

6-2009

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Publication Info

Postprint version. Published in *Cancer*, Volume 115, Issue 11, 2009, pages 2539-2552.

Hébert, J.R., Daguise, V.G., Hurley, D.M., Wilkerson, R.C., Mosley, C.M., Adams, S.A., . . . Bolick-Aldrich, S.W. (2009). Mapping Cancer Mortality-to-Incidence Ratios to Illustrate Racial and Sex Disparities in a High-risk Population. *Cancer*, 115(11), 2539-2552.

DOI: 10.1002/cncr.24270

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The definitive version is available at:

<http://onlinelibrary.wiley.com/doi/10.1002/cncr.24270/abstract>

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Published in final edited form as:

Cancer. 2009 June 1; 115(11): 2539–2552. doi:10.1002/cncr.24270.

Mapping Cancer Mortality-to-Incidence Ratios to Illustrate Racial and Sex Disparities in a High-risk Population

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Abstract

Background—Comparisons of incidence and mortality rates are the metrics used most commonly to define cancer-related racial disparities. In the US, and particularly in South Carolina, these largely disfavor African Americans (AAs). Computed from readily available data sources, the mortality-to-incidence rate ratio (MIR) provides a population-based indicator of survival.

Methods—South Carolina Central Cancer Registry incidence data and Vital Registry death data were used to construct MIRs. ArcGIS 9.2 mapping software was used to map cancer MIRs by sex and race for 8 Health Regions within South Carolina for all cancers combined and for breast, cervical, colorectal, lung, oral, and prostate cancers.

Results—Racial differences in cancer MIRs were observed for both sexes for all cancers combined and for most individual sites. The largest racial differences were observed for female breast, prostate, and oral cancers, and AAs had MIRs nearly twice those of European Americans (EAs).

Conclusions—Comparing and mapping race- and sex-specific cancer MIRs provides a powerful way to observe the scope of the cancer problem. By using these methods, in the current study, AAs had much higher cancer MIRs compared with EAs for most cancer sites in nearly all regions of South Carolina. Future work must be directed at explaining and addressing the underlying differences in cancer outcomes by region and race. MIR mapping allows for pinpointing areas where future research has the greatest likelihood of identifying the causes of large, persistent, cancer-related disparities.

Other regions with access to high-quality data may find it useful to compare MIRs and conduct MIR mapping.

Keywords

epidemiologic methods-data collection; neoplasms by site; health status disparities; healthcare disparities; geographic information systems; incidence; mortality; continental population groups; South Carolina

In the US, as in most countries, both incidence and mortality are expressed per unit population (eg, typically per 100,000 population/year).¹ Incidence rates are sensitive to a variety of influences, especially efforts aimed at early detection (with concomitant down-staging of disease and at least temporary increases in apparent incidence).² Given a reasonable understanding of the relation between early detection, stage at diagnosis, and overall incidence,³ an incidence rate based on the overall population at risk over a specified period is a reasonable comparative parameter.

Cancer incidence rates often are cited to support claims of cancer disparities between subgroups within populations.^{4,5} Considerable heterogeneity exists in site-specific cancer incidence rates by race/ethnicity, and overall disparities are greatest among African Americans (AAs) compared with any other racial/ethnic subgroup of the US population.¹ Although incidence usually is greater among AAs, mortality rates typically diverge to a greater extent.^{6,7} These rate elevations tend to be more extreme (up to 50% higher for some cancers) in South Carolina than in other places in the US, indeed, even compared with other places in the world.⁷⁻¹⁵

Although mortality is a very sensitive indicator of disparities, without accounting for incidence it can be very misleading. High mortality can result from very poor survival in a cancer with moderate or even low incidence. By contrast, high mortality can result from even moderate survival in a very high-incidence cancer. Across populations and even within racial groups in different parts of the US, mortality does not track well with incidence for a variety of reasons related to screening/early detection, differences in treatment and follow-up, and the aggressive nature of certain cancers, especially hormone-sensitive cancers that are detected at early ages.^{5-7,16} For example, in South Carolina mortality per unit incidence is much higher among AAs than among European Americans (EAs) for both breast and prostate cancers; although the incidence of breast cancer is lower among AAs,¹¹ the incidence of prostate cancer is much higher among AAs.⁹ Both of these cancers tend to occur at younger ages in AAs than in EAs. Because preventing deaths must be an important part of any competent cancer prevention and control effort, the statistics described in this study address an important need: to describe mortality in relation to incidence.

The mortality-to-incidence ratio (MIR), which can be computed relatively easily from existing sources of data, may deepen our understanding of the factors that cause departures of mortality rates from expectations based on incidence. These factors may range from true biologic differences in the virulence of disease to health system-related attributes, including access to screening, diagnostic services, treatment, and follow-up. Despite the additional information that the MIR can convey, there are very few references in the literature to the use of this parameter in comparing cancer rates.¹⁷⁻²² Virtually none of those studies used population-based data from US registry sources.

In addition to providing an accessible indicator of survival by combining mortality and incidence, mapping of MIR allows for discerning differences in geographic regions wherein individuals may have particularly worse (or better) prognoses for a given cancer diagnosis. This enables researchers to target limited resources more efficiently by pinpointing areas in

which in-depth study can identify potentially modifiable causes of large, persistent, cancer-related disparities in disease virulence. To illustrate the utility of MIR mapping to highlight particular regions that evince extreme divergences in MIR by sex and race, we used the state of South Carolina, a geopolitical entity with extreme cancer disparities disfavoring AAs⁷⁻¹⁵ and with excellent sources of relevant data.

Materials and Methods

Definition of Race and Ethnicity

Although racial designations are far from perfect,²³ the epidemiologic evidence indicates consistently that race (geographic origin), rather than skin color, is related more strongly to known or suspected cultural and biologic determinants of cancer.^{4,24} The vast majority of blacks, both in the US and in South Carolina, are of predominantly African origin, and the vast majority of whites are of predominantly European origin.^{7,23} Therefore, in this report, we use the more specific, if still imperfect, terms “African American (AA)” and “European American (EA)” as the racial designators of choice.

Incidence Data

By law, incident cancers in South Carolina state residents are required to be reported to the South Carolina Central Cancer Registry (SCCCR). Housed within the South Carolina Department of Health and Environmental Control (DHEC) Office of Public Health Statistics and Information Services (PHSIS), the SCCCR was established in 1994 with funds awarded from the National Program of Cancer Registries (NPCR). In 1996, enabling legislation was passed by the South Carolina General Assembly, and data collection began. Both *in situ* (except for cervical cancers) and invasive cancers (except for basal and squamous cell skin cancers of nongenital sites) are collected from hospitals, pathology laboratories, freestanding treatment centers, and physician offices.

