

# Trends in Colorectal Cancer Mortality in the United States, 1999 - 2020

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## Abstract

**Background:** The United States faces a significant public health issue with colorectal cancer (CRC), which remains the third leading cause of cancer-related fatalities despite early diagnosis and treatment progress.

**Methods:** This investigation utilized death certificate data from the Centers for Disease Control and Prevention Wide-Ranging OnLine Data for Epidemiologic Research (CDC WONDER) database to investigate trends in CRC mortality and location of death from 1999 to 2020. Additionally, the study utilized the annual percent change (APC) to estimate the average annual rate of change over the specific time period for the given health outcome. Incorporating the location of death in this study served the purpose of identifying patterns related to CRC and offering valuable insights into the specific locations where deaths occurred.

**Results:** Between 1999 and 2020, there were 1,166,158 CRC-related deaths. The age-adjusted mortality rates (AAMRs) for CRC consistently declined from 20.7 in 1999 to 12.5 in 2020. Men had higher AAMR (18.8) than women (13.4) throughout the study. Black or African American patients had the highest AAMR (21.1), followed by White (15.4), Hispanic/Latino (11.8), American Indian or Alaska native (11.4), and Asian or Pacific Islanders (10.2). The location of death varied, with 41.99% at home, 28.16% in medical facilities, 16.6% in nursing homes/long-term care facilities, 7.43% in hospices, and 5.80% at other/unknown places.

**Conclusion:** There has been an overall improvement in AAMR among most ethnic groups, but an increase in AAMR has been observed among white individuals below the age of 55. Notably, over one-quarter of CRC-related deaths occur in medical facilities.

**Keywords:** Colorectal cancer; Mortality; Population; Black/African American; Hispanic/Latino; White/Caucasian

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## Introduction

Colorectal cancer (CRC) is a significant public health concern in the United States, with an estimated 153,020 new cases and 52,550 deaths in 2023 [1]. Despite early detection and treatment improvements, CRC remains the third leading cause of cancer-related deaths in the United States [1]. Moreover, the recent increase in early-onset colorectal cancer (EO-CRC) [2] and the consequent modification of the recommended screening protocol by the US Preventive Service Task Force (USPSTF) have emphasized the importance of routine screening for individuals aged 45 to 75 years [3]. Given that CRC remains a leading cause of death in the USA, examining the location of death is critical in identifying the necessity of bolstering home/hospice care services and implementing appropriate palliative measures to guarantee optimal end-of-life care.

This descriptive study aimed to examine CRC mortality rates in the USA from 1999 to 2020, specifically focusing on trends by sex, race/ethnicity, and death site. The objective was to analyze CRC mortality trends in diverse population groups to illustrate the incidence of death caused by CRC.

## Materials and Methods

This descriptive study utilized death certificate data from the Centers for Disease Control and Prevention Wide-Ranging OnLine Data for Epidemiologic Research (CDC WONDER) database to identify deaths associated with CRC between 1999 and 2020. The CDC WONDER dataset includes information on the cause of death recorded on death certificates from all 50 states and the District of Columbia. Previously, this dataset has been utilized to assess patterns in disease mortality [4, 5]. CRC deaths were identified using the International Statistical Classification of Diseases and Related Health Problems-10th Revision (ICD-10) codes C18X (malignant neoplasm of the colon), C19 (malignant neoplasm of the rectosigmoid junction), and C20 (malignant neoplasm of the rectum). The data extracted for the study comprised population size, year, place of death and demographics. Demographic information included sex, age, race/ethnicity, and location of death, encompassing medical facilities (outpatient, emergency room, inpatient, death on arrival, or status unknown), home, hospice, and nursing home/long-term care facility. The classification of race/ethnicity was

based on Hispanic and non-Hispanic White, African American, and Asian or Pacific Islanders.

This project was not subject to review by the local institutional review board since it involves the use of a deidentified government-issued public use dataset and adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines. The study was conducted in compliance with the ethical standards of the responsible institution on human subjects as well as with the Helsinki Declaration. The age-adjusted rate was calculated by multiplying the age-specific death rate for each age group by the corresponding weight from the specified standard population, summing across all age groups, and then multiplying this result by 100,000.

The precise formula for calculating the age-adjusted rate is as follows:

$$\text{Age-adjusted death rate} = \text{Sum of (Age-specific death rate} \times \text{Standard population weight)} \times 100,000$$

The age-specific death rate is the number of deaths for a given age group divided by the population of that age group.

$$\text{Age-specific death rate} = \frac{\text{Number of deaths in age group}}{\text{Population of age group}}$$

The “standard population weight” for an age group is calculated by dividing the population for the age group by the sum of the populations for all of the age groups in the query [6].

$$\text{Standard population weight} = \frac{\text{Population for age group}}{\text{Sum of age group populations for all age groups in query}}$$

The study determined both crude and age-adjusted mortality rates (AAMRs) for CRC by computing the number of deaths per 100,000 individuals. Crude mortality rates were calculated by dividing the CRC-related deaths by the corresponding US population for that year. AAMRs were standardized to the 2000 US population using the same method as previous studies, with 95% confidence intervals (CIs) [7].

