Published in final edited form as:

Cancer Biomark. 2007 ; 3(6): 301–313.

African-American and Caucasian disparities in colorectal cancer mortality and survival by data source: An epidemiologic review

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Abstract

Over the past four decades in the United States, there has been a divergent trend in mortality rates between African-Americans and Caucasians with colorectal cancer (CRC). Rates among Caucasians have been steadily declining, whereas rates among African-Americans have only started a gradual decline in recent years. We reviewed epidemiologic studies of CRC racial disparities between African-Americans and Caucasians, including studies from SEER and population-based cancer registries, Veterans Affairs (VA) databases, healthcare coverage databases, and university and other medical center data sources. Elevated overall and stage-specific risks of CRC mortality and shorter survival for African-Americans compared with Caucasians were reported across all data sources. The magnitude of racial disparities varied across study groups, with the strongest associations observed in university and non-VA hospital-based medical center studies, while an attenuated discrepancy was found in VA database studies. An advanced stage of disease at the time of diagnosis among African-Americans is a major contributing factor to the racial disparity in survival. Several studies, however, have shown that an increased risk of CRC death among African-Americans remains even after controlling for tumor stage at diagnosis, socioeconomic factors, and comorbidity. Despite advances in treatment, improvements in the standard of care, and increased screening options, racial differences persist in CRC mortality and survival. Therefore, continued research efforts are necessary to disentangle the clinical, social, biological, and environmental factors that constitute the racial disparity. In addition, results across data sources should be considered when evaluating racial differences in cancer outcomes.

1. Introduction

Colorectal cancer (CRC) is among the leading causes of cancer related deaths in the United States, as cancer of the colorectum is the third most common malignancy and second most common cause of cancer mortality among men and women. There will be an estimated 153,760 new cases of CRC and 52,180 deaths due to this malignancy in 2007 [1]. In the US, there are racial differences (African-Americans compared with Caucasians) in CRC incidence, mortality, and survival [2–4]. Over the past twenty-five years, mortality rates among Caucasians have steadily declined, whereas the rates among African-Americans slowly increased until 1990, followed by a gradual reduction (Fig. 1). The divergence in mortality rates by race reflects differential CRC incidence and survival.

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The overall five-year relative survival rate for CRC is 64% [5]. Stage-specific survival rates are 96%, 87%, 55%, and 5% for TNM stage I, II, III, and IV CRC, respectively [2]. According to the American Cancer Society, when CRC is detected at an early localized stage, the five-year relative survival rate is 90%; however, only 39% of CRCs are discovered at this stage [1]. Overall and stage specific five-year CRC survival rates are higher for Caucasians compared with African-Americans [1,5], and differences are largely attributable to the stage of disease at diagnosis [6–12]. African-Americans tend to present with an advanced disease stage and have a poorer clinical outcome than do Caucasians [7–9,13–18]. Other studies, however, have shown that even with a similar distribution of tumor stage by race or after statistical adjustment for stage, survival disparities between African-Americans and Caucasians persist [19–22]. Moreover, this survival disparity has been shown to remain after controlling for socioeconomic, comorbid, and treatment factors [8,9,23–25].

Socioeconomic differences and variability in clinicopathological characteristics are the two primary factors that have been hypothesized to contribute to survival differences by race. Socioeconomic dissimilarities include differential opportunities for treatment, compliance of treatment, and varying degrees of quality of care. Clinicopathological characteristics include an advanced stage of disease at diagnosis and may include genetic or biologic variability. African-Americans are more likely to be diagnosed at a younger age than Caucasians, thus genetic and/or biologic characteristics may contribute to the racial disparity in mortality [26, 27]. Furthermore, socioeconomic differences may interact with clinicopathological traits. For example, socioeconomic factors related to screening options and patterns may result in an early or late stage of disease at diagnosis.

The purpose of this review is to evaluate descriptive and analytical epidemiologic studies pertaining to African-American and Caucasian racial disparities in CRC survival. We reviewed study findings by data source, and the differences in results across study population source are discussed. Although we feel that cancer of the colon and cancer of the rectum are distinct disease entities, most studies combine these cancer endpoints in their analyses. Thus, we refer to *colorectal* cancer (CRC), unless otherwise specified.

