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State Disparities in Colorectal Cancer Mortality Patterns in the United States

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Abstract

Background: Colorectal cancer (CRC) mortality rates have been decreasing for many decades in the United States, with the decrease accelerating in the most recent time period. The extent to which this decrease varies across states and its influence on the geographic patterns of rates is unknown.

Methods: We analyzed the temporal trend in age-standardized CRC death rates for each state from 1990 to 2007 using joinpoint regression. We also examined the change in death rates between 1990–1994 and 2003–2007 using rate ratios with 95% confidence intervals and illustrated the change in pattern using maps. The relationship between the change in mortality rates and CRC screening rates for 2004 by state was examined using Pearson's correlation.

Results: CRC mortality rates significantly decreased in all states except Mississippi between 1990 and 2007 based on the joinpoint model. The decrease in death rates between 1990–1994 and 2003–2007 ranged from 9% in Alabama to greater than 33% in Massachusetts, Rhode Island, New York, and Alaska; Mississippi and Wyoming showed no significant decrease. Generally, the northeastern states showed the largest decreases, whereas southern states showed the smallest decreases. The highest CRC mortality rates shifted from the northeastern states during 1990 to 1994 to the southern states along the Appalachian corridor during 2003 to 2007. The decrease in CRC mortality rates by state correlated strongly with uptake of screening ($r = -0.65$, $P < 0.0001$).

Conclusions: Progress in reducing CRC mortality varies across states, with the Northeast showing the most progress and the South showing the least progress.

Impact: These findings highlight the need for wider dissemination of CRC screening. *Cancer Epidemiol Biomarkers Prev; 20(7); 1296–302. ©2011 AACR.*

Introduction

Colorectal cancer (CRC) is the third leading cause of cancer death for both men and women in the United States (1). Death rates for CRC have been decreasing in the United States for the past several decades, with the decrease accelerating in the most recent time period (2, 3). The death rate decreased by 3% per year from 2003 to 2007, compared with less than 2% annually in years prior (3). This accelerated decrease in the most recent time period is thought to largely reflect increased uptake of CRC screening (2). However, the extent to which this decrease varies across states and its influence on the geographic patterns of CRC mortality rates are not documented in the peer review literature. To this end, we analyzed temporal trends in age-standardized CRC death rates from 1990 through 2007 by state and the change in geographic patterns of rates for 2 time intervals, 1990–1994 and 2003–2007. We also examined whether there was an association between the decrease in death rates and screening uptake by state.

Materials and Methods

Mortality data for cancers of the colon and rectum from 1990 through 2007 for each of the 50 states and the District of Columbia were obtained from the Surveillance Epidemiology and End Result (SEER) mortality database as reported by the National Center for Health Statistics (4). Rates were extracted using SEER*Stat software (5) and they were age standardized to the 2000 U.S. standard population and expressed per 100,000 population. Trends in the age-standardized rates from 1990 through 2007 were described using a joinpoint regression model, which involves fitting a series of joined straight lines on a log scale to the annual age-standardized rates (6). We

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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allowed a maximum of 2 joinpoints. Trends are expressed as the annual percentage changes (APC), which are the slopes of the line segment. For each state, we also calculated the change in death rates between the 1990–1994 and 2003–2007 using rate ratio (2003–2007 to 1999–1994), with 95% CI (7). All statistical tests were 2 sided ($P < 0.05$).

To examine changes in geographic patterns of CRC death rates between 1990–1994 and 2003–2007, we created U.S. state maps using ArcGIS, ESRI (8). For each time interval, age-standardized rates for each state were sorted in descending order of rates and grouped into 6 categories. The highest and lowest categories are approximately the 10th and 90th percentiles, whereas the remaining states were divided into 4 equivalent groups. The color gradient in the maps reflect the CRC burden, with states with the highest CRC mortality rate assigned the darkest color.

