

Decreasing Black-White Disparities in Colorectal Cancer Incidence and Stage at Presentation in the United States

Folasade P. May^{1,2,3}, Beth A. Glenn^{2,3,4}, Catherine M. Crespi^{3,5}, Ninez Ponce⁴, Brennan M.R. Spiegel^{4,6}, and Roshan Bastani^{2,3,4}

Abstract

Background: There are long-standing black–white disparities in colorectal cancer incidence and outcomes in the United States. Incidence and stage at diagnosis reflect the impact of national efforts directed at colorectal cancer prevention and control. We aimed to evaluate trends in black–white disparities in both indicators over four decades to inform the future direction of prevention and control efforts.

Methods: We used Surveillance, Epidemiology, & End Results (SEER) data to identify whites and blacks with histologically confirmed colorectal cancer from January 1, 1975 through December 31, 2012. We calculated the age-adjusted incidence and the proportion of cases presenting in late stage by race and year. We then calculated the annual percentage change (APC) and average APC for each indicator by race, examined changes in indicators over time, and calculated the incidence disparity for each year.

Results: There were 440,144 colorectal cancer cases from 1975 to 2012. The overall incidence decreased by 1.35% and 0.46% per year for whites and blacks, respectively. Although the disparity in incidence declined from 2004 to 2012 (APC = -3.88% ; $P = 0.01$), incidence remained higher in blacks in 2012. Late-stage disease declined by 0.27% and 0.45% per year in whites and blacks, respectively. The proportion of late-stage cases became statistically similar in whites and blacks in 2010 (56.60% vs. 56.96%; $P = 0.17$).

Conclusions: Black–white disparities in colorectal cancer incidence and stage at presentation have decreased over time.

Impact: Our findings reflect the positive impact of efforts to improve colorectal cancer disparities and emphasize the need for interventions to further reduce the incidence gap. *Cancer Epidemiol Biomarkers Prev*; 26(5); 762–8. ©2016 AACR.

Introduction

Colorectal cancer is a major contributor to cancer incidence and cancer-related mortality in the United States. Each year, over 130,000 Americans are diagnosed with colorectal cancer and over 49,000 die from the disease (1). Diagnosis, management, and treatment of colorectal cancer are also associated with significant health care costs in the United States with national expenditures for colorectal cancer exceeding \$14 billion annually (2).

There are well-documented and long-standing disparities in colorectal cancer incidence and outcomes between U.S. whites and blacks (1, 3–9). Incidence of colorectal cancer in blacks has exceeded incidence in whites since the mid-1980s (1). In addition,

blacks carry an excessive burden of disease with the highest mortality and the lowest survival rates following diagnosis when compared with other racial and ethnic groups (1, 10–15). Advanced stage disease at presentation also varies by race. Historically, blacks have been more likely to be diagnosed with colorectal cancer at late stages than whites, limiting options for treatment and leading to poor survival and mortality outcomes (1, 13, 15, 16). As 5-year survival for stage I colorectal cancer is 90%, compared with 13% for those with advanced disease at diagnosis, early disease detection is critical to reducing the burden of colorectal cancer (1).

The black–white disparity in colorectal cancer outcomes has been attributed to a genetic predisposition to colorectal cancer among blacks, a higher prevalence of colorectal cancer risk factors in blacks, and differences in access to preventive and healthcare services like cancer screening in blacks compared with whites (4, 14, 17–31). Efforts to address these inequities have included education about colorectal cancer risk factors among blacks and targeted efforts to improve colorectal cancer screening uptake in black Americans (14, 32–34). Such efforts have likely contributed to the improving black–white disparities in colorectal cancer screening uptake in national surveys. Historically, blacks have had lower colorectal cancer screening rates than whites; however, recent Centers for Disease Control (CDC) data suggest equivalent colorectal cancer screening rates among blacks and whites (35).

The effects of these interventions on black–white disparities in colorectal cancer incidence and stage at diagnosis, the outcomes most likely to be influenced by colorectal cancer screening, have

¹Division of Digestive Diseases, David Geffen School of Medicine at UCLA, Los Angeles, California. ²UCLA Kaiser Permanente Center for Health Equity, Los Angeles, California. ³Jonsson Comprehensive Cancer Center, David Geffen School of Medicine at UCLA, Los Angeles, California. ⁴Department of Health Policy and Management, UCLA Fielding School of Public Health, Los Angeles, California. ⁵Department of Biostatistics at UCLA Fielding School of Public Health, Los Angeles, California. ⁶Cedars-Sinai Center for Outcomes Research and Education (CS-CORE), Los Angeles, California.

Corresponding Author: Folasade P. May, David Geffen School of Medicine at UCLA, 650 Charles Young Drive South, Room A2-125 CHS, Los Angeles, CA 90095-6900. Phone: 310-825-4728; Fax: 310-268-4510; E-mail: fmay@mednet.ucla.edu

doi: 10.1158/1055-9965.EPI-16-0834

©2016 American Association for Cancer Research.

been less well described. To conduct a more thorough assessment of national progress toward reducing disparities in colorectal cancer outcomes, we examined trends in colorectal cancer incidence and stage at diagnosis in U.S. whites and blacks from 1975 to 2012. Both of these colorectal cancer indicators are amenable to clinical and public health intervention, and thus, provide insight into the impact of screening guidelines, national insurance policy changes, and targeted efforts to increase screening rates on colorectal cancer outcomes. Furthermore, knowledge about how colorectal cancer disparities have changed over time and have responded to previous efforts will inform future research, implementation strategy, and policy to address ongoing inequities in colorectal cancer outcomes.

