Colon cancer survival in the United States by race and stage (2001-2009): findings from the CONCORD -2 study

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Running head: Colon cancer survival by race and stage

Keywords: colon cancer, population-based survival, cancer registries, disparities

Precis: Between 2001 and 2009, there was little improvement in age-standardized 5-year net survival from colon cancer in the United States. Five-year survival among black patients has yet to reach that of white patients diagnosed 15-20 years earlier.

Disclaimer: 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.

FUNDING SUPPORT for Claudia Allemani and Michel Coleman: US Centers for Disease Control and Prevention (CDC; 12FED03123, ACO12036)

Conflict of Interest Disclosures: None

ABSTRACT

BACKGROUND: In the first CONCORD study (2008), five-year survival for patients diagnosed with colon cancer during 1990-1994 in the U.S. was among the highest in the world (60%), but there were large racial disparities in most participating states. The CONCORD-2 study (2015) enabled examination of survival trends during 1995-2009 for US states, by race and stage.

METHODS: We analyzed data from 37 state population-based cancer registries, covering approximately 80% of the U.S. population, for patients diagnosed with colon cancer during 2001-2009 and followed through 2009. Survival up to five years was corrected for background mortality (net survival) using state- and race-specific life tables, and age-standardized using the International Cancer Survival Standard weights. Survival is presented by race (all, black, white), stage, state, and calendar period (2001–03 and 2004–09) to account for changes in methods used to collect stage.

RESULTS: Five-year net survival increased 0.9% from 63.7% during 2001-2003 to 64.6% for 2004-2009. More black than white patients were diagnosed at distant stage in 2001-2003 (21.5% vs. 17.2%, respectively), and in 2004-2009 (23.3% vs 18.8%). Survival improved for both blacks and whites, but 5-year net survival was 10% lower for blacks than for whites during both 2001-2003 (54.7% vs. 64.5%) and 2004-2009 (56.6% vs. 65.4%). The absolute difference between blacks and whites decreased by only 1% during this decade.

CONCLUSION: Five-year net survival from colon cancer slightly increased over time. Survival among blacks diagnosed during 2004-2009 had still not reached the level of survival of whites diagnosed during 1990-1994, some 15-20 years earlier. These findings suggest a need for more targeted efforts to improve screening and to ensure timely, appropriate treatment.

INTRODUCTION

Worldwide, colorectal cancer is the third most common cancer diagnosed in men and the second most common cancer diagnosed in women.[1] In developed countries, the incidence of colorectal cancer is higher and mortality is lower than in less developed countries.[1] In the United States (U.S.), colon cancer comprises approximately two-thirds of incident colorectal cancer cases, and is the third most commonly diagnosed cancer among men and women.[2] There were nearly 42,000 deaths from colon cancer alone in 2013, representing nearly 81% of colorectal cancer deaths.[2] The incidence of colon cancer has been decreasing steadily since 2001; most recently, incidence declined an average of 3.1% per year between 2005 and 2014.[2, 3] Mortality from colon and rectal cancers also has been declining for the past several decades, with the most rapid declines in the early 2000's, which is likely due to screening.[3, 4] Despite these overall reductions, colon cancer incidence and mortality rates remain substantially higher in blacks than other races/ethnicities, and higher among men than women.[2]

Population-based cancer survival provides an indicator of the overall effectiveness of the health care system to deliver screening, early diagnosis, and evidenced-based treatment services to all people in the population being served.[5] The first worldwide analysis of cancer survival (CONCORD) in 31 countries for patients diagnosed during 1990-1994 and followed up to 1999 covered 42% of the US population.[6] In the US, five-year survival for colon cancer was 60.1%, with lower survival among blacks (51%) compared with whites (61%).[6] These differences may have resulted from black patients not having received the same standard of care, including access to screening, early diagnosis and optimal treatment, as white patients.[6] Subsequent analysis of cancer survival worldwide (CONCORD-2) in 67 countries compared patients diagnosed with one of 10 common cancers, including colon cancer, during 1995-2009 and followed up to 2009 or later. Five-year net survival for colon cancer was 60% or more in North America, 12 European countries and a few countries in Central and South America and Asia.[7] For

the United States, five-year net survival for colon cancer increased from 61% for patients diagnosed during 1995-1999 to 65% in 2005-2009.[7]

This study uses data from CONCORD-2 to provide the first detailed assessment of survival for colon cancer in the U.S. by state and stage at diagnosis and by race during 2001-2003 and 2004-2009.