Additionally, the study utilized the Joinpoint Regression Program (Joinpoint V 4.9.0.0, National Cancer Institute) to analyze the yearly national trends in CRC-related mortality. Through the use of log-linear regression models that accounted for changes over time, the Joinpoint Regression Program provided the means to calculate the annual percent change (APC) in AAMR, along with 95% CIs. This calculation method enabled the identification of significant changes in AAMR over time.

### Annual trends for CRC-related AAMR

In 1999, the AAMR for CRC was 20.7 per 100,000 population (95% CI: 20.6 - 20.9), which decreased to 12.5 (95% CI: 12.4 - 12.7) in 2020. In addition, the overall AAMR from 1999 to 2012 showed a steady APC reduction of -2.75 (95% CI: -2.9 to -2.6), and further reduction was observed from 2012 to 2020 with an APC of -1.86 (95% CI: -2.3 to -1.5) (Fig. 1).

### CRC-related AAMR stratified by sex

The AAMR for CRC stratified by sex revealed consistently higher rates in men than in women throughout the study period

(overall AAMR for men: 18.8 (95% CI: 18.7 - 18.8); women: 13.4 (95% CI: 13.3 - 13.4)). In 1999, the AAMR for men was 25.1 (95% CI: 24.8 - 25.4), which showed a decrease in 2020 to 15.1 (95% CI: 14.9 - 15.3) (APC: -2.6, 95% CI: -2.4 to -2.7) (Fig. 2a). Similarly, the AAMR for women in 1999 was 17.6 (95% CI: 17.4 - 17.8), which steadily declined to 10.4 (95% CI: 10.3 - 10.6) in 2020 (APC: -2.6, 95% CI: -2.5 to -2.7) (Fig. 2b).

### CRC-related AAMR stratified by race/ethnicity

When analyzed by race and ethnicity, the highest all-cause AAMR was observed in African American patients, with a rate of 21.1 (95% CI: 21.0 - 21.3), followed by White patients with a rate of 15.4 (95% CI: 15.4 - 15.4), Hispanic/Latino patients with a rate of 11.8 (95% CI: 11.7 - 11.8), American Indian or Alaska Native patients with a rate of 11.4 (95% CI: 11.1 - 11.7), and Asian or Pacific Islander patients with a rate of 10.2 (95% CI: 10.1 - 10.4).

In essence, the AAMR among African American patients decreased from 28.2 (95% CI: 27.5 - 28.9) in 1999 to 16.1 (95% CI: 15.7 - 16.5) in 2020, with a significant average APC of -2.8 (95% CI: -2.9 to -2.7). Similarly, the AAMR among White patients decreased from 20.3 (95% CI: 20.1 - 20.4) in 1999 to 12.4 (95% CI: 12.2 - 12.5) in 2020, with an APC of -2.47 (95% CI: -2.6 to -2.3). American Indian or Alaska Native patients also exhibited a trend of improvement in AAMR, with a rate of 13.4 (95% CI: 11.2 - 15.6) in 1999 and a rate of 9.7 (95% CI: 8.7 - 10.7) in 2020, with an APC of -1.75 (95% CI: -1.8 to -2.3). The AAMR among Asian and Pacific Islander patients decreased from 12 (95% CI: 11.1 - 12.8) in 1999 to 8.7 (95% CI: 8.3 - 9.1) in 2020, with an APC of -1.94 (95% CI: -2.2 to -1.7). A similar trend was observed in the Hispanic population, with a rate of 14.2 (95% CI: 13.6 - 14.9) in 1999 and 10.3 (95% CI: 10.0 - 10.6) in 2020, with an APC of -1.67 (95% CI: -1.8 to -1.5) (Fig. 3).