Materials and Methods

Data source and study population

We used data from the National Cancer Institute (NCI) Surveillance, Epidemiology, & End Results (SEER) database (36). Given that our main interest was to examine long-term trends in colorectal cancer indicators, our primary analyses were based on SEER 9 registry data, which include malignancies diagnosed in nine U.S. regions from 1975 to 2012 and represent 9.4% of the U.S. population (37). Secondary analyses included rates, proportions, and trends from SEER 13 and SEER 18 registries that provide broader geographic and demographic coverage, but over shorter periods of time. SEER 13 includes tumor registry data from 13 U.S. regions from 1992 to 2012 while SEER 18 includes data from 18 regions from 2000 to 2012 (38, 39).

The study cohort included individuals in the SEER program database with histologically confirmed colon or rectal cancer diagnosed between January 1, 1975 and December 31, 2012 as defined by the International Classification of Diseases for Oncology, Third edition (40). Analyses were limited to U.S. blacks and whites. As the SEER 9 database does not specify Hispanic ethnicity, persons of Hispanic origin are included in their respective racial group category (black or white). The SEER population is comparable with the U.S. population with respect to income level (14.1% vs. 14.3% below poverty level) and education (16% vs. 14.6% with less than high school diploma; ref. 37). Minority racial and ethnic groups, foreign-born, and urban populations are deliberately overrepresented in the SEER database to ensure adequate representation of groups that are of special interest to the SEER program (41).

Colorectal cancer indicators

The two outcomes were incidence and stage at diagnosis. For incidence, we used age-adjusted colorectal cancer incidence rates expressed per 100,000 persons as calculated from the 2000 U.S. standard population and provided in the SEER*Stat software

version 8.2.1 (36). For stage at disease presentation, we categorized tumors as early stage or late stage, using the SEER Historic Stage A variable for extent of disease at diagnosis. The SEER Historic Stage A variable is the only stage variable in SEER that has been recorded consistently from 1975 to 2012. We defined early-stage cases as localized disease confined to the colon/rectum or with intraluminal extension but no lymph node involvement at the time of diagnosis. Those presenting with colorectal cancer that extended beyond the colon/rectum or to remote parts of the body were categorized as late stage. We excluded patients in the unstaged disease category from stage trend analyses.

Statistical analyses

We used SEER*Stat version 8.2.1 (April, 2015) to specify the colorectal cancer cohort and to obtain frequencies in incidence and proportions for stage for each racial group for each year (36). We then used the Health Disparities Calculator (HD*Calc 1.2.4) provided by the NCI to determine the absolute difference in colorectal cancer incidence between blacks and whites for each year (42). In HD*Calc, incidence disparities are provided as the absolute difference in the incidence in whites and blacks for a given year. We also calculated incidence disparities as rate ratios (RR), a measure of the relative difference in rates between whites and blacks for a given year (43).

To evaluate the indicator data for significant linear trends, we used Joinpoint 4.1.1.3 (44). Joinpoint provides the annual percent change (APC) and average annual percent change (AAPC) where APC is the rate of change in an indicator over a one-year period, and AAPC is the weighted average of APCs used to describe an indicator trend over the entire SEER study period (45, 46). *P* values were calculated for each APC and AAPC where a value less than 0.05 supported a trend change significantly different from zero, and significant APCs and AAPCs represented statistically significant trends in the indicator. In Joinpoint, we also used the comparability test to compare indicator trends in the white and black cohorts, where *P* < 0.05 signified significantly different trends in whites and blacks over the given time period. The test of parallelism determined whether white and black trends were parallel over a given time period, where *P* < 0.05 signified non-parallel trends.

Results

Overall colorectal cancer incidence and late stage at diagnosis

From 1975 to 2012, there were 440,144 colorectal cancer cases in the SEER 9 regions. Colorectal cancer incidence was 54.45 per 100,000 whites and 60.22 per 100,000 blacks (Table 1). Overall, 218,385 (54.81%) whites with colorectal cancer presented with late-stage disease. In blacks, 23,853 (57.20%) cases were late-stage presentations (*P* < 0.01; Table 1).

Table 1. Colorectal cancer incidence and stage at presentation by race (1975–2012; SEER 9)

| | Age-adjusted incidence | | |
|---|------------------------|-----------------------------|-----------------|
| | Whites | Blacks | Total |
| Incidence ^a , <i>N</i> (cases per 100,000) | 398,466 (54.45) | 41,698 (60.22) ^b | 440,144 (55.1) |
| Stage at presentation, <i>N</i> (%) ^c | | | |
| Early | 154,543 (38.79) | 14,824 (35.55) ^b | 169,367 (38.48) |
| Late | 218,385 (54.81) | 23,853 (57.20) ^b | 242,238 (55.04) |
| Unstaged | 25,518 (6.40) | 3,021 (7.24) | 28,539 (6.48) |

^aIncidence rates are age-adjusted to the 2000 U.S. standard population.

^bStatistically different than white at *P* < 0.001.

^cFor stage %, denominator is total colorectal cancer cases for each race group.

