**RACE, ETHNICITY AND GEOGRAPHIC VARIATION IN COLORECTAL CANCER MORTALITY AMONG THE U.S. POPULATION 2005-2007**

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**Introduction**

Each year more than 50,000 Americans die from colorectal cancer (CRC). Many of these deaths may have been prevented through guideline consistent use of colorectal screening. In recognition of this fact, the U.S. Department of Health and Human Services set reducing colorectal cancer deaths from 17.9 per 100,000 to 14.5 per 100,000 as one of the objectives of Healthy People 2010 (U.S. Dept of Health and Human Services a). There, however; has been limited progress in reducing colorectal cancer mortality. Although the U.S. mortality rate was reduced to 17.0 per 100,000 by 2007 the Healthy People 2010 objective was not achieved and the objective for Healthy People 2020 remains the same as 2010 (U.S. Dept. of Health and Human Services b). Data from the Surveillance and Epidemiology Registry (SEER) show racial/ethnic variation in both colorectal cancer incidence and mortality (Altekruse et al., 2010). Furthermore, declines in colorectal cancer mortality rates have not been consistently observed among all race/ethnic minority groups (Atekruse et al. 2010; Scheck et al., 2006)due in part to the lower access and utilization of colorectal screening (American Cancer Society, 2010; Schneck et al., 2006).

Geographic variations in both the prevalence and magnitude of racial/ethnic disparities have been reported by others (Murray et al., 2008; Baicker et al., 2005). The failure to account for geographic variation is posited to overestimate the role of race in health disparities (Baicker et al., 2005). There are several reasons why geography, or the ‘neighborhood’ where one lives, is important in the investigation of health disparities. One, it is associated with availability and access to resources (Turner et al., 2009). Two, individuals tend to aggregate (Ricketts) and/or to be segregated with others who share their demographic characteristics. For example, the higher than average concentration of African Americans in Southern states and a higher than average concentration of Hispanics in Western states (Figures 1-2) and the persistent racial segregation within U.S. cities and states (Farley et al., 2005). Third, geography is linked to the health care delivery environment as well as the local medical culture (Ricketts; Baicker et al., 2005). Fourth, the neighborhood is a significant source of several types of environmental exposures. The concentrations of racial/ethnic minorities within specific geographic areas therefore have the potential to play a significant role in racial/ethnic health disparities.

Although other studies have investigated geographic variation in colorectal cancer outcomes they have either focused on cancer incidence (Lai et al., 2006; ) 5-year survival or were limited to investigations that focused on one state (Henry et al., 2009), did not specifically examine mortality or did not examine racial/ethnic variation in rates among geographic areas (Lai et al., 2006). In a recent study, (Shavers et al., 2010) investigators found regional differences in colorectal cancer screening by race/ethnicity. This in conjunction with observed reductions in colorectal cancer mortality attributed to increased use of screening suggests a role for geography in racial/ethnic colorectalcancer mortality disparities. Henry et al, found an association between neighborhood income and race with high income predominantly white neighborhoods having the best colorectal cancer survival and low income racially diverse neighborhoods experiencing the worse colorectal cancer survival (Henry et al., 2009).

In the current study we examine geographic variation in racial/ethnic colorectal cancer mortality and the role, if any, of socioeconomic status. We are particularly interested in identifying geographic areas where (1) racial/ethnic disparities in colorectal screening mortality are highest for AA compared to NHWs and for Hispanics compared to NHWs and (2) where colorectal cancer mortality rates substantially differ from same race/ethnic group national rates (3) areas where race/ethnic specific mortality rates differ from U.S. rates. As Chandra et al. suggests racial differences due to geography have different policy implications than racial differences due to other causes such as patient preference, provider bias or financial barriers (Chandra et al., 2003). Results from this study will provide information for targeting programs and interventions designed to decrease U.S. disparities in colorectal cancer mortality.

A description...

1. African American/Black (Non-Hispanic)
2. Hispanic

A description...

Source:[www.CensusScope.org](http://www.CensusScope.org/) Social Science Data Analysis Network, University of Michigan. www.ssdan.net.

A description...