2. SEER & population-based cancer registry studies

The Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute is the most widely used and recognized source of US estimates of cancer prevalence, incidence, mortality, and survival. Several studies have evaluated racial trends in CRC survival using SEER program data (Table 1). In *Cancer Statistics, 2006*, Jemal et al. [5] reported trends in five-year relative survival rates among African-American and Caucasian CRC patients across three diagnostic periods (1974–1976, 1983–1985, 1995–2001) based on SEER data. Among Caucasians, relative five-year colon cancer survival increased from 51% to 65% (14% change), and rectal cancer survival increased from 49% to 65% (16% change). The survival increase was less pronounced among African-Americans as colon cancer survival increased from 46% to 55% (9% change) and rectal cancer survival increased from 42% to 56% (14% change).

Chien et al. [7], in an analysis using data from 11 SEER registries, reported a CRC hazard ratio (HR) of 1.2 (95% CI: 1.2–1.3) for African-Americans compared with non-Hispanic whites, after adjustment for age, year of diagnosis, registry, stage, and treatment. The strongest association was found among African-Americans with stage I and II CRC (HR = 1.4, 95% CI: 1.3–1.5). African-Americans were significantly more likely to be diagnosed with stage III or IV CRC compared with non-Hispanic whites. Similarly, Clegg et al. [15] reported that African-Americans were 20% more likely to die from CRC within five years after diagnosis, compared with Caucasians (Males: RR = 1.2, 95% CI = 1.2–1.3; Females: RR=1.2, 95% CI: 1.1–1.2).

after adjusting for age and tumor stage. Among men, five-year survival percent increased 10.1% for Caucasians and 9.0% for African-Americans in the years 1988–1997 compared to the years 1975–1987. The magnitude of increase was not as dramatic among women, as survival percent increased 9.2% for Caucasian women and 5.9% for African-American women. Consistent findings were observed in the *Annual Report to the Nation on the Status of Cancer, 1975–2001* [4]. Using twelve area SEER program data and after adjusting for age and tumor stage, African-American men had a 26% (RR = 1.26, 95% CI: 1.20–1.32) increased risk of CRC death within five years after diagnosis compared with Caucasians. The disparity was slightly less pronounced for African-American women compared with Caucasian women (RR = 1.18, 95% CI: 1.13–1.23).

Rabeneck et al. [6] identified patients diagnosed with primary CRC between the years 1986 and 1997, and examined temporal trends in the incidence and survival of CRC in the US. For all sites and within each stage, African-Americans had lower five-year relative survival. The authors did not find statistically significant differences in survival by race, based on stage and tumor site for the years 1986–1997, however. Using an extended survival period or a period analysis, prognostic improvements over time may have been observed in Caucasians and African-Americans, with a greater magnitude of increased survival in Caucasians. Brenner [28] used period life-table analysis, based on the mortality of a population within a recent period, to obtain estimates of long-term survival rates in US cancer patients. The author included patients with a first diagnosis of cancer between 1978 and 1998 based on SEER Program data. For colon and rectal cancer, period estimates of relative survival were enhanced compared with cohort estimates for each period of follow-up (5, 10, 15, 20 years). Findings from period analysis showed improved long-term survival rates than those suggested previously by cohort-based survival analysis.

Merrill et al. [13] estimated five and ten-year survival rates, conditional on surviving one to five years after diagnosis. A significantly greater proportion of Caucasian patients were diagnosed with stage II disease, whereas African-Americans were more likely to be diagnosed with stage IV disease. Overall and stage specific survival was markedly greater among Caucasians for each stage, particularly for stage II disease. Furthermore, the authors suggest that even after surviving five years from the time of diagnosis, the probability of surviving an additional five years is affected by disease stage and race.

Potosky et al. [29] sampled stage II and III CRC patients from the SEER registry and augmented data collection by abstracting information from patient medical records. African-Americans were found to have a 32% (RR = 1.32, 95% CI: 0.96–1.82) increased risk of death after adjusting for treatment, clinicopathological, and sociodemographic factors. Caucasian patients were 75% more likely to receive standard adjuvant therapy compared with African-American patients. Using two SEER registry data sources, Merrill et al. [30] compared treatment use and long-term survival between HMOs and fee for service (FFS) settings for Medicare CRC cases. No association between African-Americans and Caucasians was observed (RR = 0.99, 95% CI: 0.88–1.12). Reasons for the null findings may include a similar subset of patients regarding overall health and quality of care, compared to the general population. Racial groups in HMO plans may be more similar in terms of treatment options, follow-up care, socioeconomic status, education, and overall health. Furthermore, the analysis did not adjust for adjuvant chemotherapy or radiation treatment, which may have attenuated the results if African-Americans and Caucasians received similar treatments. Schrag et al. [23], using a SEER-Medicare linked database, adjusted for chemotherapy, clinical, and sociodemographic characteristics, and observed a 41% (RR = 1.41, 95% CI: 1.10–1.80) increased risk for overall mortality among African-American patients with stage II colon cancer.