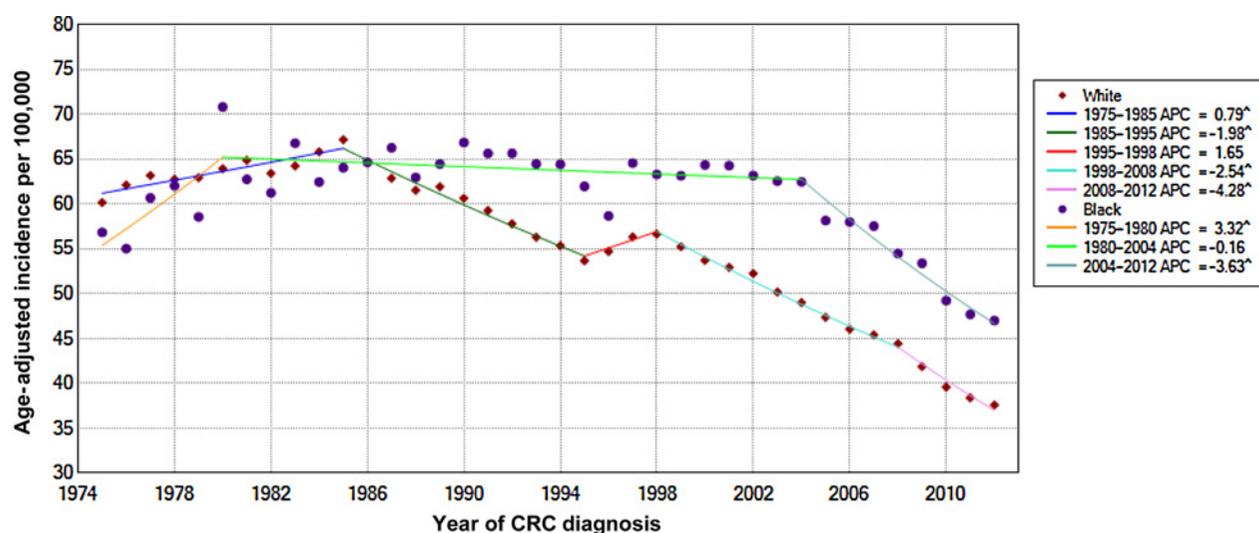


Figure 1. Evaluation for significant linear trends in colorectal cancer (CRC) incidence in whites and blacks, SEER 9 (1975–2011)*.

*. Rates are per 100,000 and age-adjusted to the 2000 U.S. standard population. APC, annual percentage change.

^, APC is significantly different from zero at $P = 0.05$.

Black–white colorectal cancer incidence trends over time

Significant linear trends in incidence are presented in Fig. 1 for each racial group. In whites, there was a significant increase in colorectal cancer incidence by 0.79% per year (APC = 0.79; $P < 0.001$) from 1975 to 1985 before incidence began to decline in 1985. Incidence declined by 1.98% per year from 1985 to 1995 (APC = -1.98 ; $P < 0.01$), remained statistically stable from 1995 to 1998 (APC = 1.65; $P = 0.25$), declined by 2.54% per year from 1998 to 2008 (APC = -2.54 ; $P < 0.01$), and further by 4.28% per year from 2008 to 2012 (APC = -4.28 ; $P < 0.01$).

Incidence in blacks rose by 3.32% per year from 1975 to 1980 (APC = 3.32; $P < 0.01$) and then remained stable from 1980 to 2004 (APC = -0.16 ; $P = 0.08$; Fig. 1). Blacks did not see a significant decrease in colorectal cancer incidence until 2004, twenty years after rates in whites began to decline. Incidence in blacks decreased by 3.63% per year from 2004 to 2012 (APC = -3.63 ; $P < 0.01$). Despite this steep decrease, incidence in blacks remained higher than incidence in whites at the end of the study period (47.0 per 100,000 blacks vs. 37.6 per 100,000 whites, $P < 0.01$). Over the entire study period, the AAPC was a 1.35% decline per year (AAPC = -1.35 ; $P < 0.01$) in whites, which was significantly different than ($P < 0.001$) and not parallel to ($P < 0.001$) the 0.46% decline in incidence per year in blacks (AAPC = -0.46 , $P < 0.01$).

Secondary analyses using a greater number of regions in the SEER 13 and SEER 18 registries supported SEER 9 findings. SEER 13 data demonstrated a rapid decline in incidence in whites from 1992 to 2012 at 2.14% per year (AAPC = -2.14 ; $P < 0.01$) and a less rapid but significant downward trend in incidence in blacks at 1.45% per year (AAPC = -1.45 ; $P < 0.01$) over the same time period. In the largest geographic SEER sample, SEER 18, both whites and blacks demonstrated declines in incidence from 2008 to 2012: the AAPC was a 2.86% decline per year for whites

($P < 0.01$), compared with a 2.38% decline per year in blacks ($P < 0.01$). Overall, all three SEER samples supported converging declines in colorectal cancer incidence in both whites and blacks since 1975 but demonstrated persistently elevated colorectal cancer incidence rates in blacks at the end of the study period. While annual colorectal cancer incidence was higher for men than women, men and women had similar incidence trends from the mid-2000s until 2012 in each racial subgroup (data not shown).

The disparity in black–white incidence over time

Figure 2 is the Joinpoint graph demonstrating significant trends in the absolute difference in colorectal cancer incidence between blacks and whites from 1975 to 2012 as calculated from the SEER 9 database. The incidence difference remained statistically stable from 1975 to 1983 (APC = -5.82 ; $P = 0.39$). During this period, colorectal cancer incidence in blacks rose and then exceeded rates in whites (Fig. 1). Thus, the downward slope in the absolute difference in incidence graph from 1975 to 1983 (Fig. 2) reflects the crossover from higher colorectal cancer rates in whites to higher rates in blacks rather than improving disparities. In 1983, the incidence difference was lowest. Because of the dramatic disproportionate decrease in incidence in whites thereafter, however, the difference increased significantly by 5.76% per year from 1983 to 2004 (APC = 5.76; $P < 0.01$). The year 2004 marked the maximal difference in incidence in whites and blacks: RD = 13.46 per 100,000 (95% CI = 9.95–16.96). In that year, the RR was 0.79 (95% CI = 0.74–0.83), suggesting that incidence in whites was 0.79 times or 21% lower than the incidence in blacks. Since 2004, the absolute difference in incidence between whites and blacks has trended downward significantly by 3.88% per year (APC = -3.88 ; $P = 0.01$).

