

# Colorectal Cancer, Socioeconomic Distribution and Behavior: A Comparative Analysis of Urban and Rural Counties in the USA

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## ABSTRACT

**BACKGROUND:** Colorectal cancer (CRC) ranks second for all cancer related deaths among men and women together and third for either sex when considered separately. Disparities exist in CRC incidence and mortality between rural and urban counties in the USA. This study sought to explore socioeconomic and behavioral factors that may partly explain these observed differences.

**METHODS:** Using educational and income levels as measures of socioeconomic status (SES), and average alcohol consumption and smoking frequency as behavioral factors, data from the Behavioral Risk Factor Surveillance System (BRFSS) and the Surveillance, Epidemiology, and End Results (SEER) program were coupled for analysis.

**RESULTS:** Results showed statistically significant inequalities for CRC incidence ( $t = 2.675$ ,  $p = 0.009$ ) and mortality ( $t = 2.328$ ,  $p = 0.022$ ), as well as socioeconomic (i.e., poverty;  $t = 4.864$ ,  $p < 0.001$ ) and behavioral (i.e., smoking;  $t = 2.777$ ,  $p = 0.007$ ) factors between selected rural and urban counties. Regression analysis for colorectal cancer incidence and mortality rates at the rural, urban, and national levels showed that smoking behavior was the strongest predictor, while relative impacts of alcohol consumption and SES were observed.

**CONCLUSION:** Health policies aimed at reducing disparities between rural and urban populations in the USA must therefore adequately address SES and behavioral factors.

*Key words:* colorectal cancer, rural health, social determinants of health, health behavior

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**DOI:** 10.2427/11604

Accepted on December 10, 2015

## INTRODUCTION

Colorectal cancer (CRC) ranks second for all cancer related deaths among men and

women together and third for either sex when considered separately in the United States of America [1]. Previous studies suggest there may be important rural/urban differences

in colorectal cancer incidence and mortality among men and women in the United States [2]. Such geographic variation may be partly due to differences in colorectal cancer screening because routine screening can reduce both mortality from the disease and morbidity over time [3]. Although colorectal cancer screening rates have increased over time, increases have been lower in those who are less educated, have a lower income, lack health insurance, and are Hispanic [4,5]. Analysis of the 1999 and 2008 BRFSS showed that rural residents were also less likely to receive recommended colorectal cancer screening than their urban counterparts [6,7]. While socioeconomic status (education and income) may directly predict cancer-screening behavior, CRC risk is also influenced by several behaviors other than screening. Regular physical activity provides a protective effect against colorectal cancer, whereas obesity is associated with increased risk [8-10]. Vegetarian diets are associated with lower incidence of colorectal cancer [11]. Equivocal evidence has also been found for a link between dietary fat intake and colorectal cancer risk [12,13]. There is accumulating evidence linking increased risk for colorectal cancer with high red meat intake [14,15] high intake of alcohol [16], and smoking [17]. These behavioral risk factors for CRC might contribute to observed differences in CRC incidence with geographic location.

Several studies have investigated the relationship between rurality and cancer. One of the most important findings is that rural residents are generally diagnosed at a later stage and have decreased survival rates as opposed to their urban counterparts [18]. The difference in outcomes has been linked to differences in socioeconomic and behavioral factors including cancer-screening behavior [19]. Secondary prevention by way of screening and early detection and treatment could reduce observed differences in CRC outcomes between rural and urban populations. In addition to efforts to increase screening rates [20], modification of behavioral risk factors [21,22] can significantly reduce CRC risk [23], even among individuals who are adherent to colorectal cancer screening [24].

The purpose of the present study is to explore any differences in CRC incidence and mortality between randomly selected rural and urban counties in the USA. The a priori hypothesis was that any observed

differences in CRC mortality between rural and urban counties would mirror differences in socioeconomic factors (Education, Income) and screening behavior. Furthermore, any observed differences in CRC incidence between rural and urban counties would be reflected by differences in behavioral risk factors for CRC such as smoking and alcohol consumption as well as educational and income levels.

