HHS Public Access

Author manuscript

Cancer Causes Control. Author manuscript; available in PMC 2020 March 01.

Published in final edited form as:

Cancer Causes Control. 2020 March ; 31(3): 241–253. doi:10.1007/s10552-020-01268-2.

Rural-urban disparities in colorectal cancer survival and risk among men in Utah: a statewide population-based study

Charles R. Rogers[1], **Brenna E. Blackburn**[1], **Matthew Huntington**[1], **Karen Curtin**[2], **Roland J. Thorpe Jr.**[3], **Kerry Rowe**[4], **John Snyder**[4], **Vikrant Deshmukh**[5], **Michael Newman**[5], **Alison Fraser**[6], **Ken Smith**[7], **Mia Hashibe**[1,8,9]

[1]Department of Family & Preventive Medicine, University of Utah

[2]Department of Medicine, University of Utah

[3]Program for Research on Men's Health, Hopkins Center for Health Disparities Solutions,, Johns Hopkins University

[4]Intermountain Healthcare

[5]CMIO Office, University of Utah Health Care

[6]Department of Family & Consumer Studies, University of Utah

[7]Department of Population Sciences, Huntsman Cancer Institute

[8]Utah Cancer Registry

[9]Huntsman Cancer Institute

Abstract

Purpose: Rural areas of the U.S. experience disproportionate colorectal cancer (CRC) death compared to urban areas. The authors aimed to analyze differences in CRC survival between rural and urban Utah men and investigate potential prognostic factors for survival among these men.

Methods: A cohort of Utah men diagnosed with CRC between 1997 and 2013 was identified from the Utah Cancer Registry. Survival and prognostic factors were analyzed via five-year CRC survival and Cox proportional hazards models, stratified by rural/urban residence.

Results: Among 4,660 men diagnosed with CRC, 15.3% were living in rural Utah. Compared with urban men, rural CRC patients were diagnosed at older ages and in different anatomic subsites; more were overweight, and current smokers. Differences in stage and treatment were not apparent between rural and urban CRC patients. Compared with urban counterparts, rural men experienced a lower CRC survival (Hazard Ratio 0.55, 95% CI=0.53, 0.58 vs 0.58, 95% CI=0.56, 0.59). Race and cancer treatment influenced CRC survival among men living in both urban and rural areas.

Corresponding author: Charles R. Rogers, PhD, MPH, MS, CHES®, Department of Family & Preventive Medicine, 375 Chipeta Way, Suite A, Salt Lake City, UT 84108, 801-581-5752, Charles.Rogers@utah.edu.

Conflict of Interest: The authors declare no potential conflicts of interest.

Conclusion: Factors of CRC survival varied greatly among urban and rural men in Utah. The influence of social and environmental conditions on health behaviors and outcomes merits further exploration.

Keywords

colonic neoplasms; health status disparities; men's health; rural health; survival; urban health

Introduction

Among residents of the U.S., men have a 32% increased risk of being diagnosed with colorectal cancer (CRC) and a 42% increased risk of dying from CRC compared with women [1]. Men diagnosed with CRC have a 62.9% chance of surviving 5 years from the date of diagnosis compared with women's 64% chance of survival [2]. The reasons for the inequity in CRC risk in men compared with women are not fully understood, but previous studies suggest that potential reasons include differences in exposures to sex hormones and higher prevalence of risk factors such as cigarette smoking [3], obesity [4], and alcohol consumption [5], as well as from multifaceted interactions between these influences.

The Centers for Disease Control and Prevention (CDC) recently reported that rural areas of the U.S. experience a disproportionate level of potentially preventable cancer death — CRC included — when compared with their metropolitan or urban counterparts [6]. According to census tract-based data provided by the U.S. Census Bureau, 9% of Utah residents live in areas that are classified as rural, defined as areas with a population less than 2,500 people [7, 8]. Remarkably, the age-adjusted mortality rate for all U.S. men with CRC is 29% greater than that of Utah men with CRC, but it is unclear whether lower CRC mortality translates to improved CRC survival across both rural and urban Utah men [1]. Although the Utah population is comprised of Whites (95.0%), Asians (2.2%), American Indian or Alaska Natives (1.5%), and Blacks (1.3%) [9], roughly 75% of Utah's residents live in an urban region in north-central Utah consisting of four contiguous counties along an approximate 80-mile corridor along the Wasatch front, while the remaining population is dispersed throughout the state primarily in rural and sparsely populated frontier settings often geographically isolated from cities [10]. Further, of those reporting a single race (97.0% of 2.76 million persons in total), Rural disparities in cancer outcomes in Utah have also been documented [11–13]. The contrasts between urban and rural population density in Utah make it an ideal state to examine cancer health disparities related to geography

Identified CRC-specific risk factors that are disproportionately experienced in rural areas and include cigarette smoking, obesity, and physical inactivity [1, 8, 14–15]. U.S. residents living in rural areas are less likely to have health insurance, have less access to healthcare, and have higher rates of poverty [16]. Evidence suggests that rural residents of Utah are less likely than urban Utahns to adhere to risk-appropriate CRC screening guidelines [17]. Fowler and colleagues reported that between 1991 and 2010, CRC incidence was equal among rural and urban Utah men, and that CRC survival improved for both rural and urban Utah men between 2006 and 2010 [11]. Although both groups improved, survival among these groups was not compared [18]. For CRC patients diagnosed between 2004–2008, a

comparable study conducted by Hashibe et al. found that rural CRC patients had lower survival, but the analysis was not stratified by sex; confirming the need to further explore the unknown differences in relative CRC survival between rural and urban Utah men [19].