METHODS

Data Source

We used data from 37 population-based state cancer registries funded by either the Centers for Disease Control and Prevention (CDC)'s National Program of Cancer Registries or the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) program, or both.[8] These registries participated in the CONCORD-2 study,[7] covered approximately 80% of the United States population, and consented to the inclusion of their data in the more detailed analyses reported here. This analysis included 813,103 males and females (aged 15-99 years) diagnosed with invasive colon cancer between 2001-2009 with follow-up through December 31, 2009. As defined in the original study, for colon cancer, we included both the colon and rectosigmoid junction (ICD-O-3 codes: C18.0–C18.9, C19.9).[7] Primary, invasive cancers were included regardless of whether the patient has had a previous cancer. If the patient was diagnosed with two or more cancers of the colon during 2001-2009, only the first cancer was considered in the survival analyses.

Patients were grouped by year of diagnosis into two calendar periods (2001-2003 and 2004-2009) to reflect changes in the methods used by US cancer registries to collect data on stage at diagnosis. From 2001 to 2003, the majority of U.S. cancer registries directly assigned Surveillance, Epidemiology and End Results (SEER) summary stage (SS2000) to their cases;[9] while in 2004, registries began using the Collaborative Staging System (CS) to derive SS2000.[10] Information on stage was not available for two states (Maryland and Wisconsin), or for Rhode Island for patients diagnosed during

2004-2009. Therefore, these states are not included in national estimates of survival by stage during these calendar periods.

Statistical analysis

Net survival (1-, 3-, and 5-year), with 95% confidence intervals (CI), was estimated for patients diagnosed during 2001-2003 and 2004-2009, by state, race and stage at diagnosis using the Pohar Perme estimator. The Pohar Perme estimator allows for an unbiased estimation of net survival, i.e. the probability for patients to survive their cancer up to a given time since diagnosis, after controlling for other causes of death (background mortality).[11] To control for wide differences in background mortality among participating states, life tables of all-cause mortality in the general population of each state were constructed from the number of deaths and the population by single year of age, sex, calendar year and, where possible, by race (Black, White) using a flexible Poisson model.[12] Methods for constructing life tables have been published.[13]

For patients diagnosed during 2001-03, the cohort approach was used to estimate net survival, since all patients had been followed up for at least five years by December 31, 2009. The complete approach was used to estimate five-year net survival for patients diagnosed during 2004-09, because five years of follow-up data were not available for all patients. Net survival was estimated for five age groups (15-44, 45-54, 55-64, 65-74, and 75-99 years). All estimates were age-standardized using the International Cancer Survival Standard (ICSS) weights.[14] If two or more of the five age-specific estimates could not be obtained, only pooled, unstandardized survival estimates for all ages combined were presented. All unstandardized estimates are italicized in Supporting Tables 2 and 3. The overall results for colon cancer were presented; however, state-specific results were reported in Supporting Tables 1, 2 and 3. Trends, geographic variations and differences in age-standardized survival by race are presented graphically in bar charts and funnel plots.[15] Funnel plots of net survival for the two calendar periods

provide a simple and informative display of geographic variations or trends in population-based cancer survival measures (e.g. age-standardized net survival) in the United States, by race and state. Specifically, the plots show how much a particular survival estimate deviates from the pooled estimate of US registries (the target represented in the plot by the horizontal line) given the precision of each estimate. [15] More detail on the data and methods is provided in an accompanying article by Allemani et al.[16]

RESULTS

Table 1 shows the distribution of patients by race, stage and calendar period of diagnosis. Of the 278,382 patients diagnosed in 2001-2003, 85.7% (n=238,690) were white and 10.7% (n=29,658) were black. Of the 534,721 patients diagnosed in 2004-2009, a slightly smaller percentage were white (83.7%; n=447,569) and slightly more were black (11.9%; n=63,704). For all races combined, there was an increase in the proportion of patients diagnosed at localized and distant stages between 2001-2003 and 2004-2009 (from 34.2% to 37.8% and from 16.6% to 19.3%, respectively) and a decrease in the proportion diagnosed at regional stage (39.3% to 34.9%; Table 1). The percentage of patients with unknown stage decreased from 8.9% to 7.9%. Among blacks, the proportion of patients diagnosed at a localized stage increased from 29.1% to 33.8%; at a regional stage decreased from 37.4% to 32.7%; and at distant stage slightly increased from 21.5% to 23.3%. Among whites, the proportion of patients diagnosed with localized stage increased from 34.8% to 38.4%; with regional stage decreased from 39.5% to 35.2%; and with distant stage increased from 17.2% to 18.8%. Between the two calendar periods, the absolute difference in the proportion of black and white patients diagnosed at localized stage fell slightly (from 5.7% to 4.6% higher among white than black patients); and was essentially unchanged for regional (from 2.1% to 2.5% higher among white than black patients) and distant stages (4.3% to 4.5% lower among white than black patients). In nearly all states, the proportion of black

patients diagnosed with localized stage was lower than for white patients in both calendar periods (Supporting Table 1).