## METHODS

### Data Collection

Data for the present cross-sectional study were collected from the Surveillance, Epidemiology, and End Results (SEER) program of the National Cancer Institute (NCI) and the Behavioral Risk Factor Surveillance System (BRFSS) of the Centers for Disease Control and Prevention (CDC). Initially, colorectal cancer incidence and mortality rates for the year 2011 were calculated for all counties in the SEER-18 registry database using SEER\*Stat version 8.1.525. Incidence and mortality rates per 100,000 at-risk citizens were generated using the 2000 US Census standard population estimates. Socioeconomic status variables for all counties in the study were also calculated using SEER\*Stat. Specifically, we created two socioeconomic variables based on the 2000 US Census: (1) percentage of the county population with less than a high school education and (2) percentage of the county population living below poverty.

Self-report data for three CRC behavioral risk factors were downloaded from the standardized 2011 BRFSS telephone survey database, which included adults aged  $\geq 18$ : (1) amount of time since last doctor visit, (2) smoking frequency, and (3) alcohol consumption. Since the data from the BRFSS were available at the individual level and data from the SEER program were available at the county level, the individual BRFSS data to match the county SEER program data were aggregated, permitting a comparison of CRC incidence/mortality, socioeconomic status, and behavioral factors. To achieve the aforementioned objective, the BRFSS participants by county were grouped and the percentages or averages for the variables listed above were calculated. Specifically, for each county, the following behavioral variables

were calculated: (1) percentage of the county population that visited the doctor within the last year, (2) percentage of the county population that reported smoking every day, and (3) the county population's average number of alcoholic drinks consumed per month.

### Sample

First, the counties were classified either as urban or as rural using the data from the 2013 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties [26]. Second, after the individual level data from the BRFSS survey were aggregated to the county level, the county listings in the SEER database and the BRFSS database were compared. A comparison of county listings enabled the creation of a database that permitted the pooling of counties held in common by the BRFSS and SEER databases. In order to randomly select urban and rural counties from the database, a random number generator in Excel version 14.4.8 with the function =RANDBETWEEN() was used. According to Cohen [27], a t-test with two groups – as in the case of the present study (i.e., rural versus urban counties) – will garner statistical power of 80 percent with a medium-large effect size if 30 observations are included in each cell. Thus, a total of 50 urban counties and 50 rural counties were randomly selected from the pool of USA counties with the method previously described, as Cohen's (1988) method is only a baseline recommendation.

### Procedures

In order to answer the research questions in the present study, a diversity of descriptive and inferential statistical techniques were applied to the data. Firstly, means and standard deviations were calculated for each variable – CRC incidence, CRC mortality, percentage of the county population that visited the doctor in the past year, percentage of the county population that reported smoking every day, alcoholic drinks consumed per month, educational levels, and poverty – in the study at the rural, urban, and national levels. We also calculated (a) mortality to incidence ratios (MIR) for CRC within rural counties, within urban counties, and

within the national sample and (b) the rate ratio (RR) for CRC incidence and mortality between rural and urban counties [28].

Secondly, a series of independent samples t-tests were conducted – after removing outliers by standardizing the observations and eliminating observations beyond 3.29 standard deviations from the mean [29] – in order to determine if rural and urban counties differed in the expression of the variables under study. To the extent that multiple t-tests were performed in the present study, we resolved to control the incidence of type I error by applying the Bonferroni correction (i.e.,  $\alpha_{\text{pairwise}} = \alpha_{\text{familywise}} / c$ , where  $c = \text{comparisons}$ ) to three families of hypothesis tests. While some researchers have suggested that a family of tests should be defined as those which are conducted within the span of a researcher's career [30], others have suggested that such an approach is too conservative and leads to the incidence of type II error; therefore, it is prudent to define a family of tests a priori as those which are related [31,32]. On the basis of the discussion herein presented, the definition of a family of t-tests in the present study followed the ensuing protocol: (1) colorectal cancer variables – Bonferroni corrected  $\alpha = 0.025$ ; (2) behavioral variables – Bonferroni corrected  $\alpha = 0.0167$ ; and (3) socioeconomic status variables – Bonferroni corrected  $\alpha = 0.025$ . We also computed Cohen's effect size "d" for each comparison, which is a measure of practical significance. As Kirk [33] explained, null hypothesis tests and their associated test statistics (i.e., t) indicate whether a result is due to sampling variability or, perhaps, chance; however, effect sizes, by showing how far apart the means of two samples are in terms of standard deviations, indicate whether the differences are useful "in the real world" (p746).

