Average Colorectal Cancer Mortality Rates and Aggregate Sociodemographic Characteristics for Mississippi Delta Region Counties, by Rural–Urban[a] Designation and Race, 1999–2018

Variable	Mean (SD)			
	Black Residents		White Residents	
	Rural	Urban	Rural	Urban
County population with <$20,000 in annual household income, %[b]	42.4 (21.7)	37.6 (10.4)	24.4 (4.5)	18.5 (4.9)
County population with <high school education, %[b]	28.8 (14.3)	23.5 (7.0)	17.6 (4.2)	13.9 (4.6)
County population living in a residence with >1 occupant per room, %[b]	2.9 (3.1)	4.6 (3.2)	1.7 (1.1)	1.8 (1.0)
County population that is Black or White, %[b]	27.5 (24.7)	32.0 (19.2)	72.5 (24.7)	68.0 (19.2)
County-level residential racial segregation[b,c]	0.5 (0.2)	0.5 (0.1)	—	—
Colorectal cancer mortality per 100,000[d]	25.6 (6.2)	21.0 (7.0)	27.5 (6.1)	21.7 (5.3)

[a] Determined by using 2013 rural-urban continuum codes (RUCCs) from the US Department of Agriculture (22). RUCCs range from 1 (counties in metropolitan areas with populations >1,000,000) to 9 (ie, completely rural or an urban population >2,500, not adjacent to a metropolitan area). All RUCCs dichotomized to indicate urban (RUCCs 1 to 3) or rural (RUCCs 4 to 9).
[b] Data source: US Census Bureau (20).
[c] Measured by the multilevel index of dissimilarity, which measures the spatial clustering of segregation in a county and is not specific to 1 racial group; it can range from 0 (no segregation) to 1 (total segregation) (19).
[d] Data source: National Cancer Institute (18).

Table 2. Factors Associated With Colorectal Cancer Mortality Rates Among Black Residents and White Residents in Counties in the Mississippi Delta Region, 1999–2018[a]

Variable	Models for Black Residents				Models for White Residents			
	Rural		Urban		Rural		Urban	
	b (SE)	*P* Value	b (SE)	*P* Value	b (SE)	*P* Value	b (SE)	*P* Value
Fixed intercept	24.84 (11.31)	.03	50.35 (17.05)	<.001	31.43 (4.64)	<.001	12.18 (10.77)	.26
Proportion of racial group in a county with <$20,000 in annual household income[a]	5.39 (9.09)	.55	−3.52 (10.83)	.75	19.44 (9.39)	.04	29.01 (13.90)	.04
Proportion of racial group in a county with <high school education[a]	−0.90 (9.41)	.92	46.88 (15.66)	<.01	8.96 (9.88)	.36	34.58 (15.92)	.03
Proportion of racial group living in a residence with >1 occupant per room (ie, overcrowding)[a]	−41.29 (26.74)	.12	−9.69 (36.77)	.79	−47.75 (35.33)	.18	14.03 (56.31)	.80
Population proportion[b]	5.78 (3.22)	.07	−2.66 (4.72)	.57	−19.43 (2.49)	<.001	−12.29 (3.06)	<.001
Residential segregation[a,c]	−10.97 (43.27)	.80	−158.99 (66.82)	.02	8.05 (13.42)	.55	23.81 (41.71)	.57
Segregation × segregation	12.47 (46.62)	.79	162.78 (64.83)	.01	1.96 (12.06)	.87	−14.61 (39.99)	.72
Random intercept	3.65 (4.09)	—	5.46 (6.90)	—	11.78 (7.01)	—	2.73 (3.08)	—

[a] Data source: US Census Bureau (20).
[b] Black population proportion for the Black model; White population proportion for the White model.
[c] Measured by the multilevel index of dissimilarity, which measures the spatial clustering of segregation in a county and is not specific to 1 racial group; it can range from 0 (no segregation) to 1 (total segregation) (19).

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 18, E90 SEPTEMBER 2021

ORIGINAL RESEARCH

Effects of Neighborhood Ethnic Density and Psychosocial Factors on Colorectal Cancer Screening Behavior Among Asian American Adults, Greater Philadelphia and New Jersey, United States, 2014–2019

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Accessible Version: www.cdc.gov/pcd/issues/2021/21_0062.htm

Suggested citation for this article: Bhimla A, Mann-Barnes T, Park H, Yeh MC, Do P, Aczon F, et al. Effects of Neighborhood Ethnic Density and Psychosocial Factors on Colorectal Cancer Screening Behavior Among Asian American Adults, Greater Philadelphia and New Jersey, United States, 2014–2019. Prev Chronic Dis 2021;18:210062. DOI: https://doi.org/10.5888/pcd18.210062.

PEER REVIEWED

Summary

What is already known on this topic?

Neighborhood ethnic density and composition may play a critical role in individual health behaviors, attitudes, and outcomes related to colorectal cancer (CRC).

What is added by this report?

Few studies have been conducted to understand whether CRC screening behavior is affected by ethnic density in Asian American neighborhoods. We examined how the neighborhood environment, specifically ethnic composition and the interplay with psychosocial factors, influences CRC screening among Asian American adults.

What are the implications for public health practice?

Cultural and environmental characteristics of ethnically dense neighborhoods should be considered to understand cancer risk behaviors and to develop future screening interventions.

Abstract

Introduction

We examined how neighborhood ethnic composition influences colorectal cancer (CRC) screening behavior in Asian American adults and explored whether associations between psychosocial predictors, including knowledge, self-efficacy, and barriers affecting CRC screening behavior, varied by level of neighborhood ethnic composition.

Methods

Filipino, Korean, and Vietnamese Americans (N = 1,158) aged 50 years or older were included in the study. Psychosocial factors associated with CRC screening, CRC screening behavior, and sociodemographic characteristics were extracted from participants' data. Neighborhood ethnic composition was characterized as the census-tract–level percentage of Asian residents. Participants' addresses were geocoded to the census tract level to determine whether they resided in an ethnically dense neighborhood. Multilevel logistic regression models were run with and without interaction terms.

Results

In mixed-effects logistic regression model 1, residing in an ethnically dense neighborhood was associated with lower odds of CRC screening (odds ratio [OR] = 0.65; 95% CI, 0.45–0.93; $P = .02$) after controlling for age, sex, education, ethnic group, and neighborhood socioeconomic status. Greater perceived barriers to CRC screening (OR = 0.62; 95% CI, 0.50–0.77; $P < .001$) resulted in significantly lower odds of obtaining a CRC screening, while higher self-efficacy (OR = 1.17, 95% CI, 1.11–1.23, $P < .001$) was associated with higher odds. In model 2, among those residing in a

high ethnic density neighborhood, greater barriers to screening were associated with lower odds of having obtained a CRC screening (OR = 0.53; 95% CI, 0.30–0.96; $P = .04$).

Conclusion

We found that residing in an ethnically dense neighborhood indicated higher disparities in obtaining CRC screenings. Future studies should examine socioeconomic and cultural disparities, as well as disparities in the built environment, that are characteristic of ethnically dense neighborhoods and assess the impact of these disparities on CRC screening behaviors.

Introduction

Colorectal cancer (CRC) is consistently one of the most commonly diagnosed cancers among Asian American adults (1). Although the US population has experienced a decline in CRC incidence, national-level data indicate sharp rises in CRC incidence among Asian American subgroups, specifically Korean and Vietnamese American individuals, as well as among Filipina women (2,3). CRC prevalence varies within populations due to a range of influences, including but not limited to heritable, environmental, behavioral, and dietary factors (4). Literature suggests that obesity, smoking, alcohol use, and minimal physical activity are modifiable risk factors significantly associated with CRC diagnosis (1).

Obtaining regular CRC screenings and early detection reduce the risk of negative outcomes associated with CRC, including late-stage diagnosis and death (5). Existing literature has shown disparities in CRC screening rates between Asian American and non-Hispanic White people (6–8). Recent screening statistics in the National Health Interview Survey indicated that Asian American adults had the lowest fecal occult blood test, colonoscopy, and sigmoidoscopy screening rates among all racial and ethnic minority groups, at 49%, compared with 65% for non-Hispanic White and 62% for Black/African American people (5). Observed CRC screening rates are low among all Asian American ethnic groups. However, the lowest screening rates were observed among Korean Americans (7). In a systematic review, only 25% to 50% of Korean Americans had received a CRC screening, in comparison to other Asian groups and non-Hispanic White people (9). Several physical and psychosocial barriers to CRC screening are faced by Asian American adults, including low levels of English proficiency, low health literacy, and lack of access to care (6,7,10–12).

Throughout the US, urbanization, migration, and immigration have contributed to population diversity and to racial and ethnic diversity in rural, urban, and suburban communities (13). The number of Asian neighborhoods in the US increased from 412 to more than 3,000 from 1980 to 2010 (14). Asian neighborhoods consist of ethnic urban enclaves and ethnoburbs in urban and suburban areas, respectively, which have varying socioeconomic conditions (14). Among Asian subgroups, Vietnamese, Filipino, and Korean communities tend to live in ethnically dense enclaves and ethnoburbs, which can strongly influence behavioral, social, psychological, and health-seeking behaviors within and across these communities (13,15). Filipino, Vietnamese, and Korean people comprise the third, fourth, and fifth largest Asian racial groups in the US, respectively (16). New Jersey has the fourth-highest population of Asian American people of all states, and Philadelphia has the tenth-highest population of Asian American people of all US cities (17). These geographical areas have hosted immigrant enclaves, such as Little Saigon, Little Manila, Koreatown, and other Asian ethnic enclaves, with ethnic enclave areas traditionally hosting recent immigrants. Ethnoburbs serve as suburbanized areas with slightly higher socioeconomic status and stability in comparison with urban ethnic enclaves (14).

Ethnic density, defined as the proportion of racial and ethnic minority residents in a specific area, is associated with social networks and social support within communities, factors that may contribute to health-seeking behaviors (18). The ethnic density effect denotes that residents of areas with higher proportions of people from one's own racial and ethnic group adopt healthier behaviors (18). Data on the protective effects of neighborhood ethnic density and health outcomes such as smoking, body mass index, and preterm birth (18) are mixed, with studies mainly reporting a lack of association. Few studies have assessed the effects of neighborhood ethnic density and ethnic enclaves on cancer screening behaviors among Asian American subgroups, including Vietnamese, Filipino, and Korean American. In a review by Fang and Tseng, a general inverse association was found in Asian neighborhoods between ethnic density and noninfectious cancer (eg, colorectal, breast) incidence, and a positive association was found between ethnic density and infectious cancer (eg, cervical, liver) incidence (13). Ethnic density may play a critical role in individual health behaviors, attitudes, and outcomes related to CRC and CRC screening procedures, such as colonoscopy and blood stool tests (13,19,20). Although no available literature is available specific to Asian American people and their subgroups on cancer screening behaviors, a recent study in Philadelphia found that high ethnic density and geographic segregation were associated with lower CRC screening rates in Black communities (21).

The summation of psychosocial factors such as social support, knowledge, social influence, health beliefs, and cultural norms that influence CRC screening initiation and long-term screening adherence may cause residents of ethnically dense communities with foreign-born and US-born Asian American populations to experience nuanced barriers to CRC screening (10,22). Considering the

wide variability in previous research findings and lack of research that focuses exclusively on the experiences of Asian American people, we aimed to fill this gap in the literature and further examine the effects of ethnic density on CRC screening behaviors in Asian American populations in Philadelphia County, Pennsylvania, and in New Jersey. We also explored whether the associations between psychosocial predictors varied by level of ethnic density.

Methods

Study design and population

This cross-sectional study included participants who were part of a clustered randomized intervention to increase CRC screening in the community. We used a community-based participatory research approach aiming to explore the impact of multilevel factors on CRC screening in a sample of Filipino, Korean, and Vietnamese American adults in the Greater Philadelphia and New Jersey areas. The study had 1,158 participants aged 50 years or older from the 3 Asian American subgroups residing in Philadelphia County and New Jersey. Participants were recruited from 48 community-based organizations (CBOs) located in the Greater Philadelphia region and southern and eastern New Jersey. CBO sites consisted of religious churches and temples, adult and senior centers, and ethnic-based community centers. Data were collected from July 2014 through March 2019.

Study participants completed a paper-based survey at baseline. The baseline survey included sociodemographic information, psychosocial predictors of CRC screening, lifestyle factors, and CRC screening history. Data on neighborhood characteristics were obtained from the 2010 US Census and the American Community Survey (ACS). Participants' residential baseline addresses were geocoded to longitude and latitude coordinates using street centerline data to pinpoint the addresses in GIS (geographic information systems). Participants' locations were joined with census tracts and neighborhood characteristics. A total of 86 participants' addresses from New Jersey and 13 participants' addresses from Philadelphia were incomplete and could not be geocoded; these were excluded from the study, leaving 1,158 participants. Participants belonged to 299 unique census tracts from the Philadelphia County and New Jersey regions.

Measures

Neighborhood characteristics

Data on ethnic density were obtained from ACS 2017 estimates and were measured by the ethnic composition of neighborhoods by obtaining the proportion of Asian American adults residing within each census tract. The density was divided into high and low, with a cut-off of the 75th percentile or above indicating high and a cut-off below the 75th percentile indicating low. Using the 75th percentile cutoff point (22.2%), 76.3% (n = 884) of the total Asian population was considered to be living in a neighborhood with low ethnic density, while the rest, 23.7% (n = 274), was considered to be living in a neighborhood with high ethnic density. Figure 1 displays the ethnic composition of neighborhoods and geographic distribution of study participants in Philadelphia County and New Jersey census tracts.

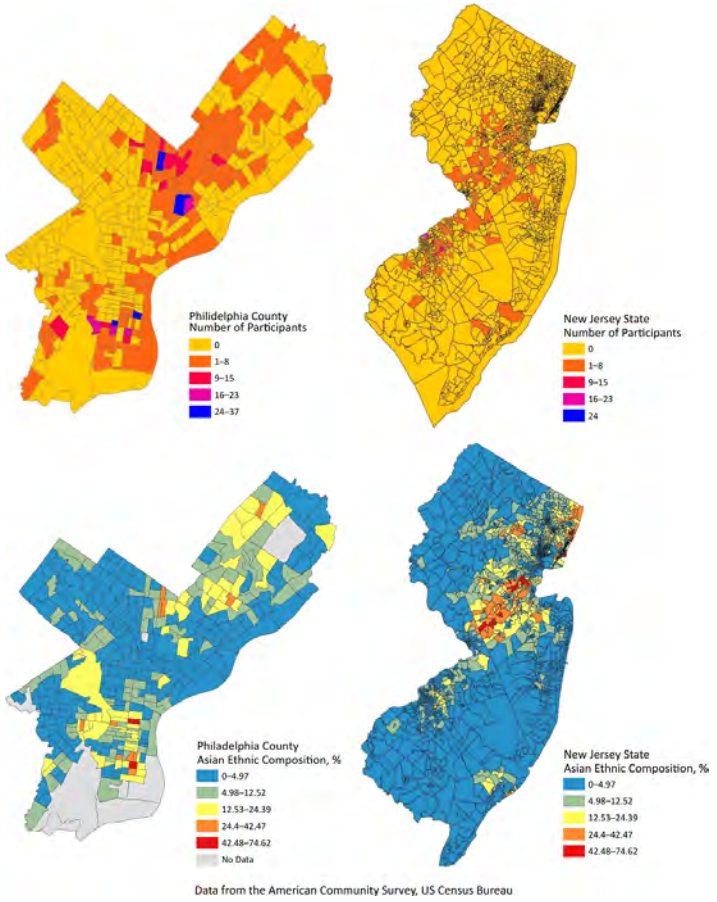

Figure 1. Asian ethnic composition in Philadelphia County and New Jersey census tracts. Data from the American Community Survey, US Census Bureau.

Neighborhood socioeconomic status (nSES) was assessed by obtaining 2017 ACS data on mean household income at the census tract level (23). Mean household income was included as a covariate in the model and was presented as a continuous variable.

Psychosocial factors

Participant's perceived psychosocial and physical barriers to CRC screening were evaluated based on the following question: "What

are the major barriers you have ever faced to obtaining a stool blood test, sigmoidoscopy, or colonoscopy?" The 3 response options were "I don't know what it is," "I feel healthy and do not need a sigmoidoscopy or colonoscopy," and "I have no insurance and cannot afford it." Each barrier was measured as 1 point, and the points were summed to obtain a barrier score (range, 0–3).

Participants were asked about their self-efficacy toward CRC screening, including whether they were confident in obtaining a screening, were able to manage emotional distress if they received a CRC diagnosis, were able to obtain information about CRC, and felt comfortable speaking to their doctor about CRC. Scores were determined using a Likert scale (0 = low self-efficacy to 10 = very high self-efficacy).

Participants' knowledge of CRC was assessed by asking whether the following were risk factors for CRC: age, diet, family, personal history of bowel disease or CRC, sedentary lifestyle, and smoking/drinking alcohol. A response of yes was coded as 1 and a response of no was coded as 0. Scores were summed to obtain a total knowledge score (range, 0–6).

The following self-reported sociodemographic factors were collected at the individual level: sex (female, male), age, Asian origin group (Filipino, Korean, Vietnamese), education level (no education or elementary school, below high school graduate, high school graduate, some university or college), and insurance status (yes, no).

Outcomes

The primary outcome was individual uptake of any CRC screening modality. This measure was determined by the individual response to questions about the participant's history of obtaining a colonoscopy or fecal occult blood test (FOBT)/fecal immunochemical test (FIT). An individual was deemed to have prior screening if he or she responded with yes to either of the screening modalities assessed with our questionnaire. A new variable was generated to reflect this convention for determining any prior CRC screening with yes being coded as 1 and no being coded as 0.