Between the two calendar periods, there were small increases in 1-, 3-, and 5-year net survival from 81.8%, 69.5% and 63.7%, respectively, in 2001-2003, to 82.9%, 70.7%, and 64.6%, respectively, in 2004-2009 (Table 2). Blacks had slightly lower 1-, 3- and 5-year survival than whites during both calendar periods but survival among blacks increased more than among whites. The absolute difference in survival between blacks and whites declined slightly between 2001-2003 and 2004-2009 (from 6.0% to 5.3% at 1-year, 8.8% to 8.3% at 3-years, and 9.8 % to 8.8% at 5-years). Survival up to five years after diagnosis was lower in blacks than in whites in nearly all states, both in 2001-2003 and 2004-2009 (Supporting Table 2).

Five-year net survival for colon cancer was highest for patients diagnosed at a localized stage, followed by regional and then distant stages (Table 3). There was no change in 5-year net survival between 2001-2003 and 2004-2009 for patients diagnosed at localized stage, but survival increased for those diagnosed at regional (68.7% to 70.2%) and distant stages (11.1% to 13.8%).

Blacks experienced poorer 5-year net survival than whites, at all stages and in both periods of diagnosis; however, the absolute difference in survival between blacks and whites decreased slightly between the two calendar periods for localized stage (from 6.7% to 4.9%) and remained essentially unchanged for regional and distant stages. Survival up to five years after diagnosis was lower in blacks than in whites in nearly all states, both in 2001-2003 and 2004-2009 (Supporting Table 3).

As shown in Figure 1, overall five-year net survival increased by 1.0%. Survival ranged from 59.8% to 69.5% in 2001-2003 and from 60.9% to 69.7% in 2004-2009 across the 37 participating states (Supporting Table 3). The largest increase in survival was 5.0%, while the largest decrease in survival was -6.6%.

Funnel plots of net survival for 2001-2003 and 2004-2009 show striking geographical and racial variation in survival (Figure 2). Although 5-year survival from colon cancer slightly increased between 2001-2003 and 2004-2009 in most states, it was lower for blacks (50-60%) than for whites (60-70%) in nearly every state for which data were available. In 2004-2009, there was a slight shift upwards in survival and some overlap whereby the highest survival for blacks was similar to the lowest survival for whites. In all 26 states for which a survival estimate could be obtained for blacks, survival was systematically lower than the pooled estimate of US registries.

DISCUSSION

This population-based study is the largest to date showing trends in survival up to 5 years after diagnosis for colon cancer by stage, race and state. There was a modest increase in 5-year colon cancer survival between 2001-2003 and 2004-2009 for patients diagnosed at regional or distant stages but not for patients with locally staged cancer where survival was already high (90%). Survival was not equal between states or by race. Five-year survival varied considerably among states but improved in most states between the two calendar periods. Five-year net survival was much lower in black patients than white patients at all stages of disease and this racial disparity only decreased by 1% over the decade.

Changes in survival likely reflect changes in screening, stage of diagnosis and treatment.[17] The small increases in 1-, 3- and 5-year colon cancer survival between the two calendar periods may reflect gains in survival achieved in the first calendar period. Since 1998, Medicare has covered annual fecal occult blood test and sigmoidoscopy every 4 years for average risk beneficiaries aged 50 years and older. In July 2001, coverage was expanded to include colonoscopy for average-risk individuals every 10 years. As a result, there was a rapid increase in the use of colonoscopy and an increased probability of diagnosis at an early stage among older adults.[18] Since 2000, screening has increased for persons aged 50-75 years and colonoscopy has become the most commonly used test, but screening test use among

blacks has remained lower than among whites.[19] In this study, there was an increase in earlier stage at diagnosis for both black and white patients. However, a larger proportion of blacks than whites were diagnosed at later stages of disease, which may be partially explained by historically lower screening rates among blacks compared with whites.[20, 21] Finally, the uneven distribution of access to high-quality treatment may explain the minimal improvement in survival. Populations that reside in low socioeconomic and/or rural areas are less likely to receive high-quality treatment for colon cancer than their counterparts.[22]