State-level CRC screening data for adults aged 50 and older in 2004 was obtained from the Behavioral Risk Factor Surveillance System (BRFSS; ref. 9), an annual, cross-sectional, population-based survey conducted by the Centers for Disease Control and Prevention. CRC screening uptake was defined as the percentage of people reporting a fecal occult blood test within the past year or a sigmoidoscopy or colonoscopy in the past 10 years. The relationship between screening rates for 2004 and the percentage change in death rates from 1990–1994 to 2003–2007 by state was examined by Pearson's correlation (10) using the statistical software SAS version 9.2 (11).

In supplemental analyses, we calculated changes in CRC incidence and mortality rates between 1992–1995 and 2004–2007 for 12 SEER cancer registries (Atlanta, Connecticut, Detroit, Hawaii, Iowa, New Mexico, San Francisco-Oakland, Seattle-Puget Sound, Utah, Los Angeles, San Jose-Monterey, and Rural Georgia) because trends in mortality rates are affected by incidence. We then examined the relationship between the changes in incidence and mortality rates by Pearson's correlation (10). We also examined temporal trends in CRC death rates from 1990 to 2007 and the change in death rates between 1990–1994 and 2003–2007 for non-Hispanic whites, non-Hispanic blacks, and Hispanics by state. This restricted the analysis to 38 states with complete Hispanic ethnicity information on death certificates for each year included in this study (5). In addition, states with less than 4 recorded deaths from CRC in any of the study years (1990–2007) were excluded from the trend analyses because of the National Centers for Health and Statistics' confidentiality requirement. This further reduced the number of states available for the trend analysis to 27 states for non-Hispanic blacks and 13 for Hispanics. Similarly, states with less than 25 deaths in either of the 2 time intervals, 1990–1994 and 2003–2007, were excluded from the analyses of change in death rates between the 2 time periods, which restricted this analysis to 31 states for non-Hispanic blacks and 17 states for Hispanics. All 38 states were available for the analyses for non-Hispanic whites. Using partial correlation analyses, we assessed the effects of state differences in percentage of rural residents and percentage of Hispanic or non-Hispanic black populations on the relationship between changes in percentage death rates over the 2 time periods and screening rates for all races combined (11).

Results

CRC mortality rates decreased significantly in all states except Mississippi between 1990 and 2007 according to joinpoint modeling (Table 1). The decrease in death rates between 1990–1994 and 2003–2007 ranged from 9% in Alabama to greater than 33% in Massachusetts, Rhode Island, New York, and Alaska, with Mississippi and Wyoming showing no significant decrease. Generally, the northeastern states showed the largest decreases, whereas the southern states showed the smallest decreases.

Figure 1 illustrates the extremes of variation in state trends in CRC mortality rates from 1990 to 2007. Whereas the decrease in CRC mortality rates in New York and Massachusetts accelerated from about 2.5% per year in the 1990s to 4% to 5% in the 2000s, rates in Mississippi and Alabama showed little or no decrease during the entire time period (Table 1). Supplemental analysis showed that state trends for non-Hispanic whites and non-Hispanic blacks are generally similar (Supplementary Table S1A and B). Rates decreased significantly for all 38 states in non-Hispanic whites and for 20 of the 27 states for non-Hispanic blacks. For both non-Hispanic whites and blacks, CRC mortality trends were more favorable in Massachusetts and less favorable in Alabama. For Hispanics, rates decreased for 6 of the 13 states considered in the analysis (Supplementary Table S1C).