Currently, the SCCCR has data-sharing agreements with 20 states to ensure that the vast majority of incident cases are reported. Since its inception, the SCCCR consistently has received the highest (ie, gold) rating for data completeness (>97.5%), timeliness, and quality from the North American Association of Central Cancer Registries and the NPCR. Currently, 100% of all cancers (cases and deaths) are geocoded; 82% are coded to a point-level address that can be linked to information in approximately 25 datasets from other state data sources ranging from hospital discharges to death registration.

In situ cancers were excluded from the current analyses, which is the convention in comparing incidence rates. Patients with *in situ* (ie, noninvasive) disease would not be expected to die of that cancer. However, staging error is a possibility. This was of concern primarily for breast cancer. Because of this exclusion, an additional quality-control check was conducted on the incidence data to assure that exclusion of *in situ* cases did not bias the results. Therefore, the most currently available linked file (2001-2005 incidence file linked to 2001-2005 cancer mortality file) was used to determine whether any of the *in situ* cases matched after controlling for multiple primary tumors.

Mortality Data

Each state requires, by law, the registration of births and deaths. An estimated 99% of births and deaths are registered in the US. Yearly, the Divisions of Vital Registry and Biostatistics within the office of PHSIS, DHEC, provides cancer mortality data to the SCCCR for use in statistical analysis. The Vital Registry Division is responsible for providing vital information pertaining to births, deaths, marriages, and divorces occurring in South Carolina, whereas the Division of Biostatistics is responsible for registering, collecting, analyzing, and disseminating

all vital events that occur in South Carolina. Mortality statistics are based on information found on death certificates of South Carolina residents. Underlying causes of death are classified according to the *International Classification of Disease, Tenth Edition*. Interjurisdictional exchange agreements with all states are in place to capture out-of-state deaths of South Carolina residents.

South Carolina Department of Health and Environmental Control Regions 1 Through 8

The South Carolina DHEC has divided the state of South Carolina into 8 Health Regions for the purposes of administering health and environmental programs. The state is predominantly rural; the largest city, Columbia, has a population of only approximately 120,000. Each region is approximately 12.5% (or an eighth) the size of the state or approximately 4000 square miles. Within each region, offices provide local support to the public primarily through health clinics and environmental quality control, which includes air and water quality as well as land and waste management.

Although the Health Regions are defined administratively, they correspond to both ecologic zones and racial differences. For example, Regions 6 through 8 are located on a low, flat, coastal plain that consists of sandy soils.²⁵ AA representation is highest in the state, and the amount of European genetic admixture among AAs is the lowest in the state, especially in Regions 7 and 8,²⁶ which, in the 18th and 19th centuries, had the highest concentrations of rice and cotton cultivation in the US.²⁷ Although equally rural, Regions 3 through 5 represent the transitional zone in terms of soils (sandy to clay), topography (rolling hills), and intermediate levels of AA representation and European genetic admixture (not as low as the coastal areas but still much lower than the US average). Regions 1 and 2 represent the transition to the Piedmont. Soils in this hilly region tend to be rocky and claylike, agriculture tends toward fruit cultivation (eg, peaches), the economy is driven more by major automotive industries (eg, BMW and Michelin), and the lowest proportional AA population in the state has the highest level of European genetic admixture.²⁶

Calculated Measures: Mortality-to-Incidence Ratios and Their 95% Confidence Intervals

Age-adjusted incidence and mortality rates were calculated using incidence data from 2001 to 2005 in the SCCCR and mortality data from 2001 to 2005 in the DHEC Vital Registry. The MIRs were calculated as the age-adjusted mortality rate divided by the age-adjusted incidence rate for each cancer. These MIRs were computed for the 8 DHEC Health Regions representing South Carolina's 4.3 million residents by race and sex over all cancers and for the following solid tumor types: breast, cervical, colorectal, lung, oral, and prostate. MIRs also were computed for EAs in the US as a whole for all cancers combined and for the 6 cancer sites. Then, these MIRs were used to compare with race-, sex-, and Health Region-specific MIRs within South Carolina. In addition, we computed 95% confidence intervals (95% CIs) for race and, where appropriate, sex-specific MIRs by race for the state as a whole. The 95% CIs were calculated in R version 2.6.1 Patched statistical software package^{28,29} using methods proposed by Fay³⁰ for directly standardized rates (DSRs) with sparse data. This method uses F intervals, which approximate exact DSR intervals and are a function of the estimated means and variances of the DSR. The F intervals are different from exact DSR intervals (which assume a multiplicative Poisson model and may not be calculated using standard algorithms for exact tests) and generally are more conservative than other methods (eg, standard-log transformed, normal, approximated intervals; Cornfield intervals) but guarantee nominal coverage.

For the purposes of comparison in the maps, we defined 4 categories for all cancers, for each cancer separately, and for sex category when appropriate. The upper bound of Category 1 is the mean for EAs nationally (ie, for the US as a whole); the upper bound of Category 2 is 10% higher than the upper bound of Category 1, the upper bound of Category 3 is 20% higher than

the upper bound of Category 1, and Category 4 consists of MIRs >20% higher than the national mean for EAs (ie, above the upper bound of Category 3).

Mapping Mortality-to-Incidence Ratios

We used the SCCCR cancer incidence and Vital Registry mortality datasets with the calculated MIRs and determined categories in ESRI ArcGIS software (version 9.2). Standard ArcGIS mapping procedures were used to map all cancers combined as well as the following anatomic sites: breast, cervical, colorectal, lung, oral, and prostate. We used the ArcGIS software capability to contrast MIRs, by race and sex, shown for each of the 8 DHEC Health Regions in South Carolina in the accompanying maps.³¹

Results

For purposes of placing population centers in geographic context, we provide a map of South Carolina (Fig. 1). The state covers 31,113 square miles and has approximately 4.3 million residents. It is a relatively poor state with a median income only 81% of that for the US as a whole.³² Nearly 40% of the state is considered rural.³³ Compared with other states, a large proportion (approximately 31%) of the population is comprised of AAs, many of whom live in rural areas.^{33,34} A higher proportion of AAs than EAs live in rural areas, which is different from other places in the US (outside of the Southeast), in which AAs reside predominately in urban settings.^{33,34}

Our analyses of breast cancer cases diagnosed with *in situ* disease revealed that 10 such cases were identified for the 5-year period with a single primary tumor that was linked to a death from the same cancer type. These 10 cases were reviewed for staging accuracy by supporting records submitted from the hospital. Follow back to the hospital was performed if sufficient records were not available to support the stage. For these 10 cases, no further information could be gleaned that justified changing the disease stage. Because of this small number of *in situ* cancer deaths, we determined that they would not have a meaningful impact on the MIRs. All subsequent analyses shown here excluded data from cases diagnosed with *in situ* disease.