Thirdly, ordinary least squares (OLS) multiple regression models were calculated in order to represent a prediction of how the various behavioral and socioeconomic status variables influenced the presentation of CRC incidence and mortality at the rural, urban, and national level. A standard forced entry method, utilizing one step, was adopted for the analysis as previous research has shown that the variables under study exert significant influence on the expression of CRC incidence and mortality. Confidence intervals (95%) were

also calculated in order to test the statistical significance of each predictor variable.

## RESULTS

### Descriptive Statistics

CRC incidence and mortality rates were the highest in rural counties ( $M_{INC} = 50.930$ ,  $SD_{INC} = 7.802$ ;  $M_{MOR} = 17.526$ ,  $SD_{MOR} = 4.961$ ;  $MIR = 0.344123$ ), followed by counties in the national sample ( $M_{INC} = 49.511$ ,  $SD_{INC} = 7.643$ ;  $M_{MOR} = 16.494$ ,  $SD_{MOR} = 4.555$ ;  $MIR = 0.329807$ ) and urban counties ( $M_{INC} = 48.092$ ,  $SD_{INC} = 7.282$ ;  $M_{MOR} = 15.441$ ,  $SD_{MOR} = 3.873$ ;  $MIR = 0.314647$ ). Calculation of RR

for CRC incidence between rural and urban counties – with the rural counties serving as the numerator in the equation – showed that rural counties were at a higher risk for CRC incidence (RR = 1.059). Similar results were obtained in the RR analysis of CRC mortality between rural and urban counties (RR = 1.135). A greater percentage of the population in rural counties – compared to urban counties – reported that they had visited the doctor at least once within the last year (Table 1). While cigarette-smoking frequency was higher in rural counties, alcohol consumption was higher in urban counties (Table 1). Additionally, lower levels of education and higher levels of poverty were evident in rural counties (Table 1).

TABLE 1

MEANS, STANDARD DEVIATIONS, AND T-TESTS FOR CRC, BEHAVIORAL FACTORS, AND SES											
	RURAL		URBAN		NATIONAL		RURAL-URBAN COMPARISONS				
	M [95% CI]	SD	M [95% CI]	SD	M [95% CI]	SD	T	DF	P	D <sup>e</sup>	
CRC											
CRC INCIDENCE <sup>a</sup>	50.930 [48.712, 53.146]	7.802	48.092 [46.286, 50.121]	7.282	49.511 [47.994, 51.027]	7.643	2.675	95	.009	*	.543
CRC MORTALITY <sup>a</sup>	17.526 [16.116, 18.936]	4.961	15.441 [14.328, 16.553]	3.873	16.494 [15.585, 17.403]	4.555	2.328	97	.022	*	.469
BEHAVIORAL FACTORS											
VISITED DOCTOR IN PAST YEAR <sup>b</sup>	70.872 [68.009, 73.736]	10.076	70.688 [67.622, 73.754]	10.788	70.780 [68.720, 72.841]	10.386	.088	98	.930		.018
SMOKE EVERYDAY <sup>b</sup>	15.144 [12.951, 17.336]	7.713	11.414 [9.840, 12.988]	5.539	13.279 [11.902, 14.656]	6.938	2.777	98	.007	*	.556
ALCOHOLIC DRINKS PER MONTH	8.491 [7.023, 9.960]	5.167	11.555 [10.435, 12.674]	3.939	10.023 [9.066, 10.980]	4.823	-3.334	98	.001	*	-.667
SOCIOECONOMIC STATUS											
EDUCATION <sup>c</sup>	25.939 [23.149, 28.728]	9.815	17.728 [15.460, 19.995]	7.978	21.833 [19.887, 23.779]	9.809	4.590	98	.001	*	.918
POVERTY <sup>d</sup>	16.361 [14.373, 18.349]	6.994	10.522 [9.154, 11.889]	4.812	13.442 [12.121, 14.762]	6.654	4.864	98	.000	*	.973