Secondary analyses using the SEER 13 and SEER 18 registries support the SEER 9 findings. In all population samples, the black–

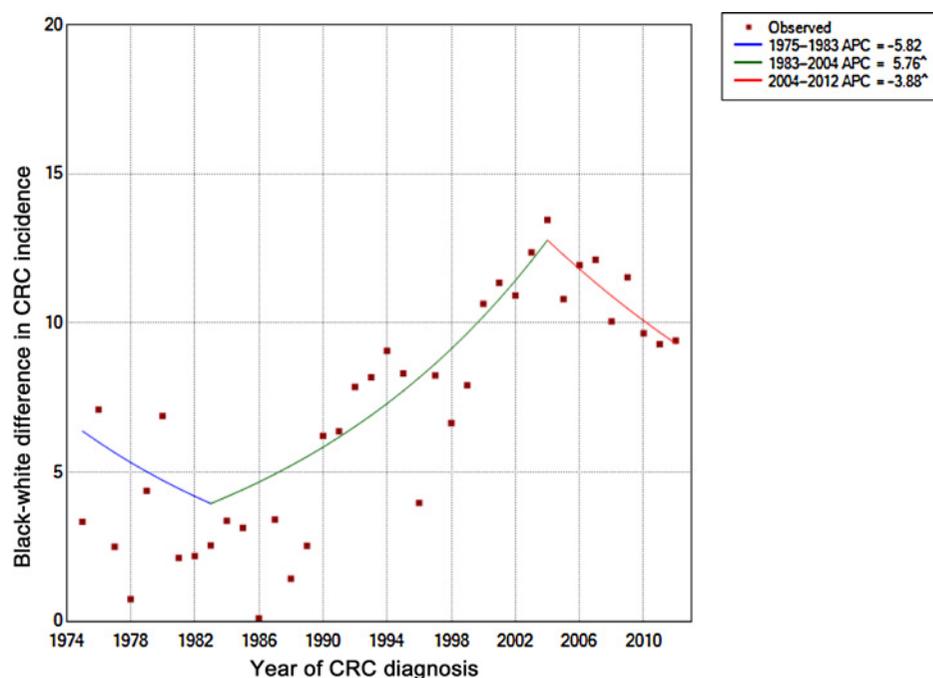


Figure 2.

Evaluation for significant trends in the absolute difference in colorectal cancer (CRC) incidence between whites and blacks; SEER 9 (1975–2011)*.

*, Observed difference is defined as the absolute difference in the incidence in whites and the incidence in blacks for a given year. APC, annual percentage change.

^, APC is significantly different from zero at $P = 0.05$.

white difference in colorectal cancer incidence decreased significantly and steadily from the early 2000s until 2012, and incidence in whites exceeding incidence in blacks at the end of the study period.

Black–white trends in late stage at presentation

In 1975, the proportion of blacks presenting with late-stage colorectal cancer (70.89%) was higher than the proportion of whites presenting with late-stage disease (63.40%; $P < 0.001$). For whites, there were periods of both significant increases and significant declines in the proportion of late-stage-presenting tumors over the study period (Fig. 3). The largest decline in late-stage presentation in whites was from 1983 to 1987 when rates decreased by 1.69% per year (APC = -1.69 ; $P < 0.01$). This period was followed by an upward trend in the incidence of late-stage disease at presentation from 1987 to 1995 (APC = 0.41 ; $P = 0.01$). At the end of the study period, the proportion of late-stage disease cases was increasing by 0.67% per year for whites (APC = 0.67 ; $P < 0.01$). Late disease presentation in blacks, on the other hand, declined significantly and steadily at a rate of 0.45% per year throughout the entire study period from 1975 to 2012 (APC = -0.45 ; $P < 0.001$). Consequently, the trends for late-stage disease in the two groups converged and were equal by the end of the study period (Fig. 3).

Secondary analyses using the SEER 13 and SEER 18 registry data also support a decreasing black–white disparity in stage at presentation over time. In both samples, the decline in late-stage disease in blacks was steeper and over a longer time period than in whites, leading to a convergence of the two trend lines in the last two years of data collection. We did not detect gender differences in these trends in either ethnic group (data not shown).

Discussion

We used the oldest population-based cancer database in the United States to demonstrate improving disparities in two major

colorectal cancer indicators: incidence and stage at presentation. Our results show that although black–white disparities in colorectal cancer incidence have improved remarkably since 1975, they persist. Furthermore, we demonstrated that historic black–white disparities in stage at diagnosis may have resolved. Both findings are driven by a disproportionate decline in colorectal cancer incidence and late-stage presentation in blacks since the early 2000s. Our findings are consistent with the downward trend in incidence disparities seen in the 1999–2012 CDC National Program of Cancer Registries data (47). By looking at long-term disparity trends, our study allows for a broad examination of national progress in colorectal cancer prevention and control over the past four decades and provides parallel information on long-term trends in incidence and stage at diagnosis.