In contrast to some of the aforementioned healthcare coverage studies, the following healthcare studies were not linked with the SEER database. Using Florida's population-based statewide cancer registry, Roetzheim et al. [20] reported that African-Americans had significantly elevated mortality (HR = 1.18, 95% CI: 1.01–1.37) compared with Caucasians after adjustment for demographic characteristics, tumor stage at diagnosis, treatment modalities, and insurance. Patients who were uninsured or insured by Medicaid or commercial HMOs had higher mortality rates compared to those with commercial fee-for-service insurance. Cooper et al. [16], in a study of CRC Medicare beneficiaries, reported that the two-year mortality rate for African-American patients was 40% compared with 33.5% for Caucasians. This disparity persisted even after stratifying by the number of major comorbid conditions. African-American patients had a 38% (OR = 1.38, 95% CI: 1.28–1.48) increased odds of death after two years of surgical resection compared with Caucasian patients. The same research group used Medicare files for patients diagnosed between 1989 and 1991, and observed similarly elevated two-year case fatality rates for African-Americans [31]. In contrast to previous findings, Rogers et al. [32] reported no difference in overall mortality between African-American and Caucasian (HR = 0.95, 95% CI: 0.81–1.11) residents of Tennessee dually enrolled in Medicaid and Medicare, who were diagnosed between 1984 and 1994. The authors suggest that equal coverage results in a similar mortality experience by race, although CRC-specific mortality results by race was not provided.

A social-epidemiologic study of possible behavioral and biologic determinants of African-American and Caucasian racial disparities in cancer survival was initiated in 1983 by the National Cancer Institute (NCI) [10]. Mayberry et al. [8] analyzed data from this population-based *Black/White Cancer Survival Study*, which consisted of 975 African-American and Caucasian patients diagnosed with colon carcinoma in 1985 through 1986 in the metropolitan areas of Atlanta, New Orleans, and San Francisco/Oakland. African-Americans had a 30% (HR = 1.3, 95% CI: 1.0–1.8) increased risk of colon cancer mortality during follow-up, after adjustment for stage and other tumor and demographic characteristics. The magnitude of racial disparity was more pronounced among patients with stage II and III colon cancer, as African-Americans had an 80% (HR = 1.8, 95% CI: 1.0–3.1) and 50% (HR = 1.5, 95% CI: 1.0–2.3) increased risk of colon cancer mortality for stage II and III disease, respectively. The stage-specific results were independent of within-stage variation of comorbidity, symptoms, treatment, and tumor characteristics, as the inclusion of these variables in their model did not reduce the observed racial disparity. For all stages combined, the authors concluded that late-stage at diagnosis accounted for more than half of the excess colon cancer mortality observed among African-Americans.

A significantly increased risk of CRC mortality for African-Americans compared with Caucasians was reported (HR = 1.19, 95% CI: 1.09–1.30) among 61,804 cases in a Pennsylvania population-based cancer registry study [9]. African-Americans were 35% (RR = 1.35, $p < 0.001$) more likely to be diagnosed with distant stage CRC compared with Caucasians. The use of administrative data in this study resulted in a considerable amount of missing tumor stage, grade, and site information, thus, the results may have been biased if the proportions of these prognostic tumor characteristics vary systematically by race.

3. Studies of the Veterans Affairs health care system

Veterans Affairs (VA) hospitals offer equal access to care and treatment to all eligible patients within their system [24,33,34]. Relatively few studies, however, have evaluated racial differences in CRC survival in this type of equal access system (Table 2). In the few studies that did evaluate race and CRC prognosis, African-Americans had shorter survival than Caucasians, although the magnitude of associations were attenuated in comparison to disparities from non-VA studies [24,25,33,35,36]. In a study of 12 medical centers within the

VA hospital system, a non-significant positive association between African-Americans and Caucasians was reported for colon cancer (HR = 1.17, 95% CI: 0.53–2.57) after adjustment for clinical and laboratory characteristics [33]. Dominitz et al. [24], in a study using Patient Treatment Files (PTF) of nationwide VA Medical Centers, found no significant differences in the proportion of African-American compared with Caucasian patients who received treatment, specifically, surgical resection, chemotherapy, and radiation therapy. A 13% (HR = 1.13, 95% CI: 1.01–1.28) increased risk of mortality over a five-year follow-up period for African-Americans compared with Caucasians was reported, however.