Note. Statistically significant p-values for pairwise comparisons are coded as \* for all Bonferroni corrected alpha levels.

<sup>a</sup> Rate per 100,000 population without outlier removal

<sup>b</sup> Percentage of county population

<sup>c</sup> Percentage of county population with less than a high school education

<sup>d</sup> Percentage of county population living below poverty

<sup>e</sup> Effect sizes were calculated with the data set adjusted for outliers

### Cancer, Behavior, and SES Comparisons Between Rural and Urban Counties

Three families of Bonferroni adjusted t-tests were generated in order to answer the research questions. Regarding cancer outcomes, significant differences were found between rural and urban counties (Table 1). Specifically, the results showed that differences between rural-urban CRC incidence rates were practically significant ( $d = .543$ ) and statistically significant ( $t = 2.675, p = .009$ ) at the Bonferroni adjusted alpha level of .025. Furthermore, differences between rural-urban CRC mortality rates were practically significant ( $d = .469$ ) and statistically significant ( $t = 2.238, p = .022$ ) at the Bonferroni adjusted alpha level of .025.

The second family of t-tests included behavioral factors implicated in the incidence of CRC. While statistically significant differences

were not detected between rural and urban counties in terms of the percentage of the population that had visited the doctor within the last year, statistically significant differences were detected for smoking frequency and alcohol consumption (Table 1). Specifically, the results showed that populations living in rural and urban counties differed in the quantity of cigarettes smoked within the last 30 days ( $t = 2.777, p = .007$ ). Practical significance was also discovered for this comparison according to Cohen's effect size index ( $d = .556$ ). Furthermore, differences in alcohol intake were practically significant ( $d = -.667$ ) and statistically significant ( $t = -3.334, p = .001$ ) for rural and urban counties at the Bonferroni adjusted alpha level of .0167.

In order to determine if rural and urban counties differed on essential socioeconomic variables, a third family of t-tests was built into

TABLE 2

UNSTANDARDIZED OLS REGRESSION COEFFICIENTS [95% CONFIDENCE INTERVALS] FOR THE ASSOCIATION OF BEHAVIORAL AND SES FACTORS TO CRC INCIDENCE AND MORTALITY						
	RURAL		URBAN		NATIONAL <sup>a</sup>	
	INCIDENCE	MORTALITY	INCIDENCE	MORTALITY	INCIDENCE	MORTALITY
<b>BEHAVIOR</b>						
VISITED DOCTOR IN PAST YEAR	.069 [-.141, .279]	-.061 [-.200, .078]	.017 [-.152, .185]	.025 [-.081, .130]	.065 [-.061, .191]	.000 [-.085, .085]
SMOKING	.487 [.213, .760]	.139 [-.042, .320]	.737 [.351, 1.124]	.316 [.096, .536]	.514 [.316, .712]	.151 [.024, .278]
ALCOHOL	-.316 [-.783, .151]	-.376 [-.686, -.067]	.096 [-.397, .589]	.107 [-.179, .392]	-.168 [-.478, .142]	-.190 [-.390, .011]
<b>SOCIOECONOMIC STATUS</b>						
EDUCATION	0.014 [-.381, .409]	-.070 [-.332, .192]	.228 [-.056, .511]	.098 [-.067, .262]	.163 [-.061, .387]	.067 [-.077, .212]
POVERTY	-0.018 [-.551, .516]	.185 [-.169, .539]	-.211 [-.671, .250]	.022 [-.243, .288]	-.141 [-.465, .184]	.063 [-.146, .272]
CONSTANT	41.257 [23.429, 59.086]	21.745 [9.924, 33.566]	35.565 [21.220, 49.909]	6.902 [-1.976, 15.780]	38.119 [27.271, 48.967]	14.075 [6.851, 21.300]
R <sup>2</sup>	0.294	.233	.405	.324	.344	.242
ADJUSTED R <sup>2</sup>	0.214	.146	.337	.245	.309	.201
F	3.670	2.672	5.982	4.115	9.860	5.941
P	.007	.034	< .001	.004	< .001	< .001

