

CANCER MORTALITY

Cancer has been the second leading cause of death in the United States since the 1930s but it is now almost tied for first with heart disease. Cancer mortality rates began to decrease sometime around 1993, [figure 1.1](#) (*Cancer Trends Progress Report* National Cancer Institute, 2007) but the proportional share of cancer mortality in relation to other leading causes of death has been increasing, as heart disease and stroke death rates have fallen at a faster pace. According to *Health US, 2007* (National Center for Health Statistics, 2007), cancer mortality has increased 16% since 1980, from 20% of all US deaths in 1980 to 23.2% in 2004. In contrast, the proportion of those dying from heart disease has fallen by 32%, from 39.7% of all deaths in 1980 to 27.1% in 2004. The same pattern is observed in North Carolina, Eastern North Carolina (ENC), and the remaining 59 counties of North Carolina (RNC).

CANCER MORTALITY

[New patterns emerge](#)

[Progress towards Cancer Mortality Reduction](#)

[Spatial Distribution of Mortality Due to Malignant Neoplasms](#)

[Analysis by gender and race](#)

[Temporal Distribution of Cancer Mortality from All Causes](#)

MORTALITY FROM CANCER OF THE TRACHEA, BRONCHUS, AND LUNG

[Progress towards TBL Cancer Mortality Reduction](#)

[Spatial Distribution of Mortality Due to TBL Cancer](#)

[Analysis by gender and race](#)

[Temporal Distribution of Mortality from Cancer of the Trachea, Bronchus, and Lung](#)

MORTALITY FROM CANCER OF THE COLON, RECTUM, AND ANUS

[Progress towards CRA Cancer Mortality Reduction](#)

[Spatial Distribution of Mortality Due to CRA Cancer](#)

[Analysis by gender and race](#)

[Temporal Distribution of Mortality from Cancer of the Colon, Rectum, and Anus](#)

MORTALITY FROM CANCER OF THE FEMALE BREAST

[Progress towards Female Breast Cancer Mortality Reduction](#)

[Spatial Distribution of Mortality Due to Female Breast Cancer](#)

[Temporal Distribution of Mortality from Cancer of the Female Breast](#)

MORTALITY FROM CANCER OF THE PROSTATE

[Progress towards Prostate Cancer Mortality Reduction](#)

[Spatial Distribution of Mortality Due to Prostate Cancer](#)

[Temporal Distribution of Mortality from Cancer of the Prostate](#)

CONCLUSION

REFERENCES

Between the years 1980 and 2004, the percentage of cancer deaths in North Carolina increased by 14%. Similar increases were seen for the two major regions of the state: 18% for ENC and 12% for RNC. To contrast, the state percentage of mortality due to heart disease decreased by 33%, while ENC fell by almost 30% and RNC more than 34%. These figures all point to a gradually shifting mortality pattern, with implications for present and future health resource planning, financing, clinical therapeutic and preventive services, in addition to public health education concerning risk reduction and health behaviors.

For the years 2000 to 2004, the average percentage of deaths attributable to cancer was 22.4% in North Carolina, while average percentage for heart disease mortality for this period comprised 25.9% of all deaths. During these years, ENC experienced 110,390 deaths, with malignant neoplasms accounting for 22.3% of these deaths and heart disease mortality accounting for

26.7%. At the same time in RNC, 249,278 people died, with 22.4% from all types of cancers and 25.5% from heart disease.

Between ENC and RNC, there is little difference in death rates from cancer when unadjusted for age structure. However, a substantial disparity results when rates are age-adjusted. RNC's 5-year (2000-2004) age-adjusted rate is 866.1 deaths per 100,000 people and ENC's rate is 972.2. This translates into a rate differential of 110.1. In other words, if ENC had the same population age structure and age-adjusted rate as RNC, the region would have experienced a comparable 2,685 fewer deaths from cancer over the five year period. The analyses below will reveal significant geographical disparities in excess deaths for some population groups and types of cancer.