Table 1 shows the South Carolina MIRs and associated 95% CIs by race and sex for breast, cervical, colorectal, lung, oral cavity, and prostate cancers and for all cancer sites combined. For all cancers combined, EA women (MIR, 0.37) had the best survival in general, whereas AA men (MIR, 0.50) had the worst. The MIR differences between race groups for both breast and cervical cancers in women, for oral cancer in both sexes, and for prostate cancer in men were striking; ie, 55%, 50%, 85%, and 58% higher, respectively, among AAs than among EAs. Colorectal cancer MIRs were somewhat higher among AA women than among EA women (only 17%; ie, nonsignificantly higher) but were 26% higher among AA men than among EA men. Lung cancer, which was the most fatal of the 6 cancers that we analyzed, was associated with MIRs that were similar by race, although men with lung cancer had approximately 14.5% higher mortality, on average, than women with lung cancer.

The MIRs are shown by DHEC Health Region in Figure 2 for all cancers combined, in Figure 3 for colorectal cancer, in Figure 4 for oral cancer, in Figure 5 for female breast cancer, in Figure 6 for cervical cancer, in Figure 7 for prostate cancer, and in Figure 8 for lung cancer. In examining the data from Figure 2, there were large (>20% higher) racial differences for cancers as a whole in both sexes. AA men had a higher MIR than EA men in all but 1 region of the state. For women, the results were more striking, with at least a 2-category difference in 7 regions and a 3-category (ie, maximal) difference in 3 of the coastal and the upstate regions. In a pattern generally consistent with overall cancers, colorectal cancer (Fig. 3) evinced moderate to large differences by race. AAs in every region had higher MIRs than EAs; in 2 regions, the rates were 2 categories higher, and 3 regions evinced a 3-category difference.

In 1 inland region, EAs were in the highest MIR category for oral cancer (Fig. 4), whereas AAs were in the highest MIR category in all but 1 region in the state. Breast cancer (Fig. 5) exhibited some of the largest racial differences by region in terms of MIR, with AA women in 7 of 8 regions falling into the highest MIR category and EA women falling into the lowest category in 6 regions and into the second category in 2 regions. For cervical cancer (Fig. 6), 1 region (Region 8) had the lowest MIR for both races. However, for every other region, AAs had a higher MIR than EAs; and in 5 regions their MIRs fell into the highest category. The differences in the MIRs for prostate cancer (Fig. 7) were extreme, with AA MIRs in the highest category in 7 of the 8 regions and EA MIRs in the lowest category in 5 regions. For lung cancer (Fig. 8), the MIRs were higher for AAs in 4 regions, and no region had an AA MIR >20% higher than the equivalent EA MIR.

Discussion

It is well known that, for many cancer sites, both incidence and mortality rates are elevated in AAs compared with EAs¹ and that inter-racial differences tend to be more extreme in South Carolina.⁷⁻¹⁵ Comparing subpopulation-specific MIRs allows for greater insight by assessing mortality and incidence jointly. For example, breast cancer mortality-given incidence among AA women is >60% in excess of what we would predict based on incidence alone (compare the race-specific MIRs in Table 1.). Although prostate cancer is nearly 80% higher among AA men than among EA men¹, the mortality-given incidence is nearly 60% higher than among EA. Although this result supports earlier findings,^{1,11} such differences can be explored much more effectively using MIRs. In addition, this method provides a standard population-based approximation of survival by stabilizing the incidence and mortality differences across cancer sites and race groups. It does so without resorting to survival studies, which are expensive, time-consuming, and fraught with logistical difficulties concerning minority participation and patient follow-up.

We observed large differences in MIR by race for all cancers combined, for all of the sex-specific cancers (female breast, cervix, and prostate), for oral cancers in both sexes, and for colorectal cancers in men (Table 1). The size of the MIR differences observed by race is noteworthy. For example, the oral cancer MIR in AA men is approximately twice as high as it is in EA men (0.44 vs 0.23). This is a remarkable difference, in that it is larger in magnitude than the difference between what normally is considered a relatively poor prognosis cancer (colon: average MIR, approximately 0.37 in the US as a whole) and what is associated with an excellent prognosis (female breast: average MIR, approximately 0.20).¹ Consistent with the overall differences observed (Table 1), mapping of the MIR for these sites by sex and race revealed striking differences across the 8 DHEC regions for female breast, cervical, colorectal, oral, and prostate cancers and for all cancers combined.

The current results sharpen and deepen our understanding of patterns of mortality-given incidence. It is also noteworthy that they are consistent with known survival differences by cancer type, sex, race, and US region.¹ Although crude differences in these parameters have been widely reported in the literature,^{3-5,35,36} to the best of our knowledge, there have been no previous attempts to test mortality-by-incidence rate differences by race or to map them to geographic coordinates. Computing and comparing MIRs can deepen our understanding of the fate of individuals who are diagnosed with cancer. Mapping them in geographic space can highlight differences in general and for specific types of cancer (eg, by anatomic site, histopathologic grade) with respect to geographic region, sex, and race.

The racial differences by sex illustrated in our study reveal similar patterns to those observed previously in other South Carolina-based reports.^{7,15} Of the 4 race-sex combinations, AA men had the highest overall MIRs. In addition, based on their absolute rate of dying from cancer

(ie, the difference in MIRs based on subtraction), AA men have far worse cancer outcomes compared with their EA counterparts than AA women compared with EA women. This is likely because of a complex set of biologic and social differences, such as higher rates of poverty and diminished socioeconomic opportunity among AA men, who tend to be worse off by any measure—from income to incarceration, education, and a wide variety of health indicators.³⁷⁻⁴⁰ Although the proportional differences (ie, obtained by dividing the MIRs) often are larger by race among women (eg, for overall cancers, AA women have an MIR that is 26% higher than EA women, whereas AA men have an MIR that is 16% higher than EA men), the absolute MIRs almost always are higher in men than in women.

Although AAs tend to use less tobacco than EAs, and tobacco use among AA women is particularly low,^{7,41} relative differences in the MIR are the most extreme for oral cancer especially among men (1.91 times higher in AAs) but also among women (1.52 times higher in AAs). By using MIRs, we exert implicit control for incidence. For example, although oral cancer incidence rates are higher for AAs than for EAs,¹³ the MIR remains much higher for AAs across the state, reflecting more fatalities from these cancers among AAs (Fig. 4). This suggests that more powerful risk factors may be operative in the AA population or that effect modification functions differentially across the races. This is an important area for research, because we would expect that risk reduction in EA populations with tobacco cessation would differ from AA populations (it could be higher or lower). It also might point to some other factor (eg, diet) that is particularly important in AAs. MIRs for cervical cancer, which is another tobacco-related cancer, were equally discrepant except in Region 8 (Fig. 5).