Rabeneck et al. [35] evaluated temporal trends in survival of 46,044 patients with a new diagnosis of CRC during 1987–1998 in the nationwide VA system. In both racial groups, significant survival increases in one, three, and five-year survival were observed. African-Americans had slightly, but significantly greater mortality throughout the follow-up period, compared with Caucasians (RR = 1.04, 95% CI: 1.01–1.09). In a subsequent study by the same authors [25], patients who received surgery in high surgical volume hospitals had greater cumulative survival compared to patients receiving surgery at low volume hospitals. Among patients with non-metastatic CRC, African-Americans were 10% (HR = 1.10, 95% CI: 1.03–1.16) more likely to die within the follow-up period, although stage (I, II, or III) at diagnosis and tumor site within the colon were not adjusted for in the analysis. In two of these studies [24,25], a relatively high proportion (Dominitz: 17% & 23%; Rabeneck: 20.6% & 22.6%) of tumors were in unspecified locations among Caucasian and African-American patients, respectively. If the location and extent of these tumors were systematically different by race with respect to prognosis, a different magnitude of association may have been observed. This is of particular interest because in both studies, unknown tumor location was statistically significant in multivariate analysis.

Compared to non-VA studies, the slighter CRC survival disparity by race observed in studies consisting solely of patients within the VA system may be a result of uniform treatment and care in the VA's equal access health care system [24,35]. Patients enrolled in and who receive treatment in the VA medical system may be of relatively lower socioeconomic status, resulting in a homogeneous group of patients specific to this potential confounding factor. In addition, these survival differences by race may be partly attributed to similarities in other confounding prognostic factors which are not as clearly defined by race in the VA population than in the general population.

4. University and other medical center studies

University, comprehensive cancer center, and other non-VA hospital-based studies (Table 3) may generally allow for more detailed information on clinical parameters than do large scale population-based registry studies. Comparatively smaller sample sizes in university and medical center studies may feasibly allow for patient specific clinicopathological data ascertainment. Smaller sample sizes, however, may reduce the precision of the estimated associations.

In a study that included patients from 11 US comprehensive cancer centers, an increased risk of death was found among African-Americans with colon cancer (HR = 1.28, $p < 0.001$) and rectal cancer (HR = 1.44, $p < 0.001$) compared with Caucasians [37]. The racial difference was most prominent for patients with localized disease. In a study using university and city hospital patient data from Nashville, Tennessee, median survival was significantly greater for Caucasian (5.7 years) patients compared with African-American (3.2 years) patients, despite similarities in tumor stage at presentation, treatment patterns, and surgeons [21]. The authors concluded that the poorer survival observed among African-American patients may be due to biological factors or other health conditions. African-Americans had a 50% (HR = 1.5, 95%

CI: 1.2–1.9) increased risk of death after adjusting for age and tumor stage, in a study that used patient data from an Arkansas university hospital [22]. This finding remained unchanged after the inclusion of socioeconomic status and treatment variables. At the University of Chicago, African-American patients with Duke's stage B and C rectal cancer were found to have significantly poorer survival (HR = 1.75, $p < 0.03$) compared with Caucasians [38].

Alexander et al. [19] evaluated racial differences in cancer-specific and within stage-specific colon cancer survival. Patient data was ascertained from University of Alabama at Birmingham medical records and surgical pathology reports. All patients received surgical resection as their only treatment; therefore, findings were not confounded or biased by racial differences in the receipt or compliance of adjuvant chemotherapy or radiation. African-Americans were 67% (HR = 1.67, 95% CI: 1.21–2.33) more likely to die from colonic adenocarcinoma within five years after surgical resection than Caucasians. This finding was independent of gender, age, tumor stage, tumor grade, and anatomic tumor subsite. Approximately 30% of the study population originated from the affiliated VA hospital; however, adjustment for treatment hospital did not alter the results. After stratification by tumor stage at diagnosis, Caucasians were found to have better survival compared with African-Americans in each stage, specifically among patients with stage II colon carcinoma. Indeed, poorer survival among African-Americans with stage II cancer has been consistently reported in prior studies [7–9, 37] (Fig. 2). In a subsequent study of this population, African-Americans with high-grade tumors were three times (HR = 3.05, 95% CI: 1.32–7.05) more likely to die of colon carcinoma within five years postsurgery, compared with Caucasians with high-grade tumors [39].