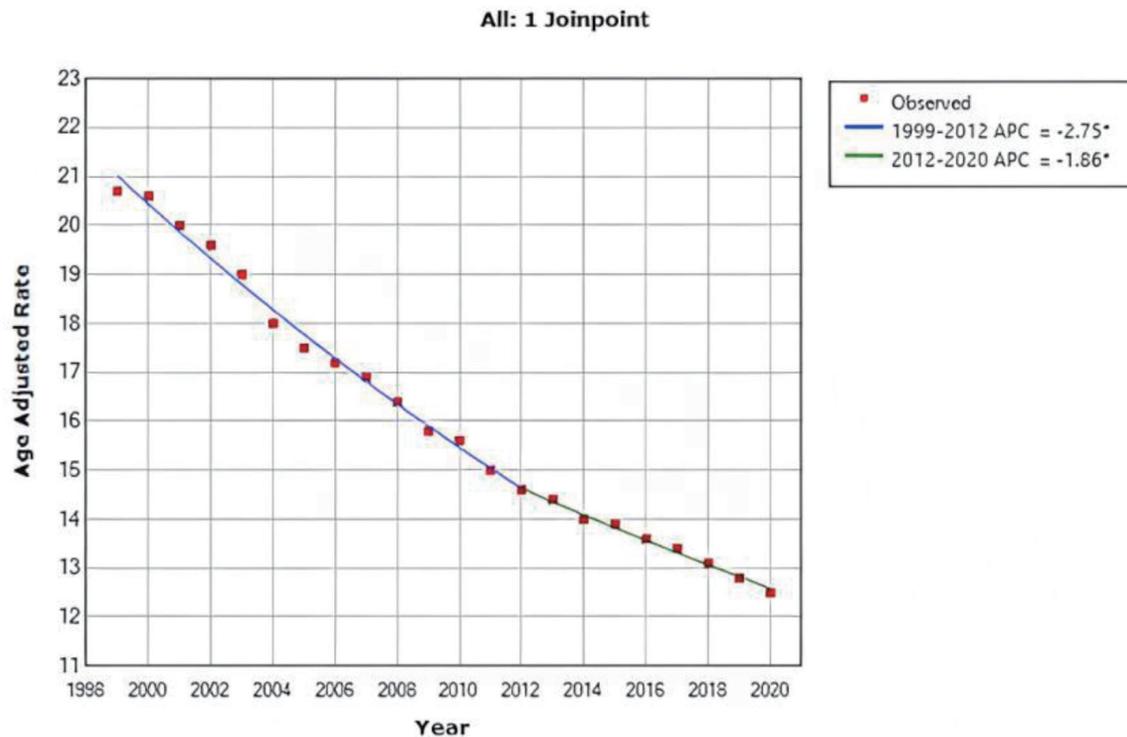
### CRC in younger patients

From 1999 to 2020, patients below the age of 55 accounted for 138,652 (11.8%) of the total deaths attributed to CRC.

Regarding annual trends for CRC AAMR, the AAMR per 100,000 population was 2.6 (95% CI: 2.5 - 2.7) in 1999 and 2.9 (95% CI: 2.8 - 2.9) in 2020. The AAMR from 1999 to 2002 showed an APC increase of 1.20 (95% CI: -0.8 to 3.2), followed by a reduction from 2002 to 2005 with an APC of -2.6 (95% CI: -6.6 to 1.4). From 2005 to 2013, the APC increase was at 1.4 (95% CI: 0.9 - 2.0), and from 2013 to 2020, the APC increase was 0.3 (95% CI: -0.2 to 0.8).

### CRC in younger patients stratified by sex and race

In the age group < 55 years, men consistently exhibited higher AAMR than women throughout the study period (overall AAMR for men: 3.1 (95% CI: 3.0 - 3.1); women: 2.3 (95% CI:



\* Indicates that the Annual Percent Change (APC) is significantly different from zero at the alpha = 0.05 level  
Final Selected Model: 3 Joinpoints.

**Figure 1.** Combined AAMR for both males and females. AAMR is represented on y-axis, while x-axis indicates the years spanning from 1999 to 2020. This graph demonstrates a consistent decrease in the AAMR for CRC from 20.7 per 100,000 population in 1999 to 12.5 per 100,000 population in 2020, indicating a significant improvement in the AAMR for CRC over the specified time period. AAMR: age-adjusted mortality rate; CRC: colorectal cancer.

2.3 - 2.3)). The AAMR for men decreased from 2.9 (95% CI: 2.8 - 3.0) in 1999 to 2.7 (95% CI: 2.6 - 2.8) in 2005 with an APC of -1.8 (95% CI: -3.4 to -0.2), but steadily increased from 2006 to 3.4 (95% CI: 3.3 - 3.5) in 2020 with an APC of 1.54 (95% CI: 1.2 - 1.9). The AAMR for women increased from 2.3 (95% CI: 2.2 - 2.4) in 1999 to 2.4 (95% CI: 2.3 - 2.5) in 2020 with an APC of 0.3 (95% CI: 0.1 - 0.5).