Figure 2 shows state variations in CRC death rates during 1990–1994 and 2003–2007. During 1990 to 1994, the highest CRC mortality rates were found in the northeast and north central parts of the country, and the lowest rates were in the west and south. In contrast, during 2003 to 2007, the highest CRC mortality rates were found in southern states along the Appalachian corridor, including West Virginia, Kentucky, Mississippi, and Louisiana. The change in CRC mortality rates from 1990–1994 to 2003–2007 by state was highly correlated ($r = -0.65$, $P < 0.0001$) with the percent of adults aged 50 and older who were current with CRC screening in 2004 (Fig. 3). The association was slightly attenuated ($r = -0.59$, $P < 0.0001$) when we accounted for state differences in percentage of rural residents. In a supplemental analysis, we also found that the change in incidence and mortality rates from 1992–1995 to 2003–2007 within each cancer registry are strongly correlated ($r = 0.86$, $P = 0.0003$; Supplementary Fig.).

Discussion

There are considerable geographic disparities in overall CRC mortality trends during 1990 to 2007, with states

Table 1. CRC death rates and trends by state, United States, 1990–2007

State	Death rate		Rate ratios (95% CI)	Trend 1		Trend 2		Trend 3	
	1990–1994	2003–2007		Years	APC	Years	APC	Years	APC
Alaska	27.1	17.1	0.63 (0.53–0.75)	1990–2007	−3.0[a]				
Massachusetts	27.5	17.4	0.63 (0.61–0.65)	1990–2002	−2.8[a]	2002–2007	−5.3[a]		
Rhode Island	26.3	17.1	0.65 (0.60–0.70)	1990–2002	−2.4[a]	2002–2007	−6.3[a]		
New York	26.4	17.4	0.66 (0.65–0.67)	1990–2000	−2.3[a]	2000–2007	−4.5[a]		
Maine	27.2	18.2	0.67 (0.62–0.72)	1990–2007	−2.8[a]				
Connecticut	24.1	16.1	0.67 (0.64–0.70)	1990–1997	−3.2[a]	1997–2000	1.1	2000–2007	−5.1[a]
Maryland	27.3	18.6	0.68 (0.66–0.71)	1990–2000	−2.3[a]	2000–2007	−3.8[a]		
New Hampshire	25.5	17.5	0.69 (0.63–0.74)	1990–1999	−1.5	1999–2007	−4.7[a]		
New Jersey	28.2	19.5	0.69 (0.67–0.71)	1990–2007	−2.8[a]				
Wisconsin	23.5	16.5	0.70 (0.68–0.73)	1990–1992	−7.4[a]	1992–2000	−1.2[a]	2000–2007	−4.3[a]
Delaware	26.6	18.9	0.71 (0.64–0.78)	1990–2007	−2.7[a]				
District of Columbia	28.5	20.3	0.71 (0.64–0.79)	1990–2007	−2.3[a]				
Florida	22.0	15.9	0.72 (0.71–0.74)	1990–1994	−0.8	1994–2007	−2.6[a]		
Pennsylvania	26.7	19.2	0.72 (0.70–0.74)	1990–2000	−1.8[a]	2000–2007	−3.5[a]		