<sup>a</sup> The national data in this table was generated by combining the rural and urban county data from the present study.



the design of the present study. The results showed that rural and urban counties differed on the following variables: percentage of the population with less than a high school education and percentage of the population living in poverty (Table 1). Differences in education levels in rural counties ( $M = 25.939$ ,  $SD = 9.815$ ) and urban counties ( $M = 17.728$ ,  $SD = 7.978$ ) were practically ( $d = .918$ ) and statistically significant ( $t = 4.590$ ,  $p = .001$ ) at the Bonferroni adjusted alpha level of .025. Differences in poverty levels in rural counties ( $M = 16.361$ ,  $SD = 6.994$ ) and urban counties ( $M = 10.522$ ,  $SD = 4.812$ ) were also practically ( $d = .973$ ) and statistically significant ( $t = 4.864$ ,  $p < .001$ ) at the Bonferroni adjusted alpha level of .025.

#### Predictors of Rural CRC Incidence and Mortality

In order to determine the extent of influence of behavioral and socioeconomic factors on the incidence and mortality of rural CRC, unstandardized OLS regression models were generated (Table 2). The regression model for rural CRC incidence was statistically significant ( $F = 3.670$ ,  $p = .007$ ) and accounted for 21.4 percent of the variance in CRC incidence. Monthly smoking frequency emerged as the strongest predictor of CRC incidence as well as the only significant predictor in the model. The regression model for rural CRC mortality, which accounted for 14.6 percent of the variance in mortality, also showed statistical significance ( $F = 2.672$ ,  $p = .034$ ). While alcohol consumption materialized as the only statistically significant predictor in this model, smoking frequency and poverty appeared to exert relative influence on rural CRC mortality.

#### Predictors of Urban CRC Incidence and Mortality

Urban CRC incidence and mortality predictors were determined using unstandardized OLS regression models (Table 2). The results showed that the regression model for urban CRC incidence – with time since last checkup at the doctor, smoking frequency, alcohol consumption, education, and poverty as independent variables – was statistically significant ( $F = 5.892$ ,  $p < .001$ ). Overall, this model accounted for 33.7 percent of the variance in the dependent variable, urban

CRC incidence. Monthly smoking frequency surfaced as the only statistically significant predictor and as the strongest predictor in the model (similar to the rural CRC incidence model), although education presented as a relatively important variable. Regarding urban CRC mortality, regression analysis revealed that the socioeconomic and behavioral variables in the study exerted relative influence ( $F = 4.115$ ,  $p = .004$ ), with smoking frequency as the strongest and only predictor. The adjusted R<sup>2</sup> value for this model suggested that the independent variables accounted for 24.5 percent of the variance in urban CRC mortality.

#### Predictors of National CRC Incidence and Mortality

The regression models for both national CRC incidence and mortality showed a good fit to the data ( $F = 9.860$ ,  $p < .001$ ) and ( $F = 5.941$ ,  $p < .001$ ), respectively, with monthly smoking frequency presenting as the most influential predictor of both CRC incidence and mortality. Overall, this model accounted for 30.9 percent of the explained variability in CRC incidence. The adjusted R<sup>2</sup> value for this model suggested that the independent variables accounted for 20.1 percent of the variance in the dependent variable. In looking at the findings of each regression model, including the national regression models, one independent variable emerged as repeatedly predictive of CRC incidence and mortality. Specifically, in all models – save the rural CRC mortality model in which alcohol was the only predictor – smoking was not the strongest predictor (as in the case of the national CRC mortality model) of CRC incidence and mortality but the only statistically significant predictor.