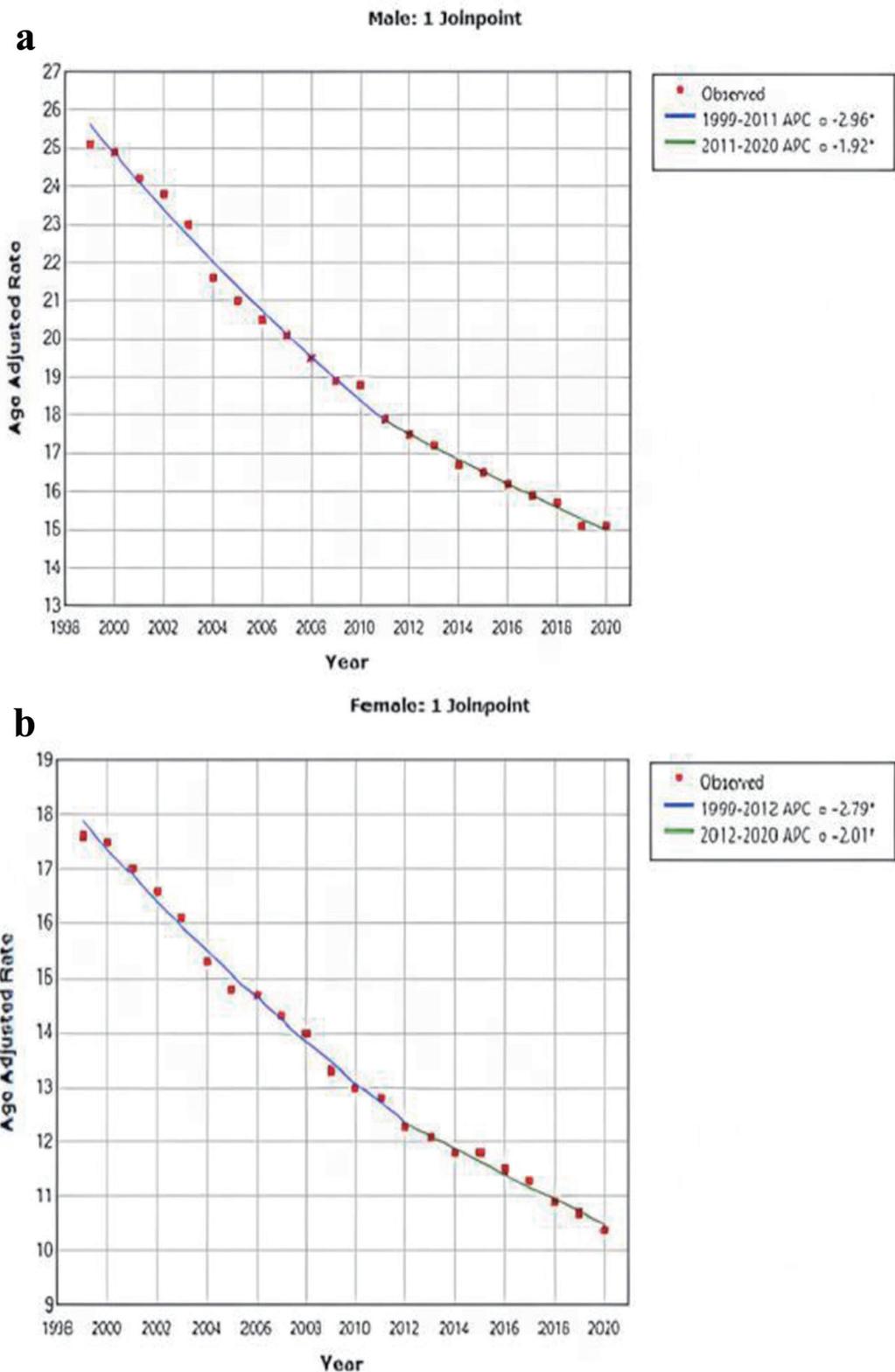
When stratified by race/ethnicity, Black or African American patients had an AAMR at 3.9 (95% CI: 3.9 - 4.0), followed by White patients at 2.5 (95% CI: 2.5 - 2.5), Hispanic/Latino patients at 1.9 (95% CI: 1.9 - 1.9), American Indian or Alaska native patients at 1.9 (95% CI: 1.8 - 2.1), and Asian or Pacific Islanders patients at 1.9 (95% CI: 1.8 - 1.9). Over a 20-year period, the mortality rate of Black or African American patients in the age group < 55 years improved from 4.2 (95% CI: 3.9 - 4.4) to 3.7 (95% CI: 3.5 - 3.9) with an APC of -0.91 (95% CI: -1.1 to -0.7), while the mortality rate in white patients increased from 2.4 (95% CI: 2.3 - 2.4) to 2.8 (95% CI: 2.7 - 2.8) with an APC of 0.94 (95% CI: 0.7 - 1.2) (Fig. 4).