Michigan	24.3	17.9	0.73 (0.71–0.75)	1990–2007	−2.4[a]				
Minnesota	21.6	15.9	0.73 (0.70–0.77)	1990–2007	−2.4[a]				
Montana	22.0	16.1	0.73 (0.66–0.80)	1990–2007	−2.1[a]				
North Dakota	24.1	17.6	0.73 (0.66–0.81)	1990–2007	−2.3[a]				
Utah	17.5	12.8	0.73 (0.67–0.80)	1990–2007	−2.4[a]				
Illinois	26.4	19.5	0.74 (0.72–0.76)	1990–2007	−2.2[a]				
California	21.1	15.8	0.75 (0.74–0.76)	1990–2007	−2.2[a]				
Iowa	24.8	18.5	0.75 (0.71–0.78)	1990–2007	−2.2[a]				
Ohio	26.1	19.6	0.75 (0.73–0.77)	1990–2007	−2.2[a]				
South Dakota	23.9	17.9	0.75 (0.68–0.82)	1990–2007	−2.1[a]				
Vermont	23.5	17.7	0.75 (0.67–0.84)	1990–2007	−2.3[a]				
Virginia	23.6	17.6	0.75 (0.72–0.77)	1990–2001	−1.4[a]	2001–2007	−3.9[a]		
Colorado	21.2	16.0	0.76 (0.72–0.80)	1990–1995	−3.6[a]	1995–2005	−1.2[a]	2005–2007	−7.8[a]
Indiana	25.4	19.2	0.76 (0.73–0.78)	1990–2001	−1.5[a]	2001–2007	−3.5[a]		
Washington	20.6	15.7	0.76 (0.73–0.79)	1990–2001	−1.4[a]	2001–2007	−3.7[a]		
Arizona	19.7	15.2	0.77 (0.74–0.81)	1990–2007	−2.0[a]				
Missouri	24.1	18.5	0.77 (0.74–0.79)	1990–2002	−1.5[a]	2002–2007	−3.7[a]		
Texas	21.8	17.0	0.78 (0.76–0.80)	1990–1998	−1.1[a]	1998–2007	−2.5[a]		
Hawaii	19.4	15.3	0.79 (0.72–0.86)	1990–2007	−1.6[a]				
Idaho	19.5	15.3	0.79 (0.72–0.86)	1990–2007	−2.0[a]				
North Carolina	22.0	17.3	0.79 (0.76–0.81)	1990–1995	0.0	1995–2007	−2.3[a]		
South Carolina	22.7	17.9	0.79 (0.75–0.83)	1990–2007	−1.8[a]				
Kansas	22.4	17.9	0.80 (0.76–0.84)	1990–2007	−1.6[a]				
Kentucky	26.1	20.8	0.80 (0.77–0.83)	1990–2007	−1.7[a]				
Nebraska	22.9	18.9	0.82 (0.77–0.88)	1990–2007	−1.4[a]				
Oregon	20.4	16.8	0.82 (0.78–0.86)	1990–2007	−1.6[a]				
Tennessee	22.9	19.0	0.83 (0.80–0.86)	1990–2007	−1.5[a]				
Arkansas	22.9	19.1	0.84 (0.79–0.88)	1990–2007	−1.2[a]				
Nevada	22.8	19.1	0.84 (0.78–0.90)	1990–2007	−1.3[a]				
Georgia	20.5	17.4	0.85 (0.82–0.88)	1990–1998	−1.6[a]	1998–2001	1.9	2001–2007	−3.1[a]
West Virginia	24.8	21.0	0.85 (0.80–0.90)	1990–2007	−1.2[a]				
Louisiana	24.3	20.9	0.86 (0.82–0.90)	1990–2003	−0.5[a]	2003–2007	−5.2[a]		
Oklahoma	21.6	18.5	0.86 (0.82–0.90)	1990–2000	−0.3	2000–2007	−2.4[a]		
New Mexico	18.4	15.9	0.87 (0.80–0.94)	1990–2007	−1.1[a]				
Alabama	20.4	18.6	0.91 (0.87–0.95)	1990–2007	−0.7[a]				
Wyoming	19.3	17.9	0.92 (0.80–1.06)	1990–1996	4.3	1996–2007	−3.0[a]		
Mississippi	21.1	20.3	0.96 (0.91–1.02)	1990–2007	−0.2				