## DISCUSSION

Health disparities have been observed between rural and urban regions around the world. Several risk factors have been described as potential drivers of this epidemiological polarization [34]. Access to health care, including distance from medical facilities, physician-to-population ratio, availability of cancer detection technologies and screening methods constitute some of the most important aspects of social

deprivation and rurality [35,36]. Limited financial resources and economic factors tend to augment these disparities even further. The availability of public versus private medical centers and public health insurance coverage of medical costs is also detrimental [37].

Moreover, health promotion and education is usually minimal in rural populations. Limited disease control and prevention (primary or secondary) is predisposing for increased incidence and mortality from chronic diseases. Behavioral factors, such as smoking, diet and alcohol consumption may alter individual outcomes, albeit cultural or religious beliefs may be equally important [38,39].

In the present study, possible variations in CRC incidence and mortality between rural and urban counties in the USA were explored. The possible role of Socio-Economic Status (SES) and behavioral risk factor variations between rural and urban counties that may partly explain any observed differences in CRC incidence and mortality between the selected rural and urban counties were also evaluated.

Specifically, educational and income levels were selected as two measures of SES since these two directly influence health and health-seeking behavior as well as health outcomes. The relative percentages of people without a high school education for the rural and urban counties were used as a measure of SES and the percentage of people living below the poverty line for the rural counties compared to the urban were also assessed.

Previous studies have already cited smoking and alcohol consumption as behavioral risk factors for CRC [16,17]. Therefore, possible differences between smoking levels and average alcohol consumption between rural and urban counties as partly responsible for any observed differences in CRC incidence and mortality between rural and urban counties were explored. Last visit to the doctor in the past year was used as a proxy of cancer screening behavior, and looked at differences between percentages of rural and urban populations who had seen a doctor in the past year to mirror possible differences in CRC incidence and mortality due to early diagnosis and relatively favorable outcomes for those screened and diagnosed in the early stages of CRC.

As mentioned in the results, and shown in Table 1, significant differences exist for CRC incidence and mortality between rural

and urban counties, both being higher in rural counties compared to urban. The Mortality-Incidence Ratio (MIR) of CRC for randomly selected rural counties stood at 0.3441 compared to 0.3146 for randomly selected urban counties. This means that 34.41 percent of all CRC cases in rural counties will have fatal outcomes compared to 31.46 percent of all CRC cases in urban counties. Some studies have used MIR as a proxy for 5-years survival rate and as an indicator for sex and racial disparities in cancer survival [40]. The difference in outcomes showed in the present investigation, can be attributed to differences in socioeconomic factors (educational level and income), CRC screening behavior which by itself may be influenced by SES factors including health insurance status as well as availability of health resources. The result of these inter-related factors will be the diagnosis of relatively more cases of CRC in advanced stages of the disease in rural settings compared to those in urban areas, where relatively higher SES levels, coupled with better health resources and CRC screening behavior lead to early diagnosis and relatively more favorable outcomes as suggested by the MIR of CRC for urban counties, compared to rural counties.

Since the results showed practically and statistically significant differences in the two important SES variables used for the analysis; educational level and poverty as shown in Table 1, it may be reasonable to say that these differences may partly explain the observed differences in CRC incidence and mortality between the selected rural and urban counties especially when the means for educational level and income are compared between the two. There are more people living below the poverty line in the rural as compared to the urban counties, and similarly, there are more people with less than a high school education in the rural compared to urban counties as shown in Table 1, which together means the socioeconomic conditions using education and income, place the urban counties above the rural. By extension therefore, since educational level is a predictor of income, and combined, the two influence health and health-seeking behavior, it stands to reason that differences in CRC incidence and mortality may partly be accounted for by the differences in educational and income levels between the rural and urban counties.