Racial and ethnic health disparities are evident in CRC incidence, mortality, and survival. Overall CRC survival among African Americans/Blacks is 58% while overall CRC survival among Whites is 65% [20]. Black men in particular experience severe CRC disparities. When compared to their White counterparts, Black men have incidence and mortality rates that are respectively, 24% and 47% higher [21, 22]. Existing CRC disparities faced by Blacks may be exacerbated by characteristics of rural areas. A study conducted by Singh et al. concluded that rural residence was a predictor of all-cancer death among Blacks and Whites [23]. Additionally, the researchers found that at each socioeconomic level (measured via a deprivation index), Blacks had worse all-cancer mortality [24].

The 2-fold aim of this study was to utilize the Utah Population Database (UPDB) to (1) determine whether there are differences in CRC survival among men living in urban and rural areas of Utah, and (2) investigate the association between potential risk factors and CRC survival among urban and rural men in the state. Our central hypothesis was that men in rural Utah have worse CRC survival compared with their urban counterparts. We also hypothesized that Black men would have the shortest survival of any racial or ethnic group in this population. Our purpose in conducting this study was to strengthen our understanding of the potential CRC health disparities experienced between rural and urban men in Utah.

Methods

The cohort of CRC patients for this study was identified within the Utah Cancer Registry (UCR; one of the original NCI Surveillance, Epidemiology, and End Results [SEER] cancer registries), which is linked within the UPDB with statewide electronic medical records (EMRs), statewide healthcare utilization data, voter registration records, residential histories, extensive family history records, and Utah birth and death certificates [24]. Healthcare data in the UPDB include ambulatory surgery and inpatient discharge data for the entire state, as well as linkages to EMR data from 2 of the state's largest healthcare providers, University of Utah Healthcare and Intermountain Healthcare. With a combined 26 hospitals and 220 clinics, these 2 systems account for approximately 85% of patient encounters in the state. This study was approved by the University of Utah Institutional Review Board and the regulatory body overseeing usage of UPDB data, the Resource for Genetic and Epidemiologic Research.

Men diagnosed with a first primary CRC between 1997 and 2013 were identified through the UCR (SEER ICD-O-3 codes: C18.0, C18.2-C18.9, C19.9 and C20.9) for patients living in Utah at the time of diagnosis. Death dates were captured using death certificates as well as the Social Security Death Index (nationwide). Men with in situ CRC (n=623) or the cancer stage unknown/missing (n=391) were excluded. Follow-up time was calculated as time from cancer diagnosis to either death or the last date the patient was known to be alive and residing in Utah.

International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes prior to cancer diagnosis were used to create the Charlson Comorbidity Index (CCI) for each patient at the time of cancer diagnosis.[25] ICD-9-CM and CPT codes were also used to identify smoking status. Cause-of-death codes (ICD-9 and ICD-10) were used to classify all or those that were CRC-specific (C18, C19, C20, and C21).

Residence at the time of cancer diagnosis was available from the UCR. The mean time from CRC diagnosis to the date that residence was captured was 14.1 days. ZIP codes were linked to Rural Urban Commuting Area Codes (RUCA) Version 2.0 (created from U.S. Census data in 2000), in which each ZIP code is designated as urban or rural [26]. In the RUCA taxonomy, *urban* comprises all ZIP codes within an urbanized area core (population >50,000) plus ZIP codes from which more than 25% of the population commutes to an urbanized area core (RUCA codes: 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, and 10.1) [26]. We used RUCA instead of the Rural Urban Continuum Codes (RUCC) because RUCA designations occur at the ZIP code level, whereas RUCC designations occur at the county level. Utah has large counties, many of which comprise both rural and urban areas [27]. All ZIP codes were linked to poverty and education data obtained through UDS Mapper, a free, publicly available resource developed with support from the U.S. Health Resources and Services Administration that incorporates data from the American Community Survey [28]. This data was available at the ZCTA (ZIP code tabulation area) level, which are generalized area representations of ZIP codes used by the U.S. Census [29]. The poverty data used were the percentage of the population in each ZCTA with incomes below the federal poverty level. The education data were the percentage of the adult population in each ZCTA who had not obtained a high school diploma.

Statistical Methods

Chi-square tests were used to assess differences in the demographic characteristics of CRC patients in rural and urban areas. Cox proportional hazards models were used to calculate hazard ratios for potential risk factors for both all-cause and CRC-specific mortality. The potential risk factors studied include: age at diagnosis, race, ethnicity, body mass index (BMI), CCI, smoking status, location, area-level poverty, area-level education, cancer stage, cancer site, and cancer treatment. All models were adjusted for potential confounders, which were assessed a priori based on the three confounders properties and include all demographic and clinical characteristics. Models stratified by rural and urban location were also run.

BMI was assessed by calculating the closest BMI at least 1 year before cancer diagnosis. For the approximately 28% of subjects for whom the data on which to base a calculation of BMI were missing, we imputed BMI using multiple imputation with linear regression, with age at diagnosis, sex, race, and CCI as predictors. To assure that our inferences did not change due to the imputation of BMI, a sensitivity analysis was conducted by comparing two Cox proportional hazards regression models, one comprising the full study population, including subjects with imputed BMI, and one limited to subjects for whom BMI data were available.

Due to risk differences identified in overweight and obese patients for overall death and CRC-specific death, we explored whether the demographic and clinical factors were associated with overweight or obesity with chi-square tests. We have masked cells in the tables with fewer than five individuals for de-identification purposes. However, we believe these groups are necessary to keep in the analyses as they are central to our aims and hypotheses. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC) and Stata 15 (StataCorp LLC, College Station, TX).

Results

The final cohort comprised 4,660 male CRC patients, 15.3% (n=712) of whom lived in rural areas at the time of cancer diagnosis (Table 1). Compared with patients living in urban areas, patients in rural areas were significantly older at the time of cancer diagnosis, were more likely to have a BMI in the overweight range, were more likely to be White, and lived in areas with higher poverty and lower education levels. Rural CRC patients had more first-, second-, and third-degree family members with CRC. There were significant differences in the site of CRC between urban and rural patients, with rural men having a higher proportion of distally located tumors in the sigmoid and descending colon. However, cancer stage and treatment did not vary significantly between urban and rural patients (Table 2).