Mortality rate is per 100,000, age adjusted to the 2000 U.S. standard population. APC, annual percent change.
[a]APC is significant ($P < 0.05$).

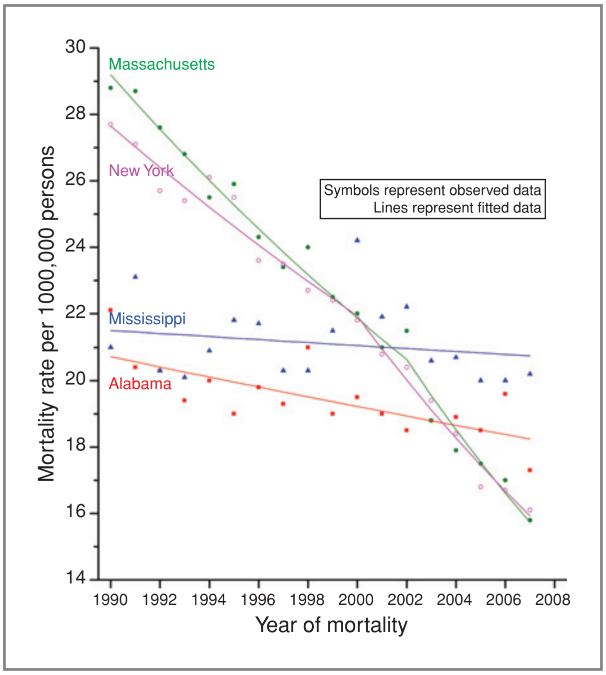

Figure 1. Trends in CRC mortality rates for selected states, 1990–2007.

in the northeast showing the largest declines and states in the south showing the smallest declines. The highest CRC death rates shifted from the northeastern states in the early 1990s to the southern states along the Appalachian corridor in the mid 2000s. These findings are consistent with higher CRC incidence and mortality rates in Appalachia compared with the rest of the United States (12–14).

Reasons for such disparities may include state differences in uptake of screening, treatment, and known risk factors. Screening for CRC detects adenomas for removal before they develop into cancer as well as detecting cancers at an early stage of the disease (15–17). Generally, the uptake of CRC screening is lower and the proportion of late stage CRC cases are higher in southern states compared with other regions (18, 19). We found that screening rates by state were strongly correlated with the decrease in CRC mortality rates ($r = -0.65$, $P < 0.0001$). Compared with other geographic areas, southern states have a larger proportion of the population that is poor and uninsured, among whom screening rates are lower. According to the U.S. Census Bureau, in 2007, 18.8% and 18.5% of the population in Mississippi and Louisiana, respectively, were

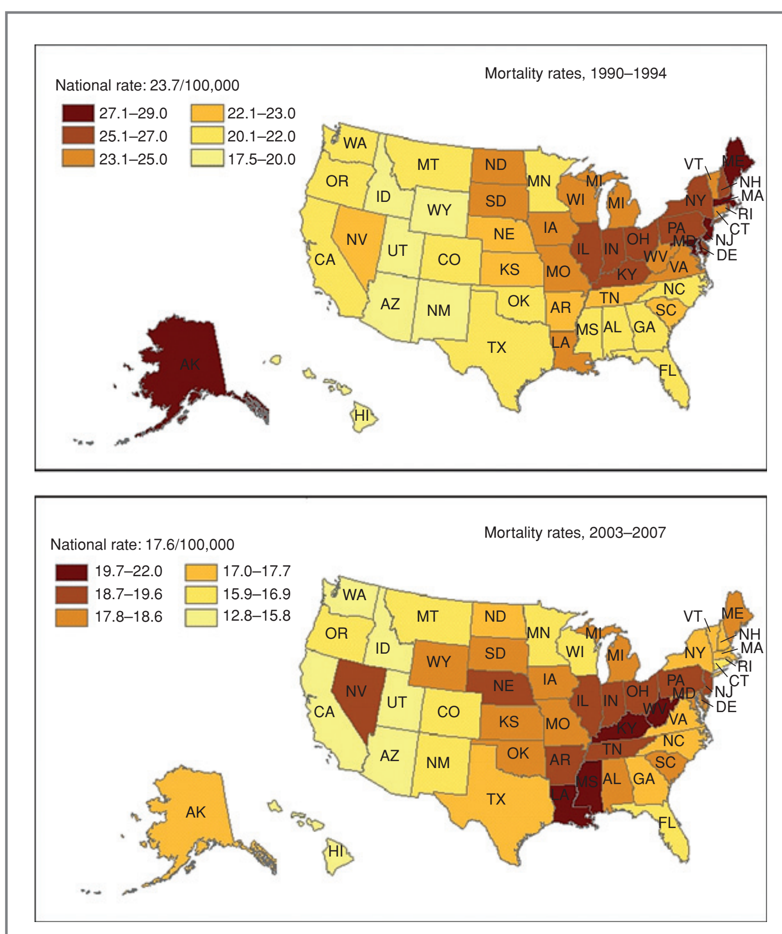

Figure 2. CRC death rates by state, 1990–1994 and 2003–2007.