Although mapping incidence and mortality data in this way cannot pinpoint causative or mediating factors or identify particular mechanisms responsible for these differences that are distributed differentially by geographic location, this method can be used to identify target areas for screening as well as areas for future research into both primary and secondary prevention of cancer. The MIR method has great utility in pinpointing specific places in need of timely, focused, additional attention (both for future study at the individual level and for the allocation of public health resources). For example, the Pee Dee, an area of extreme poverty contained in Region 4, had high MIRs for most cancers among AAs. This pattern also was observed in some of the central and north coastal areas (Regions 6 and 7). It was interesting that no consistent pattern of decreased MIRs was observed around urban centers where major hospital systems are located, such as Charleston (contained in Region 7), Columbia (contained in Region 3), and Greenville and Spartanburg (contained in Region 2). However, Greenville is close to Region 1, for which we noted anomalously low MIRs, especially for colorectal and cervical cancers, cancers for which screening is a form of primary prevention.

Future efforts might focus on comorbidities or environmental risk factors, including such spatially distributed variables as pollutant exposures and characteristics of the built environment (eg, local access to locations for physical activity or food outlets). These environmental exposures could be assessed at the individual level (eg, residential distances to food outlets or pollutant exposure levels) or at the aggregate level (eg, census tract) and combined with behavioral and health status indicators collected from individuals (perhaps including disease-free individuals enrolled as part of a cohort based in high-risk areas). Individual-level variables might include risk factors such as diet and physical activity as well as those related to the use of preventive procedures (eg, screening) and cancer treatment. Because South Carolina is a very rural state with relatively low literacy and high rates of poverty,³²⁻³⁴ these factors may be strongly operative and, thus, need to be taken into consideration. The ability to map cancer incidence and mortality across a variety of factors that are distributed differentially in space and with an ability to link to individual-level information creates considerable scope for both defining and solving the problem.

Strengths and Weaknesses

Selection bias often affects population-based studies. For this study, virtually the entire population is represented. Cancer incidence data provided by the SCCCR is excellent, with an estimated >97.5% of all incident cancers captured. Information on mortality used to compute the MIR and the ability of the SCCCR to geocode this information also are excellent, with all cases geocoded and >80% of these mapped to patient point-level addresses. In and out migration of cancer patients is minimal and is not particularly problematic for computing these MIRs. In addition, we were able to combine multiple years of data (2001-2005) to produce MIRs that were more stable than had we been constrained to using only a few years previously in areas with smaller sample sizes and higher levels of in and out migration.⁴²

High MIRs may be explained by deficiencies in early detection that leads to up-staging of disease.^{3,19} The high incidence rates for most cancers argue against this as the driver of very high MIRs in AAs. According to the 2006 Behavior Risk Factor Surveillance System, 86.8% of women in South Carolina reported having had a Papanicolaou test within the past 3 years, approaching the Healthy People 2010 goal of 90%.⁴³ With a 2006 mammogram screening rate of 74.5% for women in South Carolina aged >39 years, the Healthy People 2010 goal of 70% for screening within the past 2 years was surpassed. Among men aged ≥40 years, 56.3% reported having had a prostate-specific antigen measurement in the past 3 years. Although there is no Healthy People 2010 goal regarding prostate-specific antigen measurements, this figure is slightly higher than the US rate of 53.5%.^{43,44} These findings are consistent with South Carolina's intensive efforts aimed at broad-based screening for common cancers, such as breast, cervical, and prostate cancers. In addition, screening rates were very similar by race,⁹⁻¹¹ and recent data indicate that screening explains only a portion of survival differences in Surveillance, Epidemiology, and End Results data.⁴⁵

Cancers of all sites have a natural variability in both occurrence and mortality in different years, and this may have an impact on the precision of the MIRs. Most individuals who are diagnosed with cancer do not die of their disease. Those who do die survive for a wide variety of times. Therefore, no simple relation exists between the denominator represented by cancer incidence and the numerator represented by cancer-specific mortality. Therefore, some simplifying assumptions were needed to compute the MIR. Despite its deficiencies, it must be kept in mind that the MIR can be computed relatively easily from existing sources of relatively complete data. The alternative would require conducting survival studies, most likely in the context of extremely large cohorts that are expensive, time-consuming, and methodologically difficult.⁴⁶ Because of issues related to access and selection, these kinds of studies have an inherent bias that results in excluding the economically disadvantaged individuals who were identified using the MIR approach as being at very high risk of dying from cancer.⁴⁷

In conclusion, the results from this study, taking advantage of South Carolina's excellent data resources, describe a striking elevation in MIRs for most cancers among AAs compared with EAs in nearly all regions of the state. The ability to link across geocoded datasets creates remarkable scope for conducting analyses that can lead to understanding the causes of large racial disparities in cancer mortality. Future work might entail performing analyses at smaller levels of aggregation, perhaps at the individual level, to understand why AAs have such high rates of mortality after they are diagnosed with one of these common cancers. We encourage other states and geographic entities to conduct similar sorts of descriptive analyses. Understanding the causes of increased mortality from cancer is critical if we hope to end these cancer-related disparities that are so starkly evident using the MIR method.

Acknowledgments

Supported by the National Cancer Institute, Center for Research and Cancer Health Disparities (Community Networks Program) to the South Carolina Cancer Disparities Community Network (1 U01 CA114601-01); the South Carolina Central Cancer Registry, funded by the Centers for Disease Control and Prevention National Program of Cancer Registries (U55CCU421931); and the South Carolina DHEC.

We thank Dr. Heather Brandt for her careful review of the article.