Our finding that black–white incidence differences persists while disparities in stage at colorectal cancer presentation have resolved suggests that public efforts in colorectal cancer prevention and control have been more effective at addressing the mutable factors that affect stage at presentation than incidence. The overall decline in colorectal cancer incidence in the past several decades is likely a result of several factors, including changes in lifestyle risk factors, advances in medical technology, public awareness about colorectal cancer, and efforts to improve colorectal cancer prevention. Colorectal cancer is associated with cigarette use, high animal fat diet, low fiber diet, low physical activity, and obesity (4, 17, 18, 20). These behaviors are also associated with black race and, thus, might contribute to higher incidence in blacks overall and persistent incidence disparities today (4, 19, 20). In addition, there are historical black–white differences in access to health care services and endoscopic procedures like flexible sigmoidoscopy and colonoscopy, procedures that result in the removal of colonic adenomas before malignant transformation (48). Colorectal cancer is largely preventable with the identification and removal of premalignant colonic adenomas; thus, the earlier decline in colorectal cancer incidence among whites is likely at least partially attributable to higher use of these

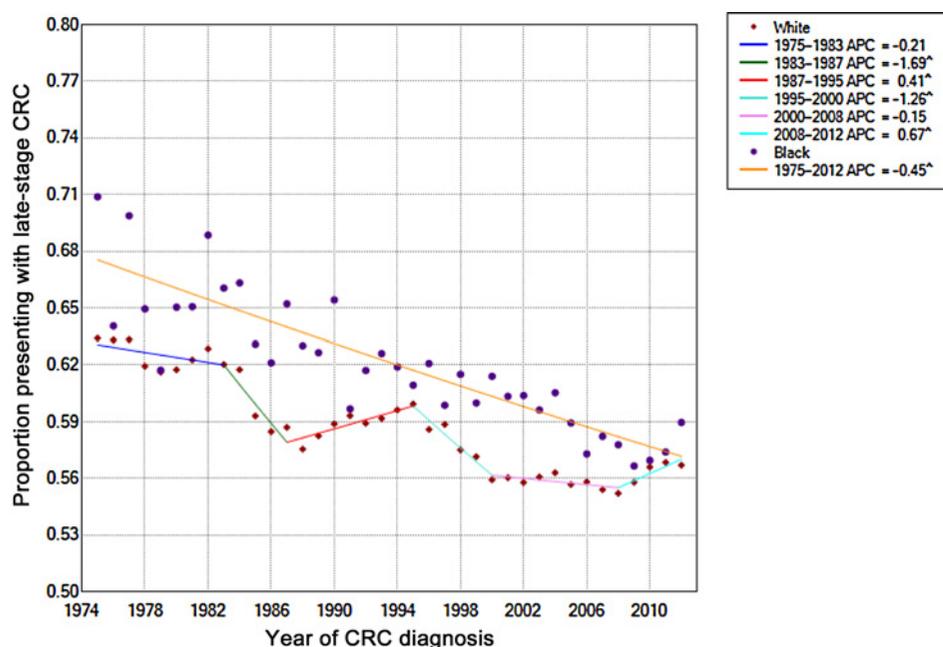


Figure 3.

Evaluation for significant linear trends in late-stage colorectal cancer presentation in whites and blacks; SEER 9 (1975–2011)*.

*, APC, annual percentage change.

^, APC is significantly different from zero at $P = 0.05$.

procedures in whites before the early 2000s (49). Increased utilization of endoscopy screening among blacks in recent years may have contributed to an incidence decline in blacks in the early 2000s, several decades after whites (35, 48). The literature, however, does not demonstrate a large decline in proximal tumors among blacks or whites from 1975 to present (50). Thus, it does not appear that the significant decline in colorectal cancer incidence in blacks was driven solely by the prevention of proximal tumors more commonly seen in this racial subgroup (50, 51).

The persistent black–white incidence disparity at the end of the study period may also reflect the role of factors other than screening. Lansdorp-Vogelaar and colleagues used a microsimulation model to estimate contributors to black–white colorectal cancer incidence disparities and demonstrated that black–white differences in screening uptake account for only 42% of the disparity in colorectal cancer incidence (52). In addition to the persistent differences in access to screening services, genetic predisposition to colorectal cancer, a higher prevalence of colorectal cancer risk factors, and differences in utilization of services like surveillance colonoscopy and timely diagnostic colonoscopy after abnormal stool-based screening may contribute to the higher incidence of colorectal cancer among blacks at the end of the study period (4, 14, 17–31).

All modalities of colorectal cancer screening have the potential to impact stage of disease at presentation, including endoscopy, fecal occult blood testing (FOBT), fecal immunochemical testing (FIT), and stool DNA (sDNA; ref. 53). While stool-based screening examinations are limited in their ability to prevent disease incidence, they are capable of detecting cancerous lesions in early stages if followed with diagnostic colonoscopy (54, 55). In national cohorts, the large black–white disparities seen in colorectal cancer screening uptake have declined, and recent data from the CDC and the Behavioral Risk Factor Surveillance Survey (BRFSS) demonstrate equal colorectal cancer screening rates in blacks and whites at 65% (35). More specifically, rates of FOBT use have declined in blacks while rates of endoscopic screening have increased (56). Thus, increasing use of endoscopic screening

methods among blacks and public health attention toward black–white colorectal cancer screening disparities may have resulted in a shift toward colorectal cancer diagnoses in earlier stages in blacks (35, 57, 58). While it is essential to see how stage trends continue in the next several years, the implication for stage at diagnosis is that blacks may have benefited disproportionately from collective colorectal cancer early detection efforts in recent years.

There are several strengths to the present analysis. First, we used a large, national cancer registry database to determine trends in colorectal cancer indicators. SEER uniquely provides access to national population-based data on cancer stage at diagnosis, likely reflecting the influence of national programs and interventions on colorectal cancer outcomes. Second, we examined colorectal cancer indicator trends over a prolonged period of time. While there are examples in the literature of recent trends in colorectal cancer incidence and outcomes, the current study explores data over four decades to comment on long-term black–white disparity trends (47). Third, we performed our analyses using three different SEER program datasets to demonstrate similar trends and conclusions across three somewhat different yet complementary populations.