There are many sites in the body where cancer can occur, ten of which account for two-thirds of all cancer deaths, and four of which account for more than half. [Figure 4.1](#) shows proportions (percentages) of cancer deaths attributed to each of the four leading causes in ENC from 2000 to 2004. Nearly a third (30.5%) of the 24,622 deaths is attributable to cancer of the trachea, bronchus and lung. A distant second in this group is cancer of the colon, rectum, and anus at less than a tenth (9.5%) of all ENC cancer deaths. The third and fourth ranks go to female breast cancer and prostate cancer at 7.6% and 6.0%, respectively. The last six of the top ten sites of cancer account for 26% of all cancer deaths. Pancreatic cancer leads this latter group in fifth place with 1,308 deaths comprising 5.3% of all cancer deaths. Virtually equal numbers of people died of leukemia and Non-Hodgkins lymphoma, 820 and 824, both holding a respective sixth and seventh place with shares of 3.3% of total cancer deaths. In eighth place is ovarian cancer (2.3%) with 562 deaths, followed by cancer of the liver (2.2%) with 532 deaths, and in tenth place stomach cancer (2.1%) with 511 deaths. Beyond tenth place, lies cervical cancer mortality. This cancer, although accounting for only 0.7% of cancer deaths in the east, is largely preventable. Nevertheless it killed 187 women in the region between 2000 and 2004.

New patterns emerge

A new pattern of mortality is emerging in the first decade of the 21st century. This change becomes evident in the 1990s (see [figures 1.1, 4.2a, and 4.2b](#)). Regionally, we can see how this transition and potential reversal in a long term mortality pattern may play out. Cardiovascular diseases (particularly heart disease) have long been the number one cause of death through the United States. This has also been true for the regions of North Carolina. For example, while ENC's population has grown by almost 35% from 1980 to 2004,¹ heart disease killed only 128 more people in 2004 (5,450) than it did in 1980 (5,578). In contrast, 2,139 more people died from cancer in 2004 (5,128) than in 1980 (2,989). Over the same period—keeping in mind population growth, RNC experienced an absolute decline of 162 deaths due to heart diseases; from 12,129 in 1980 to 11,967 in 2004. Like ENC, there was an increase of 4,599 deaths due to cancers in RNC (6,709 deaths in 1980 and 11,308 deaths in 2004). The dynamics underlying the contrasting changes in the number of people dying from both diseases is related to many factors. They include changes in risk behaviors (e.g., smoking cessation and diet), education, prevention screening, improvements in surgical techniques, follow-up care, and demographic changes such as the in-migration of populations a significant proportion of their lives in lower-risk source areas. A less obvious demographic component is the change in the arithmetic relationship between heart disease and cancer deaths. Increased survivorship of those with heart disease allows increased exposure of death from other causes, namely cancers that develop later in life. Hypothetically, this scenario would create an upward pressure on cancer rates that could counterbalance normally efficacious rate reduction efforts. This transition and relationship

¹Populations were obtained from "Log into North Carolina" (LINC) at <http://linc.state.nc.us> (accessed Nov. 29, 2008). From 1980 to 2004, RNC's population increased by more than 50%. ENC's population in 1980 made up 31.4% of the state's population with its share decreasing to 29.4%. The relative share of ENC's population to the state has been decreasing since 1790, when the region comprised more than 50% of the state's population. See http://www.ecu.edu/cs-dhs/chsrd/atlas/upload/01_Atlas_ENCShareStatePopulation.pdf for a graphic depiction of ENC's relative population decrease over 210 years.

between these two chronic diseases is a narrow analogue to the Epidemiologic Transition Model (Omran, 1977; Omran, 2005).

For a closer look at the new emerging pattern, [figures 4.2a](#) and [4.2b](#) compare the temporal trends of heart disease and cancer mortality for ENC and RNC in relation to the US. [Figure 4.2a](#) shows crude mortality rates for both diseases from 1979 to 2007 (for the US, 1900 to 2005). For both regions, the initial rates for heart disease and cancer are both significantly lower than the US and similar to one another. As the years advance from 1979 the heart disease mortality rates for ENC converges and closely matches the declining rates for the US, while for cancer, the ENC rates begin to exceed the US rates in the mid 1990s. For the next 10 to 12 years the slightly higher mortality rates in ENC exhibit little change as heart disease mortality for the region continues its decline. As of 2007, the two rates for ENC have not yet converged. The cancer mortality rates for RNC remain very close to the rates for the US, declining in the mid 1990s, while the region's heart disease mortality rates remain lower than the US rates with a sharper decline beginning around the year 2001. By 2006 both RNC rates have converged. These crude rates, while not taking into account regional population age-structure, illustrate that the regional burden of mortality due to heart disease is giving ground to the burden of cancer mortality.