Overall, there was no difference between all-cause mortality and CRC death in rural male CRC patients, as seen in Table 3. Black men had significantly increased risks for both all-cause death and CRC-specific death when compared with White men (HR=2.19, 95% CI=1.49, 3.22 and HR=2.92, 95% CI=1.94, 4.42, respectively).

Most of the prognostic factors studied were similar in rural and urban residents for both all-cause death and CRC-specific death (Table 4). Overweight urban patients had a significantly decreased risk for CRC-specific death (overweight, HR=0.87, 95% CI=0.76, 0.99) when compared with urban patients whose BMI was in the normal range. Overweight urban patients also had a decreased risk for all-cause mortality (HR=0.86, 95% CI=0.77, 0.95); however, only obese rural patients had a decreased risk for all-cause mortality (HR=0.70, 95% CI=0.52, 0.94). Having a CCI score of at least 2 was associated with an increased risk for all-cause mortality in both rural and urban patients and CRC-specific death only in urban patients (HR=1.19, 95% CI=1.03, 1.37). In Supplemental Table 1, we investigated whether other demographic and clinical variables were associated with the BMI groups among CRC patients. The overweight and obese groups had a lower proportion of patients diagnosed at older ages and lower proportions of patients diagnosed with rectal cancer.

Although the risk of CRC-specific death was high for rural Black patients (HR=10.87, 95% CI=1.51, 78.39), it is important to note that only 1 patient in this category died of CRC. Both rural and urban Black male patients had significantly increased risks for all-cause death when compared with rural and urban White male patients, respectively. Urban Asian male patients also had a significantly increased risk for CRC-specific death (HR=2.63, 95% CI=1.08, 6.39).

For all patients, the risk of both CRC-specific death and all-cause death increased with more advanced stages of CRC. For both rural and urban patients who received surgery and chemotherapy, as well as those who also received radiation, the risk of all-cause death was significantly reduced when compared with those who received surgery alone; however, this risk reduction was seen only for CRC-specific death in urban patients who received surgery and chemotherapy. Males in both rural and urban areas who received no treatment had a significantly increased risk for CRC-death compared with those who received surgery alone (HR=4.28, 95% CI=2.48, 7.38 and HR=4.17, 95% CI=3.33, 5.22, respectively).

For urban patients, both increased poverty and lower education were significantly associated with increased risks of all-cause death, but not CRC-specific death. Urban smokers also had an increased risk for all-cause death (HR=1.20, 95% CI=1.07, 1.34) and CRC-specific death (HR=1.17, 95% CI=1.02, 1.35), whereas this risk was not significant for rural smokers.

Five-year relative survival rates are shown in Table 5. Overall, male CRC patients in Utah had a 5-year survival rate of 0.57 (95% CI=0.56, 0.58). Rural males had similar survival rates as urban males (0.55, 95% CI=0.53, 0.58 vs 0.58, 95% CI=0.56, 0.59). Black males had the lowest survival rate of all racial groups at 0.35 (95% CI=0.23, 0.47).

Discussion

In a statewide cohort of primary CRC cases followed for more than 15 years, we investigated differences in CRC survival among men living in urban and rural areas of Utah and the association between potential risk factors and CRC survivorship among urban and rural men in the state. For the reason that rural areas of the U.S. have higher rates of death for tobacco use-related cancers, we hypothesized that men in rural Utah would have worse CRC survival than urban men [30]. We also anticipated that Black men would have the shortest survival of any racial and ethnic group in the sample, as mortality rates among Whites have steadily declined for more than 25 years whereas, over the same time period, mortality rates among Blacks have slowly increased [31–32].

Our findings indicate that, among study subjects living in both urban and rural areas, two factors – race and cancer treatment – influenced CRC survival. We found, unexpectedly, that overweight urban men had a significantly decreased risk for CRC-specific death, while obese rural men had a decreased risk of overall death. Upon investigating the factors associated with BMI (highlighted in Tables 1, 3, and 5), we observed that a lower proportion of the overweight and obese men were diagnosed at an older age and with rectal cancer, two factors associated with a higher risk of death. The lower proportions of these risk factors among the obese and overweight men may have contributed to confounding.

Interestingly, in the group treated with surgery, chemotherapy, and radiation, rural men appeared to have a 30% lower risk of all-cause mortality compared with urban men, although due to the overlap in confidence intervals this finding was not significant. It is possible that, compared with their urban counterparts, rural men who underwent surgery alone had relatively poorer survival. Comparable or better prognosis among rural men who underwent comprehensive treatment may reflect that access to care was not limited by rural

locale, or that rural men had an unmeasured advantage that counteracted any limitations on access to care. For example, rural men in this study were less likely than urban men to be obese at baseline, although rural men were more likely to be overweight. Rural men in general may be more likely than men employed in urban areas to work in middle- and low-skill occupations in which they are more physically active (e.g., agriculture, construction) [33, 34–36]. As it is widely accepted that physical inactivity is an important risk factor for the development of CRC, cardiovascular disease, and other conditions [35], future researchers should consider further exploring the relationship between CRC treatment and physical inactivity among urban and rural men [36].

The previous study in Utah by Hashibe and colleagues included both men and women as we did, but did not identify a survival difference between rural and urban CRC patients [20]. Generally speaking, most cancer-focused studies have confirmed – contrary to our findings – a continuous, widening gap in survival rates between rural and urban men, yet research examining urban–rural differences in CRC treatment outcomes is limited. For example, Baldwin and colleagues examined a sample of 51,982 patients identified in 2004–2006 SEER Limited-Use Data from three county-based cancer registries (rural Georgia, Atlanta, and Seattle/Puget Sound) in two states and in eight state-based cancer registries (California, Connecticut, Hawaii, Iowa, Kentucky, Louisiana, New Mexico, and Utah) to compare differences in the treatment received for early prostate cancer by rural and urban patients [37]. In that study, considerable proportions of both urban (11.4%) and rural (13.6%) participants received no treatment for early-stage prostate cancer, but the authors were unable to confirm whether this disparity and lack of treatment uptake resulted from inappropriate care.