Our study is not without limitations. The SEER 9 program database lacks designation for Hispanic ethnicity. As there are likely more white Hispanics than black Hispanics and as Hispanics have a lower incidence of colorectal cancer but later stage at diagnosis than whites, their inclusion may have overestimated incidence disparities and underestimated stage disparities between whites and blacks (1). A second weakness of our study is that we were not able to directly compare rates and proportions across the SEER 9, 13, and 18 databases because they contain different cancer registry regions and populations. While this fact limited our ability to look at long-term trends for all 18 SEER regions, it did not impact our ability to make relative statements about trends in incidence and stage in blacks compared with whites. Finally, as the SEER database does not include tumor data for all U.S. geographical areas, our findings may not be generalizable to every region of the country. When comparing SEER

age-adjusted colorectal cancer incidence rates to incidence rates provided by the North American Association of Central Cancer Registries (available only from 2009 onward), which cover 99% of the U.S. population, SEER rates appear slightly lower (59). While SEER data poses these challenges, it remains the most powerful tool to investigate national cancer disparities and is the best available source for long-term cancer data in the United States.

In conclusion, our findings support improvement in inequities in colorectal cancer incidence and stage at diagnosis over the past four decades. Contrary to the body of literature demonstrating disparities in colorectal cancer incidence and outcomes in cross-sections of the population and within various health care systems, the current study suggests that longitudinal evaluation of colorectal cancer indicators points to at least some progress in the nation as a whole (6, 60–63). While these improvements in colorectal cancer disparities are encouraging, our results do not suggest that the decades-long challenge to eliminate disparities in colorectal cancer has been fully accomplished. Efforts to improve colorectal cancer prevention and early detection may have halted the widening gap in colorectal cancer disparities; however, inequities in colorectal cancer incidence persist. The challenge now is to identify the factors that have been most effective in reducing disparities so that we can develop interventions that will continue to bend the colorectal cancer incidence curve in blacks and maintain equity in stage at diagnosis. In addition, future work must evaluate disparity trends in other colorectal cancer indicators like mortality and survival.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

References

- American Cancer Society. Colorectal cancer facts & figures 2014–2016. Atlanta, GA: American Cancer Society; 2014.
- Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010–2020. *J Natl Cancer Inst* 2011;103:117–28.
- Henschke UK, Leffall LD Jr, Mason CH, Reinhold AW, Schneider RL, White JE, et al. Alarming increase of the cancer mortality in the U.S. black population (1950–1967). *Cancer* 1973;31:763–8.
- National Cancer Institute. Cancer trends progress report [cited 2015 Feb 10]. Available from: <http://progressreport.cancer.gov>.
- Siegel R, DeSantis C, Virgo K, Stein K, Mariotto A, Smith T, et al. Cancer treatment and survivorship statistics, 2012. *CA Cancer J Clin* 2012;62:220–41.
- Irby K, Anderson WF, Henson DE, Devesa SS. Emerging and widening colorectal carcinoma disparities between blacks and whites in the United States (1975–2002). *Can Epidemiol Biomarkers Prev* 2006;15:792–7.
- Chu KC, Tarone RE, Chow WH, Alexander GA. Colorectal cancer trends by race and anatomic subsites, 1975 to 1991. *Arch Fam Med* 1995;4:849–56.
- Chu KC, Tarone RE, Chow WH, Hankey BF, Ries LA. Temporal patterns in colorectal cancer incidence, survival, and mortality from 1950 through 1990. *J Natl Cancer Inst* 1994;86:997–1006.
- Nelson RL, Persky V, Turyk M. Determination of factors responsible for the declining incidence of colorectal cancer. *Dis Colon Rectum* 1999;42:741–52.
- Rise L, Eisner M, Kosary C. SEER cancer statistic review 1975–2000. Bethesda, MD: National Cancer Institute; 2003.
- Murphy G, Devesa SS, Cross AJ, Inskip PD, McGlynn KA, Cook MB. Sex disparities in colorectal cancer incidence by anatomic subsite, race and age. *Int J Cancer* 2011;128:1668–75.
- Lieberman DA, Holub JL, Moravec MD, Eisen GM, Peters D, Morris CD. Prevalence of colon polyps detected by colonoscopy screening in asymptomatic black and white patients. *JAMA* 2008;300:1417–22.
- Rex DK, Johnson DA, Anderson JC, Schoenfeld PS, Burke CA, Inadomi JM. American College of Gastroenterology guidelines for colorectal cancer screening 2009 [corrected]. *Am J Gastroenterol* 2009;104:739–50.
- Tammanna VS, Laiyemo AO. Colorectal cancer disparities: issues, controversies and solutions. *World J Gastroenterol* 2014;20:869–76.
- Siegel R, Desantis C, Jemal A. Colorectal cancer statistics, 2014. *Cancer J Clin* 2014;64:104–17.
- Mehrkhani F, Nasiri S, Donboli K, Meysamie A, Hedayat A. Prognostic factors in survival of colorectal cancer patients after surgery. *Colorectal Dis* 2009;11:157–61.
- Huxley RR, Ansary-Moghaddam A, Clifton P, Czernichow S, Parr CL, Woodward M. The impact of dietary and lifestyle risk factors on risk of colorectal cancer: A quantitative overview of the epidemiological evidence. *Int J Cancer* 2009;125:171–80.
- Ford ES. Body mass index and colon cancer in a national sample of adult US men and women. *Am J Epidemiol* 1999;150:390–8.
- Bolen JC, Rhodes L, Powell-Griner EE, Bland SD, Holtzman D. State-specific prevalence of selected health behaviors, by race and ethnicity—Behavioral Risk Factor Surveillance System, 1997. *MMWR CDC Surve Summ Morb Mort We Re CDC Surve Summ/Cen Dis Con* 2000;49:1–60.
- Willett WC, Stampfer MJ, Colditz GA, Rosner BA, Speizer FE. Relation of meat, fat, and fiber intake to the risk of colon cancer in a prospective study among women. *N Engl J Med* 1990;323:1664–72.
- Patterson RE, White E, Kristal AR, Neuhauser ML, Potter JD. Vitamin supplements and cancer risk: the epidemiologic evidence. *Cancer Causes Control* 1997;8:786–802.
- Satia-Abouta J, Galanko JA, Martin CF, Potter JD, Ammerman A, Sandler RS. Associations of micronutrients with colon cancer risk in African