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Map of South Carolina showing Roads and Cities

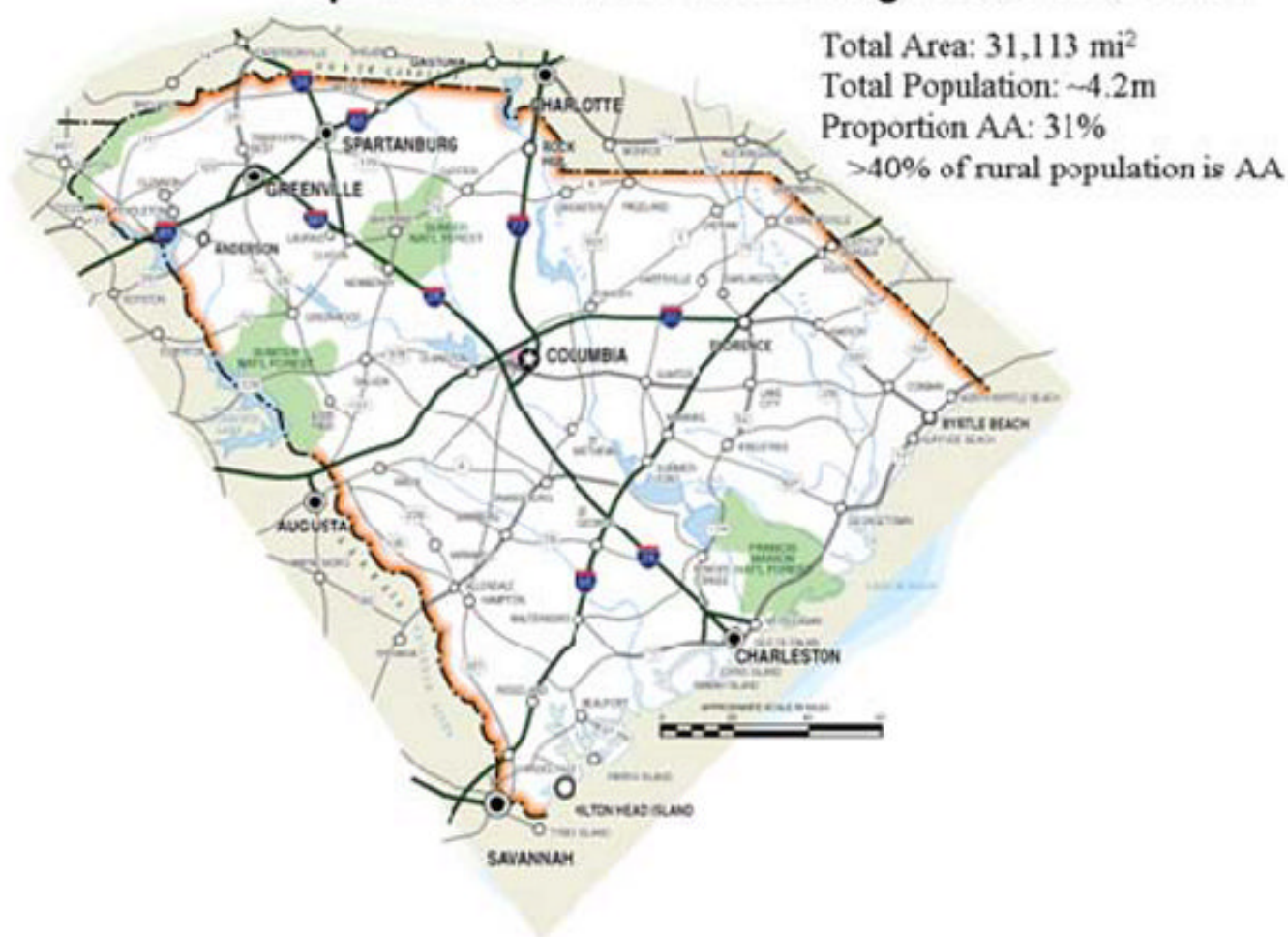
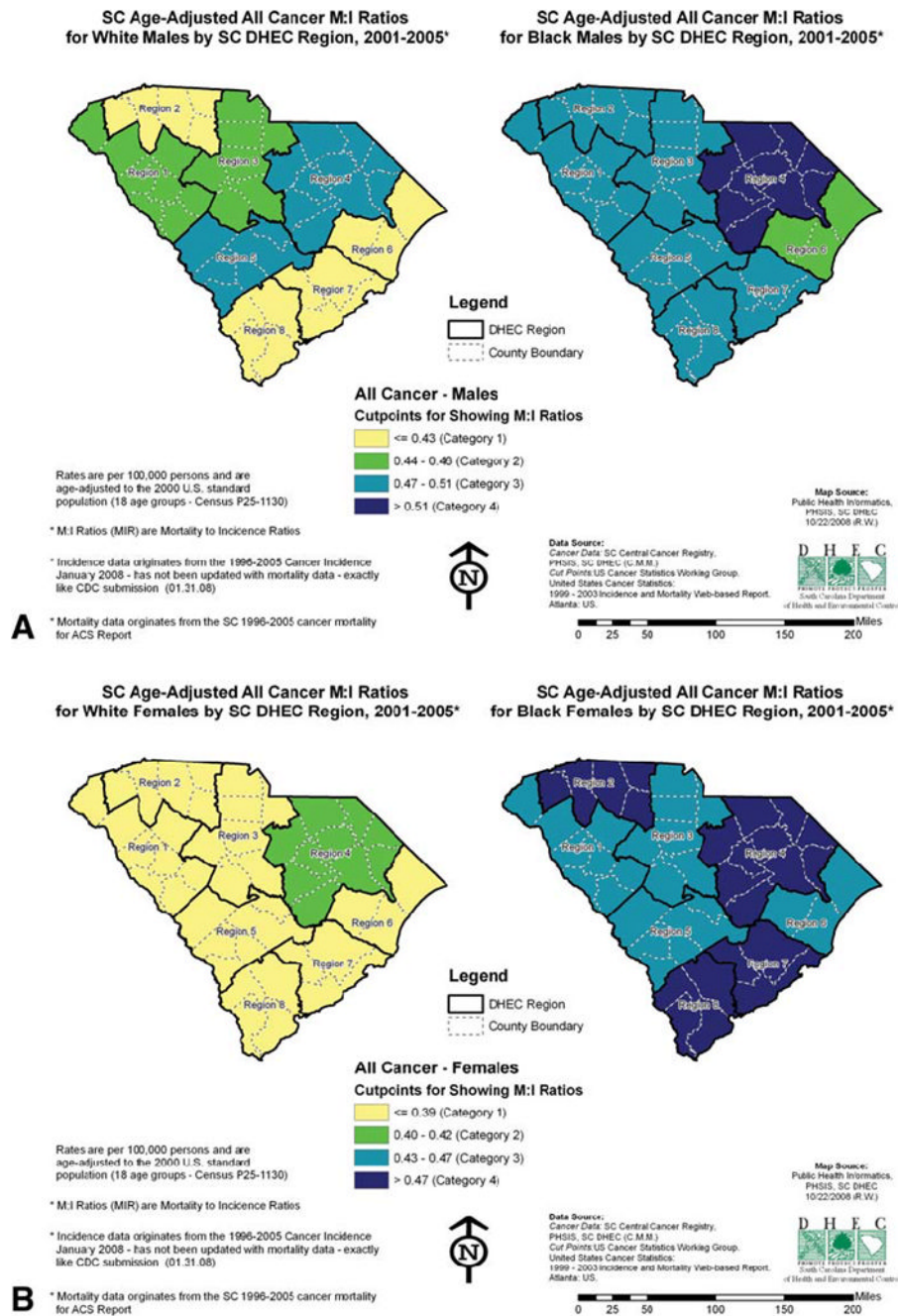


FIGURE 1.