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**Methods**

Data for this study was obtained from two sources: the U.S. Census Bureau and the Center for Disease Control; Broomfield County, Colorado, which is composed of parts of neighboring counties, and Clifton Forge City, Virginia, which is no longer recognized as a county were omitted from our spatial cluster analysis. Thirty-two of the thirty-nine independent cities of Virginia were also omitted but only in the construction of the maps.

Spatial analysis methods are generally divided into two groups global clustering analysis methods and local clustering analysis methods, where the former checks for overall clustering in a region and the latter is used to identify individual clusters (outliers) within the region (Waller., 2004). In this study, we employed the Modified Moran’s I test to check for global clustering of the colorectal mortality rate for the Hispanic/Latino, African American, and White populations across continental U.S. counties. We used colorectal cancer mortality rates by county instead of counts of colorectal cancer deaths by county to account for the differences that exist between counties in both size and population. We choose the Modified Moran’s I test over the generic Moran’s I test, Tango’s Index test, and Oden’s I test because other studies have found that it consistently has better performance given its higher power output, see (Jackson, et al., 2010). The Modified Moran’s I test affords us this extra power by capturing the variance within our data through the inclusion of a weight function in the computation the variance, which takes into account the “strength of the neighboring association” (Jackson, et al., 2010). We also used the SatScan spatial statistics software package to check for local clustering in our spatial analysis of colorectal deaths in the continental U.S. counties among our sample populations.

**Data**

County colorectal Mortality data and mean population data for African Americans, Whites, and Hispanics/Latinos for 2005-2007 was collected from the Center for Disease Control and Prevention. The population data was limited to people 50 years or older because this age group is more at risk for Colorectal Cancer. The data was then combined to create an average colorectal mortality rate for each county for 2005 through 2007 for each group.

Geographic Coordinates for all the counties in our study were collected from the U.S. Census Bureau. Coordinates from the 2000 Census U.S. Gazetteer Files were used because they were a concise match the counties included in the colorectal mortality rate data.

**Spatial Analysis**

Modified Moran’s I is defined as

and are the colorectal death rates at geographic location and , is the expected value computed using all the data, and is the total number of geographic units. The numerator of the equation is the double summation of the covariance between each data point and all points , except itself, multiplied by the weight function evaluated at the corresponding points. The denominator of the equation is the summation, between a given and all that are strictly indexed above it, of the difference of each and squared multiplied by the weight function.

The weight function is defined as,

This weight function is known as the population density adjusted exponential weight function. In this function, is the Euclidian distance between the geographical points and . The parameter can be set to small or large values and correspondingly “increases the sensitivity of the test to large or small clusters”. We choose a value of one after considering that this small value of would be sensitive to smaller clusters, which would enabling us to detect any possible clusters, not just large clusters. However, one can consider some other weight functions.

For our local clustering analysis in SatScan, we used a purely spatial Poisson-model based scan statistic using the sum of colorectal deaths that occurred from 2005 through 2007 as our study variable. The analysis was conducted by creating circles varying in size on a map centered about each geographical data point (Kulldorff, M., 1997). This process created a large set of circles of all sizes centered at different locations, all of which contained potential clusters. We chose to identify clusters using the null hypothesis that the expected number of cases in each circle was proportional to the population within the circle, and the alternative hypothesis was that the observed colorectal cancer mortality rate was significantly higher when compared to the expected rate given the population size( Kulldorff, M., 1997 ). We chose this alternative hypothesis because clusters with significantly low rates would be plentiful given the abundance of zero values in our data. We applied this analysis four times once each for our three sample populations and once more for the sum of all our sample populations together.

**Spatial Results**

Using the test statistic , we obtained a p-value, which we tested under the null hypothesis that data were not spatially correlated and the alternative hypothesis the data were spatially correlated. We applied this test three times using the R statistical analysis software, once for every one of our sample populations.

|  |  |  |
| --- | --- | --- |
| Population | Observed statistic | P-value |
| AfricanAmerican/Black | 0.008049096 | 0.00070049 |
| Hispanic/Latino | 0.00160395 | 0.4344432 |
| White | 0.0213275 | 0 |

Table . Observed Modified Moran's I with their corresponding p-value.