With regard to behavioral risk factors, the results showed that, there was no statistical significance in our proxy for cancer screening behavior – last visit to the doctor (Table 1). Nonetheless, previous studies have reported differences in cancer screening behavior between rural and urban populations as a contributor to observed disparities in CRC incidence and mortality between rural and urban counties [17,18]. Since last visit to doctor was used as a proxy to CRC screening behavior, it is likely the practical and statistical insignificance of same with regard to differences between rural and urban counties may be due to the selected variable not being a good proxy for cancer screening behavior, and so not reflecting differences that may exist between rural and urban counties in actual CRC screening behavior.

As far as smoking is concerned, the results indicate that the percentage of people who smoke every day is higher for the rural counties than it is for the urban counties. The differences so observed proved practically and statistically significant as shown in Table 1. Since smoking as indicated previously is a behavioral risk factor for CRC, again it stands to reason that the relatively higher smoking indulgence in the rural compared to urban counties may partly contribute to the observed higher incidence and mortality for CRC in rural counties compared to the urban counties.

Alcohol consumption has been suggested as a behavioral risk factor for CRC. However some studies suggest that, the risk posed by alcohol for CRC is dose-dependent. There is strong evidence for an association between alcohol drinking of >1 drink/day and colorectal cancer risk [41]. A meta-analysis of 57 cohort and case-control studies that examined the association between alcohol consumption and colorectal cancer risk showed that people who regularly drank 50 or more grams of alcohol per day (approximately 3.5 drinks) had 1.5 times the risk of developing colorectal cancer as nondrinkers or occasional drinkers [42]. From the results in Table 1, it is clear that alcohol consumption is higher in the urban counties compared to the rural. Despite this difference in alcohol consumption being practically and statistically significant, alcohol consumption by itself does not seem to contribute to the risk of CRC for either rural or urban populations since the weighted average consumption per person

is far less than the suggested threshold of 1 unit per day for any risk of CRC to be realized for both rural and urban populations. Giving that the weighted averages of alcohol consumption for either population were used rather than individual variations in alcohol consumption, the results so observed might be different if individual units of alcohol consumed per month were used in the analysis for specific cases of CRC and related outcomes for same.

The next phase of our analysis sought to examine the extent to which SES and behavioral factors influence CRC incidence and mortality for rural, urban and national populations. Using unstandardized regression models, monthly smoking frequency emerged as the only significant predictor of CRC incidence for both rural and urban counties as well as the national pool, with alcohol consumption, educational and income levels variously influencing CRC mortality across board as mentioned earlier in the results and shown in Table 2. Our results highlight the risk of smoking behavior on CRC incidence and mortality among rural and urban counties in the USA. Public health education programs and social marketing campaigns should emphasize the role of monthly smoking frequency on the manifestation of CRC, especially in rural counties – as smoking frequency is higher in rural counties than urban counties in the USA.

This paper has various strengths such as the coupling of data from the BRFSS and SEER, the identification and confirmation of existing differences in CRC incidence and mortality between rural and urban counties and the possible role of behavioral and SES factors in these observed differences. Despite these strengths, some weaknesses of this research paper have been observed. The paper used county level data, making analysis on weighted means and aggregates without recourse to individual variations in behavior and CRC incidence and outcomes across counties rural and urban. We also consider the wide variations in geographic and population size a limitation to this paper.

## CONCLUSION

Multiple SES and behavioral factors variously and independently influence the incidence and outcomes of CRC in the USA.



Without adequately addressing these palpable variations in SES and behavioral factors between rural and urban populations in the USA, the disparities in CRC incidence and mortality between rural and urban populations will likely get worse. Health policies aimed at reducing disparities between rural and urban populations in the USA must therefore

adequately address SES and behavioral factors. We recommend further research with larger sample sizes and more SES and behavioral factors to see the full dimension and impact these factors may have on CRC incidence and mortality in the USA to better inform policies meant at bridging these disparities.

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