Men often avoid the “gold standard” approaches to prostate and CRC screening because of concerns about the invasive nature of the screening tests, the need for intravenous sedation when undergoing a colonoscopy, and the possibility of erectile dysfunction occurring as a consequence of treatment for screening-detected prostate cancer [38–40]. Similar masculinity-influenced beliefs may have contributed to the lack of treatment completion among our urban men in Utah. Masculinity norms have been identified as potential barriers to a range of men’s preventive health behaviors (e.g., attending yearly physical checkups, undergoing cholesterol screening) and may be relevant to CRC treatment [41, 42]. Further investigation of the complex interplay in male patients among CRC treatment completion, urban-rural inequities, and masculinity norms is warranted.

Although the population of Utah is primarily White, Black males in our study had a significantly increased risk of all-cause death and CRC-specific death when compared with White males, as well as the lowest 5-year survival rate of all racial groups. A similar Black/White survival disparity was observed both in the study by Sineshaw and colleagues [43], who selected data for non-Hispanic Black and non-Hispanic White patients diagnosed between 2004 and 2012 with a single or first primary invasive stage I–IV CRC, and in nonelderly CRC patients aged 18–64 years in the National Cancer Database. Treatment explained less than 10% percent of the Black/White survival disparity, whereas differences in tumor presentation characteristics explained nearly two-thirds of the disparity.

Historically, Black men continue to possess the highest incidence and mortality rates for CRC among all racial and ethnic groups. The mortality rate due to CRC among Black men in the U.S. remains 47% higher than among White men [44]. While it is true that Blacks represent only 1% of the Utah population, the Utah Population Database contains demographic and health-related records of at least 90% of Black males living in Utah in the database, or approximately 25,000 individuals. Although Utah's Black population share is considerably lower than the U.S. average, due to the statewide nature of the UPDB, virtually all adult Black males 18 or older (12,500 individuals according to Census estimates) are represented in the database, and comparisons by race were therefore feasible. Moreover, Utah's population will continue to grow and become more racially diverse as the Black population is projected to quadruple in size within the next 50 years [45]. Accordingly, our findings should be interpreted with caution due to our small sample of Black men, yet more health promotion and intervention-focused research is needed that prompts equitable care to mitigate the survival disparities between Black and White male patients with CRC.

Our study has several unique strengths. The unique linkage between the UCR and UPDB enabled us to study data from numerous sources to assess demographic and cancer-specific risk factors in both rural and urban areas. This statewide study covered a time period of more than 15 years and its population-based design included more than 4,500 CRC survivors. The availability of baseline data on obesity and comorbidities through the UPDB afforded an advantage over most population-based studies on cancer survival that have not been able to report on obesity. Furthermore, we had complete EMR data from 1997 through 2013 for two of the largest medical care providers in Utah who serve the majority of the state, as well as comprehensive ambulatory surgery and inpatient data within the UPDB provided by the Utah Department of Health; access to these data sources permitted us to capture baseline CCI and smoking status.

However, this study is not without limitations. First, the population is limited to CRC patients diagnosed in Utah, and Utah is the fifth healthiest state in the U.S. [46]. Thus, our findings may not be representative of other more racially diverse or generally less-healthy populations. The Utah population, however, mirrors that of many Midwest and upper-Midwest states (e.g., Minnesota, Wisconsin). Although Utah is comprised geographically of large rural and frontier areas, for the relatively small rural population – particularly when further subdivided by other demographic variables and risk factors – our study may have been underpowered to detect a significant risk. Another limitation of this study was the use of ZCTA level education and poverty data in addition to zip codes to classify rural and urban. Some ZCTAs may contain multiple codes, as ZCTAs are generalized zip code approximations. However, nearly 96% of the ZCTAs in Utah are comprised of a single zip code. Therefore, we would have minimal residual confounding due to analysis with zip code and ZCTA level variables.

Conclusion

To our knowledge, the present study is one of the first population-based studies to assess the association between potential risk factors for CRC and rural-urban disparities in CRC survival among males. Among this cohort of men residing in the Rocky Mountain Region of

U.S., race, cancer treatment options, and socioeconomic status were found to be prognostic factors for a diagnosis of CRC. Although rural residence was not significantly associated with CRC survival, as hypothesized, we did find that men in both rural and urban areas who received no treatment had a significantly increased risk for death due to CRC compared with men who received surgery alone. As postulated, Black men had the lowest survival of all racial groups. Persistent CRC survival inequities among Black men necessitate further investigative and intervention-focused research. Future research should also endeavor to understand how social and environmental conditions influence the health behaviors and health outcomes of rural and urban Black and White men with CRC.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

The research team extends gratitude to Eleanor Mayfield for editorial assistance.

Funding: This study was funded by National Cancer Institute (Grant Nos. K01CA234319 (CRR), R21 CA185811 (MH), and R03 CA159357 (MH)). RJT was supported by the National Institute on Aging (K02AG059140) and National Institute on Minority Health And Health Disparities (U54MD000214). Funding also stemmed from the Huntsman Cancer Institute Cancer Control and Population Sciences Program (P30CA042014) and National Center for Research Resources (R01 RR021746). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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Table 1.