In previous publications that used a subset of patients that were included in the above studies, Manne et al. evaluated the prognostic value of nuclear accumulation of p53, a protein product of a tumor suppressor gene [40], immuno-phenotypic expression of Bcl-2, p27^{kip-1} [41], suppressin [42], and the mucin antigens, MUC1 and MUC2 [43]. Findings from these studies suggested that the prognostic value of these molecular markers may vary by race, anatomic tumor location, and pathologic stage. For example, nuclear accumulation of p53 was found to be a strong predictor of poor survival in Caucasian patients, but not in African-American patients with primary adenocarcinomas of the proximal colon [40]. Similarly, MUC1 was found to be an indicator of increased risk of death from CRC in only Caucasians [43]. These findings, however, need to be corroborated in larger studies before conclusions can be drawn from these molecular inferences.

In a study using data from randomized clinical trials of the National Surgical Adjuvant Breast and Bowel Project (NSABP), Dignam et al. [11,44] reported increased risks of overall mortality among African-Americans with colon cancer (HR = 1.21, 95% CI: 1.06–1.37) and rectal cancer (HR = 1.45, 95% CI: 1.09–1.93). McCollum et al. [45] reported a weakly increased risk of death among African-Americans after adjustment for treatment assignment and tumor characteristics in a randomized phase III trial of adjuvant chemotherapy.

5. Discussion

Despite improvements in treatment, standard of care, and screening options, studies indicate that racial disparities persist in CRC incidence, mortality, and survival. The age-adjusted CRC mortality trends by race have followed a relatively divergent pattern for over twenty years. While the rates for Caucasians have slowly but steadily decreased, those for African-Americans have been relatively stable over time [46]. Based on SEER data, between 1980 and 2000, the age-adjusted mortality rate decreased 7.9% among Caucasians and only 0.5% among African-Americans [46]. This racial disparity in CRC mortality is a reflection of incidence and survival, as African-Americans have the highest incidence rates and lowest survival rates for cancer of the colon and rectum among all racial and ethnic groups in the United States [2,47,48].

Previous publications have offered a wealth of possible reasons that may explain the racial disparity in CRC survival. These include varied screening patterns [31,49–51] that result in disparate disease stages [8,9,12,17,37,48,52,53] at diagnosis, comorbid conditions [21,54], histologic type [53], tumor grade [39], quality of and access to care [12,16,24,31,32,44,48, 51,55], follow-up surveillance [49,56], biological variability [15,21,57], clinical under-staging [8–10,48], and differences in treatment offered or accepted [11,19,22,29,32,55,58–62] including racial differences in the compliance of treatment regimens. In addition, socioeconomic [9,10,14,47] and sociodemographic [47,63] factors including education [12, 62], religious involvement and social support [63,64], poverty level [12], insurance status [16], physical activity, obesity, and attitudes and beliefs [65] about cancer fatalism [66] may contribute to CRC racial disparities in survival.

In the vast majority of CRC studies, a greater proportion of African-Americans were diagnosed with advanced stage CRC compared with Caucasians [6–9,13,15,16,19,22,24,32,33,35,37, 62]. This is of great concern since pathologic tumor stage is the single most powerful prognostic indicator of CRC [67], although several studies have reported that race is a stage-independent prognostic factor of CRC [4,8,9,19,20,22,37,44]. One of the many possible explanations for the discrepancy in stage distribution by race is that Caucasians are more likely to have early stage (localized) disease detection in screening tests, and in contrast; African-Americans are more likely to have symptomatically detected late stage (distant) tumors. Cooper et al. [49] found that colonoscopy, sigmoidoscopy, and fecal occult blood tests were performed more commonly in Caucasians for screening and surveillance purposes, however, colonoscopies were performed more often in African-Americans for diagnostic purposes. A delay in the use of screening procedures for colorectal cancer until signs or symptoms develop may contribute to the disparate proportion of late stage tumors among African-Americans. In addition, African-Americans are more likely to be diagnosed at a younger age and with proximal (right-side) tumors compared with Caucasians [11,26,27,68]. Consequently, the American College of Gastroenterology's Committee of Minority Affairs and Cultural Diversity has issued new screening recommendations to African-Americans that include "first line" colonoscopy screening at the age of 45, rather than age 50 [27]. The use of colonoscopy is likely to improve overall detection rates including right side tumors of the colon that cannot be reached by flexible sigmoidoscopy [27].

Several factors may influence delays in the use of screening options and medical procedures, including education, social support, poverty, and diminished access to health and medical services and refusal of treatment [9,14,62,63]. Mandelblatt et al. [14] observed that even among all persons living in the poorest socioeconomic status area, African-Americans continued to have significantly higher rates of late stage disease than Caucasians (OR = 1.24, 95% CI: 1.13–1.36). Kinney et al. [63] examined the relationship between social ties and the risk of colon cancer stage at diagnosis, and found that among African-Americans, minimal social support was associated with risk of both local (OR = 3.69, 95% CI: 1.08–12.69) and advanced (OR = 5.10, 95% CI: 2.03–12.82) stage disease. Robinson et al. [69] assessed cancer awareness among African-Americans and found that they were less knowledgeable than Caucasians with regard to treatment modalities, and were more likely to perceive surgery as contributing to metastases.