Population centers shown in geographic context. AA indicates African American.

**FIGURE 2.**

Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for all cancers combined in (A) males and (B) females. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

SC Age-Adjusted Colorectal Cancer M:I Ratios for Whites by SC DHEC Region, 2001-2005*

SC Age-Adjusted Colorectal Cancer M:I Ratios for Blacks by SC DHEC Region, 2001-2005*

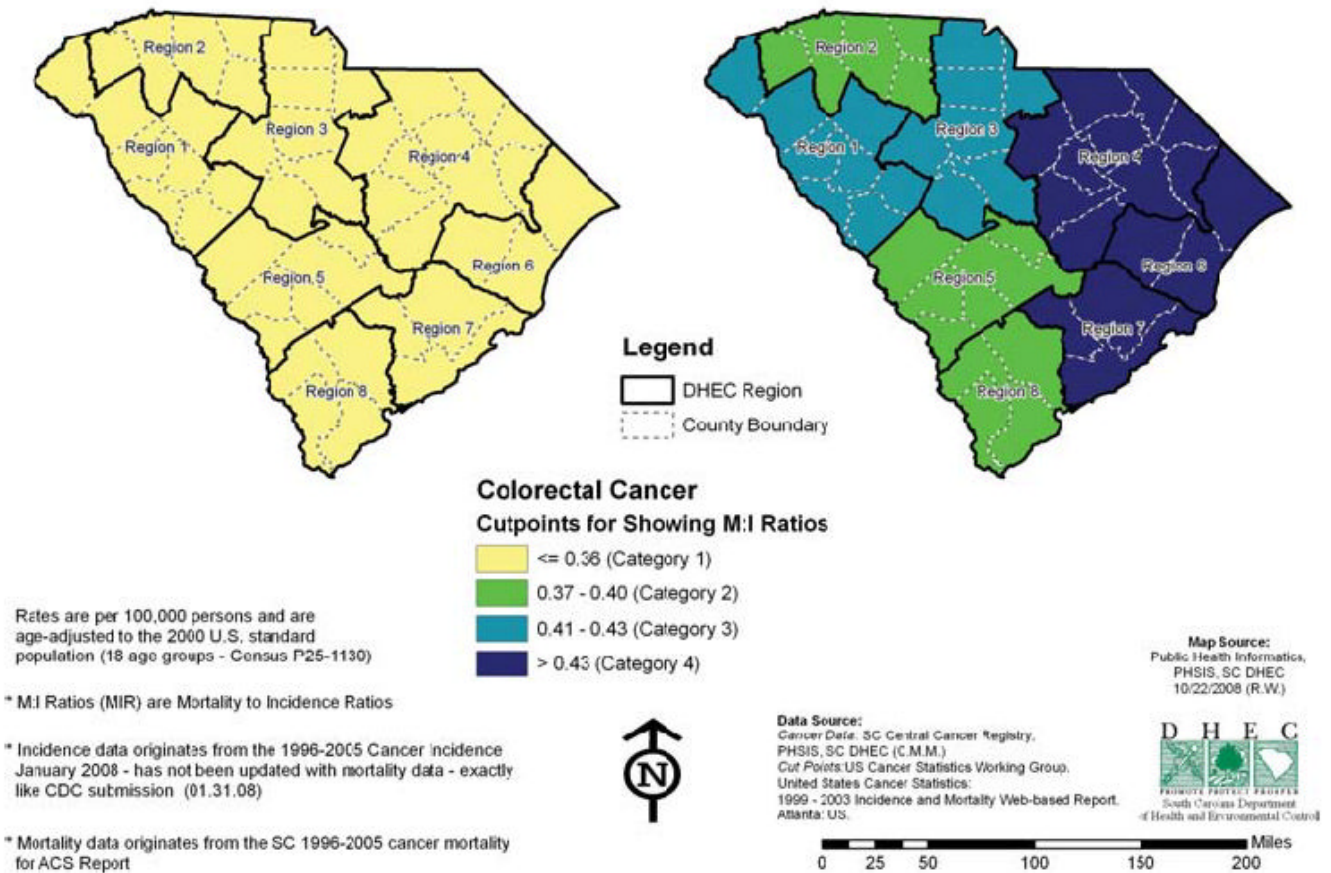


FIGURE 3.

Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for colorectal cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