Data analysis

Descriptive, bivariate analyses (ANOVA, analysis of variance) and logistic regression were conducted with sociodemographic, psychosocial, and neighborhood predictors. Sociodemographic variables, such as sex, Asian origin group, education, and insurance, were compared between high and low ethnic densities against CRC screening history by using bivariate analyses. These variables were further examined against the 3 psychosocial variables (barriers, knowledge, self-efficacy scores) using one-way ANOVA. Multilevel logistic regression models were used to estimate the β coefficients, odds ratios (ORs), and 95% CIs for examining neighborhood predictors of CRC screening, with a random effect for each census tract to account for the clustering of individuals (level 1) residing within neighborhoods (level 2). The multilevel logistic regression models were adjusted for sex, age, education, Asian origin group, and nSES. Model 1 presents the association between ethnic density, psychosocial predictors, and CRC screening, and model 2 presents the interaction effects between high and low ethnic density for psychosocial predictors on CRC screening history. Statistical analyses were conducted using Stata 16 (StataCorp LLC).

Results

Descriptive statistics of participants

The mean age of participants was 66.5 (SD, 10.0) years, and 59% (n = 678) of participants were female (Table 1). Among all participants, slightly more than half (57%, n = 655) were from the Vietnamese community, while 38% (n = 441) reported being from the Korean community and 5% (n = 62) reported being from the Filipino community. Approximately half (55%, n = 643) of participants identified zero barriers in access to medical care, while 35% (n = 400) identified 1 barrier, 8% (n = 93) identified 2 barriers, and 2% (n = 22) identified 3 barriers. The nSES measured by mean family income of the study sample was $75,143. The mean score of participant barrier knowledge was 0.56 (SD, 0.72), mean score of CRC knowledge was 1.55 (SD, 1.31), and self-efficacy was 6.38 (SD, 3.33. Overall, 31% (n = 355) reported having any CRC screening history (colonoscopy or blood stool test).

Bivariate assessment of potential confounders

Asian origin group and education were identified as potential confounders through binomial regression. We found significant differences among the 3 communities (Vietnamese, Korean, Filipino) in knowledge scores ($F_{1,1156} = 89.61$, $P < .001$) and in self-efficacy scores ($F_{1,1156} = 163.1$, $P < .001$). We found significant differences among the 3 education levels (below high school graduate, high school graduate, university or some college) in barrier scores ($F_{3,1120} = 9.618$, $P < .001$), and in self-efficacy scores ($F_{3,1120} = 4.005$, $P = .008$).

Regression analyses with predictors and moderators associated with CRC

After adjusting for Asian origin group, education, age, sex, and nSES, results showed that Asian American adults (n = 1,158 after adjusting for missing data) who lived in a neighborhood with high Asian ethnic density had significantly lower odds of having completed CRC screening (OR = 0.65; 95% CI, 0.45–0.93; $P = .02$)

(Table 2). A significant association was also observed between CRC screening behavior and participant barrier scores. For each 1-unit increase in barrier score, the odds of CRC screening completion were reduced by 38% (OR = 0.62; 95% CI, 0.50–0.77, $P <$ .001). In other words, the higher the barrier score, the less likely that participants had completed screening. Although not significant, a 1-unit increase in knowledge score was associated with 1.09 times greater odds of CRC screening completion (95% CI, 0.97–1.23; $P = .14$). For every 1-unit increase in self-efficacy score, the odds of CRC screening completion increased 1.17 times (95% CI, 1.11–1.23; $P < .001$). A 1-unit increase in age (OR = 1.02; 95% CI, 1.01–1.04; $P = .005$) was associated with a greater likelihood of CRC screening, while not graduating from high school (OR = 0.44; 95% CI, 0.24–0.81; $P = .009$), being Vietnamese (OR = 0.18; 95% CI, 0.12–0.27; $P < .001$), and being Filipino (OR = 0.40; 95% CI, 0.21–0.75; $P = .005$) were associated with a lower odds of CRC screening.

Multiple logistic regression analyses after adjustment for Asian origin group, education, age, sex, and nSES were performed to assess interaction effects between high and low ethnic density for psychosocial predictors on CRC screening history. Ethnic density did not moderate the relationship between knowledge (OR = 1.15; 95% CI, 0.86–1.54; $P = .35$) or self-efficacy (OR = 1.06; 95% CI, 0.93–1.19; $P = .40$) and colorectal cancer screening behavior (Table 2).

The effect of neighborhood ethnic density on CRC screening history was significantly dependent on an individual's barrier score (OR = 0.53; 95% CI, 0.30–0.96; $P = .04$). CRC screening completion rates were similar when no barriers were identified (Figure 2). However, the more barriers that an individual identified, the more that living in a high ethnic density neighborhood negatively affected CRC screening completion.

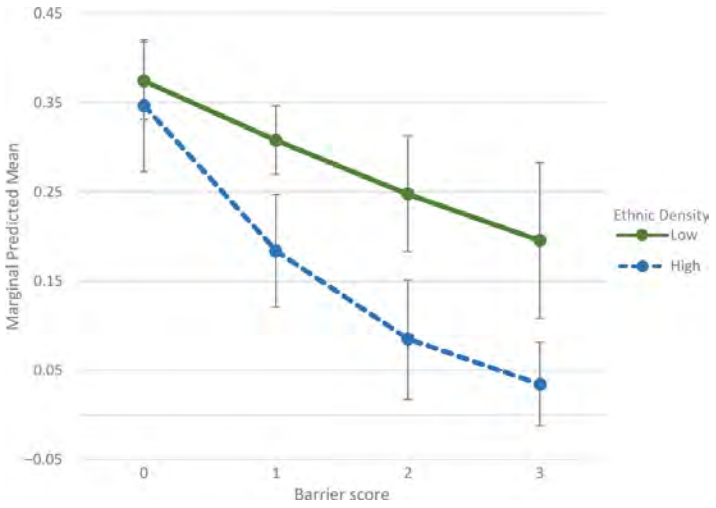

Figure 2. Interaction effects of high ethnic density and low ethnic density groups for barrier score on colorectal cancer (CRC) screening behavior. Three perceived barriers to CRC screening were assessed, each totaling 1 point, and summed to produce the barrier score (range, 1–3). Error bars represent 95% CIs.

Discussion

We aimed to determine the relationship between ethnic density and CRC screening among a sample of Asian individuals residing in Philadelphia and New Jersey. We found that residing in an ethnically dense Asian neighborhood was associated with negative CRC screening history without interaction terms introduced into the model. Asian American adults living in ethnically dense neighborhoods had 35% lower odds of being screened compared with those living in lower ethnic density neighborhoods when controlling for nSES. When barrier score was added as an interaction term in model 2, we found a significant effect of ethnic density on CRC screening, depending on an individual's barrier score. When participants reported having no barriers at all, the odds for CRC screening completion in both low and high ethnic density groups were similar (0.35). However, the more barriers an individual identified, the more that living in an ethnically dense neighborhood negatively affected screening completion. These observations indicate that a dose–response effect may be present, with this psychosocial factor playing a moderating role. For instance, in high ethnic density neighborhoods, an individual who reported the maximum number of barriers had screening odds of 0.05. On the other hand, in low ethnic density neighborhoods, an individual reporting the same barriers had much higher odds of CRC screening at 0.25.

Cultural factors, such as cultural norms and beliefs, may be pertinent to ethnically dense neighborhoods and may comprise the

mechanism at play (13). For example, individual barriers related to screening consisted of a lack of insurance, knowledge, and perceived health regarding CRC, all of which may be affected by cultural factors. More specifically, cultural beliefs surrounding screening, such as traditional beliefs regarding fatalism, have been reported to have adverse effects on health behaviors and have been linked to a lower adherence to screening in ethnic minority communities (8,13,24). Stigma, fatalism, and negative cultural attitudes toward cancer reinforce pre-existing barriers to screening. Further, literature suggests that there are intergenerational differences in observed cancer screening behaviors, influenced by the length of residence in the US and level of acculturation or adjustment (25). Ultimately, these systemic and social factors affect CRC screening intention and behavior, offering a sociopolitical explanation to our study results. Furthermore, individuals from ethnically dense communities are more likely to be underinsured or lack access to insurance (13). The interplay of structural barriers to screening, cultural norms, and residing in ethnically dense neighborhoods calls for efforts to better identify cultural factors to promote CRC screening. A need also exists to distinguish between ethnoburbs and ethnic enclaves to provide a greater understanding of potential moderating effects on CRC screening.

Ethnic density and ethnic neighborhood composition are associated with long-term health outcomes, access to care, and cancer screening behaviors (1). Cultural and socioeconomic factors are inextricably linked to long-term access to care, social determinants of health, and health outcomes among ethnic minorities. Although no previous research has specifically investigated the effect of ethnic density on CRC screening, studies have found that living in ethnically dense Asian or immigrant neighborhoods is associated with greater odds of late-stage CRC diagnoses and that this in turn is closely related to reduced CRC screening (26,27). Albeit a different racial group, a recent study conducted in Philadelphia found that high racial density was associated with lower rates of CRC screening in Black participants (21).

Our data suggest that Asian American adults living in ethnically dense communities are statistically less likely to have completed CRC screening. Among the Korean, Vietnamese, and Filipino American participants in our study, the CRC screening completion rate was 32%. In 2016, self-reported rates of CRC screening in the general population were 62% in Philadelphia and 65% in New Jersey (28,29). In our study, Korean American adults had the highest proportional rate of CRC screening, at 49%, compared with 47% in Filipino and 22% in Vietnamese communities. In the regression models, we found differences in the screening odds between Vietnamese, Filipino, and Korean American subgroups; compared with Korean American adults, Vietnamese American adults and Filipino American adults were 82% and 60% less likely to have completed CRC screenings, respectively. Our findings are contrary to those of other studies, such as those conducted by Hwang (30) and Juon et al (31), which found that Korean Americans had the lowest rates for screening among Asian American subgroups, specifically in the Baltimore–Washington Metropolitan area. Although the authors attributed the level of education and knowledge to such differences, the implications require confirmation through epidemiologic studies that are specifically designed to study differences between Asian American subgroups.

Strengths and limitations

This study was among the first to examine interactions between psychosocial factors and ethnic density as predictors of CRC screening in Asian American subgroups. We used primary data collected from neighborhoods representing immigrant communities. Given that this survey was administered in multiple languages, we were able to capture non–English-speaking participants. This study has several limitations. We collected data from a convenience sample of Asian American adults residing in Philadelphia County and the state of New Jersey, so the findings may not be generalizable to a population-based, randomized stratified sample of all Asian American populations within the observed geographic area. Therefore, our findings should be interpreted with consideration of local social and cultural contexts. In addition, our study did not include several Asian American subgroups, such as Chinese, Cambodian, Indian, and Indonesian Americans, that also account for the total Asian American population in the area of interest; also, we did not include nativity as a variable in the analysis. Moreover, ethnic density measured by using census tracts may not exactly correspond to individuals' perceived boundaries and perceptions of their neighborhood, and CRC screening completion does not necessarily indicate one's adherence to national CRC screening guidelines. Lastly, our study relied on self-reported data, including CRC screening history, which can be subject to recall and social desirability bias.

Future research recommendations

Disaggregating data to identify specific barriers, needs, and norms through an intercommunal and an intrapersonal lens is a critical need. Immigration data suggest that although Chinese American people make up a large portion of Asian people in the US, there is still in-group heterogeneity that influences education, socioeconomic status, and occupation (32). In-group heterogeneity is also observed among Asian sub-ethnic groups, including but not limited to Korean, Filipino, and Vietnamese American people (32). In accordance with class assimilation theory, individual social opportunity and development drives divergence from temporary reliance on the ethnic enclave or community for support (32).

In our analysis, we observed a relationship between high ethnic density in Asian American populations and negative CRC screening behaviors. It is imperative that future studies and interventions further assess intracommunity beliefs to identify differences in generational cohorts, socioeconomic status, and degree of assimilation within each subethnic group. Future studies could assess ethnic enclaves using mixed-methods research to identify these characteristics. Our study findings support the development of personalized and culturally informed CRC interventions that focus on ethnically dense neighborhoods as a study population.

Acknowledgments

This research project was supported by grant no. R01 MD010627 (principal investigator: Grace X. Ma, PhD) of the National Institute on Minority Health and Health Disparities (NIMHD) of the National Institutes of Health (NIH) and partially supported by grant no. U54 CA221704(5) funded by the National Cancer Institute (NCI) of NIH (contact principal investigators: Grace X. Ma, PhD, and Olorunseun O. Ogunwobi, MD, PhD). The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of NIMHD, NCI, or NIH. No copyrighted materials or tools were used in this research.

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Tables

Table 1. Sociodemographic and Psychosocial Characteristics of Participants, by Ethnic Density, Study of the Effects of Neighborhood Ethnic Density and Psychosocial Factors on Colorectal Cancer Screening Behavior Among Asian American Adults (N = 1,158), Greater Philadelphia and New Jersey Areas, United States, 2014–2019[a]

Variable	Low Ethnic Density (≤22%)	High Ethnic Density (>23%)	Overall
Mean barrier score (range, 0–3)[b] (SD)	0.56 (0.71)	0.57 (0.74)	0.56 (0.72)
Mean knowledge score (range, 0–6)[c] (SD)	1.55 (1.30)	1.55 (1.33)	1.55 (1.31)
Mean self-efficacy score (range, 0–10)[d] (SD)	6.45 (3.30)	6.16 (3.40)	6.38 (3.33)
Neighborhood SES, mean income (SD), $	74,165 (41,403)	78,297 (52,940)	75,143 (44,414)
Age, mean (SD), y	66.4 (10.0)	66.8 (9.7)	66.5 (10.0)
Sex			
Female	522 (59.3)	156 (57.1)	678 (58.8)
Male	357 (40.6)	117 (42.9)	474 (41.2)
Asian origin group			
Korean	325 (36.8)	116 (42.3)	441 (38.1)
Vietnamese	501 (56.7)	154 (56.2)	655 (56.5)
Filipino	58 (6.6)	4 (1.5)	62 (5.4)
Education			
No education or elementary school	121 (14.2)	33 (12.3)	154 (13.7)
Below high school graduate	109 (12.8)	35 (13.0)	144 (12.8)
High school graduate	323 (37.8)	102 (37.9)	425 (37.8)
University or some college	302 (35.3)	99 (36.8)	401 (35.7)
Insurance			
Yes	627 (76.6)	191 (74.0)	818 (76.0)
No	191 (23.4)	67 (26.0)	258 (24.0)
CRC screening history (colonoscopy or FOBT/FIT)			
Yes	284 (34.1)	71 (27.2)	355 (32.4)
No	549 (65.9)	190 (72.8)	739 (67.6)

Abbreviations: CRC, colorectal cancer; FOBT/FIT, fecal occult blood test/fecal immunochemical test; SES, socioeconomic status.

[a] Values are no. (%) unless otherwise indicated.

[b] Barriers to CRC screening were assessed with the following question: "What are the major barriers you have ever faced to obtaining a stool blood test, sigmoidoscopy, or colonoscopy?" The 3 response options were "I don't know what it is," "I feel healthy and do not need a sigmoidoscopy or colonoscopy," and "I have no insurance and cannot afford it." Each barrier was measured as 1 point, and scores were summed to obtain a total barriers score (range, 0–3).

[c] Participants were asked whether the following were risk factors for CRC: age, diet, family, personal history of bowel disease or CRC, sedentary lifestyle, and smoking/drinking alcohol. A response of yes was coded as 1 and a response of no was coded as 0. Scores were summed to obtain a total knowledge score (range, 0–6).

[d] Participants' self-efficacy was assessed with the following measures: whether they were confident in obtaining a screening, whether they were able to manage emotional distress if they received a CRC diagnosis, whether they were able to obtain information about CRC, and whether they felt comfortable speaking to their doctor about CRC. Scores were determined using a Likert scale (0 = low self-efficacy to 10 = very high self-efficacy).