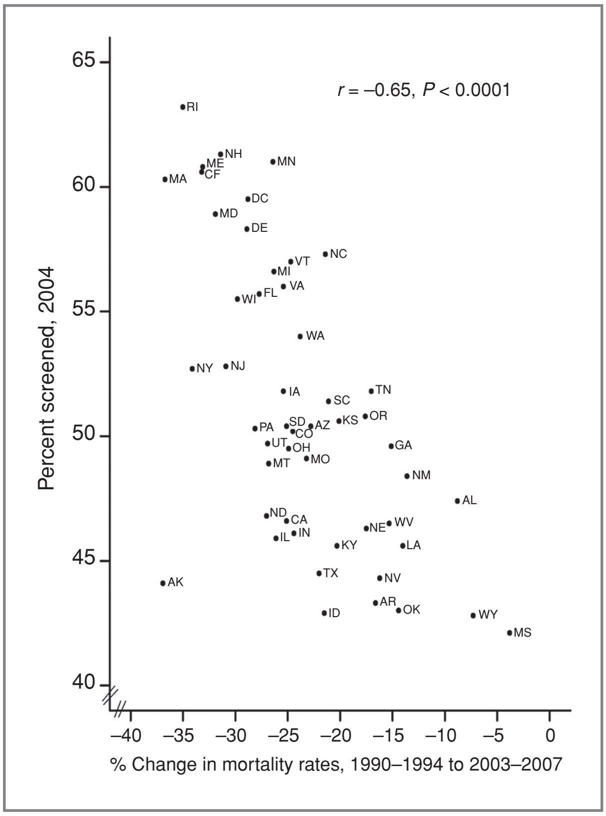

Figure 3. Relationship between percent change in CRC death rates and percentage screened, adults aged 50 and older.

uninsured compared with 5.4% in Massachusetts (20). Over 20% of the population in Mississippi was below the poverty line in 2007, compared with the national average of 13% (21). Higher death rates in the Appalachian region have also been noted for cervical cancer (22–25), which has a similar window of opportunity for prevention and early detection through screening.

Timely treatment is an important factor for survival following a CRC diagnosis. Several studies have shown that people with lower socioeconomic status (SES) delay treatment for CRC due to a host of factors, including lack of knowledge, referral bias, inadequate health insurance, and limited access to health care facilities (26–28). Although data on regional variations in CRC treatment are limited, CRC patients residing in rural areas or poorer neighborhoods are less likely to receive adjuvant chemotherapy than patients residing in urban or more affluent areas (29, 30). A recent study reported that women with early stage breast cancer in rural Appalachia are less likely than those in other regions to receive adjuvant chemotherapy following breast conserving surgery (31).

While obesity and smoking increase the risk of CRC (32, 33), use of menopausal hormone therapy and aspirin and other nonsteroidal anti-inflammatory drugs decrease risk (34, 35). Generally, prevalence of obesity has been much higher in the southern states (36) and progress in reducing smoking prevalence has been slower in southern states, compared with northeastern and western states (37). These trends may have attenuated the decrease in CRC death rates in these states. The use of menopausal hormone therapy among women has generally been higher in the southern and western states than in the northeastern states (38). Nevertheless, the decrease in CRC death rates for men and women by state were strongly and positively correlated ($r = 0.76$, $P < 0.0001$), suggesting that the trends were unlikely to be driven by sex-specific factors that affect CRC occurrence or survival.