Distribution of demographic characteristics of male CRC patients in Utah, overall and by rural/urban residence

	Total (n=4,660) n (%)	Rural (n=712) n (%)	Urban (n=3,948) n (%)	p-value
Age at cancer diagnosis				
< 40 years	237 (5.1)	14 (2.0)	223 (5.7)	0.0003
40–49 years	434 (9.3)	56 (7.9)	378 (9.6)	
50–59 years	1,072 (23.0)	160 (22.5)	912 (23.1)	
60–69 years	1,221 (26.2)	195 (27.4)	1,026 (26.0)	
70–79 years	1,040 (22.3)	183 (25.7)	857 (21.7)	
80+ years	656 (14.1)	104 (14.6)	552 (14.0)	
BMI at baseline				
Underweight	21 (0.5)	**	18 (0.5)	0.0249
Normal	1,253 (26.9)	196 (27.5)	1,057 (26.8)	
Overweight	2,203 (47.3)	364 (51.1)	1,839 (46.6)	
Obese	1,183 (25.4)	149 (20.9)	1,034 (26.2)	
Race				
White	4,474 (96.1)	692 (97.2)	3,784 (95.9)	0.0041
Black	39 (0.8)	**	38 (1.0)	
American Indian/Alaska Native	44 (0.9)	12 (1.7)	32 (0.8)	
Asian	72 (1.6)	6 (0.8)	66 (1.7)	
Pacific Islander	27 (0.6)	**	26 (0.7)	
Unknown	**	**	**	
Ethnicity				
Non-Hispanic	4,304 (92.4)	674 (94.7)	3,630 (92.0)	0.012
Hispanic	356 (7.6)	38 (5.3)	318 (8.1)	
Charlson Comorbidity Index score				
0	2,520 (54.1)	383 (53.8)	2,137 (54.1)	0.9569
1	1,002 (21.5)	152 (21.4)	850 (21.5)	
2+	1,138 (24.4)	177 (24.9)	961 (24.3)	
Smoking status at baseline				
Non-smoker	3,706 (79.5)	534 (75.0)	3,172 (80.3)	0.0011

	Total (n=4,660)	Rural (n=712)	Urban (n=3,948)	
	n (%)	n (%)	n (%)	p-value
Smoker	954 (20.5)	178 (25.0)	776 (19.7)	
Vital Status				
Alive	2,160 (46.4)	313 (44.0)	1,847 (46.8)	0.1645
Dead	2,500 (53.7)	399 (56.0)	2,101 (53.2)	
Cause of death				
Colorectal cancer	1,476 (31.7)	228 (32.0)	1,248 (31.6)	0.828
% below poverty at ZCTA level				
<10%	2,019 (43.3)	235 (33.0)	1,784 (45.2)	<0.0001
10–15%	1,268 (27.2)	267 (37.5)	1,001 (25.4)	
>15%	1,373 (29.5)	210 (29.5)	1,163 (29.5)	
% Without a high school diploma at ZCTA level				
<6%	1,759 (37.8)	84 (11.8)	1,675 (42.4)	<0.0001
6–11%	1,700 (36.5)	364 (51.1)	1,336 (33.8)	
>11%	1,201 (25.8)	264 (37.1)	937 (23.7)	

ZCTA: ZIP code tabulation area

*
at least one year before cancer diagnosis

**
cells with fewer than five individuals have been masked for de-identification purposes

Table 2.

Distribution of cancer-specific demographics of male CRC patients in Utah overall and by rural/urban residence

	Total (n=4,660) n (%)	Rural (n=712) n (%)	Urban (n=3,948) n (%)	p-value
Family history of any cancer				
First degree relative	1,805 (38.7)	330 (46.4)	2,473 (37.4)	<0.0001
Second degree relative	2,183 (46.9)	382 (53.7)	1,801 (45.6)	<0.0001
Third degree relative	2,124 (45.6)	387 (54.4)	1,737 (44.0)	<0.0001
Any relative	2,667 (57.2)	454 (63.8)	2,213 (56.1)	0.0001
Family history of colorectal cancer				
First degree relative	406 (8.7)	79 (11.1)	327 (8.3)	0.0143
Second degree relative	640 (13.7)	122 (17.1)	518 (13.1)	0.0042
Third degree relative	829 (17.8)	175 (24.6)	654 (16.6)	<0.0001
Any relative	1,431 (30.7)	267 (37.5)	1,164 (29.5)	<0.0001
Diagnosis year				
1997–1999	725 (15.6)	110 (15.5)	615 (15.6)	0.5965
2000–2002	778 (16.7)	114 (16.0)	664 (16.8)	
2003–2005	875 (18.8)	130 (18.3)	745 (18.9)	
2006–2008	877 (18.8)	140 (19.7)	737 (18.7)	
2009–2011	840 (18.0)	119 (16.7)	721 (18.3)	
2012–2013	565 (12.1)	99 (13.9)	466 (11.8)	
Cancer stage at diagnosis				
Localized	2,151 (46.2)	304 (42.7)	1,847 (46.8)	0.1898
Regional, direct extension only	436 (9.4)	67 (9.4)	369 (9.4)	
Regional, regional lymph nodes only	1,173 (25.2)	198 (27.8)	975 (24.7)	
Distant	900 (19.3)	143 (20.1)	757 (19.2)	
Site				
Cecum	702 (15.1)	116 (16.3)	586 (14.8)	0.0201
Ascending colon	485 (10.4)	74 (10.4)	411 (10.4)	
Hepatic flexure of colon	150 (3.2)	10 (1.4)	140 (3.6)	
Transverse colon	226 (4.9)	25 (3.5)	201 (5.1)	
Splenic flexure of colon	99 (4.0)	11 (1.5)	88 (2.2)	

	Total (n=4,660) n (%)	Rural (n=712) n (%)	Urban (n=3,948) n (%)	p-value
Descending colon	184 (4.0)	29 (4.1)	155 (3.9)	
Sigmoid colon	1,096 (23.5)	189 (26.5)	907 (23.0)	
Large intestine, NOS	98 (2.1)	20 (2.8)	78 (2.0)	
Rectosigmoid junction	337 (7.2)	51 (7.2)	286 (7.2)	
Rectum	1,283 (27.5)	187 (26.3)	1,096 (27.8)	
Treatment				
None	234 (5.0)	38 (5.3)	196 (5.0)	0.6273
Surgery only	2,669 (57.3)	412 (57.9)	2,257 (57.2)	
Surgery, chemotherapy, and radiation	591 (12.7)	90 (12.6)	501 (12.7)	
Surgery and chemotherapy	790 (17.0)	106 (14.9)	684 (17.3)	
Other combination	286 (6.1)	47 (6.6)	239 (6.1)	
Missing	90 (1.9)	19 (2.7)	71 (1.8)	

Table 3.