Table 2. Mixed-Effects Logistic Regression, With Psychosocial Predictors and Interaction Terms, in Predicting CRC Screening Among Asian American Adults (N = 1,158), Greater Philadelphia and New Jersey Areas, United States, 2014–2019

Variable	Model 1[a]		Model 2[b]	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
High ethnic density (reference group, low)	0.65 (0.45–0.93)	.02	0.33 (0.08–1.29)	.11
Neighborhood mean income	1.00 (0.99–1.00)	.98	0.99 (0.99–1.00)	.65
Barrier score	0.62 (0.50–0.77)	<.001	0.70 (0.55–0.90)	.004
Knowledge score	1.09 (0.97–1.23)	.14	1.07 (0.94–1.21)	.34
Self-efficacy score	1.17 (1.11–1.23)	<.001	1.16 (1.10–1.23)	<.001
Age	1.02 (1.01–1.04)	.005	1.02 (1.01–1.04)	.004
Male sex (reference group, female)	1.06 (0.70–1.27)	.71	1.05 (0.77–1.41)	.77
Education (reference group, below elementary)				
Below high school graduate	0.44 (0.24–0.81)	.009	0.44 (0.24–0.82)	.009
High school graduate	0.75 (0.48–1.19)	.22	0.75 (0.48–1.20)	.23
University or some college	0.86 (0.52–1.44)	.58	0.86 (0.51–1.46)	.58
Asian origin group (reference group, Korean)				
Vietnamese	0.18 (0.12–0.27)	<.001	0.18 (0.12–0.27)	<.001
Filipino	0.40 (0.21–0.75)	.005	0.41 (0.22–0.78)	.006
Ethnic density*barrier score	—	—	0.53 (0.30–0.96)	.04
Ethnic density*knowledge score	—	—	1.15 (0.86–1.54)	.35
Ethnic density*self-efficacy score	—	—	1.06 (0.93–1.19)	.40

Abbreviations: —, not assessed; nSES, neighborhood socioeconomic status.
[a] Model 1 variables: ethnic density, nSES, barriers, knowledge, self-efficacy, age, sex, education, Asian origin group.
[b] Model 2 variables: ethnic density, nSES, barriers, knowledge, self-efficacy, age, sex, education, Asian origin group, ethnic density*barrier, ethnic density*knowledge, ethnic density*self-efficacy.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 18, E20 MARCH 2021

ORIGINAL RESEARCH

Spatial Insights for Understanding Colorectal Cancer Screening in Disproportionately Affected Populations, Central Texas, 2019

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Accessible Version: www.cdc.gov/pcd/issues/2021/20_0362.htm

Suggested citation for this article: Zhan FB, Morshed N, Kluz N, Candelaria B, Baykal-Caglar E, Khurshid A, et al. Spatial Insights for Understanding Colorectal Cancer Screening in Disproportionately Affected Populations, Central Texas, 2019. Prev Chronic Dis 2021;18:200362. DOI: https://doi.org/10.5888/pcd18.200362.

PEER REVIEWED

Summary

What is already known on this topic?

Not much is known about factors associated with colorectal cancer screening rates among low-income populations.

What is added by this report?

Based on geocoded patient-level data in Central Texas, a large urban safety-net health system, our study suggests that patients residing less than 20 miles from primary care and screening facilities who regularly visit a primary care physician and have health insurance are positively associated with high rates of screening uptake.

What are the implications for public health practice?

Programs that are focused on increasing colorectal cancer screening among low-income populations can be more effective by providing assistance, such as mailed stool testing, to patients who live far from primary care and screening facilities and to those who do not regularly visit a primary care physician.

Abstract

Introduction

Colorectal cancer (CRC) screening can reduce morbidity and mortality; however, important disparities exist in CRC uptake. Our study examines the associations of distance to care and frequency of using primary care and screening.

Methods

To examine the distribution of screening geographically and according to several demographic features, we used individual patient-level data, dated September 30, 2018, from a large urban safety-net health system in Central Texas. We used spatial cluster analysis and logistic regression adjusted for age, race, sex, socioeconomic status, and health insurance status.

Results

We obtained screening status data for 13,079 age-eligible patients from the health system's electronic medical records. Of those eligible, 55.1% were female, and 55.9% identified as Hispanic. Mean age was 58.1 years. Patients residing more than 20 miles from one of the system's primary care clinics was associated with lower screening rates (odds ratio [OR], 0.63; 95% CI, 0.43−0.93). Patients with higher screening rates included those who had a greater number of primary care–related (nonspecialty) visits within 1 year (OR, 6.90; 95% CI, 6.04−7.88) and those who were part of the county-level medical assistance program (OR, 1.61; 95% CI, 1.40−1.84). Spatial analysis identified an area where the level of CRC screening was particularly low.

Conclusion

Distance to primary care and use of primary care were associated with screening. Priorities in targeted interventions should include identifying and inviting patients with limited care engagements.

Introduction

Colorectal cancer (CRC) screening is effective but underused, especially in medically underserved and disproportionately affected populations. Demographic factors and access to care variables are associated with screening (1–6). Although many factors are widely understood, including the importance of having health insurance and a regular source of care, the association between geography and cancer screening has been partially explored, and cancer

screening in urban environments has not been well described. Spatial insights from geographic associations might help promote greater understanding of how different factors affect CRC screening, particularly among populations that are highly affected and may be more challenged by geographic barriers because of limitations in transportation and other competing demands (7–10). As such, spatial insights might be used to enhance interventions designed to overcome screening barriers.

Spatial insights are patterns related to a set of location-based observations and factors associated with the patterns. Spatial insights may provide novel information beyond commonly measured predictors of screening, such as insurance status or race/ethnicity. Furthermore, insights into patterns and factors may provide actionable information at the patient level to directly support the enhancement and implementation of effective interventions. Our study aimed to provide insights and help enhance efforts focused on increasing CRC screening rates in underserved populations of a large urban safety-net health system in Central Texas. Our primary objective was to determine the factors that are significantly associated with up-to-date CRC screening. Our secondary objective was to identify geographic areas where screening levels of patients are significantly lower in this safety net-health system.

Methods

We used electronic health records, supplemented by additional geographic information, to examine CRC screening in an urban setting. The Office of Research Support and Compliance at the University of Texas at Austin and at Texas State University approved the institutional review board application for this study, and a waiver of informed consent was granted for the use of deidentified patient data (Box).

Box. Data Sets Used in Spatial Insights for Understanding Colorectal Cancer Screening, 2019

Data set	Source	Variables in analyses
CommUnityCare (CUC) patient data	Data Core, The University of Texas, Dell Medical School	Resident addresses Race Ethnicity Age Medical home Sex CRC screening status Date of screening Financial class Primary care physician Number of primary care–related visits in 1-year
CUC clinics	CUC Health Centers	Clinic names Clinic addresses
Census tract-level data	US Census Bureau	TIGER/Line Shapefiles
Road networks	Environmental Systems Research Institute (ESRI)	Shapefile

The study was conducted in a large urban county in Central Texas among patients of a large federally qualified health center (FQHC) system. The system had approximately 100 providers serving nearly 98,000 patients in 2018 and provided care at 21 clinics that year. Because we were interested in average-risk screening, we studied adults older than 49 as of September 30, 2018. We defined the CRC screening status of a patient as either screened or unscreened as of September 30, 2018, based on records of having a stool test within the previous year or a colonoscopy within the previous 10 years. We extracted these data from patient records. We used FQHC system databases to collect patient information on several demographic variables and used other relevant databases for the spatial analysis.

Health insurance status indicated sources of financial support for health care, such as Medicaid, Medicare, private insurance, the Medical Access Program (MAP), grants for health care, or unknown (information not available). The MAP is a local program in Travis County provided by Central Health that covers medical care for qualifying Travis County residents. Patients with MAP benefits have low incomes, are ineligible for or not enrolled in Medicare or Medicaid, and are not covered by private insurance. Medical home was defined as the clinic where the patient received primary care and point of contact for CRC screening. Typically, Dell Seton Medical Center (DSMC) was the only site where uninsured patients were referred for colonoscopies and was also the main site of referral for health-insured patients in this system.

The initial patient data set contained 27,285 records. We obtained geographic locations of individual patients, based on their residential addresses, through geocoding. The locations of the 21 medical homes of the CommUnityCare patients and the DSMC were also geocoded based on the addresses of these entities. We used the geocoding tool in ArcGIS (ESRI) to perform geocoding (11). Among the 27,285 records, 3,843 cases (14.1%) were excluded from geocoding because of incomplete, insufficient, or incorrect addresses during initial examination of the records. In addition, 1,519 cases (5.6%) could not be included in geocoding because of incomplete or incorrect addresses. Some patients were homeless and did not have addresses on file. A total of 21,923 CommUnityCare patients were geocoded to street level to produce the geo-

coded patient data set that yielded an overall geocoding rate of 80.4%. All coordinates used in the analysis were residence locations at street level, not at the zip code polygon or any other areal unit level.

We then prepared 2 data sets for analysis. Data set 1 contained the 21,923 patient records. This data set was used for spatial analysis and mapping. Data set 2 consisted of 13,079 patient records with complete aspatial and spatial data for all needed variables used in logistic regression analysis. Aspatial data is information that is not related to location. This second data set included data only for non-Hispanic White, Hispanic, and African American patients.

When preparing data set 2, we began with the 21,923 records of patients with geocoded residence locations and excluded 8,844 (40.3% of 21,923) records to obtain the 13,079 records. Among these 8,844 records, 5,388 (24.6% of 21,923) records did not have information needed to accurately determine the driving distances from the patient locations to their medical homes because some patients were served by mobile medical facilities, and information about mobile facilities was not available. We defined driving distance as the shortest distance between the patient residence and the location of the health care facility in question. A total of 2,593 patients (11.8%) either did not have complete information about race/ethnicity or were categorized into population groups other than White, Hispanic, or African American; 371 (1.7%) had no information about sex; 376 (1.7%) had no information on health insurance status, and 116 (0.5%) were older than 75.

Logistic regression analysis

We used logistic regression to examine how various individual and spatial factors were associated with up-to-date CRC screening. Other analyses were performed by using only aspatial variables to examine whether findings for the constrained population of 13,079 differed from those of the larger population of 27,285. Information is included to distinguish patients supported by the MAP or partially covered based on a sliding income scale. Logistic regression analysis was also performed using the larger data set. Results of these additional analyses confirmed results from the 13,079 data set.

Spatial cluster analysis

To achieve the second objective of our study, we used spatial cluster analysis to determine whether significant concentrations of patients existed without up-to-date CRC screening. We used SaTScan version 9.6 (SaTScan) to perform the cluster analysis. This tool is based on the Spatial Scan statistic developed by Kulldorff (12), initially distributed by the National Cancer Institute. To avoid statistical bias, we followed standard practice and used the maximum allowable cluster size covering 50% of the total patients in the study area (13). Maximum allowable cluster size avoids the use of a predetermined cluster size, and therefore, helps detect any cluster size smaller than an area covering up to about 50% of the geocoded patients in this study. We used the Poisson probability model and performed 3 separate cluster analyses using residence locations of each patient for all patients combined, Hispanic patients only, and African American patients only.

Results

Complete spatial and aspatial data were available for the analyses of the 13,079 patients. Among these patients, the overall up-to-date screening rate was 33.9%, and mean age was 58.1. Slightly more than one-half (55.1%) were female, and 56.0% identified as Hispanic, and most had MAP benefits. For the 27,285 patients in the initial patient data set, the overall up-to-date screening rate was 30.8%, and the rate among the 21,923 patients with geocoded residence locations was 32. 0%. Rates for other categories among the 27,285 patients and the 21,923 patients were similar. These categories include race/ethnicity, age group, sex, health insurance status, number of primary care–related visits in 1 year, spatial access to a medical home, and spatial access to the DSMC (Table 1).

Bivariate analysis

Distance of more than 20 miles to the offices of a primary care physician was negatively associated with CRC screening uptake (OR, 0.63; 95% CI, 0.43−0.93); we found similar results for distance to DSMC endoscopic services (OR, 0.80; 95% CI, 0.64−1.00). The number of primary care–related visits in 1 year was the strongest factor associated with up-to-date screening. Hispanic patients were more likely to be up to date than non-Hispanic White or African American patients, and women more likely to be screened than men. Patients aged 65 to 75 were more likely to keep up-to-date with screening than those aged 50 to 64. Patients supported financially by the county MAP or other grants had higher up-to-date screening rates, compared with those receiving benefits from Medicare, Medicaid, or private insurance (Table 2).

Multivariate analysis

Effects of residing more than 20 miles away from a patient's medical home or DSMC endoscopic services were no longer significant after adjustment for other variables. The association between up-to-date screening and each of the other variables was almost unchanged after adjustment. The number of primary care–related visits significantly influenced CRC screening, even after adjustment for race, ethnicity, age, sex, health insurance status, and spatial access to care (Table 3).

Geographic concentration of patients without up-to-date CRC screening

In the cluster analysis, only the clusters for all 21,923 patients combined were significant. We detected no significant clusters for either Hispanic patients or African American patients alone. For all patients combined, we found a cluster without up-to-date CRC screening that covered a large urban area located slightly toward the southwest part of urban Austin (Figure).

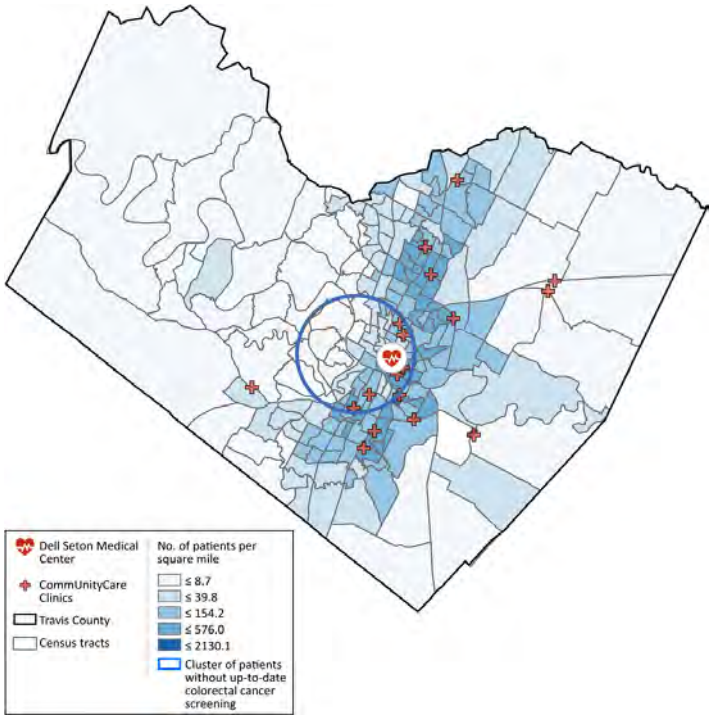

Figure. Medical facilities serving patients in Travis County, Texas and density of geocoded patients per square kilometer at the census tract level. A cluster shows levels of colorectal cancer screening was significantly lower, relative to patients from areas outside of the cluster but also served by the system of federally qualified health centers in the county. Radius of the circle is 4.0 miles.

The other significant cluster covered a smaller area southeast of the study area, where a correctional facility was located. Although the clusters associated with Hispanic and African American patients were not significant, they provided information about priority areas for interventions designed for these populations. Overall, the analysis identified areas for targeted intervention among the patients.

Discussion

In a population of patients served by a large FQHC system, we found that residing more than 20 miles of driving distance from a primary care clinic was associated with low screening rates, and having more primary care visits within 1 year was associated with higher rates in unadjusted analyses. Driving distance, however, was not associated with screening after we adjusted for all covariates. The number of primary care visits remained a key factor after multivariate adjustment, suggesting that both access and use of care are key factors that affect screening for patients in this system. Overall screening rates in the system were generally low, a finding similar for other FQHC systems (14–16). Interventions that seek to increase screening in ways that do not require in-person visits or extended travel, such as mailed stool testing programs, may be effective in overcoming barriers (4,5,17).

Spatial analysis identified an area where the level of CRC screening was particularly low among the study population. These findings suggest the importance of identifying cluster area variations, engaging patients and providers, and increasing access for those who reside far from sources of care. The identified cluster area provides information about specific, localized needs for a geographically targeted intervention; however, additional data and community-engaged research are needed to examine factors associated with lower, up-to-date screening rates.

A large body of literature is available about CRC prevention, CRC screening, late-stage diagnosis, cancer mortality, and disparities (17–26). Our search for this study, however, found only 2 studies in the United States that examined the association between CRC screening status and travel time to care (21,22). One study found no association between travel time and the likelihood of metastatic cancer in an insured population, but it did find an association between previous use of preventive care and the likelihood of metastatic cancer (21). The other study examined multiple factors associated with screening in patients at the Bellevue Hospital system in New York City. That study found no association between screening and travel time among patients who had at least one clinic visit; however, more primary care visits were positively associated with screening (22). In contrast, our study indicates that driving distance to care more than 20 miles is negatively associated with CRC screening uptake. We found that a large number of primary care visits within 1 year was significantly associated with a high rate of up-to-date CRC screening. This finding echoes the literature (21–24) and suggests that more primary care–related visits increase opportunities for screening.

Our study has several limitations. First, nearly 20% of the records in the original CommUnityCare patient database had either incomplete, insufficient, or incorrect address information, which that made it impossible to achieve a high rate of geocoding. Second, we had to exclude more than 40% of the geocoded patient records

in our logistic regression analysis involving both aspatial and spatial data because of incorrect or insufficient information. Results from the larger set of 27,285 patients, with only aspatial variables in the supplemental analyses, however, confirmed results reported in this study.

Third, many patients use public transportation to reach a clinic. This mode of transportation is different from using an automobile. Thus, the use of driving distance as a measure of spatial access might underestimate the challenges some patients face in accessing care, and we did not have individual-level data for transportation access to better explore this phenomenon. Fourth, we had to rely on a limited number of covariables available from administrative data sets. We hope to extend our analysis with additional clinical and behavioral variables in future research.

Fifth, the overall CRC screening rate in the study population was low, even in comparison with rates of CRC screening among other FQHC patients. This low rate suggests that opportunistic efforts alone have been ineffective and may be a result of competing health care demands, including preventing and treating other chronic conditions and the lack of a preventive care reminders in the FQHC's electronic health record system. Associations identified here may differ in other populations, including other groups of disproportionately affected patients who have higher levels of screening (15). Finally, our study examined patients in an urban FQHC system in a county that offers a medical assistance program. The factors affecting screening are likely to be different for people who do not have a regular source of care, for those who reside in rural areas, or those who do not have access to preventive care.