More direct comparisons of mortality rates between the two areas can be made when age-adjustment is made. [Figure 4.2b](#) again compares the rates of mortality for heart disease and cancer between the two regions showing little difference from the previous chart except that the mortality rates for heart disease in ENC are continuously higher than the nation's as are the rates for cancer mortality. The latter rates do show a slight decline from the mid-1990s and it appears that convergence between the region's two rates will occur sometime in the near future. Convergence has already occurred (2006) between the two rates for RNC. The observed temporal trends for both rate types strongly suggest that a new mortality regime is beginning to emerge.

Progress towards Cancer Mortality Reduction

The *Healthy People 2010* (U.S. Department of Health and Human Services, 2000) target objective for all-sites cancer mortality is 159.9 age-adjusted deaths per 100,000 people. The two regions mapped in [figure 4.3](#) illustrate how far counties in the east and the rest of the state have to go to meet the objective, based on the recent 5-year rate for all-site mortality. The only county to achieve the target rate objective is Watauga, located in the western Mountain region of the state. If the current trend holds, ENC as a region is projected to reach the target around the year 2023, RNC in the year 2018, and the US in 2017 (see [figure 4.8](#)). If ENC's rate had already achieved the target objective, 5,910 age-adjusted deaths would have been spared during the years 2000 to 2004. Thus far, no counties in the east have surpassed or achieved the target objective during these years. In fact, all ENC counties are more than 10% above the target. Of these, the lowest rate counties are Brunswick, Chowan, Johnston, Jones, New Hanover, Pamlico, and Pender for a combined total of 4,744 deaths, representing slightly more than 19% of ENC's mortality attributed to some form of cancer. If these counties, with the best rates in the region, had achieved the target rate, 840 cancer deaths would have been averted. Six ENC counties: Bertie, Camden, Edgecombe, Hertford, Hoke, and Tyrrell have rates that are more than 30% higher (the highest category) than the target rate. These counties experienced a total of 1,716 deaths or slightly less than 7% of regional cancer deaths. If these counties had the target rate during the 5-year study period, 565 fewer deaths (or 2.3% of the regional total) would have occurred.

Spatial Distribution of Mortality Due to Malignant Neoplasms

The study of mortality in their regional contexts is useful for understanding large scale (i.e., historical or secular) differences in the geographic patterns of death. Different spatial patterns in mortality are most likely the result of different underlying processes stemming from demographic,

socio-economic, health behaviors, and relevant risk factors. To illustrate, [table 4.1](#) contains summary rates for several different regions of North Carolina and the United States. (Rates for the rest of the states have been calculated using data for 2002 and are found in [appendix X](#)) The 2002 age-adjusted mortality rate for malignant neoplasms in the United States was 193.5 per 100,000 people. This compares to the ENC age-adjusted 5-year mortality rate (with 2002 as the median year) of 210.4--9.7% more than the national rate. ENC's 2002 age-adjusted mortality rate ranks 46th of all 53 states and regions in [appendix X](#). Kentucky had the highest state rate for the single year 2002. Utah's age-adjusted rate was the lowest for the nation in 2002 at 143.5, 25.8% less than the US age-adjusted rate and 31.8% lower than ENC's. If ENC had Utah's demographic characteristics and 2002 rate, it would translate into more than 7,800 eastern North Carolina lives being spared from 2000 to 2004. If age structure is not controlled, a similar comparison of the observed death rates (i.e., crude death rates) would yield a more dramatic difference of 12,232 lives. (Utah's 2002 crude death rate is 101.6 and ENC's 2000 to 2004 crude death rate is nearly double that at 201.9.) These large scale comparisons show that the patterns of mortality over geographic space are not uniform. Processes operating in space and time exert influence on mortality patterns—where a person lives, and for how long, will have an effect on how he or she dies.

In ENC, approximately one out of every 495 individuals died from cancer during the years 2000 to 2004. This compares not unfavorably to the US value for 2002, with one out of 517 individuals dying from cancer. Within ENC, these ratios range from one cancer death out of 319 people in Tyrrell County to one in 825 dying from cancer in Onslow County over these five years. This is the observable death from cancer experience for these counties at its most rudimentary level. Chances are that if you lived in Tyrrell County from 2000 to 2004 you were 2.5 times more likely to know someone who had died from some form of cancer than if you lived in Onslow County. This county, with a 2002 median age of 24.4, possesses a large young population, whereas Tyrrell County has a significantly older population, with half of the county over the age of 39.4.² As populations age, their susceptibility to chronic diseases and mortality increases. As heart disease continues to recede from being the leading cause of death in ENC the ratio of those dying from cancer to the general population will continue to increase.