The wide variation in survival observed between states may reflect differences in access to screening and high-quality treatment. States that have a greater proportion of rural and lower socioeconomic status (SES) populations tend to fare worse in colon cancer outcomes.[23]Populations with low SES, including the uninsured, are less likely to be up-to-date for colorectal (CRC) screening according to recommendations. In 2015, the lowest colorectal cancer screening use was reported by persons who were uninsured (25.1%).[19] Access to and receipt of high quality treatment varies geographically. Residents of rural and/or low SES neighborhoods have more limited access to hospitals that offer high quality treatment than residents of urban areas or high-SES neighborhoods. One study found that patients treated in hospitals without Commission on Cancer designation or with lower surgical volumes had lower odds of adequate lymph node assessment, [24] a key factor in staging and treatment. Another study found that colon cancer patients residing in low- and lower-middle-SES neighborhoods had decreased odds of receiving surgery and chemotherapy than patients residing in high SES neighborhoods.[22] It also found that rural residents had an increased risk of death from colon cancer that was explained by treatment differences and neighborhood SES.[22]

Five-year survival showed modest improvement between the two calendar periods for patients diagnosed with regional and distant stage colon cancers. Advances in treatment have improved survival for later stage disease.[25-27] In the late 1980s, 5-fluorouracil-based adjuvant chemotherapy for patients

with surgically re-sectable Stage III colon cancer was introduced.[28, 29] In clinical trials, this treatment reduced mortality from colon cancer by as much as 30%. Later, the 1990 National Institutes of Health expert panel recommended that patients with Stage III colon cancer receive adjuvant therapy with 5-fluorouracil-based chemotherapy and levamisole.[26] Since that time, there have been new additions to adjuvant treatment that have a survival advantage over these therapies. After 2004, oxaliplatin in combination with fluoropyrimidine-based therapy became the predominant adjuvant treatment for both stage II and stage III colon cancer.[27] Improvements in outcome in metastatic colorectal cancer were associated with an increased use of hepatic resection in some patients during 1998 to 2006 and advancements in medical therapy from 2004 to 2006.[30]

Five-year net survival for colon cancer among black patients diagnosed in 2004-2009 has yet to reach that of white patients diagnosed 15-20 years earlier. In the first CONCORD study, cancer survival among blacks diagnosed during 1990-94 was 51.5% in men and 51.0% in women, while survival in whites was 60.5% and 60.8%, respectively.[6] Survival among black patients diagnosed during 2004-2009 was 54.5% in men and 58.6% in women compared with 64.5% and 66.4%, respectively among whites.[16] The disparities observed may reflect differences in access to screening and receipt of high quality health care.[17, 31, 32] Factors that have been shown to be associated with racial disparities in survival include differences in socioeconomic status,[33] tumor biology, sub-site (proximal versus distal)[34], stage at diagnosis,[3] comorbid conditions limiting treatment choices,[4, 25, 33] and access to timely, high-quality treatment.[35, 36]

Blacks had lower stage-specific 5-year survival than whites. The decrease in the magnitude of the disparities was present, though small, between the two calendar periods at every stage. Several studies have found that black colorectal cancer patients are less likely than white patients to receive appropriate surgery, adjuvant chemotherapy, and radiation treatments.[33, 35] In settings where black and

white patients with similarly staged disease receive comparable cancer treatment, survival differences by race are reduced.[37]

Clinical Perspective

To further reduce colon cancer incidence and mortality and improve survival, increased efforts are needed to ensure that people are offered screening at the appropriate age, receive timely diagnostic follow-up, get high-quality treatment and have adequate post-treatment surveillance. For colon cancers diagnosed at invasive stages, the wide differences in net survival between blacks and whites, and by state, reflect both the uneven use of effective treatment and the distribution of factors that affect recommendation of and uptake of treatment (e.g. SES, health literacy, health care access, insurance coverage, physician recommendation, and patient factors such as health beliefs, culture, and co-morbidities). Additional investigation may be needed to assess adherence to standards of treatment for colon cancer and to develop effective interventions to improve recommendation of and adherence to high-quality treatment.

Recent research has shown that primary tumor location may play a role in survival for colon cancer. Patients whose primary tumors originate on the left side of the colon survive significantly longer than those whose tumors originate on the right side.[38] Right-sided colon cancers are more likely to have poorly differentiated tumors and to be diagnosed at a more advanced stage, both factors that are associated with poor survival. [39] Additional research is needed to understand better the tumor biology behind these differences in survival to inform whether there is a need to change the approach to colon cancer treatment by managing colon cancer by tumor location. Ultimately, better understanding of the differences in tumor biology may also affect the choice of treatment modalities, specifically the chemotherapy regimens that are used for right- versus left-sided colon cancer.