Authors' Contributions

Conception and design: F.P. May, B.A. Glenn, N. Ponce, B.M.R. Spiegel, R. Bastani

Development of methodology: F.P. May, C.M. Crespi, N. Ponce, B.M.R. Spiegel, R. Bastani

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): F.P. May

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): F.P. May, B.A. Glenn, C.M. Crespi, N. Ponce, R. Bastani

Writing, review, and/or revision of the manuscript: F.P. May, B.A. Glenn, C.M. Crespi, N. Ponce, B.M.R. Spiegel, R. Bastani

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): F.P. May

Study supervision: F.P. May, B.M.R. Spiegel, R. Bastani

Acknowledgments

The authors would like to thank the SEER*Stat Technical Support team with special acknowledgements to Steve Scoppa and Dave Annett for their help with the data analysis and interpretation. The research presented in this manuscript was part of the Fielding School of Public Health at UCLA doctoral dissertation in Health Policy and Management for F.P. May.

Grant Support

This work was supported by the NIH Training grant (T32DK07180—40; to F.P. May), the NIH grant P30 CA16042 (to C.M. Crespi), and a grant from Aetna, Inc. (to N. Ponce).

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received October 18, 2016; revised December 14, 2016; accepted December 15, 2016; published OnlineFirst December 29, 2016.