Based on data about patients served by an urban FQHC system in Central Texas, our study achieved its objectives. We found that regular visits for primary care are positively associated with up-to-date CRC screening, and residing greater than 20 miles of driving distance to care providers is negatively associated with CRC screening uptake. Additionally, our study detected that patients in the southwest area of urban Austin, Texas, have a significantly low rate of up-to-date CRC screening. The analyses provide valuable insights to support targeted interventions to increase screening, both for our FQHC system and others. We prioritize interventions that identify unscreened patients apart from opportunistic visit-based care, inform patients about their eligibility for screening, and invite them into care. Mailed fecal immunochemical test programs are particularly effective and efficient (4,5,17) and are the principal intervention in our system to increase CRC screening, coupled with patient navigation to help identify and reduce transportation barriers. We plan to adopt a new electronic health record that includes preventive care prompting and to conduct additional formative work to understand barriers for patients who do not respond to the interventions.

Acknowledgments

The following supplemental materials are available upon request from the corresponding author: results of logistic regression analyses of the larger dataset, procedure for the cluster analysis and results, and results from the larger set with only aspatial variables that confirm primary results. All authors of this article report no financial disclosures and declare they have no actual or potential competing financial interests. This study was supported, in part, by a grant from the Livestrong Cancer Institutes at the University of Texas Dell Medical School and grant no. PP170082 from the Cancer Prevention and Research Institute of Texas. This study did not use borrowed materials, copyrighted surveys, instruments, or tools.

Part of this work was presented in a preliminary format at an internal meeting during a research retreat of the Livestrong Cancer Institutes at the University of Texas Dell Medical School and during Geographic Information System Day at the Texas Department of State Health Services in October and November 2019.

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Tables

Table 1. Characteristics of Patients in Colorectal Cancer Screening Study (N = 13,079), Central Texas, 2018

Characteristics	No. Patients (%)
Race/ethnicity	
Non-Hispanic White	3,194 (24.4)
Non-Hispanic African American	2,573 (19.6)
Hispanic	7,312 (55.9)
Age group, y	
50–64	10,941 (83.7)
65–75	2,138 (16.3)
Sex	
Male	5,878 (44.9)
Female	7,201 (55.1)
Health insurance status	
Medicare	1,173 (9.0)
Medicaid	1,958 (15.0)
Private	2,757 (21.1)
Medical access program	6,873 (52.6)
Grants	318 (2.4)
Number of primary care–related visits in 12 months	
0	2,622 (20.1)
1 or 2	3,960 (30.3)
3 or 4	3,146 (24.1)
>5	3,351 (25.6)
Spatial access to medical home	
Very close (<5 miles)	6,856 (52.4)
Close (>5 miles to <10 miles)	4,141 (31.7)
Far (>10 miles to <20 miles)	1,945 (14.9)
Very far (>20 miles)	137 (1.1)
Spatial access to Dell Seton Medical Center	
Very close (<5 miles)	2,592 (19.8)
Close (>5 miles to <10 miles)	6,193 (47.4)
Far (>10 miles to <20 miles)	3,865 (29.6)
Very far (>20 miles)	429 (3.3)

Table 2. Patient Screening Status (N = 13,079) and Unadjusted Odds Ratios of Up-to-Date Screenings, Central Texas, 2018

Variable	Screened (%)	Unscreened (%)	OR (95% CI)
Race/ethnicity			
Non-Hispanic White	970 (30.4)	2,224 (69.6)	1 [Reference]
Non-Hispanic African American	800 (31.1)	1,773 (68.9)	1.03 (0.92–1.16)
Hispanic	2,662 (36.4)	4,650 (63.6)	1.31 (1.20–1.44)[a]
Age group, y			
50–64	3,640 (33.3)	7,301 (66.7)	1 [Reference]
65–75	792 (37.0)	1,346 (63.0)	1.18 (1.07–1.30)[a]
Sex			
Male	1,736 (29.5)	4,142 (70.5)	1 [Reference]
Female	2,696 (37.4)	4,505 (62.6)	1.43 (1.33–1.54)[a]
Health insurance status			
Medicare	329 (28.1)	844 (72.0)	1 [Reference]
Medicaid	535 (27.3)	1,423 (72.7)	0.96 (0.82–1.13)
Private	775 (28.1)	1,982 (71.9)	1.00 (0.86–1.17)
Medical Access Program	2,649 (38.5)	4,224 (61.5)	1.61 (1.40–1.84)[a]
Grants for health care	144 (45.3)	174 (54.7)	2.12 (1.65–2.74)[a]
Number of primary care–related visits in 1 y			
0	337 (12.9)	2,285 (87.2)	1 [Reference]
1 or 2	1,107 (28.0)	2,853 (72.1)	2.63 (2.30–3.01)[a]
3 or 4	1,298 (41.3)	1,848 (58.7)	4.76 (4.16–5.45)[a]
≥5	1,690 (50.4)	1,661 (49.6)	6.90 (6.04–7.88)[a]
Spatial access to medical home			
Very close (≤5 miles)	2,359 (34.4)	4,497 (65.6)	1 [Reference]
Close (>5 miles to ≤10 miles)	1,388 (33.5)	2,753 (66.5)	0.96 (0.89–1.04)
Far (>10 miles to ≤20 miles)	651 (33.5)	1,294 (66.5)	0.96 (0.86–1.07)
Very far (>20 miles)	34 (24.8)	103 (75.2)	0.63 (0.43–0.93)[b]
Spatial access to Dell Seton Medical Center			
Very close (≤5 miles)	855 (33.0)	1,737 (67.0)	1 [Reference]
Close (>5 miles to ≤10 miles)	2,114 (34.1)	4,079 (65.9)	1.05 (0.96–1.16)
Far (>10 miles to ≤20 miles)	1,342 (34.7)	2,523 (65.3)	1.08 (0.97–1.20)
Very far (>20 miles)	121 (28.2)	308 (71.8)	0.80 (0.64–1.00)[b]

[a] $P < .001$.
[b] $P < .05$.

Table 3. Adjusted Odds Ratios (aORs) of Up-to-Date Screening of 13,079 Patients, Central Texas, 2018

Variables	aOR (95% CI)
Race/ethnicity	
Non-Hispanic White	1 [Reference]
African American	0.58 (0.39–0.87)[b]
Hispanics	0.94 (0.64–1.40)
Ages, y	
50–64	1 [Reference]
65–75	1.24 (1.11–1.38)[a]
Sex	
Male	1 [Reference]
Female	1.24 (1.15–1.35)[a]
Health insurance status	
Medicare	1 [Reference]
Medicaid	0.98 (0.82–1.16)
Private	1.30 (0.85,1.99)
Medical access program (MAP)	1.98 (1.70–2.31)[a]
Grants for health care	1.80 (1.12–2.89)[b]
Number of primary care–related visits in 1 y	
0	1 [Reference]
1 or 2	2.67 (2.34–3.06)[a]
3 or 4	4.68 (4.08–5.36)[a]
≥5	6.72 (5.87–7.70)[a]
Spatial access to medical home	
Very close (≤5 miles)	1 [Reference]
Close (>5 miles to ≤10 miles)	1.00 (0.91–1.09)
Far (>10 miles to ≤20 miles)	0.96 (0.85–1.08)
Very far (>20 miles)	0.79 (0.50–1.24)
Spatial access to Dell Seton Medical Center	
Very close (≤5 miles)	1 [Reference]
Close (>5 miles to ≤10 miles)	1.04 (0.93–1.15)
Far (>10 miles to ≤20 miles)	0.98 (0.87–1.10)
Very far (>20 miles)	0.82 (0.63–1.08)

[a] $P < .001$.
[b] $P < .05$.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 17, E140 NOVEMBER 2020

ORIGINAL RESEARCH

Urban–Rural Disparities in Access to Low-Dose Computed Tomography Lung Cancer Screening in Missouri and Illinois

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Accessible Version: www.cdc.gov/pcd/issues/2020/20_0202.htm

Suggested citation for this article: Rohatgi KW, Marx CM, Lewis-Thames MW, Liu J, Colditz GA, James AS. Urban–Rural Disparities in Access to Low-Dose Computed Tomography Lung Cancer Screening in Missouri and Illinois. Prev Chronic Dis 2020; 17:200202. DOI: https://doi.org/10.5888/pcd17.200202.

PEER REVIEWED

Summary

What is already known on this topic?

Low-dose computed tomography (LDCT) screening for lung cancer is recommended for current and former smokers meeting eligibility criteria. As of 2017, rural areas generally had less geographic access to LDCT screening than urban areas.

What is added by this report?

Despite the recent proliferation of LDCT screening, rural areas in Missouri and Illinois have low levels of access to screening. We observed no association between geographic access to screening and lung cancer mortality.

What are the implications for public health practice?

As LDCT screening becomes more widespread, future studies need to evaluate its effects on population-level lung cancer mortality rates in urban and rural areas.

Abstract

Introduction

Low-dose computed tomography (LDCT) lung cancer screening is recommended for current and former smokers who meet eligibility criteria. Few studies have quantitatively examined disparities in access to LDCT screening. The objective of this study was to examine relationships between 1) rurality, sociodemographic characteristics, and access to LDCT lung cancer screening and 2) screening access and lung cancer mortality.

Methods

We used census block group and county-level data from Missouri and Illinois. We defined access to screening as presence of an accredited screening center within 30 miles of residence as of May 2019. We used mixed-effects logistic models for screening access and county-level multiple linear regression models for lung cancer mortality.

Results

Approximately 97.6% of metropolitan residents had access to screening, compared with 41.0% of nonmetropolitan residents. After controlling for sociodemographic characteristics, the odds of having access to screening in rural areas were 17% of the odds in metropolitan areas (95% CI, 12%–26%). We observed no association between screening access and lung cancer mortality. Southeastern Missouri, a rural and impoverished area, had low levels of screening access, high smoking prevalence, and high lung cancer mortality.

Conclusion

Although access to LDCT is lower in rural areas than in urban areas, lung cancer mortality in rural residents is multifactorial and cannot be explained by access alone. Targeted efforts to implement rural LDCT screening could reduce geographic disparities in access, although further research is needed to understand how increased access to screening could affect uptake and rural disparities in lung cancer mortality.

Introduction

Low-dose computed tomography (LDCT) screening has increased the ability to detect early-stage lung cancer in recent years (1). The National Lung Screening Trial showed that LDCT screening reduces risk of lung cancer death by up to 20%, compared with chest x-ray (1). In light of this evidence, the US Preventive Services Task Force (USPSTF) issued a recommendation to provide annu-

al LDCT screening to adults aged 55 to 80 who have at least a 30 pack-year smoking history, currently smoke or quit in the past 15 years, and have no lung cancer symptoms (2). Medicare subsequently began reimbursing screening of adults aged 55 to 77 (2). Unique among cancer screenings, LDCT reimbursement is contingent on provision of smoking cessation counseling and shared decision making, both of which are also billable services (2).

The burden of these requirements on physician practices, along with the high rate (>95%) of false-positive test results (1), may explain why screening rates are low. Although the number of accredited LDCT centers nationwide increased from an estimated 203 in 2014 to 1,748 in early 2017 (3), a study of 10 geographically diverse US states found that 12.7% of adults aged 55 to 80 met USPSTF criteria for LDCT screening in 2017, but of these adults, only 12.5% reported receiving screening in the previous year (4).

Barriers to LDCT screening persist — rural residents nationwide have less access, defined as distance and driving time, to LDCT screening than their urban counterparts (3,5). Although more than 95% of adults aged 55 to 79 in 8 northeastern states (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island) have access to a screening center within 30 miles (Euclidean distance), the proportion in the Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin) is lower and highly variable (22%–93%) (3).

Our investigation focused on Missouri and Illinois, both Midwestern states in the upper Mississippi Delta, a region marked by high cancer mortality (6). Missouri and Illinois are home to 6.1% of the US population and contain a heterogeneous mix of geographies, from densely populated cities to rural farmland. Both states reflect the nationwide pattern of higher smoking prevalence in rural areas than in urban areas (7).

The 2 states have significantly different policies on health care and tobacco. Illinois was an early expander of Medicaid under the Affordable Care Act, whereas Missouri was not. The state cigarette tax is more than 15 times higher in Illinois ($2.98/pack) than in Missouri ($0.17/pack) (8). Demographically, Missouri has a higher proportion of rural residents than the United States as a whole (29.6% for Missouri vs 19.3% nationwide), whereas Illinois, at 11.5%, has a lower proportion (9). A study published in 2018 identified Missouri as a state with moderate access to LDCT screening and high lung cancer mortality and Illinois as a state with high access to screening and moderate mortality (3).

Given rural–urban differences and the importance of using precise and localized estimates to drive public health priorities (10), we performed a detailed analysis of screening access in Missouri and Illinois. Efforts to reduce rural–urban disparities in LDCT screening and lung cancer mortality require county-specific information on screening "deserts" and mortality hotspots (6). As such, the primary objective of this study was to identify locations in Missouri and Illinois that have high lung cancer mortality and/or cigarette smoking rates but low levels of access to LDCT screening; these locations are priority areas for intervention. We built on previous work (5) by using multilevel, mixed-effects modeling to quantify the association between rurality, sociodemographic characteristics, and access to screening at the census block group level. Additionally, a secondary objective was to conduct an exploratory analysis of the relationship between access to screening and lung cancer mortality.

Methods

Data management

We collected and organized data by using methods similar to those of Eberth et al (3). In May 2019, we obtained addresses of screening centers accredited by the American College of Radiology (11) and Lung Cancer Alliance (now GO_2 Foundation for Lung Cancer) Screening Centers of Excellence (12). We compiled addresses for 356 centers in Missouri, Illinois, and all neighboring states (Arkansas, Indiana, Iowa, Kansas, Kentucky, Michigan, Nebraska, Oklahoma, Tennessee, Wisconsin). We collected addresses from neighboring states because patients may cross state lines to reach the nearest center. When multiple screening centers were located on a single hospital campus, we randomly chose 1 center. Additionally, we removed from analysis 1 center in Indiana that was closed. We performed automatic geocoding in ArcGIS Desktop version 10.6 using the USA Geocoding Service (Esri). We used interactive rematch for screening centers that matched equally well to multiple street addresses.

We manually rematched all unmatched centers and centers matched to a zip code rather than a street address (n = 56 centers) by using a Google Maps API (application programming interface; https://developers.google.com/maps/documentation/geocoding/intro). Consistent with the methods of Eberth et al, we constructed a 30-mile planar buffer around each screening center to represent the area in which that center was deemed accessible (3). A nationwide study comparing driving distance and straight-line distance from all census tracts to the closest hospital found that the 2 measures are highly correlated in the absence of shorelines, mountains, or other physical barriers (13). Missouri and Illinois contain few such barriers; thus, we felt justified in using a 30-mile straight-line buffer. Hospital "deserts" are defined by the lack of a hospital within a 30-mile radius (14). Consistent with Eberth et al, we con-

sidered a center accessible to residents of census block groups whose centroids lay inside the buffer (3).

We used these data to calculate the county-wide percentage of residents aged 55 to 79 who have access to LDCT screening within 30 miles. We obtained census block group–level data on age from American Community Survey (ACS) 2013–2017 five-year estimates (15). Of the available categories, the age group 55 to 79 was the closest option to the recommended screening age range of 55 to 80 (15).

Measures

Screening access measure. We dichotomized access to LDCT screening at the census block group–level as presence or absence of at least 1 center within 30 miles of the centroid. At the county level, we quantified access by the proportion of adults aged 55 to 79 who lived in a census block group and met this criterion. Because appropriate data on smoking status were unavailable, we assumed that the ratio of adults aged 55 to 79 to LDCT-eligible adults was roughly constant across all census block groups in a county.

Rurality measures. We used census tract–level rural–urban commuting area (RUCA) codes to measure rurality (16). For modeling purposes, we grouped codes 1 to 3 as metropolitan, codes 4 to 6 as micropolitan, and codes 7 to 10 as small town/rural areas. However, because lung cancer mortality data were available only at the county level, we used the National Center for Health Statistics (NCHS) county-level classification (17) for our exploratory mortality model. NCHS codes range from 1 (large central metro) to 6 (noncore). We used RUCA codes for our main access model because they provide more fine-grained information than NCHS codes on rurality in a census tract and its census block groups.

Sociodemographic characteristics. We obtained demographic census block group–level data from ACS 2013–2017 five-year estimates (15). We defined income as median annual household income (in thousands of dollars), education as percentage of residents aged 25 or older with at least a college degree, and race as the percentage of White residents and the percentage of African American residents.

Lung cancer and smoking measures. We obtained county-level, age-adjusted lung and bronchus cancer mortality rates during 2013–2017 from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program via SEER*Stat software version 8.3.6 (18). We used mortality rates (per 100,000) for people aged 60 or older. Given the lead-time bias and additional survival time after lung cancer diagnosis, we believed mortality in this age range was most likely to be affected by a screening program for people aged 55 to 80. We suppressed data from 1 county in Missouri because of a small number (<10) of deaths. We obtained data on 2019 adult smoking prevalence from County Health Rankings (19). We classified adults as smokers if they reported currently smoking every day or most days and having smoked at least 100 cigarettes in their lifetime.

Map development. We obtained census block group shapefiles from the Census Bureau (15) and state-level and county-level shapefiles from Esri (20). We created categories by rounding quintiles to the nearest 10% for access to screening, nearest 10 per 100,000 for lung cancer mortality, and nearest 0.5% for smoking prevalence. Mortality and smoking quintiles were based on national (rather than bi-state) data, to emphasize how Illinois and Missouri compare with other states. We created maps in ArcGIS Desktop version 10.6 (Esri).