Cancer Control Perspective

CDC's efforts to reduce the burden of colon cancer in the United States have largely focused on colorectal cancer screening, awareness and education. CDC's Colorectal Cancer Control Program (CRCCP) funds states, universities and tribal organizations to partner with health care systems to implement evidence-based interventions to increase the use of CRC screening tests for adults aged 50-75 years.[8, 40] In some states, the program also provides screening and follow up for positive tests for adults aged 50–64 years who are uninsured or underinsured and below 250% of the federal poverty level.[40] In addition to the CRCCP, the National Comprehensive Cancer Control Program brings together key partners and organizations to develop and implement plans to address the cancer burden.[8, 41] Finally, CDC and its partners are leading a national initiative to increase CRC screening rates to 80% by 2018.[42] By achieving this goal, it is estimated that approximately 280,000 new cancer cases and 200,000 cancer deaths will be averted within 20 years.[42]

To help achieve this goal, public health professionals could partner with healthcare systems to help design processes that ensure patients receive quality care along the entire continuum of care from screening to diagnosis to treatment and survivorship, including the provision of culturally and linguistically appropriate services or implementation of the National CLAS Standards.[43] Cancer screening registries can be used to improve follow-up among patients with positive screening tests and to implement evidence-based interventions, such as reminder systems.[44] Further, to address the disparities observed in this study, more research is needed to explore the geographic distribution of screening and treatment services, and factors contributing to the use or non-use of these services, within and between states, and what can be done to improve access in low-access areas and in medically underserved populations.

Strengths and Limitations

The CONCORD-2 study is the largest comparative study of population-based survival in the U.S. and includes high quality data that covers 80% of the U.S. population. The overall quality of the CONCORD-2 data, the rigorous statistical methods used and the large population coverage are such that the results presented provide a broad and comprehensive overview of trends and racial disparities in survival among cancer patients diagnosed in the U.S. Details on the strengths and limitations of these data are described elsewhere.[45] For colon cancer, there was a high percentage of microscopically confirmed colon cancer cases (97.6%), with no differences by race, indicating a high degree of clinical investigation of patients in the U.S.[16] Further, considering the population-based nature of this study, the proportion of colon cancer cases with unknown stage was remarkably low (8.9% for 2001-03 and 7.9% for 2004-09). The stage was unknown slightly more often in blacks than in whites (11.9% vs. 8.6% in 2001-03 and 10.2% vs. 7.5% in 2004-09). However, the completeness of stage information is remarkably high, and the differences in the proportion of unknown stage by race are not large. We would not expect these differences to affect the comparison of stage-specific survival by race.

Our findings are subject to some limitations.[45] First, caution should be used in comparing these results with other published studies using U.S. data. In the CONCORD-2 study, cancers that occur in the sigmoid-rectum junction were classified as colon cancer. In the U.S., this site is typically classified as cancer of the rectum. Second, there were several state estimates that fell outside the control limits as shown in the funnel plots. For estimates that were above the control limits (i.e., survival was higher than expected), caution should be used in interpreting these results because these registries may have not captured all particularly for patients who leave the United States between the time of their diagnosis and death.

Conclusions

The United States has made some progress in improving survival for patients diagnosed with colon cancer, particularly for patients whose cancers were diagnosed at a regional or distant stage. However, progress was not uniform across all states and by race. Five-year survival among blacks diagnosed during 2004-2009 had still not reached the level of survival of whites diagnosed during 1990-94, some 15-20 years earlier. More work needs to be done to reduce the wide disparities observed by state and race and targeted interventions are needed to reach the most vulnerable populations. Trends in population-based cancer survival can be used to inform policy and can serve as a benchmark for states to measure the impact of their cancer control programs.

REFERENCES

1. Ferlay J SI, Ervik M, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray, F. GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 11 [Internet]. Available from URL: http://globocan.iarc.fr

[accessed April 18, 2016].

2. U.S. Cancer Statistics Working Group. United States Cancer Statistics: 1999–2012 Incidence and Mortality Web-based Report. Available from URL: www.cdc.gov/uscs.

3. Howlader N NA, Krapcho M, Miller D, Bishop K, Kosary CL, Yu M, Ruhl J, Tatalovich Z, Mariotto A, Lewis DR, Chen HS, Feuer EJ, Cronin KA (eds),. SEER Cancer Statistics Review, 1975-2014. Available from URL: http://seer.cancer.gov/csr/1975_2013/ [accessed June 15, 2017].

4. Edwards BK, Noone AM, Mariotto AB, et al. Annual Report to the Nation on the status of cancer, 1975-2010, featuring prevalence of comorbidity and impact on survival among persons with lung, colorectal, breast, or prostate cancer. Cancer. 2014;120: 1290-1314.

5. Allemani C, Coleman, M.P. Public health surveillance of cancer survival in the US and world-wide: the contribution of the CONCORD programme. Cancer. 201x.

6. Coleman MP, Quaresma M, Berrino F, et al. Cancer survival in five continents: a worldwide population-based study (CONCORD). Lancet Oncol. 2008;9: 730-756.