The relatively higher proportion of blacks in southern states is another factor that may have contributed to the less favorable trend in reducing CRC mortality for all races combined in this region. Nationally, reduction in CRC death rates has been much slower in blacks than in whites (39), partly because blacks are more likely to have lower SES, which is associated with poorer access to treatment and preventive services (26), to have higher risk perception to interventions (29, 40, 41), are less likely to be screened or referred for CRC screening by their physicians (42, 43). However, the direction of the trend in CRC death rates within each state was generally similar in non-Hispanic blacks and non-Hispanic whites, though the magnitude of the trend varied for some states (Supplementary Table S1A and B). Particularly, the CRC mortality pattern for non-Hispanic whites was generally similar to those of all races (Table 1). For example, the highest CRC death rates in all races and in non-Hispanic whites occurred in Appalachian states, including West Virginia, Kentucky, and Ohio. Accounting for state differences in the proportion of non-Hispanic black population slightly strengthened the association ($r = -0.53$ to $r = -0.58$) between percentage change in death rates and CRC screening rates for all races combined in the 38 states that met high quality data for information on Hispanic ethnicity. Reasons for the relatively high rates in Nevada in the most recent time period are unknown but may in part reflect the low colorectal screening rate in the state; Nevada had the sixth lowest CRC screening rate by state in 2004 (9).

The less favorable CRC trend in many states for Hispanics may in part reflect the lower prevalence of screening in this population (9, 44). According to 2008 NHIS data, about 37% of Hispanic adults 50 year or older were current with their CRC screening compared with 56% of non-Hispanic whites and 49% of non-Hispanic blacks (45). About 40% of Hispanics are foreign born (46), and CRC cancer screening rates for immigrants who resided fewer than 10 years in the United States are half as high as for those born in United States (45). Despite the slow progress in reducing CRC mortality death rates, rates in Hispanics are lower than non-Hispanic whites and blacks due, in part, to lower prevalence of known risk factors for CRC, such as smoking, and a higher prevalence of protective factors, such as a vegetable and legume–based diet

(47–49). However, it is noteworthy that Hispanic subpopulations vary substantially by state distribution and CRC burden (50–54). Cubans have the highest CRC rates and predominantly reside in the south (Florida), whereas Mexicans have the lowest CRC rates and mainly reside in the southwest regions (50). Similar to non-Hispanic blacks, accounting for state differences in the proportion of Hispanic population did not affect the correlation ($r = -0.53$) between change in death rates and screening rates for all races combined.

A limitation of our study is its ecological nature, and we can only speculate about the factors that have contributed to state differences in the progress against CRC. Inaccuracies in underlying cause of death from death certificates according to International Classification of Diseases (ICD) are potential limitations in the interpretation of mortality trends. The concordance between the underlying cause of death from death certificates and cancer diagnosis recorded in population-based cancer registries for CRC in the United States is about 87% according to ICD-10 and 95% according to ICD-9 (55). However, the extent of variations in accuracy of underlying cause of death for CRC across states is unknown. The analysis by Hispanic ethnicity could also be affected by inaccuracies in race/ethnicity classification in death certificates and census estimates (56). Finally, screening rates by state are based on BRFSS, a telephone survey with low response rates that does not discern between screening and diagnostic procedures (57, 58). However, BRFSS is the only data source for screening prevalence by state.

In conclusion, progress in reducing CRC mortality rates varies significantly across states, with those in the Northeast showing the most progress and those in the South showing the least progress. As a result, the highest burden of CRC mortality shifted from the Northeast in the early 1990s to the southern states along the Appalachian corridor in the mid 2000s. Improving screening rates through state-specific initiatives and/or expansion of the Colorectal Cancer Control Program of the Centers for Disease Control and Prevention (59) to the Appalachian region and certain southern states could lessen the disproportionately high burden of CRC in these states.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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