## Discussion

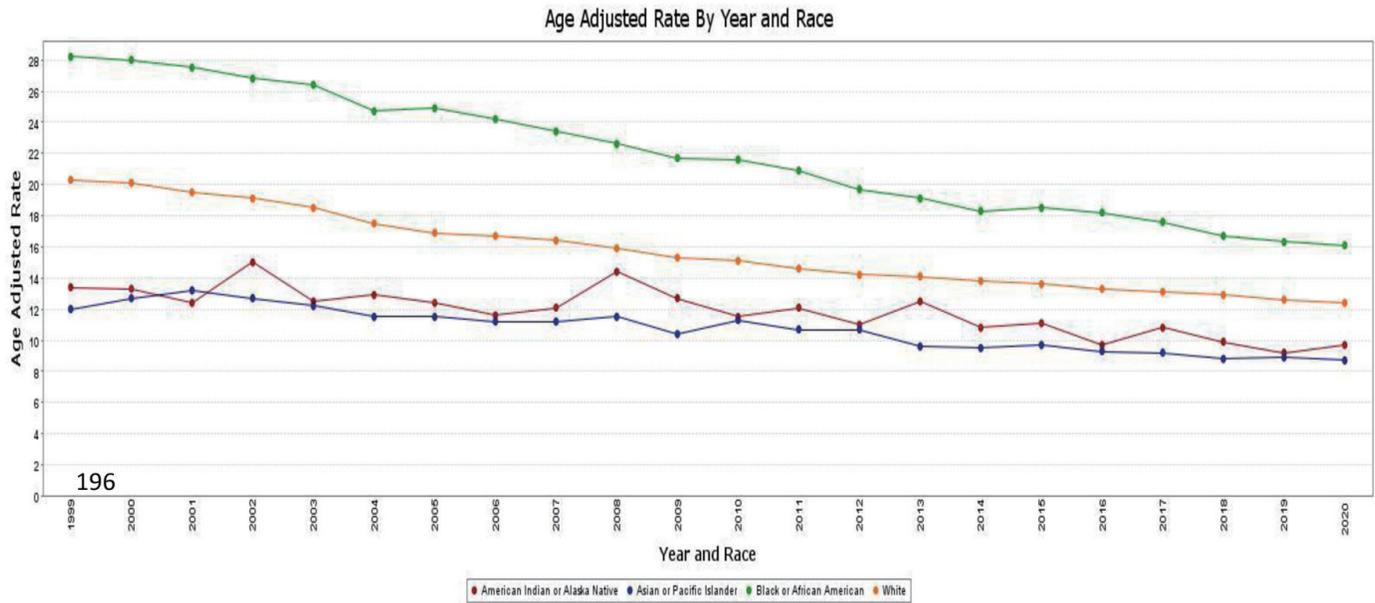
Our investigation has yielded several noteworthy results pertaining to 20-year mortality data sourced from the CDC WON-

DER database. Firstly, a consistent downward trend in the annual mortality rate of CRC was observed from 2002 to 2012, with a steady reduction in APC of -2.75. This decline persisted until 2020, although with a slightly lower APC of -1.86 between 2012 and 2020. Additionally, it was observed throughout the 20-year period that men exhibited a consistently higher AAMR than women. Secondly, African Americans demonstrated the highest AAMR, followed by White patients, those of Hispanic/Latino origin, American Indian or Alaska native patients, and finally, Asian or Pacific Islanders. Differences in the frequency of risk factors and access to high-quality medical care contribute to varying CRC outcomes among different racial or ethnic groups [8]. The increased incidence of colon cancer among Black men compared to White individuals is thought to be the outcome of a combination of multiple factors, including genetic, lifestyle, socioeconomic, and health disparity factors that interact in a complex manner.