- Americans and whites: results from the North Carolina Colon Cancer Study. *Cancer Epidemiol Biomarkers Prev* 2003;12:747–54.
23. O'Keefe SJ, Ou J, Aufreiter S, O'Connor D, Sharma S, Sepulveda J, et al. Products of the colonic microbiota mediate the effects of diet on colon cancer risk. *J Nutr* 2009;139:2044–8.
 24. Agrawal S, Bhupinderjit A, Bhutani MS, Boardman L, Nguyen C, Romero Y, et al. Colorectal cancer in African Americans. *Am J Gastroenterol* 2005;100:515–23.
 25. Berkowitz Z, Hawkins NA, Peipins LA, White MC, Nadel MR. Beliefs, risk perceptions, and gaps in knowledge as barriers to colorectal cancer screening in older adults. *J Am Geriatr Soc* 2008;56:307–14.
 26. James AS, Daley CM, Greiner KA. Knowledge and attitudes about colon cancer screening among African Americans. *Am J Health Behav* 2011;35:393–401.
 27. Palmer RC, Chhabra D, McKinney S. Colorectal cancer screening adherence in African-American men and women 50 years of age and older living in Maryland. *J Community Health* 2011;36:517–24.
 28. Palmer RC, Midgette LA, Dankwa I. Colorectal cancer screening and African Americans: findings from a qualitative study. *Cancer Control* 2008;15:72–9.
 29. Palmer RC, Midgette LA, Mullan ID. Colorectal cancer screening preferences among African Americans: which screening test is preferred? *J Cancer Educ* 2010;25:577–81.
 30. Ashktorab H, Nourai M, Hosseinkhah F, Lee E, Rotimi C, Smoot D. A 50-year review of colorectal cancer in African Americans: Implications for prevention and treatment. *Dig Dis Sci* 2009;54:1985–90.
 31. Dimou A, Syrigos KN, Saif MW. Disparities in colorectal cancer in African-Americans vs Whites: before and after diagnosis. *World J Gastroenterol* 2009;15:3734–43.
 32. Rawl SM, Skinner CS, Perkins SM, Springston J, Wang HL, Russell KM, et al. Computer-delivered tailored intervention improves colon cancer screening knowledge and health beliefs of African-Americans. *Health Educ Res* 2012;27:868–85.
 33. Myers RE, Sifri R, Daskalakis C, DiCarlo M, Geethakumari PR, Cocroft J, et al. Increasing colon cancer screening in primary care among African Americans. *J Natl Cancer Inst* 2014;106:pii: dju344.
 34. Naylor K, Ward J, Polite BN. Interventions to improve care related to colorectal cancer among racial and ethnic minorities: a systematic review. *J Gen Intern Med* 2012;27:1033–46.
 35. Centers for Disease Control and Prevention. Vital signs: colorectal cancer screening test use—United States, 2012. *MMWR Morb Mortal Wkly Rep* 2013;62:881–8.
 36. Surveillance Epidemiology and End Results (SEER) Program. SEER*Stat Database: Incidence - SEER 9 Regs Research Data (1973–2012), National Cancer Institute, released April 2015, based on the November 2014 submission. Available from: <http://www.seer.cancer.gov/>.
 37. National Cancer Institute. Surveillance Epidemiology and End Results (SEER) Program SEER*Stat Databases: November 2014 Submission; Rate and Prevalence Sessions; National Cancer Institute, released April 2015. Available from: <http://seer.cancer.gov/data/seerstat/nov2014/>.
 38. Surveillance Epidemiology and End Results (SEER) Program SEER*Stat Database: Incidence - SEER 13 Regs Research Data (1992–2012), National Cancer Institute, released April 2015, based on the November 2014 submission. Available from: <http://www.seer.cancer.gov/>.
 39. Surveillance Epidemiology and End Results (SEER) Program. SEER*Stat Database: Incidence - SEER 18 Regs Research Data (2000–2012), National Cancer Institute, released April 2015, based on the November 2014 submission. Available from: <http://www.seer.cancer.gov/>.
 40. Fritz A, Percy C, Jack A, Shanmugaratnam K, Sobin L, Parkin D, et al. editors. *International Classification of Diseases for Oncology*. 3rd ed. Geneva, Switzerland: World Health Organization; 2000.
 41. Frey CM, McMillen MM, Cowan CD, Horm JW, Kessler LG. Representativeness of the surveillance, epidemiology, and end results program data: recent trends in cancer mortality rates. *J Natl Cancer Inst* 1992;84:872–7.
 42. National Cancer Institute. Health Disparities Calculator V-O. Division of Cancer Control and Population Sciences, Surveillance Research Program and Healthcare Delivery Research Program; 2013. Available from: <https://seer.cancer.gov/hdcalc/>.
 43. Harper S, Lynch J, Meersman SC, Breen N, Davis WW, Reichman ME. An overview of methods for monitoring social disparities in cancer with an example using trends in lung cancer incidence by area-socioeconomic position and race-ethnicity, 1992–2004. *Am J Epidemiol* 2008;167:889–99.
 44. National Cancer Institute. Joinpoint Regression Program. 2014. Available from: <https://surveillance.cancer.gov/joinpoint/download>.
 45. Clegg LX, Hankey BF, Tiwari R, Feuer EJ, Edwards BK. Estimating average annual per cent change in trend analysis. *Stat Med* 2009;28:3670–82.
 46. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000;19:335–51.
 47. U.S. Cancer Statistics Working Group. United States Cancer Statistics: 1999–2013 Incidence and Mortality Web-based Report. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; 2016. Available from: www.cdc.gov/uscs.
 48. McMahon LF Jr, Wolfe RA, Huang S, Tedeschi P, Manning W Jr, Edlund MJ. Racial and gender variation in use of diagnostic colonic procedures in the Michigan Medicare population. *Med Care* 1999;37:712–7.
 49. Richards RJ, Reker DM. Racial differences in use of colonoscopy, sigmoidoscopy, and barium enema in Medicare beneficiaries. *Dig Dis Sci* 2002;47:2715–9.
 50. Murphy CC, Sandler RS, Sanoff HK, Yang YC, Lund JL, Baron JA. Decrease in incidence of colorectal cancer among individuals 50 years or older after recommendations for population-based screening. *Clin Gastroenterol Hepatol*. 2016 Sep 5. [Epub ahead of print].
 51. Rex DK, Rawl SM, Rabeneck L, Rex EK, Hamilton F. Colorectal cancer in African Americans. *Rev Gastroenterol Disord* 2004;4:60–5.
 52. Lansdorp-Vogelaar I, Kuntz KM, Knudsen AB, van Ballegoijen M, Zauber AG, Jemal A. Contribution of screening and survival differences to racial disparities in colorectal cancer rates. *Cancer Epidemiol Biomarkers Prev* 2012;21:728–36.
 53. Fazio L, Cotterchio M, Manno M, McLaughlin J, Gallinger S. Association between colonic screening, subject characteristics, and stage of colorectal cancer. *Am J Gastroenterol* 2005;100:2531–9.
 54. Miutescu B, Sporea I, Popescu A, Bota S, Iovanescu D, Burlea A, et al. Effectiveness of the immunochemical fecal test (FIT) for detection of advanced adenomas in colorectal carcinoma screening in an asymptomatic population. *Rev Med Chir Soc Med Nat Iasi* 2013;117:302–7.
 55. Imperiale TF, Ransohoff DF, Itzkowitz SH, Levin TR, Lavin P, Lidgard GP, et al. Multitarget stool DNA testing for colorectal-cancer screening. *N Engl J Med* 2014;370:1287–97.
 56. Bandi P, Cokkinides V, Smith RA, Jemal A. Trends in colorectal cancer screening with home-based fecal occult blood tests in adults ages 50 to 64 years, 2000–2008. *Cancer* 2012;118:5092–9.
 57. Gornick ME, Eggers PW, Riley GF. Associations of race, education, and patterns of preventive service use with stage of cancer at time of diagnosis. *Health Serv Res* 2004;39:1403–27.
 58. Bian J, Bennett C, Cooper G, D'Alfonso A, Fisher D, Lipscomb J, et al. Assessing colorectal cancer screening adherence of medicare fee-for-service beneficiaries age 76 to 95 years. *J Oncol Pract* 2016;12:e670–80.
 59. Cancer in North America. Age-adjusted invasive cancer incidence rates in North America [cited 2016 Dec 10]. Available from: <http://cancer-rates.info/naaccr/>.
 60. Halpern MT, Pavluck AL, Ko CY, Ward EM. Factors associated with colon cancer stage at diagnosis. *Dig Dis Sci* 2009;54:2680–93.
 61. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2013. *CA Cancer J Clin* 2013;63:11–30.
 62. Soneji S, Iyer SS, Armstrong K, Asch DA. Racial disparities in stage-specific colorectal cancer mortality: 1960–2005. *Am J Public Health* 2010;100:1912–6.
 63. Steinhorn SC, Kopecky KJ, Myers MH, Ball C. Characteristics of colon cancer patients reported in population-based tumor registries and Comprehensive Cancer Centers. *J Natl Cancer Inst* 1983;70:629–34.