Even though African-Americans tend to be diagnosed with a later stage of disease than Caucasians, a greater disparity in survival is found at an earlier stage of disease (i.e., stage II) among these two racial groups than at later stages of disease (Fig. 2). This early stage disparity persists even after analyzing patients who received surgical resection as their only treatment procedure. The role of adjuvant therapy in patients with stage II CRCs remains controversial [73], however, African-Americans with specified clinicopathological characteristics, such as high-grade tumors, may benefit from adjuvant chemotherapy. Future research in this important clinical area is recommended.

We examined the degree of CRC racial disparity in survival and mortality according to study population data source. Overall, the greatest disparities have been found in non-VA hospital-based and university-based studies (Fig. 3). Lesser racial disparities exist in SEER and other population-based cancer registry studies and health care coverage database studies, and minimal disparities were found in studies of patients within the VA medical system. The precision of associations was greatest among the SEER and VA studies, which consisted of large sample sizes (Table 1, Fig. 3).

Findings from some studies have indicated that quality of care and equal access to care result in similar mortality experiences by race [24,32]. This is evident among studies in which patients are equally insured or are in an equal access medical system such as that of the VA integrated health care program. The case mix from the VA system is relatively more homogeneous with respect to sociodemographic confounding variables compared with the general population [70]. Despite homogeneity in terms of equal access care, insurance status, treatment, and social factors, an increased risk of mortality among African-Americans has been observed [24,25, 35], albeit an attenuated magnitude of risk compared to non-VA studies. Because of the potential intrinsic population similarities within the VA medical system, the generalizability (external validity) to the US population is limited. Furthermore, the majority of VA patients are men. Other potential shortcomings of using the VA database may include a lack of information pertaining to clinical detail, care received in other institutions may not be captured in the VA system, and missing information based on the use of Veterans Health Administration data [71,72]. In addition, reported associations in these studies were generally not stage-specific, thus, interpretation of racial disparities by stage is limited.

Based on SEER data, African-Americans are generally considered to have an approximately 20% increased risk of CRC mortality compared with Caucasians. Large scale population-based studies serve to provide descriptive statistics pertaining to CRC survival on the aggregate level. In some studies of this nature, it is not feasible to ascertain information on detailed clinical and pathological characteristics or data on treatment in terms of receipt and compliance. Therefore, findings from these studies may not offer patient specific prognostic patterns in the clinical setting, but do offer descriptive insight to nationwide disease patterns. Not all SEER studies are limited in patient information, however. A unique feature of SEER registry data is that patient data can be linked with medical coverage databases, and the SEER database can be sampled and merged with more informative patient medical records. Potosky et al. [29], for example, sampled from the SEER database and identified treating physicians in order to verify the use of chemotherapy and radiotherapy. Augmenting SEER data with more detailed clinical information may increase study validity by the ability to control for potential confounding factors.

In university-based and non-VA hospital studies, African-Americans generally have a greater risk of CRC mortality than what is typically observed in other studies. This may in part, be explained by more efficient control of confounding factors compared to large population or registry based research. University and non-VA-based studies usually entail comparatively smaller sample sizes that allow feasible data ascertainment directly from medical records, physician charts, and surgical pathology reports. This type of data extraction increases the internal validity of study findings since detailed and objective clinicopathological information can be directly obtained to evaluate the study hypothesis. In contrast, studies that rely solely on data for administrative purposes may be relatively more susceptible to coding errors or problems with missing data [24,71]. Limitations from university and hospital-based studies may include less precise findings due to comparatively small sample sizes, and findings from single institution studies may only be generalizable to limited populations due to the study sample being drawn from specific hospital catchment areas.

6. Conclusion

In the US, African-Americans have worse disease specific and overall survival for colon cancer or rectal cancer compared with Caucasians, even after controlling for tumor stage, sociodemographic factors, and comorbidity. This observation has been reported consistently across all study data sources, however, the strongest associations have been found among non-VA hospital-based and university-based medical center studies, while slightly weaker associations have been generally reported in population-based cancer registry studies. Although a racial disparity still exists, the discrepancy in survival between African-Americans and Caucasians is least evident in VA medical system studies that theoretically offer equal access to care. Taken together, descriptive and analytical research is instrumental in disentangling the clinical, social, biological, and environmental factors that constitute the racial disparity in CRC mortality and survival. Future studies should focus on evaluating colon cancer and rectal cancer as separate disease entities; and researchers should make an effort to control for treatment, clinicopathological, and sociodemographic characteristics that will allow for a more accurate measure of the disparity between African-Americans and Caucasians. Furthermore, results across data sources should be considered when evaluating racial differences in cancer survival.