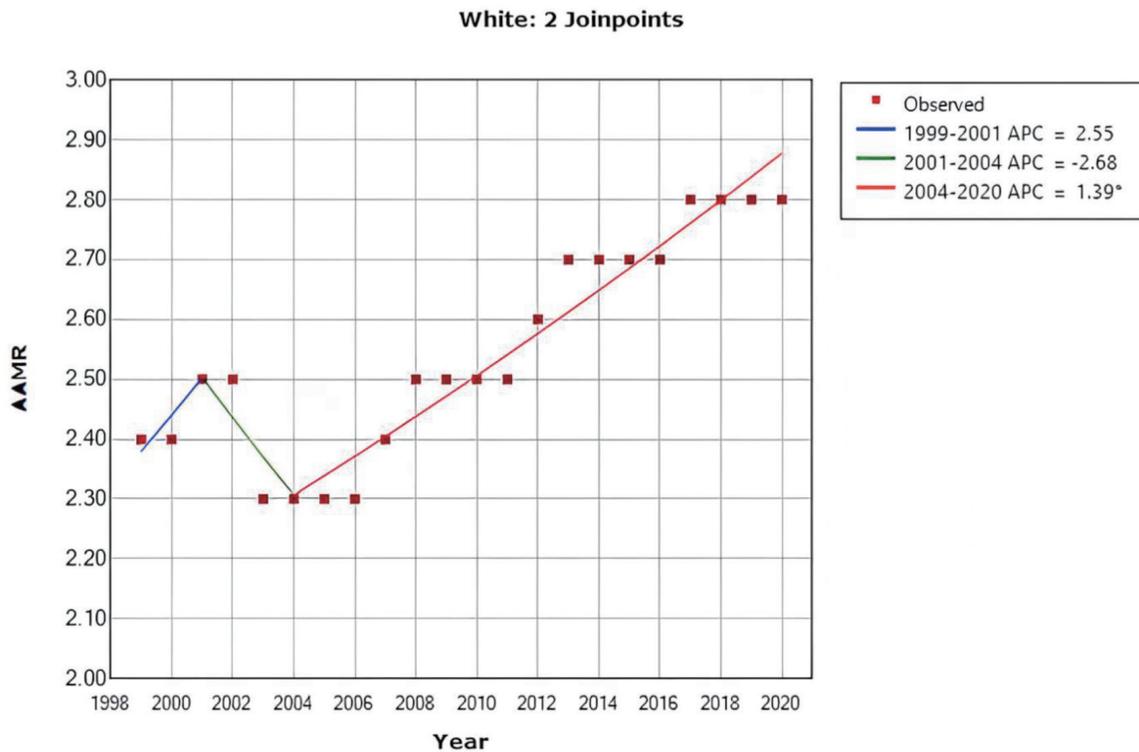
Current data suggest that in the past, there has been a disparity between Black individuals and White individuals in terms of CRC screening rates, although this gap appears to be gradually narrowing [9]. As a result, the recent decrease in CRC cases among African Americans can largely be attributed to an increased adoption of colonoscopic screening within this population [10]. The persistently higher incidence of CRC among African Americans can be attributed to various factors, includ-



**Figure 2.** AAMR for CRC is stratified for male (a) and female (b). Y-axis on both graphs represents AAMR, while x-axis represents the years spanning from 1999 to 2020. Both graphs demonstrate a significant improvement in the AAMR. For men, the AAMR decreased from 25.1 to 15.1, and for women, it decreased from 17.6 to 10.4. AAMR: age-adjusted mortality rate; CRC: colorectal cancer.



**Figure 3.** AAMR associated with CRC is stratified by race/ethnicity, with x-axis representing the year and race and y-axis indicating the AAMR. Green line: African American patients (AAMR decreased from 28.2 in 1999 to 16.1 in 2020). Orange line: White patients (AAMR decreased from 20.3 in 1999 to 12.4 in 2020). Red line: American Indian or Alaska native patients (AAMR decreased from 13.4 in 1999 to 9.7 in 2020). Blue line: Asian and Pacific Islander patients (AAMR decreased from 12 in 1999 to 8.7 in 2020). AAMR: age-adjusted mortality rate; CRC: colorectal cancer.



\* Indicates that the Annual Percent Change (APC) is significantly different from zero at the alpha = 0.05 level  
 Final Selected Model: 2 Joinpoints.

**Figure 4.** AAMR in white patients below the age of < 55 years, indicating an increase in the mortality rate from 2.4 to 2.8. AAMR: age-adjusted mortality rate.

ing a lower likelihood of having awareness about their ancestral cancer history compared to White patients [11], as well as a general reluctance among family members to share information about the identification of colonic polyps with others [12]. Another factor that contributes to this is the increased probability of African American individuals being diagnosed with CRC before the age of 50, in contrast to the overall population. This highlights the inadequacy of the previous screening guidelines, which commenced screening at the age of 50, as it potentially overlooked a considerable portion of the African American population compared to the general population [13, 14].

Several other factors have been recognized to contribute to the risk of CRC within the African American population, including genetic predisposition and phenotypic differences in presentation. As an instance, a study by Mendelsohn et al [15] discovered that advanced adenomas were more prevalent among African Americans, although these findings were not confirmed in similar studies [16, 17]. Furthermore, a historical observation has revealed that African Americans have shown a higher propensity for presenting with advanced metastatic colon cancer upon diagnosis. One possible explanation for this trend is the elevated likelihood of African Americans having proximal CRC, which primarily affects the right side of the colon. It is worth noting that colonoscopy exhibits reduced effectiveness in detecting proximal CRCs in comparison to distal CRCs [17, 18]. These findings align with the research conducted by Lieberman et al [19], which indicates a higher prevalence of advanced polyps in the proximal location among African Americans (53.3%) compared to White Americans (50.6%).