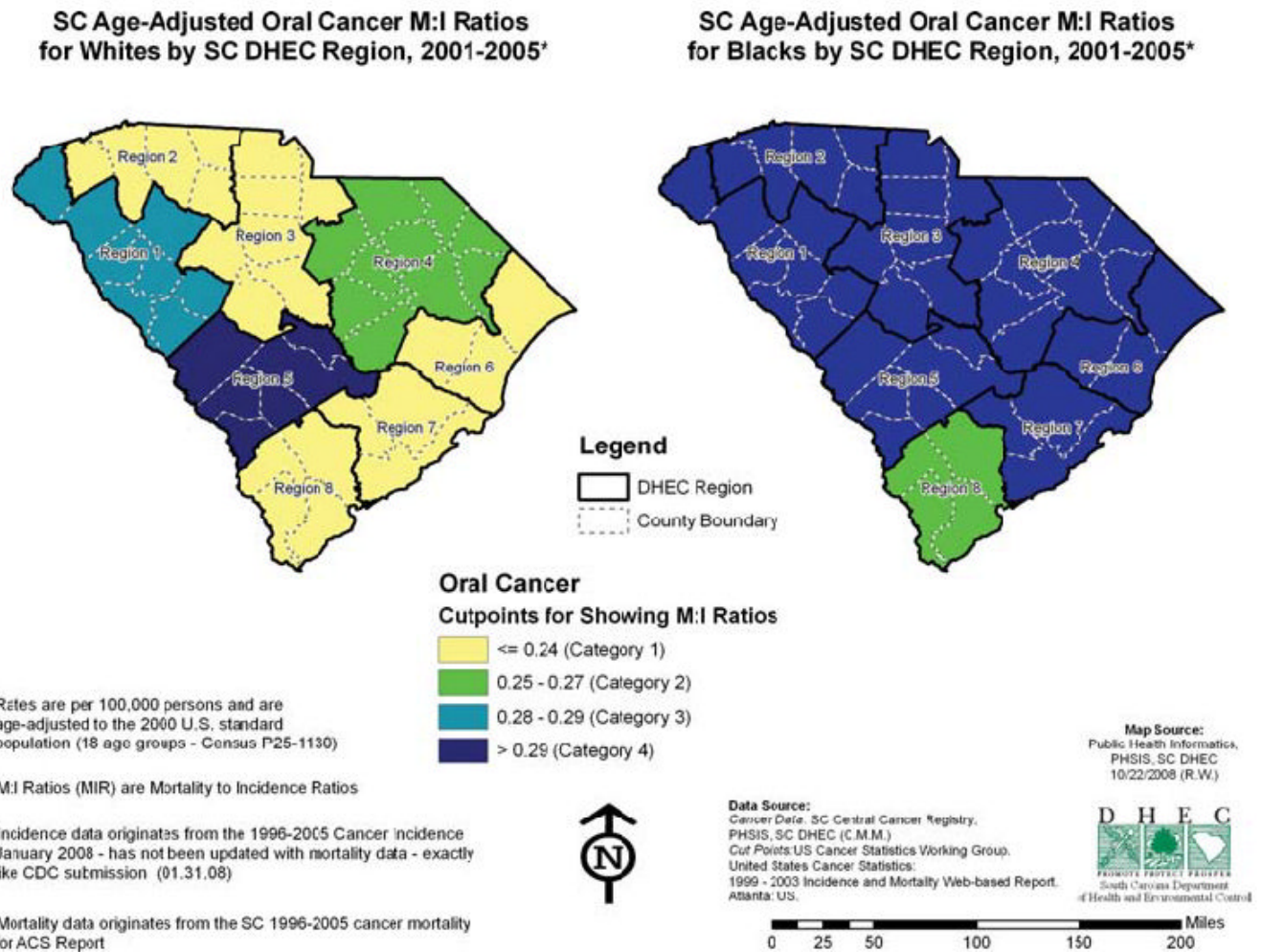


FIGURE 4. Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for oral cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

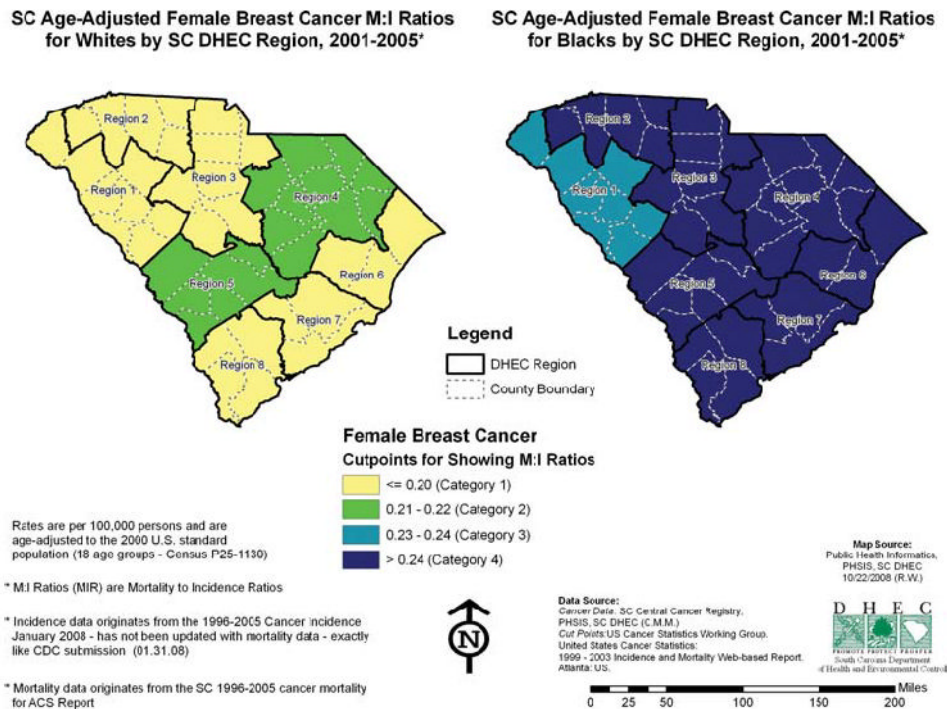


FIGURE 5. Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for female breast cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

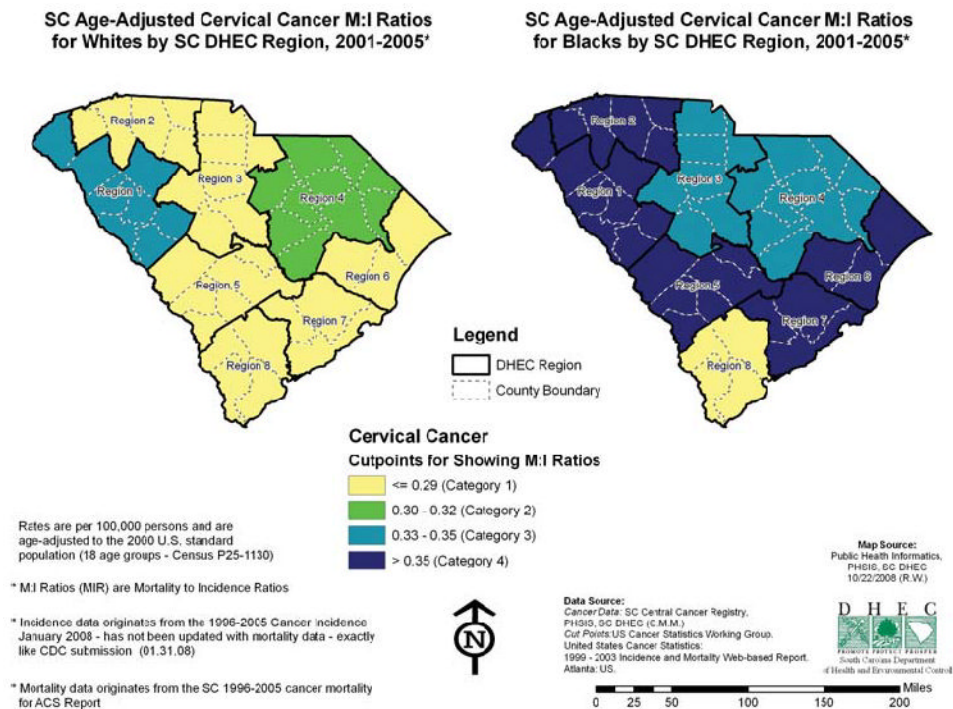


FIGURE 6. Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for cervical cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