Acknowledgements

This work was supported partially by a grant from the National Institute of Health/National Cancer Institute (RO1-CA098932-01) and the Early Detection Research Network (CA086359-07). Additional support was provided by the National Cancer Institute's Fellowship in Cancer Prevention and Control 5R25CA47888. The authors express gratitude to Jason Pope and Mary Becker of the Exponent Graphics Department.

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Source: Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Mortality - All COD, Public-Use With State, Total U.S. (1969–2003), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2006. Underlying mortality data provided by NCHS (www.cdc.gov/nchs).

Fig. 1. Age-adjusted total US mortality rates for colorectal cancer, 1969–2003

Source: Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Mortality - All COD, Public-Use With State, Total U.S. (1969–2003), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2006. Underlying mortality data provided by NCHS (www.cdc.gov/nchs).

Note: Findings presented only for those studies that presented relative risk estimates for more than one category of stage.

Fig. 2.
Relative risk estimates of stage-specific colorectal cancer mortality: African-Americans compared with Caucasians (referent).

Fig. 3.
Relative risks of colorectal cancer mortality for African Americans compared with Caucasians, based on data source of study.

SEER program, population-based cancer registry, and health care coverage database studies

Table 1

Author and Publication Date	Cancer Type	Source of Study Population; Years of Diagnosis	Sample Size (n)	CRC Mortality Relative Risk (95% CI), (AA vs. Caucasian)	Variables in Multivariate Model
Chien et al.; 2005	Colorectal	11 population based SEER registries; 1988–2000	Non-Hispanic white = 120,491 AA = 14,003	All CRC deaths: HR = 1.2 (1.2–1.3) Stage I and II: HR = 1.4 (1.3–1.5) Stage III and IV: HR = 1.1 (1.1–1.2)	Age, dx year, registry, surgical treatment, radiation, stage
Jemal et al.; 2004	Colorectal	12 population based SEER registries; 1975–2001	—	Dx 1992–2000: Men: RR = 1.26 (1.2–1.3) Women: RR = 1.18 (1.1–1.2)	Gender, tumor stage
Rogers et al.; 2004	Colorectal	Persons dually enrolled in Tennessee Medicaid and Medicare; 1984–1994	969	Overall mortality: HR = 0.95 (0.81–1.11)	Stage, comorbidities, age, gender
Potosky et al.; 2002	Colorectal	SEER (9 geographic regions) augmented with additional data; 1987–1991, 1995	4,706	Stage III colon, stage II/III rectal: RR = 1.32 (0.96–1.82)	Therapy, dx year, age, sex, region, marital status, income, cancer site, tumor extent, nodal status, histologic grade, comorbidities
Schrag et al.; 2002	Colon	SEER-Medicare linked database; 1991–1996	3,151	Stage II: RR = 1.41 (1.10–1.80)	Adjuvant chemotherapy, age, sex, examined nodes, tumor differentiation, admission type, comorbidity, dx year, income
Clegg et al.; 2002	Colorectal	9 population based SEER registries; 1975–1997	225,104	Dx 1988–1997: Men: RR = 1.2 (1.2–1.3) Women: RR = 1.2 (1.1–1.2)	Age, tumor stage
Marcella et al.; 2001	Colorectal	Pennsylvania State Tumor Registry; 1987–1993	61,804	All Stages: HR = 1.19 (1.09–1.30) Men: Localized HR = 1.59 ($p < 0.01$) Regional HR = 1.38 ($p < 0.01$) Women: Localized HR = 1.33 ($p < 0.01$) Regional HR = 1.23 ($p < 0.01$)	For all stage analysis: gender, gender*race ^a , age, stage, site, grade, SES. Stage specific analysis: age, tumor characteristics
Roetzheim et al.; 2000	Colorectal	Florida Cancer Data System (FCDS); 1994	8,128	RR = 1.18 (1.01–1.37)	Gender, age, marital status, insurance, education, income, residence, anatomic site, comorbidity, smoking, stage, treatment
Merrill et al.; 1999	Colorectal	2 population based SEER registries augmented with Medicare data (SF/Oak, Seat); 1985–1992	15,352	RR = 0.99 (0.88–1.12)	HMO enrollment, age, gender, region, education, stage, comorbidity, cancer site
Cooper et al.; 1996	Colorectal	Medicare Provider Analysis and Review Files; 1987	63,405	OR = 1.38 (1.28–1.48)	Gender, age, comorbidity, tumor site and extent
Merrill et al.; 1998	Colon	9 population based SEER registries; 1983–1987	34,963	N/A	N/A