The decline in CRC incidence rate among American Indians has been slower in comparison to African Americans. This can be partially attributed to the lower life expectancy within the American Indian population, which is influenced by the burden of conditions like diabetes mellitus and metabolic syndrome. As a result, there has been relatively less time available for the development of CRC due to the overall lower life expectancy in this population [20, 21].

Historically, Asian Americans and Pacific Islanders have exhibited lower rates of CRC screening in comparison to other groups, such as White individuals or African Americans. It is important to recognize that within the Pacific and Asian Islander categorization, there are distinct racial and ethnic entities. While there may be cultural and geographical intersections in specific regions, these groups are acknowledged as separate entities. Furthermore, they often consist of unique subgroups that have diverse factors influencing the observed variations in AAMRs related to CRC [22].

A study conducted by Lee et al examined the disparities in CRC screening among Asian Americans and Pacific Islanders. The findings indicated that the overall CRC screening rate for this population was 46.8%, which was lower compared to the rate among White individuals (57.7%). However, significant differences were observed when further analyzing the various existing subgroups. For instance, Koreans exhibited the lowest CRC screening rate at 32.7%, while Japanese had the highest rate at 59.8%. These trends within different subpopulations may potentially mask worsening screening rates among smaller subgroups, as improvements in screening rates occur in other larger groups [23].

Considering that each subgroup within the Asian American and Pacific Islander population has variations in lifestyles, health beliefs and behaviors, as well as socioeconomic statuses, further research is necessary to analyze and address the heterogeneous disease patterns within each subgroup individually [24, 25].

The US Multi-Society Task Force on Colorectal Cancer recommended in 2008 that individuals of average risk should begin screening for CRC at age 50 [26]. However, other organizations, such as the American College of Gastroenterology in 2009 and the American College of Physicians in 2012, had already suggested earlier colon cancer screening in African Americans aged 45 and 40, respectively [27, 28]. More recently, the USPSTF updated their guidelines for CRC screening in May 2021, recommending that individuals of average risk should start screening at 45 instead of 50 [29]. The studies mentioned earlier, as well as the collaborative efforts, have led to a remarkable improvement in the AAMR of colon cancer in most patients' groups, particularly in African American patients, with a decrease in AAMR from 28.2 (95% CI: 27.5 - 28.9) to 16.1 (95% CI: 15.7 - 16.5) in 2020 within the last two decades. Additionally, advancements in treatment modalities such as surgery, chemotherapy, radiation, and immunotherapy have improved survival rates and decreased morbidity [30-32]. Also, there are several other contributing factors to the continued decline in the AAMR of CRC. These factors may include advancements in screening techniques, such as fecal occult blood tests, computed tomographic colonography, sigmoidoscopy, and colonoscopy [33].

Women consistently had a lower AAMR during the study period than men. While the underlying factors contributing to this difference are likely multifaceted and diverse, estrogen is thought to be a contributing factor in lowering the risk of CRC in women. However, the precise mechanism by which estrogen confers this protection remains to be elucidated [34].

Thirdly, we analyzed the trends for CRC in patients below the age of 55 between 1999 and 2020. EO-CRC is the term used for cases diagnosed before the age of 50 [35]. Despite the apparent improvement in CRC trends in patients aged 50 and above, there has been a continual rise in the incidence of EO-CRC in recent years which is likely going to continue for the next decade [36]. In general, men had higher AAMRs than women in the age group under 55 years, with an overall AAMR of 3.1 (95% CI: 3.0 - 3.1) for men and 2.3 (95% CI: 2.3 - 2.3) for women. From our data, it can be observed that the mortality rate of African American patients in the age group of less than 55 years improved from 4.2 (95% CI: 3.9 - 4.4) to 3.7 (95% CI: 3.5 - 3.9) over a 20-year period. The estimated APC was -0.91 (95% CI: -1.1 to -0.7), indicating a decrease in mortality rates during the study period. Conversely, the mortality rate in White patients increased from 2.4 (95% CI: 2.3 - 2.4) to 2.8 (95% CI: 2.7 - 2.8) over the same 20-year period, with an estimated APC of 0.94 (95% CI: 0.7 - 1.2). Our study corroborates the results of previous research, which suggest a particular increase in EO-CRC, especially in White individuals, likely related to a rise in rectal cancer [37, 38].

Other factors contributing to the increase in CRC among White individuals are multifaceted and not fully comprehended, and research has indicated that genetic mutations in DNA mismatch repair (MMR) genes may play a role in the development

of certain types of CRCs [39]. Furthermore, it is important to consider that other factors may be contributing to the observed trends in CRC mortality. For instance, research has suggested that type II diabetes mellitus [40] and childhood obesity [41] are prevalent among various racial and ethnic groups, particularly with a recent increase within the white population, which could be exacerbating the current situation [42]. In general, an increase in EO-CRC has been documented in multiple Western countries, such as Australia, Slovakia, Canada, and New Zealand. The steepest rise in EO-CRC was observed in South Korea [35, 42]. Additionally, this trend has been noted among various ethnic groups, particularly among Hispanic/Latinos [43]. However, our assessment using the CDC WONDER database did not reveal a clear visualization of this trend in this subgroup. Overall, the underlying mechanisms responsible for the development of EO-CRC are not entirely comprehended.