7. Allemani C, Weir HK, Carreira H, et al. Global surveillance of cancer survival 1995-2009: analysis of individual data for 25,676,887 patients from 279 population-based registries in 67 countries (CONCORD-2). Lancet. 2015;385: 977-1010.

8. White MC, Babcock, F., Hayes, N.S., Mariotto, A.B., Wong, F.L., Kohler, B.A., Weir, H.K. The history and use of cancer registry data and public health cancer control programs in the United States. Cancer. 201x;XX.

9. Young JL RS, Ries LAG, Fritz AG, Hurlbut AA. . SEER Summary Staging Manual-2000: Codes and Coding Instructions. Bethesda, MD: National Cancer Institute, 2001.

10. Surveillance Epidemiology and End Results program. Collaborative Stage. Available from URL: http://seer.cancer.gov/tools/collabstaging/ [accessed April 1, 2016].

11. Perme MP, Stare J, Esteve J. On estimation in relative survival. Biometrics. 2012;68: 113-120.

12. Rachet B, Maringe C, Woods LM, Ellis L, Spika D, Allemani C. Multivariable flexible modelling for estimating complete, smoothed life tables for sub-national populations. BMC Public Health. 2015;15: 1240.

13. Spika D, Bannon F, Bonaventure A, et al. Life tables for global surveillance of cancer survival (the CONCORD programme): data sources and methods. BMC Cancer. 2017;17: 159.

14. Corazziari I, Quinn M, Capocaccia R. Standard cancer patient population for age standardising survival ratios. Eur J Cancer. 2004;40: 2307-2316.

15. Quaresma M, Coleman MP, Rachet B. Funnel plots for population-based cancer survival: principles, methods and applications. Stat Med. 2014;33: 1070-1080.

16. Allemani C, Harewood, R., Johnson, C., Carreira, H., Spika, D. Bonaventure, A., Ward, K., Weir, H.K., Coleman, M.P. Population-based cancer survival in the U.S.: data, quality control and statistical methods. Cancer. 201x.

17. Tong L, Ahn C, Symanski E, Lai D, Du XL. Relative impact of earlier diagnosis and improved treatment on survival for colorectal cancer: a US database study among elderly. Cancer Epidemiol. 2014;38: 733-740.

18. Gross CP, Andersen MS, Krumholz HM, McAvay GJ, Proctor D, Tinetti ME. Relation between Medicare screening reimbursement and stage at diagnosis for older patients with colon cancer. JAMA. 2006;296: 2815-2822.

19. White A, Thompson TD, White MC, et al. Cancer Screening Test Use - United States, 2015. MMWR Morb Mortal Wkly Rep. 2017;66: 201-206.

20. Fenton JJ, Tancredi DJ, Green P, Franks P, Baldwin LM. Persistent racial and ethnic disparities in up-to-date colorectal cancer testing in medicare enrollees. J Am Geriatr Soc. 2009;57: 412-418.

21. Rim SH, Joseph DA, Steele CB, et al. Colorectal cancer screening - United States, 2002, 2004, 2006, and 2008. MMWR Suppl. 2011;60: 42-46.

22. Hines R, Markossian T, Johnson A, Dong F, Bayakly R. Geographic residency status and census tract socioeconomic status as determinants of colorectal cancer outcomes. Am J Public Health. 2014;104: e63-71.

23. Jemal A, Siegel RL, Ma J, et al. Inequalities in premature death from colorectal cancer by state. J Clin Oncol. 2015;33: 829-835.

24. Fleming ST, Mackley HB, Camacho F, et al. Clinical, sociodemographic, and service provider determinants of guideline concordant colorectal cancer care for Appalachian residents. J Rural Health. 2014;30: 27-39.

25. Tong L, Ahn C, Symanski E, Lai D, Du XL. Effects of newly developed chemotherapy regimens, comorbidities, chemotherapy-related toxicities on the changing patterns of the leading causes of death in elderly patients with colorectal cancer. Ann Oncol. 2014;25: 1234-1242.

26. Adjuvant therapy for patients with colon and rectum cancer. NIH Consens Statement Online, 1990:8(4): 1-25.

27. Abrams TA, Brightly R, Mao J, et al. Patterns of adjuvant chemotherapy use in a population-based cohort of patients with resected stage II or III colon cancer. J Clin Oncol. 2011;29: 3255-3262.

28. Laurie JA, Moertel CG, Fleming TR, et al. Surgical adjuvant therapy of large-bowel carcinoma: an evaluation of levamisole and the combination of levamisole and fluorouracil. The North Central Cancer Treatment Group and the Mayo Clinic. J Clin Oncol. 1989;7: 1447-1456.