Hazard ratios for all-cause death among male CRC patients in Utah and stratified by rural/urban residence

	Total population		Urban		Rural	
	# deaths per total	HR (95% CI)	# deaths per total	HR (95% CI)	# deaths per total	HR (95% CI)
Location						
Urban	2,053/3,948	Reference				
Rural	389/712	0.96 (0.86, 1.07)				
Age at cancer diagnosis						
<40 years	101/237	0.98 (0.80, 1.22)	96/223	1.03 (0.83, 1.28)	5/14	0.67 (0.27, 1.67)
40–49 years	168/434	**0.79 (0.66, 0.93)**	142/378	**0.78 (0.64, 0.93)**	26/56	0.90 (0.58, 1.39)
50–59 years	364/1,072	**0.70 (0.61, 0.80)**	307/912	**0.72 (0.62, 0.83)**	57/160	**0.61 (0.44, 0.85)**
60–69 years	605/1,221	Reference	505/1,026	Reference	100/195	Reference
70–79 years	660/1,040	**1.48 (1.32, 1.65)**	547/857	**1.55 (1.37, 1.75)**	113/183	1.22 (0.94, 1.60)
80+ years	544/656	**2.59 (2.30, 2.91)**	456/552	**2.64 (2.32, 3.01)**	88/104	**2.34 (1.74, 3.14)**
Race						
White	2,324/4,474	Reference	1,947/3,784	Reference	377/692	Reference
Black	26/39	**2.19 (1.49, 3.22)**	25/38	**2.16 (1.46, 3.21)**	**	**7.56 (1.05, 54.24)**
American Indian/Alaska Native	26/44	1.23 (0.84, 1.81)	20/32	1.27 (0.82, 1.97)	6/12	1.09 (0.49, 2.44)
Asian	49/72	**1.50 (1.13, 1.99)**	44/66	**1.51 (1.12, 2.04)**	**	1.52 (0.63, 3.67)
Pacific Islander	17/27	1.39 (0.86, 2.24)	17/26	1.47 (0.91, 2.36)	**	**
Ethnicity						
Non-Hispanic	2,273/4,304	Reference	1,900/3,630	Reference	373/674	Reference
Hispanic	169/356	1.07 (0.91, 1.24)	153/318	1.02 (0.86, 1.20)	16/38	1.49 (0.92, 2.43)
BMI						
Underweight	14/21	1.39 (0.85, 2.29)	12/18	1.34 (0.79, 2.29)	**	2.42 (0.60, 9.87)
Normal	715/1,253	Reference	595/1,057	Reference	120/196	Reference
Overweight	1,135/2,203	**0.86 (0.79, 0.95)**	934/1,839	**0.86 (0.77, 0.95)**	201/364	0.90 (0.72, 1.12)
Obese	578/1,183	**0.89 (0.80, 1.00)**	512/1,034	0.93 (0.83, 1.05)	66/149	**0.70 (0.52, 0.94)**
CCI						
0	1,194/2,520	Reference	1,003/2,137	Reference	191/383	Reference
1	516/1,002	1.05 (0.95, 1.17)	435/850	1.04 (0.93, 1.16)	81/152	1.10 (0.84, 1.45)

	Total population		Urban		Rural	
	# deaths per total	HR (95% CI)	# deaths per total	HR (95% CI)	# deaths per total	HR (95% CI)
2+	732/1,138	**1.38 (1.24, 1.53)**	615/961	**1.35 (1.21, 1.51)**	117/177	**1.45 (1.12, 1.87)**
Smoking status at baseline						
Non-smoker	1,905/3,706	Reference	1,612/3,172	Reference	293/534	Reference
Smoker	537/954	**1.18 (1.07, 1.31)**	441/776	**1.20 (1.07, 1.34)**	96/178	1.16 (0.91, 1.48)
% below poverty at ZCTA level						
<10%	969/2,019	Reference	842/1,784	Reference	127/235	Reference
10–15%	700/1,268	**1.12 (1.01, 1.23)**	543/1,001	**1.12 (1.00, 1.24)**	157/267	1.07 (0.84, 1.35)
>15%	773/1,373	**1.15 (1.05, 1.26)**	668/1,163	**1.20 (1.08, 1.33)**	105/210	0.89 (0.69, 1.14)
% Without a high school diploma at ZCTA level						
<6%	857/1,759	Reference	812/1,675	Reference	45/84	Reference
6–11%	904/1,700	**1.12 (1.02, 1.23)**	708/1,336	**1.11 (1.00, 1.23)**	196/364	1.08 (0.78, 1.51)
>11%	681/1,201	**1.23 (1.11, 1.36)**	533/937	**1.24 (1.11, 1.39)**	148/264	1.11 (0.78, 1.56)
Stage						
Localized	787/2,151	Reference	674/1,847	Reference	113/304	Reference
Regional, direct extension only	209/436	**1.36 (1.17, 1.58)**	178/369	**1.36 (1.16, 1.61)**	31/67	1.41 (0.95, 2.10)
Regional, regional lymph nodes only	631/1,173	**1.90 (1.71, 2.10)**	514/975	**1.80 (1.60, 2.01)**	117/198	**2.63 (2.01, 3.44)**
Distant	815/900	**9.64 (8.66, 10.73)**	687/757	**9.69 (9.62, 10.89)**	128/143	**10.47 (7.90, 13.87)**
Site						
Cecum	407/702	Reference	335/586	Reference	72/116	Reference
Ascending colon	262/485	**0.83 (0.71, 0.97)**	218/411	0.87 (0.73, 1.03)	44/74	**0.66 (0.45, 0.96)**
Hepatic flexure of colon	89/150	1.04 (0.83, 1.31)	83/140	1.11 (0.87, 1.41)	6/10	0.62 (0.28, 1.35)
Transverse colon	119/226	1.01 (0.83, 1.23)	106/201	1.08 (0.87, 1.33)	13/25	0.68 (0.37, 1.23)
Splenic flexure of colon	54/99	0.93 (0.70, 1.22)	50/88	1.00 (0.75, 1.35)	4/11	0.48 (0.17, 1.32)
Descending colon	97/184	1.07 (0.86, 1.33)	81/155	1.10 (0.86, 1.40)	16/29	0.93 (0.54, 1.60)
Sigmoid colon	558/1,096	**0.85 (0.75, 0.97)**	455/907	0.90 (0.79, 1.04)	103/189	**0.63 (0.47, 0.85)**
Large intestine, NOS	80/98	**1.85 (1.45, 2.36)**	65/78	**2.03 (1.55, 2.66)**	15/20	1.24 (0.71, 2.18)
Rectosigmoid junction	181/337	0.97 (0.82, 1.16)	153/286	1.02 (0.84, 1.23)	28/51	0.75 (0.48, 1.16)
Rectum	595/1,283	0.92 (0.81, 1.05)	507/1,096	0.96 (0.84, 1.10)	88/187	**0.73 (0.53, 1.00)**
Treatment						
No treatment	208/234	**3.17 (2.67, 3.77)**	176/196	**3.13 (2.59, 3.78)**	32/38	**3.24 (2.11, 4.95)**