Author and Publication Date	Cancer Type	Source of Study Population; Years of Diagnosis	Sample Size (n)	CRC Mortality Relative Risk (95% CI), (AA vs. Caucasian)	Variables in Multivariate Model
Mayberry et al; 1995	Colon	NCI Black/White Cancer Survival Study; Atlanta, New Orleans, San Francisco/Oakland; 1985–1987	975	All Stages: HR = 1.3 (1.0–1.8) Stage II: HR = 1.8 (1.0–3.1) Stage III: HR = 1.5 (1.0–2.3)	All stages combined: age, gender, location, stage, symptoms, comorbidity, health behavior, treatment, sociodemographics. Stage II and III: age, gender, location

HR: hazard ratio; OR: odds ratio; RR: rate ratio; Dx: diagnosis.

^aGender by race interaction.

Table 2

Veterans Affairs (VA) health care system studies

Author and Publication Date	Cancer Type	Source of Study Population; Years of Diagnosis	Sample Size (n)	CRC Mortality Relative Risk (95% CI), (AA vs. Caucasian)	Variables in Multivariate Model
Rabeneck et al.; 2004	Colorectal	VA Patient Treatment Files; 1991–2000	22,633	Non-metastatic CRC patients: HR = 1.10 (1.03–1.16)	Year of Dx, age, gender, marital status, Deyo score, CRC site, chemotherapy, hospital volume
Rabeneck et al.; 2003	Colorectal	VA Patient Treatment Files; 1987–1998	45,143	HR = 1.04 (1.01–1.09)	Age, comorbidity, site, metastases, cohort year
Dominitz et al.; 1998	Colorectal	VA Patient Treatment Files; 1989	3176	HR = 1.13 (1.01–1.28)	Age, service eligibility, VA region, comorbidity, distant metastases, tumor location
Akerley et al.; 1993	Colon	Patients ascertained from 12 VA hospitals; 1981–1986	719	HR = 1.17 (0.53–2.57)	Clinical and laboratory characteristics

HR: hazard ratio; Dx: diagnosis.

Table 3

University and other medical centers studies

Author and Publication Date	Cancer Type	Source of Study Population; Years of Diagnosis	Sample Size (n)	CRC Mortality Relative Risk (95% CI), (AA vs. Caucasian)	Variables in Multivariate Model
Alexander et al.; 2004	Colon	University hospital and VA Medical Center; 1981–1993	398	5-yr: HR = 1.67 (1.21–2.33) 10-yr: HR = 1.52 (1.20–2.07)	Age, gender, hospital, stage, grade, anatomic subsite
Govindarajan et al.; 2003	Colorectal	University Hospital: Institutional Tumor Registry; 1984–1997	617	HR = 1.5 (1.2–1.9)	Age, stage
Dignam et al.; 2003	Rectal	Randomized clinical trials of the National Surgical Adjuvant Breast and Bowel Project (NSABP); 1977–1992	1174	HR = 1.45 (1.09–1.93)	Age, gender, stage, anatomic subsite, surgery type
McCollum et al.; 2002	Colon	Patients from a phase III trial of adjuvant chemotherapy; enrolled 1988–1992	3380	HR = 1.1 (0.9–1.3)	Age, gender, performance status, tumor stage, nodal involvement, tumor location, presence of clinical obstruction, and treatment assignment.
Wudel et al.; 2002	Colorectal	University Medical Center, city hospital; 1990–1999	668	N/A	N/A
Dignam et al.; 1999	Colon	Randomized clinical trials of the National Surgical Adjuvant Breast and Bowel Project (NSABP); 1977–1992	6,632	HR = 1.21 (1.06–1.37)	Age, gender, anatomic subsite, treatment, no. of positive nodes
Michelassi et al.; 1988	Rectal	University of Chicago Medical Center; 1965–1981	147	1.75 ($p < 0.03$) (calculated from their beta coefficients)	Stage, tumor morphology, vascular-lymphatic microinvasion
Dayal et al.; 1987	Colon & Rectal	11 US Comprehensive Cancer Centers; 1977–1982	Colon: 3617 Rectal: 1528	Colon: HR = 1.28 ($p < 0.001$) Rectum: HR = 1.44 ($p < 0.001$)	SES, age, gender, stage

HR: hazard ratio.