29. Moertel CG, Fleming TR, Macdonald JS, et al. Levamisole and fluorouracil for adjuvant therapy of resected colon carcinoma. N Engl J Med. 1990;322: 352-358.

30. Kopetz S, Chang GJ, Overman MJ, et al. Improved survival in metastatic colorectal cancer is associated with adoption of hepatic resection and improved chemotherapy. J Clin Oncol. 2009;27: 3677-3683.

31. Lansdorp-Vogelaar I, Kuntz KM, Knudsen AB, van Ballegooijen M, Zauber AG, Jemal A. Contribution of screening and survival differences to racial disparities in colorectal cancer rates. Cancer Epidemiol Biomarkers Prev. 2012;21: 728-736.

32. Le H, Ziogas A, Lipkin SM, Zell JA. Effects of socioeconomic status and treatment disparities in colorectal cancer survival. Cancer Epidemiol Biomarkers Prev. 2008;17: 1950-1962.

33. White A, Vernon SW, Franzini L, Du XL. Racial disparities in colorectal cancer survival: to what extent are racial disparities explained by differences in treatment, tumor characteristics, or hospital characteristics? Cancer. 2010;116: 4622-4631.

34. Henry KA, Sherman RL, McDonald K, et al. Associations of census-tract poverty with subsite-specific colorectal cancer incidence rates and stage of disease at diagnosis in the United States. J Cancer Epidemiol. 2014;2014: 823484.

35. White A, Liu CC, Xia R, et al. Racial disparities and treatment trends in a large cohort of elderly African Americans and Caucasians with colorectal cancer, 1991 to 2002. Cancer. 2008;113: 3400-3409.

36. Potosky AL, Harlan LC, Kaplan RS, Johnson KA, Lynch CF. Age, sex, and racial differences in the use of standard adjuvant therapy for colorectal cancer. J Clin Oncol. 2002;20: 1192-1202.

37. Bach PB, Schrag D, Brawley OW, Galaznik A, Yakren S, Begg CB. Survival of blacks and whites after a cancer diagnosis. JAMA. 2002;287: 2106-2113.

38. Yahagi M, Okabayashi K, Hasegawa H, Tsuruta M, Kitagawa Y. The Worse Prognosis of Right-Sided Compared with Left-Sided Colon Cancers: a Systematic Review and Meta-analysis. J Gastrointest Surg. 2016;20: 648-655.

39. Meguid RA, Slidell MB, Wolfgang CL, Chang DC, Ahuja N. Is there a difference in survival between right- versus left-sided colon cancers? Ann Surg Oncol. 2008;15: 2388-2394.

40. Joseph DA, Redwood D, DeGroff A, Butler EL. Use of Evidence-Based Interventions to Address Disparities in Colorectal Cancer Screening. MMWR Suppl. 2016;65: 21-28.

41. Seeff LC, Major A, Townsend JS, et al. Comprehensive cancer control programs and coalitions: partnering to launch successful colorectal cancer screening initiatives. Cancer Causes Control. 2010;21: 2023-2031.

42. Meester RG, Doubeni CA, Zauber AG, et al. Public health impact of achieving 80% colorectal cancer screening rates in the United States by 2018. Cancer. 2015;121: 2281-2285.

43. U.S. Department of Health and Human Services Office of Minority Health. National Standards for Culturally and Linguistically Appropriate Services in Health and Health Care. Available from URL: https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=2&lvlid=53 [accessed January 6, 2017].

44. Plescia M, Richardson LC, Joseph D. New roles for public health in cancer screening. CA Cancer J Clin. 2012;62: 217-219.

45. Weir HK SS, Allemani, C, White MC, Thomas CC, White A, Coleman MP and the CONCORD Working Group (US members). Population-based cancer survival (2001-2009) in the United States: Findings from the CONCORD-2 study. Cancer. 201x.

Figures and Tables

Figure 1- Colon cancer: 5-year age-standardized net survival (%) for patients (15-99 years) diagnosed during 2001-2003 and 2004-2009, and absolute change (%): states grouped by US Census Region.

Note: States are ranked within Census Region by the survival estimate for 2004-2009.
Note: Dark colors – states affiliated with the National Program of Cancer Registries (NPCR); pale colors – states affiliated with the Surveillance, Epidemiology and End Results (SEER) Program. * Registries affiliated with both federal surveillance programs. Change (%) not plotted because at least one calendar period estimate was not age-standardized.

Figure 2. Colon cancer: 5-year age-standardized net survival (%) for patients (15-99 years), by state, race and calendar period of diagnosis.

Note: the pooled (US) survival estimates for each calendar period are shown by the horizontal (solid) line with corresponding 95.0% and 99.8% control limits (dotted lines).