	Total population		Urban		Rural	
	# deaths per total	**HR (95% CI)**	**# deaths per total**	**HR (95% CI)**	**# deaths per total**	**HR (95% CI)**
Surgery only	1,262/2,669	Reference	1,050/2,257	Reference	212/412	Reference
Surgery, radiation, and chemotherapy	254/591	**0.65 (0.56, 0.75)**	220/501	**0.70 (0.59, 0.82)**	34/90	**0.44 (0.29, 0.66)**
Surgery and chemotherapy	417/790	**0.63 (0.56, 0.71)**	359/684	**0.63 (0.55, 0.72)**	58/106	**0.63 (0.46, 0.87)**
Other combination	245/286	**1.44 (1.23, 1.69)**	203/239	**1.46 (1.23, 1.75)**	42/47	1.27 (0.86, 1.89)

CCI: Charlson Comorbidity Index, ZCTA: ZIP code tabulation area

a: adjusted for age at diagnosis, baseline BMI, baseline CCI, smoking status, race, ethnicity, poverty, education, cancer stage, cancer site, cancer treatment

b: adjusted for BMI at baseline, CCI at baseline, race, ethnicity, smoking status, poverty, education, and location

c: crude

d: adjusted for age at diagnosis, race, ethnicity, poverty, education, and location

e: adjusted for age at diagnosis, BMI at baseline, race, ethnicity, poverty, education, and location

f: adjusted for CCI at baseline, BMI at baseline, age at diagnosis, race, ethnicity, poverty, education, and location

g: adjusted for age at diagnosis, sex, race, ethnicity, and location

h: adjusted for cancer site, age at diagnosis, year of diagnosis, BMI at baseline, CCI at baseline, race, ethnicity, smoking status, poverty, education, and location

i: adjusted for cancer stage, age at diagnosis, year of diagnosis, BMI at baseline, CCI at baseline, race, and ethnicity

j: adjusted for BMI at baseline, CCI at baseline, race, ethnicity, poverty, education, location, cancer stage, and cancer site

Table 4.

Hazard ratios for CRC specific death among male CRC patients in Utah and stratified by rural/urban residence

	Adjusted HR (95% CI)		
	Total Population	**Urban**	**Rural**
Location[a]			
Urban	Reference		
Rural	0.93 (0.81, 1.08)		
Age at cancer diagnosis[b]			
< 40 years	1.20 (0.94, 1.53)	1.25 (0.97, 1.61)	1.00 (0.39, 2.51)
40–49 years	0.96 (0.78, 1.18)	0.92 (0.74, 1.15)	1.24 (0.76, 2.03)
50–59 years	**0.79 (0.67, 0.92)**	**0.83 (0.69, 0.98)**	**0.64 (0.42, 0.96)**
60–69 years	Reference	Reference	Reference
70–79 years	**1.26 (1.09, 1.46)**	**1.37 (1.17, 1.60)**	0.89 (0.62, 1.28)
80+ years	**1.82 (1.55, 2.15)**	**1.85 (1.55, 2.22)**	**1.66 (1.12, 2.47)**
Race[c]			
White	Reference	Reference	Reference
Black	**2.92 (1.94, 4.42)**	**2.86 (1.88, 4.37)**	**10.87 (1.51, 78.39)**
American Indian/Alaska Native	1.12 (0.66, 1.89)	1.29 (0.73, 2.28)	0.60 (0.15, 2.41)
Asian	**1.56 (1.10, 2.23)**	1.46 (0.99, 2.15)	**2.63 (1.08, 6.39)**
Pacific Islander	1.22 (0.64, 2.35)	1.29 (0.67, 2.48)	--
Ethnicity[c]			
Non-Hispanic	Reference	Reference	Reference
Hispanic	0.94 (0.78, 1.13)	0.88 (0.72, 1.07)	1.56 (0.80, 3.03)
BMI[d]			
Underweight	1.00 (0.48, 2.12)	1.10 (0.52, 2.34)	--
Normal	Reference	Reference	Reference
Overweight	**0.88 (0.78, 0.99)**	**0.87 (0.76, 0.99)**	0.93 (0.69, 1.25)
Obese	**0.85 (0.74, 0.98)**	0.88 (0.75, 1.02)	0.70 (0.48, 1.04)
CCI[e]			
0	Reference	Reference	Reference