Statistical analysis

For the first analysis, our outcome of interest was access to screening within 30 miles of the census block group centroid (binary). Predictor variables were rurality as quantified by RUCA codes (main predictor; categorical), income (continuous), education (continuous), and race (continuous). We used multilevel, mixed-effects logistic regression modeling to determine the association between outcome and predictor variables. In this model, the census block group was the unit of analysis. We defined RUCA codes at the census tract level; all other variables were defined at the census block group level.

Our modeling procedure was as follows: first, we considered bivariate logistic models to examine crude associations between screening access and each predictor. We then used the full additive model with all predictor variables (fixed effects) and random intercepts for each state and county. Counties were nested within states. Census tract was not considered a random effect because of the small number of census block groups in some tracts. We then tested models involving interaction terms and random slopes for various predictors. These terms were all nonsignificant and thus not included in the final model. We calculated the odds ratio (OR), 95% CI, and *P* value associated with each fixed-effect parameter.

Our second, exploratory model used the county as the unit of analysis. We sought to determine the association between access to LDCT screening, defined as the proportion of residents aged 55 to 79 whose census block group of residence is located within 30 miles of a screening center (main predictor), and lung cancer mortality rate in adults aged 60 or older (outcome). Other covariates included adult smoking prevalence, rurality (NCHS code), income, education, race, and state in which the county is located. We used multiple linear regression modeling for this county-level analysis. We defined all variables at the county level, and all vari-

ables except NCHS code were continuous. Because only 3 counties in the study area were designated as large central metro (level 1), we performed a sensitivity analysis using a dichotomized rurality variable (levels 1–4 [all metro area counties] vs levels 5–6 [micropolitan and noncore]).

For both analyses, all tests were 2-sided and $P < .05$ was considered significant. We calculated variance inflation factors to assess evidence of multicollinearity. For the main mixed-effects model, we assessed county-level random intercepts for normality. For the multiple regression model, we checked residual plots for normality and constant variance. We performed statistical analyses in R version 3.6.1 (The R Project for Statistical Computing).

Results

Overall, 91.2% of Illinois residents aged 55 to 79 and 78.3% of their Missouri counterparts were within 30 miles of an LDCT screening center. Areas with low access to screening corresponded roughly to the states' most rural regions (Figure 1). These areas of low access included central northern Missouri, the Bootheel region in southeastern Missouri, and southern Illinois (Figure 2A). LDCT screening centers in Illinois and Missouri were located in census block groups whose residents were more likely than residents in the 2-state region as a whole to identify as White (76.6% vs 67.6%) and have at least a college degree (45.1% vs 31.8%). Similarly, weighted median income in census block groups containing screening centers was $72,222, compared with $57,750 across all census block groups.

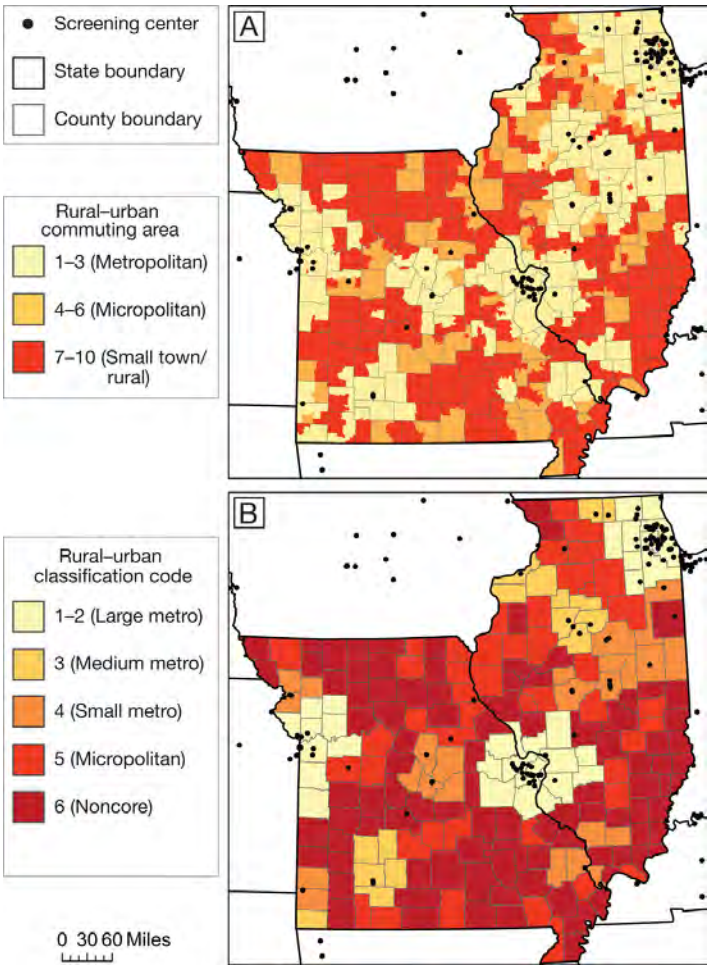

Figure 1. Measures of rurality in Missouri and Illinois and location of low-dose computed tomography screening centers. A, Rural–urban commuting area (RUCA) categories at the census tract level, determined by US Department of Agriculture Economic Research Service (16). B, National Center for Health Statistics (NCHS) rural–urban classification codes at the county level (17). Data on screening centers obtained from American College of Radiology (11) and GO_2 Foundation for Lung Cancer (12). Shapefiles obtained from ESRI (20).

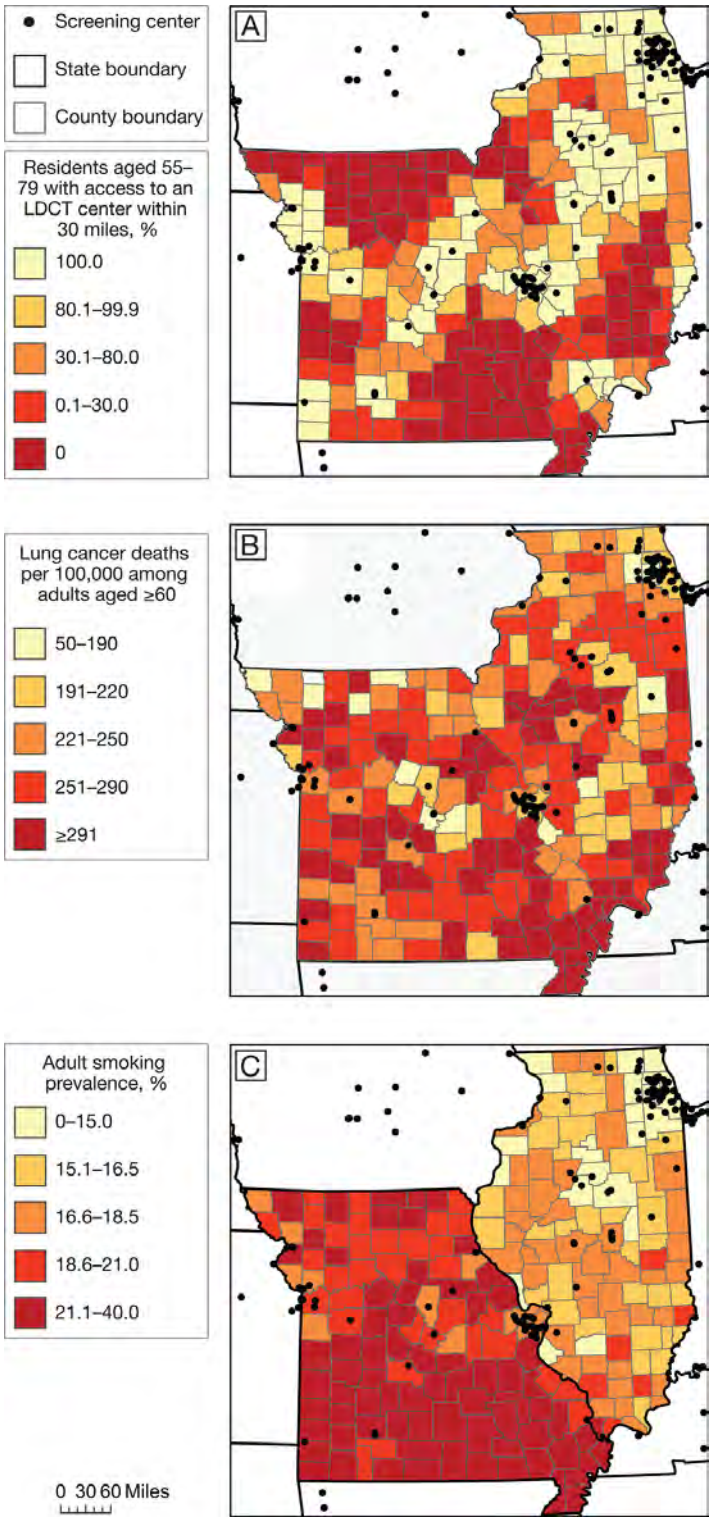

Figure 2. Access to LDCT lung cancer screening, lung cancer mortality, and smoking prevalence in Missouri and Illinois. A, Percentage of residents aged 55–79 with access to an LDCT lung cancer screening center within 30 miles. B, Lung cancer mortality (deaths per 100,000) among adults aged ≥60. C, Adult smoking prevalence. All maps are at the county level, and categories are based on rounded quintiles. Data obtained from American College of Radiology (11), GO_2 Foundation for Lung Cancer (12), Surveillance, Epidemiology, and End Results program (18), and County Health Rankings (19). Shapefiles from ESRI (20). Abbreviation: LDCT, low-dose computed tomography.

Both states had pockets of high lung cancer mortality, although smoking rates were consistently higher in Missouri than in Illinois (Figure 2B and 2C). Southeastern Missouri had the highest concentration of both lung cancer mortality and adult smokers.

In metropolitan area cores or nearby commuting areas (RUCA codes 1–3), 97.6% of residents had access to LDCT screening, compared with 41.0% of residents in micropolitan or small town/rural areas (codes 4–10). This difference in access was similar across NCHS county-level codes (Table 1). Furthermore, as rurality increased, we observed higher rates of adult smoking and lung cancer mortality among adults aged 60 or older.

The mixed-effects logistic regression model of access to LDCT screening within a 30-mile radius achieved convergence, and a likelihood ratio test showed that inclusion of random effects significantly improved fit ($\chi^2 = 3417.6$; $df = 2$; $P < .001$). Small town and rural census block groups had significantly lower adjusted odds than metropolitan census block groups of access to screening within a 30-mile radius (OR = 0.17; 95% CI, 0.12–0.26) (Table 2). Screening access in micropolitan areas was similarly lower than in metropolitan areas (OR = 0.17; 95% CI, 0.10–0.27).

In the county-level models, we found no significant relationship between access to LDCT screening and lung cancer mortality after adjusting for smoking prevalence, rurality, and demographic characteristics ($P = .68$) (Table 3). The variables most strongly associated with lung cancer mortality per 100,000 residents were smoking prevalence (β = 9.7; 95% CI, 4.6 to 14.9), percentage of population aged 25 or older with a college degree (β = −2.7; 95% CI, −1.5 to −3.9), and residence in Missouri (β = −41.2; 95% CI, −68.2 to −14.2). Thus, a 1 percentage-point increase in smoking prevalence was associated with a mortality increase of 9.7 per 100,000 residents, and a 1 percentage-point increase in the fraction of individuals aged 25 or older with a college degree was associated with a decrease of 2.7 per 100,000. Rurality and other variables showed no association, and use of a binary rurality variable (all metropolitan vs micropolitan/noncore) yielded nearly identical results.

Discussion

Our study examined access to LDCT screening across diverse urban and rural areas, and in communities of varying sociodemographics. The odds of urban populations having access to screening were more than 5 times greater than those of micropolitan or rural counterparts. After adjusting for smoking prevalence and demographic characteristics, we found no evidence that greater access to screening or greater urbanization is associated with lower county-level lung cancer mortality. However, counties with a larger proportion of college-educated residents or lower smoking prevalence tended to have lower lung cancer mortality.

Several studies reported that rural residents have lower access to LDCT screening (3,5,21), and our study confirms those findings. Our study also found that micropolitan areas have no better access than rural areas. Findings from our study reveal a negligible association between access to LDCT screening and lung cancer mortality rates.

Most likely, the observed lack of association between access to screening and mortality was due to the nascent state of LDCT screening and low uptake during the years of mortality data used in our study (2013–2017) (4). Screening can detect early-stage and slow-growing cancers that would not have otherwise been diagnosed for quite some time. Because lung cancer tends to be diagnosed at late stages with poor survival rates, several years of higher rates of screening may be needed before reduced mortality is seen. The overall delay from screening implementation to decrease in mortality roughly equals the sum of lead-time bias (approximately 1–3 years for LDCT) (22) and the traditional (without screening) survival time. Other variables may have affected our mortality analysis. In Illinois, a major coal-producing state, residential proximity to coal mines is associated with increased lung cancer incidence and mortality (23). Regardless, our analysis represents valuable baseline research and demonstrates the importance of attending to county-level disparities. An increase in LDCT screening uptake would likely reduce lung cancer mortality at the population level. On the basis of colorectal cancer screening research, we believe that greater geographic access to LDCT screening could effectively increase uptake (24). Improving geographic access to a service with low uptake is still worthwhile, because poor access may be contributing to low uptake.

Although rural areas are associated with poorer health outcomes than urban areas (25), we must also consider the urban–rural paradox, which suggests that among urban residents, greater distance to health care facilities is inversely associated with receiving care, but among rural residents, greater distance is positively associated with receiving care (26). Using 2015 data, Odahowski et al found that LDCT screening uptake was similar across metropolitan and nonmetropolitan counties, although low rates in both areas (<4%) make it difficult to understand why uptake is similar and whether the similarity will be maintained over time (27). The similarity in screening uptake rates may result from selection bias: the few people who completed screening may be the most enthusiastic and well-resourced patients in both urban and rural areas. Increased geographic access to LDCT screening may be needed to further increase uptake in rural areas. Further studies using discriminate, comprehensive measures of access and uptake are needed to explore whether geographic availability of screening has a different effect on mortality in urban and rural areas.

Previous research on geographic access to LDCT screening is minimal. To our knowledge, ours is the first study to assess access to LDCT screening, associated demographic determinants, and implications for mortality at a local population level. However, our study has several limitations. First, limited availability of public data necessitated the use of variables from 2 different periods. Demographic and lung cancer mortality data were from 2013–2017, whereas data on smoking prevalence and access to screening were from 2019. Second, we used data from multiple sources, including telephone surveys, online surveys, and government registries. Each source has its own limitations and can contribute to biased model estimates. Third, the ecological study design based on census block group–level and county-level data precludes extensive application of our conclusions about the relationships between rurality, access, and mortality to any 1 person. Fourth, in our exploratory analysis, county-level rates of access to LDCT screening were based on all residents aged 55 to 79, regardless of smoking status or other screening eligibility criteria. By taking this approach, we assumed that the percentage of residents aged 55 to 79 who meet eligibility criteria was roughly constant within a county; we made no assumptions about differences between counties. Finally, we included in our analyses only GO_2 Foundation Screening Centers of Excellence and American College of Radiology accredited centers. Thus, our analyses may have underestimated the proportion of residents, especially in rural areas, who had access to some form of screening. However, accredited LDCT programs may deliver a better level of care than nonaccredited programs (28).

This study underscores the need for further research and creative solutions for increasing LDCT screening in rural areas, especially in the Mississippi Delta region, where significant cancer disparities exist. Not doing so may propagate the urban–rural disparities that exist in other cancer screening programs, such as mammography (25). Further research may be especially important in areas with high rates of smoking and lung cancer mortality, such as southeastern Missouri. In the past few years, mobile LDCT

screening has been introduced in dozens of rural communities in Georgia and Tennessee (29). Incorporation of telemedicine could also circumvent the difficulty of finding qualified on-site specialists to interpret LDCT scans and recommend treatment in rural areas. Teleradiology is now a ubiquitous practice, allowing radiologists to bill for LDCT and other interpretations furnished offsite. Some teleoncology programs offer remote interpretation of biopsy specimens (30), which is occasionally required as a follow-up to LDCT screening. Additionally, screening must be coupled with effective smoking cessation interventions to maximize reductions in mortality.

Finally, our results emphasize the need for data-driven, locally targeted programs to increase screening and decrease mortality. In Missouri and Illinois, many areas with high rates of smoking and lung cancer mortality have low access to screening. However, some areas with high rates of smoking and lung cancer mortality, such as the rural counties north of Kansas City, have good access to screening. State or national one-size-fits-all programs to simply add more screening centers may not be helpful in these communities.

Our study adds to the growing body of evidence on urban–rural disparities in access to screening, while exploring the effects of access to LDCT screening on lung cancer mortality. County-specific approaches are needed to increase access to screening in rural areas with high mortality. At the same time, further implementation research is needed to understand how to effectively minimize individual and system-level barriers to rural screening.

Acknowledgments

We thank Jennifer Moore for her assistance in finding a geocoding tool and Lindsey Manshack for her editing assistance. K.W.R. received support from the DeNardo Scholars Fellowship through the Washington University School of Medicine. M.W.L. was partially supported by grant no. T32CA190194 from the National Institutes of Health (principal investigators, G.A.C. and A.S. J.). G.A.C., A.S.J., M.W.L., J.L., and C.M.M. received partial support from Siteman Cancer Center (P30 CA091842) and The Foundation for Barnes-Jewish Hospital. The content is solely the responsibility of the authors and does not necessarily represent the official view of the National Institutes of Health. No copyrighted materials were used in this study.