Finally, between 1999 and 2020, a total of 1,166,158 deaths related to CRC were reported. Out of these cases, the majority, 489,693 (41.99%), occurred at individuals' residences, while 328,447 (28.16%) took place within medical facilities. Additionally, 193,608 (16.6%) deaths were recorded in nursing homes or long-term care facilities, 86,722 (7.43%) occurred in hospices, and 67,688 (5.80%) deaths were classified as occurring in other or unknown locations.

Limited information is available regarding the specific location of death associated with CRC. Only one study, conducted by Jones et al in the United Kingdom in 2006 [44], explored the care pathway and place of death among CRC patients, taking into account hospitalization duration. The study involved 671 patients categorized into three groups: those who underwent tumor resection, non-resectional surgery for defunctioning or bypassing the tumor, and a non-surgical group. The findings suggested that the majority of CRC-related deaths occurred within hospices, although statistical significance was not observed. Furthermore, individuals who underwent surgical resection demonstrated an extended period of time between their diagnosis and death, during which they were primarily hospitalized. Moreover, this group exhibited a greater probability of experiencing mortality within a hospital setting when compared to the other treatment groups. However, it is challenging to directly apply the results from this study to our data due to advancements in surgical treatments, chemotherapy, and overall different healthcare system. Additionally, our study lacks comprehensive information regarding the involvement of palliative care in the home setting.

This topic is highly relevant as the landscape of CRC is changing, with an increasing number of younger patients being diagnosed before the age of 50. Further research is needed to identify patients who are at risk of mortality and to effectively categorize them in order to ensure that their preferred end-of-life care is appropriately provided if needed. This is particularly important as the provision of end-of-life care, which has traditionally been preferred at home for individuals with cancer, may require a more nuanced approach [45, 46].

## Limitations

To begin with, the use of ICD codes and death certificates may lead to an under-representation of CRC as a cause of death.

Additionally, the dataset relies on information reported by healthcare providers, which may be subject to errors or inaccuracies, which is particularly pertinent with regard to essential variables such as race and ethnicity.

Furthermore, the lack of detailed information on individual risk factors or potential confounders that may influence the development or progression of CRC may also restrict the capacity to explore complex relationships between variables comprehensively. According to our data, there was an uptick in AAMR among White individuals under the age of 55. Even though EO-CRC typically refers to cases diagnosed before the age of 50, our findings showed a notable increase and were included in the manuscript, despite not meeting the full criteria for EO-CRC. We acknowledge the challenges associated with grouping different populations, such as the Pacific and Asian Islander categorization, as distinct subgroups within this classification can exhibit varying outcomes in mortality rates. However, it is important to note that this analysis may not fully capture these variations due to the grouping of these subgroups.

## Conclusion

From 1999 to 2020, the AAMR for CRC showed a steady decrease from 20.7 to 12.5. Men consistently had a higher AAMR than women, and Black or African American patients had the highest AAMR during the study period. Although most subgroups experienced a decline in AAMR, there was a notable increase among White individuals under the age of 55, with mortality rates rising from 2.4 (95% CI: 2.3 - 2.4) to 2.8 (95% CI: 2.7 - 2.8) over a 20-year span and an estimated APC of 0.94 (95% CI: 0.7 - 1.2). Additionally, the location of death varied, with 41.99% of deaths occurring at home, 28.16% within medical facilities, and 16.6% taking place in nursing homes or long-term care facilities, highlighting the diverse settings in which individuals pass away from CRC.

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## Financial Disclosure

None to declare.

## Conflict of Interest

None to declare.

## Informed Consent

Not applicable.

## Author Contributions

Dr. Alweis supervised the entire project including the design and the analysis. Dr. Kusnik and Dr. Renjithlal designed the study, performed data analysis, and wrote the final manuscript. Dr. Kusnik and Dr. Renjithlal were responsible for interpretation of data for the work. Dr. Chodos, Dr. Shanmukhappa, Dr. Eid and Dr. Renjiith critically revised the manuscript for important intellectual content. Final approval of the version to be published was collected from each author before submission. All authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## Data Availability

The CDC WONDER database is a publicly available online system developed by the CDC in the United States. This database offers a vast collection of data related to public health, which can be used to track disease outbreaks, identify trends, and evaluate the success of public health interventions. The CDC WONDER database is accessible for free, and users can easily access the data via the CDC WONDER website.

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