Table 1 lists resulting observed test statistic and p-value for Modified Moran’s I test on each of our study populations. Using a significance value of 0.05, there was significant evidence to indicate the existence of spatial correlation in the African American and White populations, but not enough evidence to suggest global spatial correlation in the Hispanic/Latino Population.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Most Likely Cluster for African American | Most Likely Cluster for Hispanics | Most Likely Cluster for Whites |
| Cluster Size | Small | Small | Large |
| Number of Cases | 107 | 21 | 48760 |
| Expected Cases | 0.059 | 0.092 | 46051.95 |
| Annual cases / 100000 | 317164.0 | 18276.1 | 151.3 |
| Observed / expected | 1804.51 | 227.51 | 1.06 |
| Relative risk | 1814.26 | 228.13 | 1.10 |
| Log likelihood ratio | 695.637979 | 93.091876 | 125.890991 |
| P-value. | < 0 | < 0 | < 0 |

Table . Local clusters (outliers) with high CRC mortality rates.

Table 2 lists the primary cluster, the cluster with the smallest p-value, for each population. Small clusters contain 1-5 counties, medium clusters contain 5-20 counties, and large clusters contain 20 or more counties. Small primary clusters were found for both the African American and Hispanic Populations, while large clusters were found for the white and combined population.

**Maps**

Using the software R, with the library maps, to create CRC mortality rate per 1000 people maps of all continental (Alaska, Hawaii, and Puerto Rico where not included) U.S. counties. We excluded thirty-two of the thirty-nine independent cities of Virginia because the maps we used did not distinguish them as separate counties. We also excluded La Paz, AZ and Menominee, WI because the mapping software did not recognize them as counties. Smoothed county and country rate maps were constructed using values provided by the CDC.

Figure . County Colorectal Death Rate of Hispanics, 2005-2007

Figure . County Colorectal Death Rate for African American, 2005-2007.

Figure .County Colorectal Death for Whites, 2005-2007.

Figure . U.S. smoothed colorectal cancer mortality rate disparites between hispanic and white (non-hispanic) from 2005-2007.

Figure . U.S smoothed colorectal cancer mortality rate disparities between African American non-Hispanic and white non-Hispanic from 2005-2007

Figure . US African American non-Hispanic smoothed colorectal cancer mortality rate difference between county rates and U.S Rates from 2005-2007.

Figure . U.S Hispanic Smoothed colorectal cancer mortality rate difference between county rates and U.S. rates from 2005-2007.

Figure . U.S. white non-hispanic smoothed colorectal cancer mortality rate difference between county rates and U.S. rates from 2005-2007.

The results of the Modified Moran’s I test indicated that global clusters existed in the African American population and the White population but not in the Hispanic population. These conclusions are supported by figures 3 through 5. Figure 5 shows clustering of the values ranging from 1-2 and 2-5 for the White population, where the former is prevalent in the west coast, parts of the east coast, and the latter is prevalent from the Midwest to the east coast. Figure 4 shows clusters for the values ranging from 2-5, and 5-20, where both rates are prevalent throughout southeast and part of the southwest, which are areas of the U.S. with the highest African American population density (see figure 2). Also, a cluster of values ranging from 0 to1 is visible in the west mountain area of the country, but can be explained by the fairly small density of the African American population in that area. Finally, Figure 3 seems to have a very small local cluster of values less than one in the southwest, but other than that has a heterogeneous mixture of rates throughout the country that precludes any global clustering pattern. The results of the Hispanic global clustering analysis is fairly surprising because we expected to clustering behavior in southwestern states due to the large concentration of Hispanic/Latino individuals in this area, much as we see it in the African American population.

Figures 3, 4, and 5 serve to further the argument that whites are at a lower risk of dying of colorectal cancer. The predominant trend of smaller rates of CRC mortality for whites across the United States was expected and serves as a stark contrast with the mortality rates of both the black and Hispanic populations which are riddled with significantly higher rates of colorectal mortality. Interestingly, Figures 3 and 4 seem to indicate that Hispanics suffer from higher colorectal mortality rates throughout the country than both Whites and African Americans because of the greater number of pockets with substantially high mortality rates. We must take into account that areas with very low rates generally surround these small pockets of high mortality rates for Hispanics while clusters of high rates exist for the African American population, which indicates that African Americans do in fact suffer from higher colorectal mortality rates throughout the country than both Whites and Hispanics.