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Tables

Table 1. Lung Cancer Screening Access Within 30 Miles, Adult Smoking Prevalence, and Age-Adjusted Lung Cancer Mortality, by Urban–Rural Designations, Missouri and Illinois, 2013–2019

Urban–Rural Designation[a]	No. of Counties	Population Aged 55–79, N (%)[b]	Population With Screening Access, %[c]	Adult Smoking Prevalence, %[d]	Age-Adjusted Lung Cancer Mortality Among Residents Aged ≥60[e]
Large central metro	3	1,378,581 (30.6)	100.0	15.2	214
Large fringe metro	30	1,524,652 (33.8)	98.6	16.0	226
Medium metro	16	351,843 (7.8)	96.4	18.4	244
Small metro	25	416,522 (9.2)	89.3	18.2	250
Micropolitan	46	418,276 (9.3)	42.8	19.2	269
Noncore	97	421,917 (9.4)	34.9	20.0	277

[a] Determined by National Center for Health Statistics (17).
[b] Based on 2013–2017 data (15).
[c] Based on 2019 data on screening center location (11,12). Proportion of population whose census block group of residence is within 30 miles of a screening center; computed as averages of county-level data weighted by number of residents aged 55–79 (as of 2013–2017).
[d] Based on 2019 data (19). Proportion of adults who currently smoke and have smoked ≥100 cigarettes in their lifetime; computed as averages of county-level data weighted by number of adult residents (as of 2013–2017).
[e] Based on 2013–2017 data (18). Rate per 100,000 population; computed as averages of county-level data weighted by number of residents aged ≥60 (as of 2013–2017).

Table 2. Census Block Group–Level (N = 13,834 Census Block Groups) Association Between Degree of Rurality (in 2019) and Access to Lung Cancer Screening Within 30 Miles (in 2019) Adjusted for Demographic Characteristics, Missouri And Illinois, 2013–2017

Model Parameter	Unadjusted Model		Adjusted Model	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Degree of rurality[a]				
Metropolitan (RUCA codes 1–3)	1.00 [Reference]		1.00 [Reference]	
Micropolitan (RUCA codes 4–6)	0.019 (0.016–0.022)	<.001	0.17 (0.10–0.27)	<.001
Small town or rural (RUCA codes 7–10)	0.017 (0.015–0.020)	<.001	0.17 (0.12–0.26)	<.001
Demographic characteristics[b]				
Median annual household income, in thousands, $[c]	1.03 (1.03–1.03)	<.001	1.01 (1.00–1.02)	.09
Percentage of population aged ≥25 with a college degree[d]	1.05 (1.05–1.06)	<.001	1.01 (1.00–1.03)	.08
Percentage of population that is White[d]	0.91 (0.91–0.92)	<.001	1.02 (1.00–1.03)	.05
Percentage of population that is African American[d]	0.95 (0.94–0.96)	<.001	1.01 (0.99–1.03)	.32

Abbreviations: OR, odds ratio; RUCA, rural–urban commuting area.
[a] Census tract–level RUCA codes used to measure rurality (16).
[b] Determined by American Community Survey 5-year estimates (15).
[c] Odds ratio represents $1,000 increase in median annual household income.
[d] Odds ratio represents 1 percentage-point increase in the corresponding variable.

Table 3. County-Level (N = 210 Counties) Association Between Proportion of Residents With Access to Screening Within 30 Miles (in 2019) and Age-Adjusted Lung Cancer Mortality Among Adults Aged ≥60 (in 2013–2017), Adjusted for Rurality (in 2019), and Demographic Characteristics (in 2013–2017), Missouri and Illinois

Model Parameter	Change in Mortality per 100,000 Population, β (95% CI) [*P* Value]
Percentage of census block groups with access to lung cancer screening within 30 miles	0.04 (−0.15 to 0.23) [.68]
Degree of rurality[a]	
Large central metro	1 [Reference]
Large fringe metro	8.9 (−54.8 to 72.6) [.78]
Medium metro	−8.7 (−74.5 to 57.0) [.79]
Small metro	3.4 (−58.3 to 65.2) [.91]
Micropolitan	2.7 (−60.9 to 66.3) [.93]
Noncore	−4.6 (−68.5 to 59.3) [.89]
State	
Illinois	1 [Reference]
Missouri	−41.2 (−68.2 to −14.2) [.003]
Demographic characteristics	
Percentage of population that reports smoking[b]	9.7 (4.6 to 14.9) [<.001]
Median annual household income, in thousands, $[c]	0.4 (−0.9 to 1.8) [.52]
Percentage of population aged ≥25 with a college degree[c]	−2.7 (−3.9 to −1.5) [<.001]
Percentage of population that is White[c]	0.2 (−1.1 to 1.6) [.76]
Percentage of population that is African American[c]	0.8 (−1.1 to 2.7) [.42]

[a] Determined by National Center for Health Statistics (17).
[b] Determined by 2019 County Health Rankings (19).
[c] Determined by American Community Survey 5-year estimates (15).

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 17, E62 JULY 2020

ORIGINAL RESEARCH

Effectiveness of Interventions to Increase Colorectal Cancer Screening Among American Indians and Alaska Natives

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Accessible Version: www.cdc.gov/pcd/issues/2020/20_0049.htm

Suggested citation for this article: Haverkamp D, English K, Jacobs-Wingo J, Tjemsland A, Espey D. Effectiveness of Interventions to Increase Colorectal Cancer Screening Among American Indians and Alaska Natives. Prev Chronic Dis 2020; 17:200049. DOI: https://doi.org/10.5888/pcd17.200049.

PEER REVIEWED

Summary

What is already known about this topic?

Reducing client and structural barriers can result in greater participation in colorectal cancer screening, when stool-based tests are used.

What is added by this report?

Direct mailing of fecal immunochemical test kits was an effective strategy to increase colorectal cancer screening participation at rural, tribally operated health care facilities.

What are the implications for public health practice?

Stool-based testing is often the most accessible colorectal cancer screening option at rural, tribally run health care facilities. Direct mailing of fecal immunochemical tests may increase colorectal screening at health care facilities that serve American Indian and Alaska Native populations.

Abstract

Introduction

Screening rates for colorectal cancer are low in many American Indian and Alaska Native (AI/AN) communities. Direct mailing of a fecal immunochemical test (FIT) kit can address patient and structural barriers to screening. Our objective was to determine if such an evidence-based intervention could increase colorectal cancer screening among AI/AN populations.

Methods

We recruited study participants from 3 tribally operated health care facilities and randomly assigned them to 1 of 3 study groups: 1) usual care, 2) mailing of FIT kits, and 3) mailing of FIT kits plus follow-up outreach by telephone and/or home visit from an American Indian Community Health Representative (CHR).

Results

Among participants who received usual care, 6.4% returned completed FIT kits. Among participants who were mailed FIT kits without outreach, 16.9% returned the kits — a significant increase over usual care ($P < .01$). Among participants who received mailed FIT kits plus CHR outreach, 18.8% returned kits, which was also a significant increase over usual care ($P < .01$) but not a significant increase compared with the mailed FIT kit–only group ($P = .44$). Of 165 participants who returned FIT kits during the study, 39 (23.6%) had a positive result and were referred for colonoscopy of which 23 (59.0%) completed the colonoscopy. Twelve participants who completed a colonoscopy had polyps, and 1 was diagnosed with colorectal cancer.

Conclusion

Direct mailing of FIT kits to eligible community members may be a useful, population-based strategy to increase colorectal cancer screening among AI/AN people.

Introduction

Colorectal cancer (CRC) is the second leading cause of death from cancer among American Indian and Alaska Native (AI/AN) men and third among AI/AN women (1). Although screening has been shown to reduce death rates, the percentage of people up to date with CRC screening is low in many AI/AN communities. Less than half (48.4%) of AI/AN adults aged 50 to 75 were up to date with CRC screening in 2015 (2).

The US Preventive Services Task Force (USPSTF) recommends stool-based tests and direct visualization tests (colonoscopy, flexible sigmoidoscopy, or virtual colonoscopy) for CRC screening. (3). In health care systems with limited capacity to provide direct-visualization screening tests, stool-based tests such as high-sensitivity, guaiac-based fecal occult blood tests (FOBT) and fecal immunochemical tests (FIT) are often the most accessible options for CRC screening. However, various patient and structural barriers exist to completing FOBT and FIT: geographic isolation, lack of a regular health care provider, failure of providers to recommend screening, lack of clinical tracking and reminder systems, lack of transportation, embarrassment, privacy concerns, distrust of the health care system, and insufficient knowledge about CRC, its risk factors, and screening recommendations (4). Many of these barriers can be mitigated. According to the Community Preventive Services Task Force, there is sufficient evidence that using patient reminders and small media (eg, letters, pamphlets, brochures, flyers) can increase CRC screening with stool tests (5). Reducing structural barriers (eg, eliminating or simplifying administrative procedures required for CRC screening, reducing time or distance for screening services) is also an effective way to increase the use of stool tests (6). Direct mailing of FOBT or FIT is an approach that can address both patient and structural barriers. Mailing FOBT or FIT kits to patients and providing outreach through telephone calls and home visits can reduce patient and structural barriers, and both have been shown to be effective strategies to improve participation in CRC screening in various underserved populations (7–10). The objective of our study was to determine if such evidence-based interventions could also lead to increased CRC screening among rural AI/AN populations.

Methods

Participant recruitment

We recruited 3 tribally operated health care facilities with which we had a previous working relationship to participate in our study. The selected facilities were in different tribal communities. At each facility, the clinic director used Resource and Patient Management System Query Manager (11) to generate a list of active clinic users (people who had obtained services at least once in the past 3 years), were aged 50 to 75, were not up to date with CRC screening per USPSTF criteria at the time the study began (had not had an FOBT or FIT in the past year, flexible sigmoidoscopy in the past 5 years combined with FOBT or FIT in the past three years, or colonoscopy in the past 10 years) (12), and had no history of CRC or total colectomy. These criteria were met by 1,288 people. Our study was approved by institutional review boards of the Centers for Disease Control and Prevention (CDC) and the 3 participating tribal health care facilities.

Study design. At each facility, study participants were randomly assigned to 1 of 3 study groups: group 1 (the control or usual care group), in which participants visited the clinic with the same frequency as they would outside study conditions and received a FIT kit only if a provider recommended one; group 2 (mailing alone), in which participants were mailed FIT kits (Polymedco OC-Light), completion instructions (in English), a letter (in English) notifying them that they were due for CRC screening, and a prestamped, pre-addressed envelope for returning their completed FIT kit; and group 3 (mailing plus outreach), in which participants were mailed the same materials as group 2 and also received telephone and/or home visit follow-up from an American Indian Community Health Representative (CHR) if they did not return the completed test (Figure 1). At 2 study facilities, we randomized 133 CRC screening-eligible participants to each of the 3 groups, and included the remaining 205 screening-eligible patients at these 2 facilities in the usual-care group (124 people at one clinic and 81 people at the other clinic) (Table). Because 1 study clinic had a smaller patient population, we randomized all 285 CRC screening-eligible people at that facility equally among the 3 study groups (95 in each group). Providers were blinded to their patients' involvement in the study or study group. We hypothesized that the percentage of eligible persons completing FIT in each of the 2 intervention groups would be significantly higher than the percentage completing FIT in the usual care group (group 1), and that the percentage completing FIT in the mail-out plus outreach group (group 3) would be significantly higher than the percentage completing FIT in the mail-out alone group (group 2).

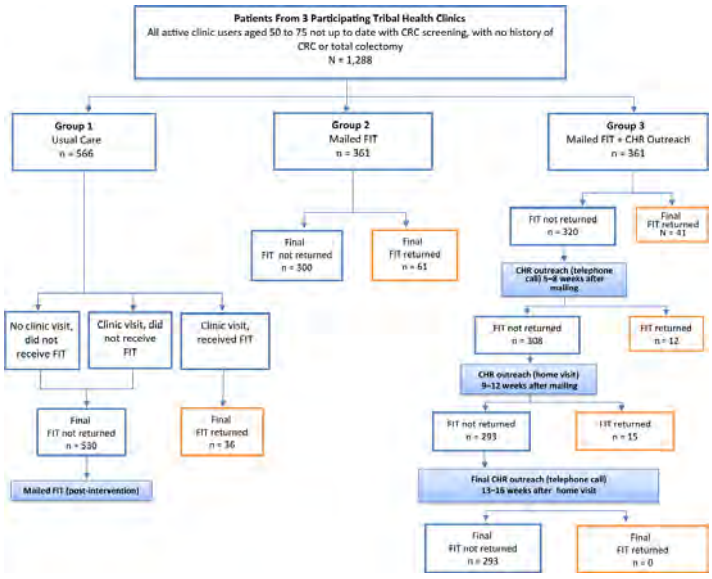

Figure 1. Participant selection, randomization, and outcomes in 3 study groups, intervention to increase colorectal cancer screening among American Indian and Alaska Native people (N = 1,288) served by 3 tribally operated health care clinics, April to November, 2014. Group 1, usual care, consisted of people who either did not visit the clinic, visited the clinic and did not receive a fecal immunochemical test (FIT) kit, or visited and received a FIT kit and instructions to complete at home. Group 2 participants received a FIT kit and completion instructions by mail. Group 3 participants received a mailed FIT kit and instructions, and nonrespondents received follow-up from a tribal community health representative after 4 weeks (by telephone), after 8 weeks (by home visit), and after 12 weeks by telephone. Abbreviations: CHR, community health representative; FIT, fecal immunochemical test.

Intervention design. We educated CHRs from each facility about CRC screening recommendations and our intervention protocol. We also informed clinic administrators and staff at each facility about the study. In April 2014, we mailed FIT kits, instructions for completion, an official letter from the clinic, and prestamped envelopes to participants in the intervention groups (groups 2 and 3). In August 2014, we mailed a follow-up letter to nonrespondents in groups 2 and 3 who had not yet returned kits, encouraging them to do so. The intervention period for all study groups was April 2014 through November 2014.

The outreach intervention protocol (group 3) instructed CHRs to make up to 5 attempts to contact by telephone all participants who had not returned their FIT kits within 4 weeks of the mailing; CHRs were to make up to 3 attempts to conduct a home visit to those who had not returned their FIT within 8 weeks, and up to 5 attempts to contact nonrespondents by telephone who had not returned the kits by the end of week 12 (Figure 1). If at first attempt a participant's telephone number was found to be disconnected or incorrect, CHRs were to visit that participant's home as the initial outreach activity. As part of their outreach, CHRs were to confirm that the participant received the mailed FIT kit (and provide another FIT kit if the participant did not receive the first), discuss the importance of CRC screening, review procedures for completing the FIT kit, encourage the participant to complete the FIT kit, answer questions, and offer to transport the completed FIT kit to the clinic laboratory.

Data tracking procedures. We created 2 databases to track results: 1 for laboratory staff to collect patient contact information and demographics, how and when FIT kits were disseminated and returned, and test results and another for CHRs to gather patient contact information and demographics, outreach type (telephone call or home visit), and other outreach details. Only clinic directors (or their designees), laboratory directors, and CHRs had access to the databases.

On-site clinic laboratories processed all completed FIT kits. Laboratory staff recorded FIT results in the participant tracking database and patient medical charts. Per standard operating procedures (3), clinic providers were instructed to refer any participant with a positive FIT result for colonoscopy.

Data analysis. Both the laboratory and CHR tracking databases were de-identified after the study intervention period, and the data files from all 3 facilities were merged. We used SPSS 22 (IBM Corp) software to perform Pearson χ^2 testing to determine significant differences ($P < .05$) in FIT completion between study groups.

Results

The mean age of the 1,288 study participants was 60, half were aged 50 to 59, and 52% were women. (Table). Overall, 12.8% (165/1,288) returned a completed FIT kit to their clinic, and FIT completion did not differ by sex ($P = .52$). The proportion who returned FIT kits increased with age: 10.8% (70/648) aged 50 to 59, 13.6% (66/484) aged 60 to 69, and 18.8% (29/154) aged 70 to 75 ($P = .02$). Most who completed FIT kits hand delivered them to the clinic (83.0%), whereas 16.4% used the pre-stamped, preaddressed envelope to return the kit by mail. Only one completed FIT kit (0.6%) was delivered to the clinic by a CHR.

The percentage of returned FIT kits varied by study group (Figure 2). Among the participants who received usual care (group 1), 6.4% (36/566) completed their FIT kits at home and returned them to the clinic. In group 2 (mailing alone), 16.9% (61/361) returned the FIT kits, a significant increase over group 1 ($P < .01$). In group 3 (mailing plus outreach), 18.8% (68/361) returned FIT kits to the clinic, a significant increase over group 1 ($P < .01$), but not group 2 ($P = .44$) (Figure 2). Among those who returned a FIT kit, more women than men returned them in group 3 (50.0% vs 31.6%) and more men than women in group 2 (43.0% vs 31.4%) ($P = .06$).

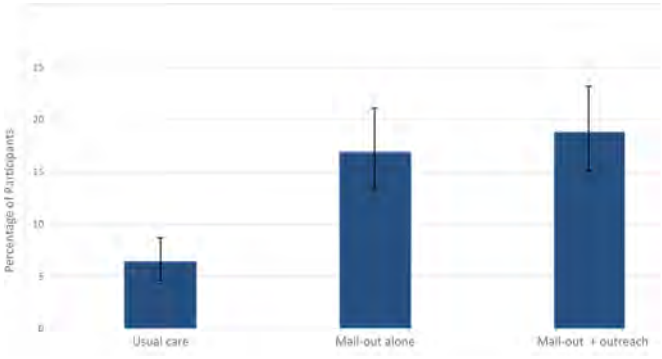

Figure 2. Percentage of participants who completed the fecal immunochemical test, by intervention group. Brackets indicate confidence intervals.