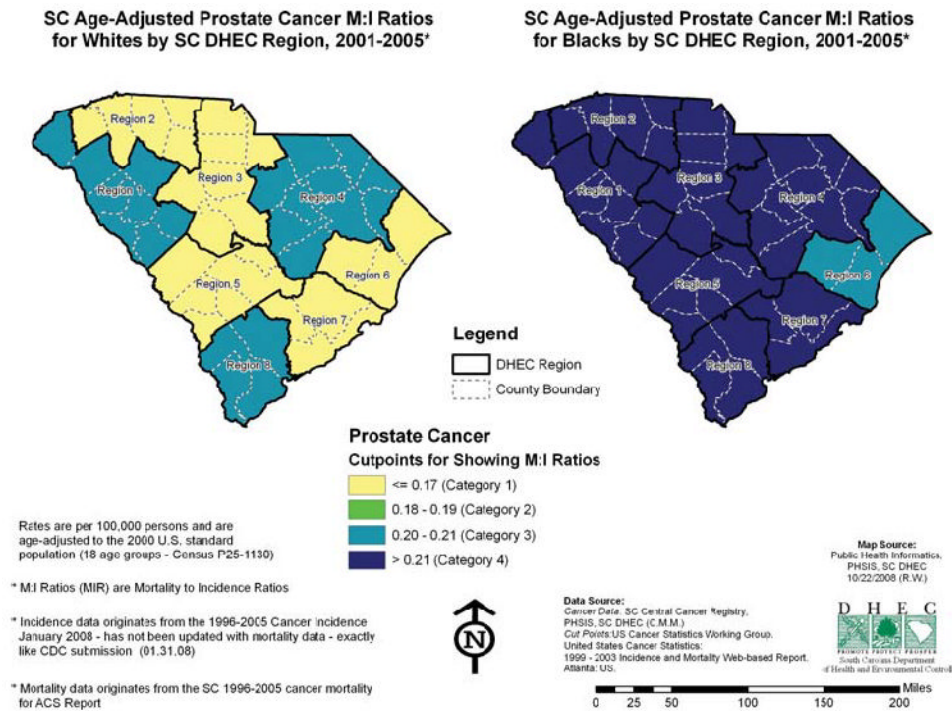


FIGURE 7. Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for prostate cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

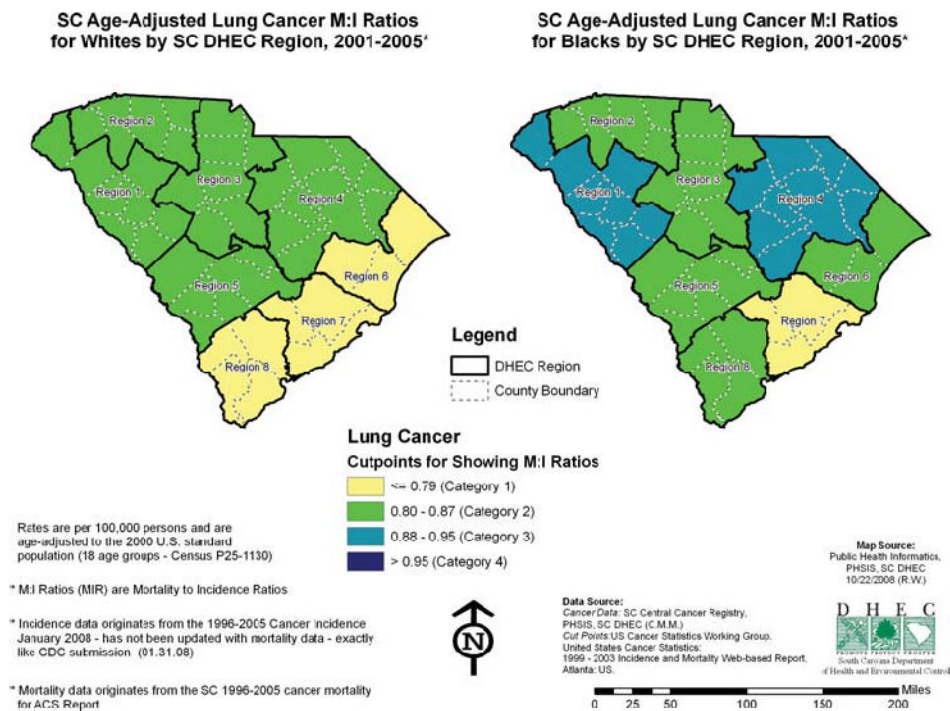


FIGURE 8. Mortality-to-incidence (M:I) rate ratios by South Carolina Department of Health and Environmental Control (SC DHEC) Health Region for lung cancer. CDC indicates Centers for Disease Control and Prevention; ACS, American Cancer Society; PHSIS, Public Health Statistics and Information Services; C.M.M., Center for Medicare and Medicaid Services.

Table 1

South Carolina Mortality-to-Incidence Ratios and 95% Confidence Intervals for All Cancer Sites Combined and Specified Cancer Sites by Race and Sex, 2001-2005

Cancer Site	Blacks (African Americans)*		Whites (European Americans)*	
	MIR	95% CI	MIR	95% CI
All cancer sites combined [†]	0.479	0.468-0.490 [‡]	0.400	0.395-0.405 [‡]
Women [†]	0.470	0.454-0.486 [‡]	0.373	0.366-0.381 [‡]
Men [†]	0.499	0.484-0.515 [‡]	0.430	0.422-0.438 [‡]
Breast ^{†,§}	0.292	0.271-0.314 [‡]	0.188	0.179-0.197 [‡]
Cervix ^{†,§}	0.410	0.335-0.500 [‡]	0.273	0.228-0.325 [‡]
Colon/rectum (overall)	0.418	0.390-0.447 [‡]	0.344	0.330-0.360 [‡]
Women	0.395	0.359-0.435	0.337	0.316-0.359
Men [†]	0.442	0.400-0.488 [‡]	0.352	0.331-0.375 [‡]
Lung (overall)	0.838	0.795-0.882	0.807	0.786-0.829
Women	0.775	0.708-0.848	0.760	0.729-0.793
Men	0.880	0.824-0.940	0.848	0.818-0.878
Oral cavity (overall) [†]	0.414	0.359-0.476 [‡]	0.224	0.201-0.250 [‡]
Women [†]	0.346	0.247-0.480	0.228	0.186-0.279
Men [†]	0.436	0.371-0.513 [‡]	0.225	0.197-0.257 [‡]
Prostatey ^{†,}	0.259	0.241-0.277 [‡]	0.164	0.155-0.174 [‡]

MIR indicates mortality-to-incidence ratio; 95% CI, 95% confidence interval.

* The terms black and white are used in cancer registration; these are for South Carolina as a whole.

[†] A statistically significant difference was observed in the MIR between African Americans and European Americans.

[‡] Nonoverlapping 95% CI.

[§] Women only.

^{||} Men only.