	Adjusted HR (95% CI)		
	Total Population	**Urban**	**Rural**
1	0.99 (0.86, 1.13)	0.97 (0.84, 1.12)	1.07 (0.75, 1.51)
2+	**1.22 (1.07, 1.39)**	**1.19 (1.03, 1.37)**	1.35 (0.96, 1.90)
Smoking status at baseline[f]			
Non-smoker	Reference	Reference	Reference
Smoker	1.14 (1.00, 1.30)	**1.17 (1.02, 1.35)**	0.99 (0.72, 1.37)
% below poverty at ZCTA level[a]			
<10%	Reference	Reference	Reference
10–15%	1.08 (0.96, 1.22)	1.08 (0.94, 1.24)	1.02 (0.76, 1.38)
>15%	1.02 (0.90, 1.15)	1.07 (0.94, 1.23)	0.71 (0.50, 1.01)
% Without a high school diploma at ZCTA level[g]			
<6%	Reference	Reference	Reference
6–11%	1.04 (0.92, 1.17)	1.02 (0.89, 1.16)	1.11 (0.73, 1.70)
>11%	1.09 (0.95, 1.25)	1.11 (0.96, 1.28)	1.01 (0.65, 1.58)
Stage[h]			
Localized	Reference	Reference	Reference
Regional, direct extension only	**2.06 (1.64, 2.58)**	**2.12 (1.66, 2.70)**	1.75 (0.92, 3.32)
Regional, regional lymph nodes only	**3.80 (3.26, 4.43)**	**3.67 (3.11, 4.33)**	**4.63 (3.07, 6.97)**
Distant	**20.78 (17.85, 24.20)**	**21.09 (17.88, 24.86)**	**21.20 (14.09, 31.90)**
Site[i]			
Cecum	Reference	Reference	Reference
Ascending colon	**0.73 (0.59, 0.90)**	**0.72 (0.57, 0.90)**	0.81 (0.50, 1.33)
Hepatic flexure of colon	1.20 (0.89, 1.62)	1.30, 0.95, 1.77)	0.51 (0.16, 1.68)
Transverse colon	0.90 (0.69, 1.18)	0.96 (0.72, 1.27)	0.56 (0.24, 1.34)
Splenic flexure of colon	0.74 (0.49, 1.10)	0.75 (0.49, 1.13)	0.79 (0.19, 3.28)
Descending colon	1.08 (0.81, 1.43)	1.04 (0.76, 1.43)	1.25 (0.64, 2.48)
Sigmoid colon	**0.77 (0.65, 0.91)**	**0.80 (0.67, 0.96)**	**0.63 (0.42, 0.96)**
Large intestine, NOS	**1.44 (1.05, 0.98)**	**1.48 (1.04, 2.10)**	1.31 (0.63, 2.75)
Rectosigmoid junction	0.94 (0.75, 1.16)	0.98 (0.77, 1.24)	0.72 (0.40, 1.31)
Rectum	0.94 (0.80, 1.11)	0.96 (0.81, 1.15)	0.81 (0.53, 1.23)

	Adjusted HR (95% CI)		
	Total Population	**Urban**	**Rural**
Treatment[j]			
No treatment	**4.24 (3.45, 5.20)**	**4.17 (3.33, 5.22)**	**4.28 (2.48, 7.38)**
Surgery only	Reference	Reference	Reference
Surgery, radiation, and chemotherapy	0.85 (0.71, 1.03)	0.91 (0.74, 1.12)	0.63 (0.38, 1.04)
Surgery and chemotherapy	**0.83 (0.71, 0.96)**	**0.83 (0.71, 0.98)**	0.80 (0.54, 1.20)
Other combination	**1.82 (1.51, 2.19)**	**1.87 (1.53, 2.30)**	1.51 (0.94, 2.41)

CCI: Charlson Comorbidity Index, ZCTA: ZIP code tabulation area

a: adjusted for age at diagnosis, baseline BMI, baseline CCI, smoking status, race, ethnicity, poverty, education, cancer stage, cancer site, cancer treatment

b: adjusted for BMI at baseline, CCI at baseline, race, ethnicity, smoking status, poverty, education, and location

c: crude

d: adjusted for age at diagnosis, race, ethnicity, poverty, education, and location

e: adjusted for age at diagnosis, BMI at baseline, race, ethnicity, poverty, education, and location

f: adjusted for CCI at baseline, BMI at baseline, age at diagnosis, race, ethnicity, poverty, education, and location

g: adjusted for age at diagnosis, sex, race, ethnicity, and location

h: adjusted for cancer site, age at diagnosis, year of diagnosis, BMI at baseline, CCI at baseline, race, ethnicity, smoking status, poverty, education, and location

i: adjusted for cancer stage, age at diagnosis, year of diagnosis, BMI at baseline, CCI at baseline, race, and ethnicity

j: adjusted for BMI at baseline, CCI at baseline, race, ethnicity, poverty, education, location, cancer stage, and cancer site

Table 5.

Five-year unadjusted relative survival rates for male CRC patients in Utah

	Number of patients	Number of deaths in first 5 years	5-year relative survival rates
Overall	4,660	1,900	0.57 (0.56, 0.59)
Location			
Urban	3,948	1,591	0.58 (0.56, 0.59)
Rural	712	309	0.55 (0.51, 0.59)
Race			
White	4,474	1,801	0.58 (0.56, 0.59)
Black	39	25	0.29 (0.14, 0.45)
American Indian/Alaska Native	44	22	0.49 (0.34, 0.63)
Asian	72	39	0.44 (0.32, 0.55)
Pacific Islander	27	13	0.49 (0.28, 0.66)