Table 1. Colon cancer: number of cases for males and females (15-99 years) diagnosed 2001-2009 and distribution (%) by SEER Summary Stage 2000, race and calendar period of diagnosis.

Stage		2001-2003			2004-2009		
		All races	**White**	**Black**	**All races**	**White**	**Black**
No. of patients		278,382	238,690	29,658	534,721	447,569	63,704
Localized	(%)	34.2	34.8	29.1	37.8	38.4	33.8
Regional	(%)	39.3	39.5	37.4	34.9	35.2	32.7
Distant	(%)	17.6	17.2	21.5	19.3	18.8	23.3
Unknown	(%)	8.9	8.6	11.9	7.9	7.5	10.2

Table 2. Colon cancer: age-standardized net survival (%) at 1-, 3- and 5-years for males and females (15-99 years) diagnosed 2001-2009, by race and calendar period of diagnosis.

	2001-2003						2004-2009					
	All races		**White**		**Black**		**All races**		**White**		**Black**	
Years	**NS (%)**	**95% CI**	**NS (%)**	**95% CI**	**NS (%)**	**95% CI**	**NS (%)**	**95% CI**	**NS (%)**	**95% CI**	**NS (%)**	**95% CI**
1	**81.8**	81.6 - 81.9	**82.3**	82.1 - 82.5	**76.3**	75.8 - 76.8	**82.9**	82.8 - 83.0	**83.4**	83.2 - 83.5	**78.1**	77.8 - 78.5
3	**69.5**	69.3 - 69.7	**70.3**	70.1 - 70.6	**61.5**	60.8 - 62.1	**70.7**	70.5 - 70.8	**71.4**	71.3 - 71.6	**63.1**	62.6 - 63.6
5	**63.7**	63.4 - 63.9	**64.5**	64.3 - 64.8	**54.7**	54.0 - 55.5	**64.6**	64.4 - 64.9	**65.4**	65.2 - 65.7	**56.6**	55.9 - 57.3

Table 3. Colon cancer: 5-year age-standardized net survival (%) for males and females (15-99 years) diagnosed 2001-2009, by SEER Summary Stage 2000, race and calendar period of diagnosis.

	2001-2003						2004-2009					
	All races		White		Black		All races		White		Black	
SEER Summary Stage	NS (%)	95% CI	NS (%)	95% CI	NS (%)	95% CI	NS (%)	95% CI	NS (%)	95% CI	NS (%)	95% CI
All stages	**63.7**	63.4 - 63.9	**64.5**	64.3 - 64.8	**54.7**	54.0 - 55.5	**64.6**	64.4 - 64.9	**65.4**	65.2 - 65.7	**56.6**	55.9 - 57.3
Localized	**89.8**	89.4 - 90.1	**90.2**	89.8 - 90.5	**83.5**	82.3 - 84.8	**89.7**	89.4 - 90.0	**90.0**	89.6 - 90.3	**85.1**	83.9 - 86.2
Regional	**68.7**	68.3 - 69.0	**69.3**	68.9 - 69.6	**62.3**	61.1 - 63.4	**70.2**	69.8 - 70.6	**70.7**	70.2 - 71.1	**63.9**	62.6 - 65.1
Distant	**11.1**	10.8 - 11.4	**11.4**	11.1 - 11.8	**7.9**	7.2 - 8.6	**13.8**	13.4 - 14.1	**14.2**	13.8 - 14.6	**10.9**	10.0 - 11.7
Unknown	**51.9**	51.1 - 52.6	**52.1**	51.2 - 53.0	**46.9**	44.9 - 48.9	**49.4**	48.6 - 50.2	**49.4**	48.5 - 50.2	**45.4**	43.5 - 47.3

Supporting Table 1. Colon cancer: number of cases for males and females (15-99 years) diagnosed 2001-2009 and distribution (%) by SEER Summary Stage 2000, race, calendar period of diagnosis, and US Census Region and States.

Note: Information on stage was not available for two states (Maryland and Wisconsin), or for Rhode Island for cases diagnosed during 2004-2009.

Supporting Table 2. Colon cancer: age-standardized net survival (%) at 1-, 3- and 5-years for males and females (15-99 years) diagnosed 2001-2009, by race, calendar period of diagnosis, and US Census Region and States.

Note: Unstandardized estimates are italicized.

Supporting Table 3. Colon cancer: 5-year age-standardized net survival (%) for males and females (15-99 years) diagnosed 2001-2009, by SEER Summary Stage 2000, race, calendar period of diagnosis and US Census Region and States.

Note: Information on stage was not available for two states (Maryland and Wisconsin), or for Rhode Island for cases diagnosed during 2004-2009. Unstandardized estimates are italicized.