Among all group 3 participants, 11.4% (41/361) returned their FIT kit during the 4-week period before any CHR outreach began. After receiving a single round of CHR outreach, an additional 3.3% (12/361) returned their FIT kit. Following a second round of CHR outreach, another 4.2% (15/361) returned their FIT kit. No additional FIT kits were returned to the clinics among participants who received a third round of outreach (Figure 1). Because of delays in the implementation of the CHR intervention, varying rounds of outreach were still being conducted with participants in the months following the mailing of a reminder letter at the end of the intervention timeframe. Following the reminder letter mailing, 17 people in group 3 and 13 in group 2 returned their FIT kits. Of these 17 from group 3, 10 also received CHR outreach during that time. Overall, 51.5% (35/68) of group 3 participants who returned their FIT kits received outreach of some kind (telephone call and/or home visit) during the intervention period, including a few who received telephone call or home visit outreach even though they had already returned their FIT kit. Of the 293 participants in group 3 who did not return FIT kits, 76.8% (225/293) received outreach of some kind (telephone call and/or home visit) during the intervention period.

Of the 165 FIT kits returned, 39 had a positive result; all 39 were referred for colonoscopy, and 23 of the 39 completed the colonoscopy. Results of those colonoscopies showed that 12 participants had polyps, and 1 participant was diagnosed with CRC.

Discussion

Our study showed that a significant increase in CRC screening participation is possible in AI/AN communities by mailing FIT kits and instructions to eligible community members and providing easy options for returning the kits to the clinic. The addition of telephone and home visit outreach following the FIT mailing also increased screening compared with the usual care group in our study, but not significantly beyond the level attained by only mailing FIT kits. Results similar to ours were reported by Coronado et al (8), with post-intervention CRC screening rates of 26% among Hispanic patients who received mailed FOBT only and 31% in the group that received mailed FOBT plus telephone call and home visit outreach; both results were significantly higher than the 2% screened in the usual care group, but not significantly different from one another. Another study demonstrated that the addition of telephone calls to encourage screening and to address barriers did not result in increased FIT completion compared with just mailing a FIT kit with printed educational materials (13). In contrast, Walsh et al (7) reported that self-reported FOBT screening rates among Latinos and Vietnamese patients at 1-year follow up increased by 7.8% in the usual care group, 15.1% in an FOBT mailing and brochure group, and 25.1% in a mailing, brochure, and telephone counseling group. The differences were significant between usual care and each intervention and between the 2 intervention groups.

One possible reason that our study's CHR outreach failed to significantly boost the FIT return percentage compared with mailing alone was the lack of the CHR intervention among many group 3 participants. Of those in group 3 who did not return their FIT, nearly 1 in 4 did not receive any outreach. This most likely occurred because of staff turnover during the study period and competing CHR job duties that limited the time available to implement the outreach as specified in the study protocol. In some instances, CHRs could not reach participants because of incorrect phone numbers or addresses — a common barrier to conducting community outreach. In a similar study by Jean-Jacques et al (14), 23% of participants had incorrect or nonfunctional telephone numbers. Lasser et al (15) reported that of those eligible for patient navigation, 25% could not be contacted after 8 to 11 telephone call attempts. When a tribal facility or health system chooses to use CHRs to assist with cancer screening, CHRs need to have designated time to focus on this task. Patient navigators hired in 1 facility in Alaska specifically to assist with CRC screening efforts dramatically increased the number of CRC patients' first-degree relatives who completed screening (16). Future studies could seek to determine how much outreach is appropriate before reaching saturation. In our study, no additional FIT kits were returned after the second round of outreach.

Even though our study showed a significant increase in return of FIT kits from participants who received mailed kits compared with usual care, the percentage of mailed kits that were returned in both intervention groups combined (17.9%) was still low. Many reasons have been identified for nonresponse to a direct mailing of stool test kits, including fear of results, cost of follow-up colono-

scopy, not having received the mailed test, concerns about mailing fecal matter, and forgetfulness (17). Cultural barriers in AI/AN communities, such as medical mistrust, may also be a factor (4). Most participants in our study hand-delivered their completed FIT to the clinic instead of using the mailing envelope. Concern over mailing fecal material could be investigated further in this population. Additionally, some study participants may have had a language barrier. In our study, all written information with the FIT kit was in English. One alternative is to send out wordless instructions (eg, images/photographs) for completing the mailed FIT kit (18).

When stratified by age, our results showed that the percentage of returned FIT kits was highest at older ages. In the overall US population, CRC screening has been shown to be about 18% at age 50, increasing to 28% by age 51 (19). AI/AN people are less likely than other racial/ethnic groups to initiate screening at the recommended aged of 50 (20) and are more likely to be diagnosed with CRC at ages younger than 50, compared with non-Hispanic white people (21). Providers serving AI/AN populations need to ensure that their patients begin screening at the appropriate age and continue screening at the correct intervals, depending on their chosen method of screening and CRC risk level.

A large percentage of participants who returned FIT kits in our study (24%) had a positive FIT result. In a study by Hubbard et al (22), the risk of having a false-positive result from an FOBT was significantly greater among AI/AN than white patients. The greater risk of false-positive results among AI/AN populations could be a result of using FOBT for both symptomatic and asymptomatic patients. Any facility considering implementing population-based screening with FOBT or FIT in a population that has not been screened previously may need to prepare for a higher-than-expected proportion of positive test results and secure a facility that can perform the necessary follow-up colonoscopies.

Screening with FOBT or FIT reduces mortality from CRC only if patients with positive results undergo a follow-up colonoscopy. In our study, 41% of those with positive FIT results did not receive a follow-up colonoscopy. Several documented reasons for not completing colonoscopy are competing health concerns, failure to respond to follow-up outreach telephone calls and mailings, refusal, moving, and comorbidities that preclude safe colonoscopy (23). Others have suggested that noncompliance may be due to a combination of factors at the patient, provider, and health systems levels (24). Stock et al (25) showed that a notification sent directly to FOBT-positive screening patients increased colonoscopy uptake. A telephone call reminder, in addition to a mailed notification, may also improve the acceptance rate of colonoscopy in patients with a positive FIT (26).

Our study had several limitations. We conducted the study in 3 Southwest tribal communities, so results are not generalizable to all AI/AN populations. CHRs were unable to carry out all outreach as directed by the study protocol, compromising the comparison in FIT return between groups 2 and 3. Finally, we cannot conclude that group 3 participants who returned FIT kits after the outreach did so as a proximal result of outreach instead of the mailing itself.

The elimination of structural barriers through direct mailing of FIT kits to eligible community members is a useful, population-based approach to increase CRC screening among AI/AN people. The role of CHRs in improving CRC screening efforts could be studied further. Identifying interventions that increase the use of FOBT or FIT among AI/AN populations could have important implications for the uptake of CRC screening services and for decreased CRC mortality.

Acknowledgments

We acknowledge community health representatives, laboratory staff, and all others from the 3 participating Tribal health care facilities for their dedication to this project throughout the study period and afterwards. Funding for this study came from the Division of Cancer Prevention and Control, Centers for Disease Control and Prevention (CDC). The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC. Use of trade names is for identification only and does not imply endorsement by the US Department of Health and Human Services. No copyrighted materials were used in this article.

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Table

Table. Colorectal Cancer Screening Interventions in 3 Tribally Operated Health Care Centers Using the Fecal Immunochemical Test (FIT), 3 Intervention Groups, April–November 2014[a]

Variable	Group 1, Usual Care[b] (n = 566)	Group 2, Mailing Alone[c] (n = 361)	Group 3, Mailing + Outreach[d] (n = 361)	Total (N = 1,288)
Center				
1	257 (45.4)	133 (36.8)	133 (36.8)	523 (40.6)
2	95 (16.8)	95 (26.3)	95 (26.3)	285 (22.1)
3	214 (37.8)	133 (36.8)	133 (36.8)	480 (37.3)
Age, y[e]				
Mean, (standard deviation)	60.6 (7.0)	60.8 (6.8)	59.8 (6.7)	60.4 (6.9)
50–59	284 (50.3)	170 (47.2)	194 (53.7)	648 (50.4)
60–69	204 (36.1)	149 (41.4)	131 (36.3)	484 (37.6)
70–75	77 (13.6)	41 (11.4)	36 (10.0)	154 (12.0)
Women	291 (51.4)	179 (49.6)	200 (55.4)	670 (52.0)

[a] Values are number (percentage) unless otherwise indicated.
[b] No outreach apart from provider screening advice given during clinic visits.
[c] Mailing FIT kit with instructions for use.
[d] Mailing FIT kit with instructions for use. If no response, follow-up telephone call after 4 weeks, follow-up home visit after 8 weeks, and telephone call after 12 weeks.
[e] Values for 3 groups may not equal totals because some participants did not provide age.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
Volume 17, E129 OCTOBER 2020

ORIGINAL RESEARCH

Inclusion of Evidence-Based Breast Cancer Control Recommendations and Guidelines in State Comprehensive Cancer Control Plans

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Accessible Version: www.cdc.gov/pcd/issues/2020/20_0046.htm

Suggested citation for this article: Soori M, Platz EA, Kanarek N. Inclusion of Evidence-Based Breast Cancer Control Recommendations and Guidelines in State Comprehensive Cancer Control Plans. Prev Chronic Dis 2020;17:200046. DOI: https://doi.org/10.5888/pcd17.200046.

PEER REVIEWED

Summary

What is already known on this topic?

State comprehensive cancer control (CCC) plans are supported through national programs in the United States and are written and updated by using consensus strategies.

What is added by this report?

Using breast cancer as an example, we describe adherence to national recommendations or guidelines in crafting objectives in state CCC plans.

What are the implications for public health practice?

To raise awareness of all that can be done to address the burden of cancer in their state, states need to heed evidence-based recommendations and guidelines and give attention to completeness of objectives in their state CCC plans.

Abstract

Introduction

Each US state, territory, and tribe/tribal organization is supported by the Centers for Disease Control and Prevention to develop and implement a comprehensive cancer control (CCC) plan. The objective of this study was to inform areas for improvement of those plans.

Methods

To show how CCC plans can be improved, we used the example of breast cancer, which has a long public health history and an established, broad spectrum of prevention and control activities. We evaluated the inclusion of evidence-based breast cancer prevention topics as provided by guidelines from the Centers for Disease Control and Prevention (CDC) and recommendations of the US Preventive Services Task Force (USPSTF) in each state's CCC plan. From January through March 2019, we downloaded CCC plans from each state and the District of Columbia and abstracted and quantified the content of plans for 1) discussion of data on breast cancer mortality, breast cancer incidence, uptake of mammography; 2) statement of objective to reduce the burden of breast cancer; and 3) review of CDC guidelines and USPSTF recommendations.

Results

The discussion of breast cancer–relevant topics and specification of objectives was incomplete. Of 51 plans, data on breast cancer mortality and incidence and uptake of mammography were reported in 53% (n = 27) to 76% (n = 39) of plans. CDC and USPSTF recommendations for breast cancer–specific interventions were discussed in only 6% (n = 3) to 37% (n = 19) of plans. Discussion of general cancer prevention topics relevant to breast cancer ranged from 10% (n = 5) to 61% (n = 31) of plans.

Conclusion

Our findings inform areas for quality improvement of state CCC plans and may contribute to other areas of public health planning.

Introduction

Breast cancer is the most commonly diagnosed cancer and the most common cause of cancer-related death among women in the United States (1). Breast cancer development is attributable to both nonmodifiable (eg, genetic predisposition) and modifiable (eg, reproductive, lifestyle) factors. Modifiable risk factors correlate with a spectrum of interventions available to address reductions in incidence or mortality. Maintaining a healthy weight, being physically active, eating an optimal diet (nutrition) with moderate to no alcohol intake, and breastfeeding may account for future declines in incidence by 29% (2–4). Timely age-specific

screening accounts for a 28% to 65% decrease in mortality (5,6). High-risk status has often been determined from nonmodifiable factors (genetic factors and previous benign breast disease) (7,8). For women at high risk of breast cancer, chemoprevention and prophylactic surgery are available as primary prevention strategies (2–4,9).

The Centers for Disease Control and Prevention's (CDC's) National Comprehensive Cancer Control Program (NCCCP) funds US states, territories, and tribes/tribal organizations to develop and implement plans to control cancer. CDC recommends state Comprehensive Cancer Control (CCC) plans include evidence-based recommendations and guidelines (10). Accordingly, CDC recommends that state plans, which vary in their content and organization, present valid data from the state's cancer registry, describe the prevalence of cancer in diverse populations, and provide information on state population demographic characteristics. Plans should also present logically linked, clearly labeled specific, measurable, attainable, relevant and time-phased (SMART) objectives (10).

Because breast cancer has a long history of extensive research supporting policy and program development and a broad spectrum of prevention and control activities, it provides a key test case for determining the quality of CCC plans, and more generally, for studying pitfalls and challenges of cancer prevention and control planning. We evaluated whether CCC plans discussed evidence-based breast cancer prevention topics as described in the most recent CDC guidelines and US Preventive Services Task Force (USPSTF) recommendations (Table 1). Our study objective was to inform areas for quality improvement of state CCC plans by using the example of breast cancer. This study may also inform state planning strategies (eg, SMART objectives) for additional areas of public health.

Methods

We abstracted information from CCC plans on 3 population-based measures of breast cancer burden, 2 breast cancer–specific topics, and 5 general primary prevention topics that would be included in state CCC plans if CDC and USPSTF recommendations and guidelines had been incorporated (Table 1). We downloaded 51 current CCC plans, from 50 US states and the District of Columbia, from the CDC website (10) from January through March 2019. We did not include in our analysis the CCC plans in US territories because not all territories have a CCC plan.

Every state writes a self-determined CCC plan consistent with CDC plan guidance (10). States select format, priorities, audience, and content of CCC plans. To accommodate this variety, we used a standardized method to abstract and classify from each plan information on breast cancer–related topics occurring in any section in the CCC plan. One member of the research team (M.S.) created a database, abstracted the content, and to ensure accuracy of abstraction, scanned each plan twice.

Evidence-based breast cancer–related topics in CDC guidelines and USPSTF recommendations. We reviewed the most up-to-date recommendations and guidelines as of November 30, 2019, on breast cancer control and prevention from USPSTF recommendations (7,8, 11–14) and CDC guidelines (15–22) (Table 1, Table 2) We classified topics by whether they were breast cancer–specific topics, general cancer prevention topics that apply to breast cancer, or measures of breast cancer mortality, incidence, or screening (timely mammogram) prevalence. We defined breast cancer–specific topics as 1) chemoprevention for women at high risk of breast cancer and 2) genetic risk assessment, testing, and screening for breast cancer susceptibility 1 and 2 (*BRCA 1/2*) gene mutations. We defined general cancer prevention topics that applied to breast cancer as 1) alcohol intake, 2) breastfeeding, 3) diet/nutrition, 4) healthy weight, and 5) physical activity. We defined measures of breast cancer burden as 1) mortality, 2) incidence, and 3) prevalence of a timely mammography.

We then summarized the breast cancer prevention recommendations and guidelines issued by the USPSTF, including only recommendations with an A or B rating (7,8,11–14), and CDC (15–22) (Table 2). Both CDC and USPSTF addressed mammograms; breastfeeding; genetic risk assessment, testing and screening; healthy weight; chemoprevention; and alcohol use. CDC addressed all general cancer prevention topics that apply to breast cancer and referred to the dietary guidelines from the US Department of Agriculture and the US Department of Health and Human Services (3). The USPSTF also has recommendations for weight loss to avoid obesity (13).

SMART objectives. To evaluate written objectives (10) we used CDC guidelines for objectives that are SMART: specific, measurable (baseline and target), attainable/achievable (target setting method), relevant (with data source), and time-bound (dated). Specific objectives refer to a particular topic, for example, in our study, mortality caused by breast cancer. Measurable objectives are made concrete by quantification: How will the objective be measured? Achievable targets are often based on history (eg, performance in the previous 5 years) or outcomes achieved by others (eg, median of all states) or are aspirational (eg, "best"). Objectives are most useful when oriented to attainable targets. We did not address "attainable/achievable" unless it met a USPSTF recommendation or CDC guideline. Relevant objectives have an existing, accessible, and specific source of data. As an example, all states have data collection systems for collecting and reporting cancer mortality, incidence, and screening prevalence. We con-

sidered both collectors of data (primary sources such as an incidence registry) and users who publish reports (secondary sources) to be data sources. We defined "time-bound" as the baseline date and end date of the CCC plan and refer to it as "time period specified" in this study.

Abstraction of content from CCC plans. We used the following search terms to locate content relevant to breast cancer in each CCC plan: alcohol, BRCA, breast, breast cancer, breastfeeding, chemotherapy, chemoprevention, diet/nutrition, drink, family history, food, fruit, gene, genetic, hereditary, obese, obesity, physical activity, mammogram, mammography, nutrition, screening, vegetable, and weight.

To assess the extent of coverage of measures, we created a standardized form to abstract plan content by dichotomous (yes/no) assignment in Excel (Microsoft Corporation) based on the criteria listed in the CDC and NCI cancer control plan development and assessment tool; the form also included a notation on topic or data with source and date and relevant SMART objective, where applicable (10). In the Excel spreadsheet, we assigned breast cancer–related topics and objectives extracted from CDC and USPSTF recommendations and guidelines to columns, and US states and the District of Columbia to rows. We revised the abstraction strategy several times based on the content obtained from CCC plans we considered a priori of high quality. By using the key term search feature of Microsoft Edge, we located plan content in any part of the CCC plan (eg, background information, information related to objectives), classified content into dichotomous variables, evaluated the key term, and then evaluated the surrounding text of the key terms for relevance to breast cancer in all plans. We quantified a dichotomous (yes/no) assignment by using the "count if" feature of Excel, and we spot checked assignments manually to ensure quality. We ascertained date and source of baseline measures and categorized them as present or not present.