After analyzing the results of our local cluster (outlier) spatial analysis, we found small primary clusters of high mortality colorectal cancer mortality rates for the African American population and the Hispanic population. Figures 3 and 4, which contain many dispersed, small, and isolated counties with very high colorectal cancer mortality rates support this result. In contrast, we found a large primary cluster for the White population, which indicated that clusters of high mortality colorectal cancer mortality rates existed in this population but only when considering very large areas, which was consistent with the dearth of isolated counties with very high CRC mortality rates in figure 5.

Figure 6 displays a significant difference between White and Hispanic CRC mortality rates in the southwest part of the country, which could indicate that Hispanics in this region are at a higher risk for CRC death than whites. Figure 7 displays a significant difference between white CRC mortality rates and African American mortality rates in the southeast and parts of the northeast, which could indicate that African American in these region are at a higher risk of CRC mortality than whites.

Figure 9 displays a significant difference between the smoothed Hispanic country CRC mortality rate and the smoothed county Hispanic CRC mortality rates in the southwest part of the country, which indicates that Hispanics in this region of the country are at a higher risk of CRC mortality than in most other regions. There appears to be a difference between the smoothed AA country CRC mortality rate and the smoothed county African American CRC mortality rates in the southeast and parts of the northeast in figure 8, which indicates that African American’s in this region of the country are at a higher risk of CRC mortality than in most other regions. These observations create a stark picture for both these populations because they seem to indicate that higher CRC mortality rates coincide with the regions of the country where the densities of these populations are the highest(southwest/east). It is also important to note that this trend does not hold true for the white population. Figure 10 shows that there is no significant difference between smoothed county and country CRC mortality rates for whites, and that the small differences that do exist do not vary geographically.

**Discussion**

In the current study, we examine geographic variation in racial/ethnic colorectal cancer mortality and the role, if any, of socioeconomic status. We are particularly interested in identifying geographic areas where (1) racial/ethnic disparities in colorectal screening mortality are highest for AA compared to NHWs and for Hispanics compared to NHWs and (2) where colorectal cancer mortality rates substantially differ from same race/ethnic group national rates (3) areas where race/ethnic specific mortality rates differ from U.S. rates. As Chandra et al. suggests racial differences due to geography have different policy implications than racial differences due to other causes such as patient preference, provider bias or financial barriers (Chandra et al., 2003).

Conducting a Moran’s I global cluster analysis on the counties CRC mortality rates for 2005-2007 and a purely spatial Poisson-model local cluster (outlier) analysis on the CRC mortality counts for 2005-2007. The results of these tests indicated the existence of global clusters in both the African American (AA) population and NHW population, as well as the existence of small primary clusters in the Hispanic and African American populations. In order to visualize these results we constructed various maps that plotted the CRC mortality rates in their corresponding county. We found that our maps matched our test results very well, given the clear clustering pattern found in the AA and NHW CRC mortality rate maps (Figures 4 and 5) and the lack of a pattern in the Hispanic CRC mortality rate map (Figure 3). We then constructed a series of other maps depicting the difference in smoothed CRC mortality rates between NHW, AA, and Hispanics (Figures 6 and 7); as well as maps depicting the difference between smooth county rates and smooth country rates of each population (Figures 8-10).

We limited our study to the continental U.S., which excluded many counties from other states, Alaska and Hawaii, in our study. We could further study these counties separately, and thereby further our geographic understanding of CRC mortality throughout the United States. We only used aggregate data for 2005 through 2007, which may have limited the scope of our analysis. It would therefore be of great interest to conduct this study using more recent data and compare both of the results to see the changes that have occurred over time, if any. Creating comparisons between our spatial study of CRC mortality rates and spatial poverty rates/income could give us a clearer indication of the spatial relationship between race, economic status, region of residence, and colorectal cancer mortality.

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