We assessed topics in 2 ways: 1) whether the topic (yes/no) was discussed in the CCC plan and 2) whether a topic-specific objective was stated (yes/no). We quantified the findings in Excel as percentage of state plans covering each topic.

Results

Of the 51 CCC plans, 71% (n = 36) presented data on breast cancer incidence and 76% (n = 39) presented data on mortality (Table 3). Most plans complied with the CDC data quality requirement by including information on the date and source of data. The placement of this information varied among plans: next to these data, in the text, in figures or tables, or at the end of the plan in the plan's list of references. A few plans referenced other reports rather than citing the primary data source and date. Although data on breast cancer incidence and mortality were commonly included in plans, 12 plans did not include these data. Two states and the District of Columbia presented data on the geographic distribution of breast cancer incidence and mortality across wards (in the District of Columbia) or counties. About half (n = 27) of the plans presented data on the prevalence of a timely mammography.

Components of SMART objectives were included infrequently for breast cancer incidence (2%; n = 1) and mortality (19%–23%; n = 10–12). When mammography objectives were presented, they usually referred to each SMART component; components least often mentioned were relevant data source (65%; n = 33) and time period specified (67%; n = 34) (Table 3).

Nineteen plans discussed hereditary breast cancer; 14 discussed genetic screening for *BRCA 1/2* mutations. Three plans discussed chemoprevention for women at high risk of breast cancer, and 1 of these CCC plans specified high-risk breast cancer target populations. Uniformly, when chemoprevention was included, the CCC plans did not indicate breast cancer–specific SMART objectives.

Other breast cancer–specific prevention topics were covered to a varying extent in background information. Many plans provided data on these topics in their discussion of baseline rates, prevalence, or whether an objective was met or not in the background section. Five plans discussed breastfeeding as a primary prevention strategy, without any state-specific data (Table 4).

Approximately 39% to 60% (n = 20–31) of plans covered 5 general cancer prevention topics that apply to breast cancer (alcohol intake, breastfeeding, diet/nutrition, healthy weight, and physical activity) (Table 4); fewer plans (n = 6–22) discussed the link between these factors and breast cancer. Alcohol intake was addressed in 11 plans; 10 states stated an alcohol-related objective. Specific SMART objectives on healthy weight, physical activity, and nutrition were included in 29 to 36 plans, most often presented with SMART objectives. In addition, a state's objective targets were presented in most plans, but only 3 plans described the methods for setting goal (target) amounts for their objectives, and of these 3 only 1 plan described methods for every general cancer prevention objective. Some plans used Healthy People 2020 targets or specified a percentage improvement.

Discussion

Not all 51 CCC plans discussed CDC and USPSTF guidelines and recommendations, and at least half of the plans covered only 4 of the 8. Not all plans addressed SMART objectives, despite CDC's recommendation to include SMART objectives. Our findings on breast cancer from CCC plans may be transferable and beneficial

to planning for other types of cancer to reduce cancer burden state by state and ultimately provide a state planning example to other spheres of public health.

Omission of data on breast cancer mortality in CCC plans was unexpected, because every state and the District of Columbia has agency over their death data. Central cancer registries are a more recent source of data, and inclusion of incidence data was almost as common as inclusion of mortality data, which suggests that data on mortality and incidence may be coming from the same agency source or that states' understanding of cancer burden encompasses both incidence and mortality data. Mammography data, however, which can be obtained from CDC's Behavioral Risk Factor Surveillance System surveys ("Women aged 50–74 who have had a mammogram within the past two years") that are conducted at the state level and are publicly available, were included approximately half the time in the CCC plan background sections and were just as often included as an objective baseline elsewhere. Neglecting to highlight mammography in background information is potentially detrimental to states' efforts to decrease breast cancer mortality, because screening accounted for more than one-quarter of the decline in breast cancer mortality (5,6) in the past 10 to 25 years. Presenting mammography rate as background information highlights its importance as a public health intervention and can increase survival rates through early detection.

Other topics were discussed in plans to a modest extent: healthy weight (60%), physical activity (43%), nutrition (39%), hereditary breast cancer (37%), testing for *BRCA 1/2* gene mutations (27%), alcohol (21%), breastfeeding (10%), and chemoprevention (6%). Specifying the role of *BRCA 1/2* was less frequent than including the more general topic of hereditary breast cancer. We might expect that these 2 topics would be covered similarly because, as targets for breast cancer prevention, *BRCA 1/2* gene mutations are a subset of heredity breast cancer, although the role of additional genes is becoming more evident over time. We found no SMART objectives for these recommendations. Only 1 in 5 plans specified alcohol use as a risk factor and only 1 in 10 plans specified breastfeeding as a preventive factor. These omissions are surprising, given the evidence base for each. Alcohol use is a modifiable breast cancer risk factor, even at 1 drink per day, and thus even moderate risk projections of breast cancer occurrence can be lowered with abstinence (23). Breastfeeding is also a modifiable factor; the risk of developing breast cancer decreases 4.3% for each year of breastfeeding (24). These preventive factors have not been customary targets of cancer prevention and control programs and will demand work with public health partners across domains and less single-focus thinking about what can be done to enhance cancer prevention.

In general, the topics of primary and secondary prevention of breast cancer and conformance to SMART objectives were mentioned in many, but not all, state CCC plans. For states without such content, a review of the epidemiology literature or a compendium of authoritative recommendations and guidelines for breast cancer prevention would inform and perhaps encourage including them in CCC plans. Surveilling changes in guidelines and recommendations and the use of SMART objectives are additional and valuable feedback to states' cancer prevention and control efforts as their CCC plans are updated. The inconsistent inclusion of evidence-based primary and secondary prevention recommendations and guidelines as SMART objectives in state CCC plans suggests that CDC, as the funder of state CCC plan development, may need to provide more guidance and technical support on these topics, including information on best practices that illustrate the practical benefit of inclusion. Some resources currently provided at the CDC website are the Cancer Plan Self-Assessment Tool (10), Nutrition and Physical Activity Strategies for Cancer Prevention (25), and Principles for Community Engagement (26). For transparency and validity reasons, developers of state plans need to improve the identification, use, and citation of authoritative sources of data on breast cancer incidence, breast cancer mortality, and mammography prevalence. CDC may need to provide additional guidance and technical support to encourage state plan developers to engage with public health professionals who are familiar with these data sources in their own states or with databases available through resources such as the National Cancer Institute's Cancer Control Planet State Profiles (26).

In reviewing the 51 CCC plans, we noted features in some that may be useful for implementation of plan objectives. For example, 3 states presented maps of breast cancer incidence and mortality. In studies of US county data, outcomes differ among counties and are influenced by characteristics such as urbanization or population demographics (26,27).

Other sources of variation in breast cancer data are age at diagnosis, race, and ethnicity. Breast cancer diagnosis peaks in the 60s and 70s (26,27). Age at diagnosis is critically informative in planning for breast cancer survivorship among the more than 250,000 women in the United States annually who survive breast cancer (1). Moreover, race/ethnicity and age have traditionally segmented risk status for breast cancer incidence and survival. Median age at diagnosis is a few years younger for non-Hispanic Black women, partly because their rate of triple negative breast cancer, which occurs at younger ages, is twice that of other racial/ethnic subgroups (26,27). Information on age at diagnosis among diverse populations is helpful for setting state-specific subgroup screening guidelines. More importantly, subgroup identification is necessary to address and ultimately achieve equity in outcomes.

Among topics specific to breast cancer, screening by mammography is well covered in CCC plans, especially in the section on objectives. Effectiveness of breast cancer screening in decreasing breast cancer mortality is supported by scientific literature (5,6), and new evidence, such as the evidence provided in our study, contributes to new or amended recommendation statements. Differences between guidance and state objectives may be due to the publication date of the plan predating the latest recommendation or guideline (28). One solution is to revise state CCC plans on a periodic schedule short enough to ensure that new information is incorporated in a timely way.

Breastfeeding, chemoprevention, and hereditary breast cancer barely covered SMART objectives in CCC plans. However, they are included in recommendations and guidelines. Absence in the plans may be due to factors such as lack of awareness among program staff, their smaller effect on risk of developing breast cancer, or a relatively small target population. Their absence further emphasizes the importance of regular staff training, academic and clinical partnerships, and formal specification of recommendation statements in state intervention programs. Anecdotally, state funding may be a single-focus issue in that state programs do not interact with other key programs even when common issues exist (eg, maternal and child health, breastfeeding).

Although the topics of physical activity (22), healthy weight (20), and diet/nutrition (18) are covered extensively on CDC websites and discussed in the guidelines of the US Department of Agriculture and the US Department of Health and Human Services (3), alcohol intake guidelines (15,23) are not frequently covered in CCC plans. CDC may need to conduct educational programs about this lifestyle behavior risk.

State plans vary in their length and style, which may indicate that the plan writers are trying to reach various audiences. CDC may be able to assist with assembling data and plans for these audiences, as the agency is already doing with data visualizations (1).

Our study has several limitations. First, our assessment did not cover all topics recommended by CDC in state CCC plans. For example, CDC recommends discussing information on state demographic factors (10), but it does not specify discussion of these factors in relation to breast cancer recommendations, even though breast cancer has been linked epidemiologically to age, race, ethnicity, income, education, and other factors. Knowledge of these demographic factors is important in designing and carrying out a plan that addresses diversity and ensures equity (29,30). Second, we reviewed the CCC plans available at a single point in time. The periods during which the plans were assembled and intended to serve varied; states having the most plan editions will most likely also be the most complete in the inclusion of topics and use of SMART objectives. In a study of the guidelines and recommendations in the Maryland CCC plan, Fowler and colleagues found that 9 of 19 cancer-related CDC guidelines or USPSTF recommendations had not been issued at the time of 2010–2015 plan publication (28). An ongoing process of reviewing national guidelines and recommendations and updating state CCC plans is needed, especially when the time span of the state's cancer plan is lengthy (>5 y) or occurs when the next plan is revised.

The evaluation of SMART objectives in our study may have implications for other health planning in the nation, states, or localities (31,32). The highest priorities of the Association of State and Territorial Health Officials for State Health Improvement Plans include assembling data and writing objectives (31). Use of SMART objectives gives all partners a common lexicon, an expectation of achievement over time, and clarity on the path to success. SMART objectives, when complete, are associated with improved outcomes (30).

Our examination of breast cancer–related evidence-based coverage and completeness of plan objectives in state CCC plans shows there is room for improvement. Our findings can guide efforts to improve the quality of all CCC plan topics. However, CDC guidance alone may not be enough to ensure a high-quality plan in every state. In addition to raising awareness of evidence-based planning, other measures may be needed to incentivize best practices in cancer prevention and other areas of public health planning.

Acknowledgments

We thank Dr David Celentano for his support during preparation of this article. Norma Kanarek and Elizabeth Platz are supported in part by the Maryland Cigarette Restitution Fund Research Grant at Johns Hopkins and the National Cancer Institute Cancer Center Support Grant (P30 CA006973). No copyrighted materials were used in this article.

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Tables

Table 1. General and Breast Cancer Prevention Topics Discussed in the Recommendations of the US Preventive Services Task Force (USPSTF) and Guidelines From the Centers for Disease Control and Prevention (CDC)[a]

Topic	USPSTF	CDC
Breast cancer burden		
Mammogram	x	x
Breast cancer–specific topics		
Chemoprevention	x	x
Genetic risk assessment, testing, screening	x	x
General cancer prevention topics that apply to breast cancer		
Alcohol intake	x	x
Breastfeeding	x	x
Diet/nutrition		x
Healthy weight	x	x
Physical activity		x

[a] This table was designed by the authors to enable a study of breast cancer–related content in the Comprehensive Cancer Control plans in 50 states and the District of Columbia, January–March 2019.

Table 2. Summary of Breast Cancer–Related Recommendations and Guidelines Published by the US Preventive Services Task Force (USPSTF) and the Centers for Disease Control and Prevention (CDC)[a]

Topic	Population	Recommendation
USPSTF		
Alcohol intake (11)	Adults and adolescents	Screening for unhealthy use of alcohol.
Breastfeeding (12)	Pregnant women, new mothers, and their children	Provide interventions during pregnancy and after birth to support breastfeeding. Grade: B
Chemoprevention (7)	Women aged ≥35 y at increased risk for breast cancer	Offer to prescribe risk-reducing medications, such as tamoxifen, raloxifene, or aromatase inhibitors. Grade: B
	Women aged ≥35 y not at increased risk for breast cancer	Do not routinely use risk-reducing medications, such as tamoxifen, raloxifene, or aromatase inhibitors. Grade: D
Genetic risk assessment, testing, screening (8)	Women with a personal or family history of breast, ovarian, tubal, or peritoneal cancer or who have an ancestry associated with *BRCA 1/2* gene mutations	Assess with an appropriate brief familial risk assessment tool. Grade: B
	Women whose personal or family history or ancestry is not associated with potentially harmful *BRCA 1/2* gene mutations	Do not perform routine risk assessment, genetic counseling, or genetic testing. Grade: D
Healthy weight (13)	Adults with a body mass index ≥30	Offer or refer to intensive, multicomponent behavioral interventions. Grade: B
Mammogram (14)	Women aged 40–49 y	The decision to start screening should be an individual one. Grade: C
	Women aged 50–74 y	Screen every 2 years. Grade: B
	Women aged ≥75 y	No recommendation. Grade: I (Insufficient evidence)
CDC		
Alcohol intake (15)	—	CDC recommends drinking alcohol in moderation and refers to the Dietary Guidelines for Americans for recommendations.
Breastfeeding (16)	Pregnant women	Recommend exclusive breastfeeding for 6 months, and then continuing breastfeeding while introducing complementary foods until the baby is aged 12 months or older
Chemoprevention (17)	Women at high risk of breast cancer	Prescribe aromatase inhibitors, tamoxifen or raloxifene.
Diet/nutrition (18)	—	CDC extensively discusses the topic and refers to Dietary Guidelines for American.
Genetic risk assessment, testing, screening (19)	Women at high risk of breast cancer	CDC extensively discusses the topic but does not provide any guidelines.
Healthy weight (20)	—	CDC extensively discusses the topic and refers to Dietary and Physical Activity Guidelines for Americans for recommendations but does not provide any guidelines.
Mammogram (21)	—	CDC extensively discusses the topic but does not provide any guidelines.
Physical activity (22)	Preschool-aged children (aged 3–5 y)	Every day throughout the day.
	Children and adolescents (aged 6–17 y)	1 hour or more of moderate-to-vigorous intensity physical activity daily.
	Adults (aged 18–64 y)	At least 150 minutes per week of moderate-intensity activity. At least 2 days per week of activities that strengthen muscles.
	Older adults (≥65 y)	At least 150 minutes per week of moderate-intensity activity. At least 2 days per week of activities that strengthen muscles. Activities to improve balance.

[a] This table was designed by the authors to enable a study of breast cancer–related content in the Comprehensive Cancer Control plans in 50 states and the District of Columbia, January–March 2019.

Table 3. Comprehensive Cancer Control Plans That Included Data on Breast Cancer Incidence and Mortality and the Prevalence of a Timely Mammogram and Specified SMART Objective Components[a], 50 States and the District of Columbia[b]

Topic	Measure			SMART Component[b]				
	Discussed in Plan	Dates Are Specified for Data	Sourced	Specific Objective	Measured Baseline	Measured Target	Relevant Data Source	Time Period Specified
Incidence	36 (71)	34 (67)	25 (49)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)
Mortality	39 (76)	37 (73)	27 (54)	12 (23)	11 (21)	11 (21)	10 (19)	12 (23)
Prevalence of a timely mammogram[c]	25 (49)	29 (57)	34 (67)	43 (85)	41 (81)	40 (79)	33 (65)	34 (67)

[a] SMART objectives are specific, measured, attainable/achievable (not assessed in this study), relevant data, with the time specified (10).
[b] Study was conducted January-March 2019. All values presented are number (percentage).
[c] Per US Preventive Services Task Force recommendations (14).

Table 4. General Cancer Prevention Topics That Apply to Breast Cancer in Comprehensive Cancer Control Plans, 50 States and the District of Columbia[a]

General Prevention Topics	Topic Included	Stated Link to Breast Cancer	Component of SMART Objective[b]				
			Specific Objective	Measured Baseline	Measured Target	Relevant Data Source	Time Period Specified
Alcohol intake	11 (21)	10 (20)	10 (20)	10 (20)	10 (20)	8 (15)	7 (14)
Breastfeeding	5 (10)	5 (10)	5 (10)	5 (10)	5 (10)	4 (8)	5 (10)
Diet/nutrition	20 (39)	6 (12)	29 (57)	24 (47)	23 (45)	20 (39)	24 (47)
Healthy weight	31 (60)	22 (43)	36 (71)	35 (69)	32 (63)	31 (61)	27 (53)
Physical activity	22 (43)	10 (20)	31 (60)	27 (53)	26 (52)	22 (43)	26 (51)

[a] Study was conducted January through March 2019. All values presented are number (percentage).
[b] SMART objectives are specific, measured, attainable/achievable (not assessed in this study), relevant data, with the time specified (10).


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