The number of people in ENC who died from cancer during years 2000 to 2004 is equivalent to the city of New Bern's entire estimated population for the year 2004 (24,761)³. Approximate figures describing the magnitude and impact of cancer mortality on regional mortality can be derived from [table 4.1](#) and [figure 4.4](#). The map of crude mortality at the top of the figure has 10 counties classified into the highest rate category. Together, these counties comprise a little more than 8% of the region's population but account for 11% of all deaths (2,812) due to cancer. This translates into 853 more deaths than can be expected by the size of the population. When the age structure of the population is controlled, the mortality picture changes slightly: the 15 counties in the highest category account for nearly 24% of the region's population and produce almost 27% of its observed cancer mortality (6,552), translating into 887 excess deaths.

The societal burden of cancer death is most appropriately measured by crude mortality rates, listed in [table 4.1](#) and shown in the top map of [figure 4.4](#). The burden is concentrated geographically in the northern third of ENC. The greatest burden is experienced by Tyrrell County at 313.2 with 65 cancer deaths. The highest crude mortality rate with substantially more deaths is found for Northampton County at 297.3 per 100,000—based on 325 cancer deaths in five years. If Northampton County had the same crude rate as ENC (201.9), then approximately 105 fewer individuals would have died from a malignant neoplasm. Onslow County has the least cancer mortality burden with 907 deaths producing a rate of 121.2 deaths per 100,000. If ENC had experienced the same cancer mortality rate as Onslow County over the same time period,

² Median ages were obtained from North Carolina State Data Center's website: <http://demog.state.nc.us/>, accessed on February 27, 2008.

³ Municipal populations were obtained from North Carolina State Data Center's website: <http://demog.state.nc.us/>, accessed on February 29, 2008. Municipal populations are interpolated between the years 2000 (April 1) and 2006 (July 1).

then more than 9,840 lives would have been spared from cancer. It should be recalled that the unequal excess cancer mortality for counties and regions is a function of their differences in age-structure. Counties with younger populations (e.g., Onslow) will tend not to experience the accumulated mortal effects of chronic diseases—a stark contrast to places found in the northern part of ENC. When age-structure is controlled, regional and county rates and their differential mortality become more comparable (the effects of race are discussed below). The geographic distribution of rates can also shift, as can be seen in the bottom pair of maps in [figure 4.4](#).

Age-adjustment reveals a significant shift in the distribution of counties with the highest and lowest rates of cancer mortality with one exception. In the crude rate state-wide map, western (mountain) counties have higher rates of cancer mortality but when age is controlled, many of these counties have relatively low cancer mortality rates. Conversely, ENC counties with low crude rates shift to higher rate categories. An exception to the effects of age-adjustment can be seen for the counties of the northern third of ENC. For these counties, age adjusting the rates has little effect, which may be due to the age structure resembling the structure of the standard population used in calculating these rates. Geographically, the overall effect of age adjustment concentrates high cancer mortality rates into ENC—from the original 18 counties, 27 now belong to the two highest rate categories after calculation. The Piedmont's northern-most tier of counties also gains membership into the highest rate category, contrasting sharply with both the rates in this region's urban crescent counties and the western mountain counties. The shift in rates and their geographic redistribution will have some effect on the analysis of excess mortality.

With few exceptions, those counties that have high crude rates in the northern part of ENC retain their high rates when age adjusted (see [table 4.1](#)). Together, Northampton, Hertford, Bertie, Martin, Washington, Tyrrell, and Camden counties experienced 1,600 deaths due to cancer over the course of five years. Collectively, these counties would have suffered 265 (17%) fewer cancer deaths if their joint age-adjusted rate was similar to the rest of the state's (191.6) and 486 (30%) fewer deaths if they had the HP 2010 objective target rate of 159.9. No ENC age-adjusted county rate achieved the RNC rate, the HP 2010 rate, or even the WNC (Western North Carolina) rate of 187.4. The next step is to determine which populations within ENC are contributing to the higher observed and age adjusted-rates found in this region.

Analysis by gender and race

[Figure 4.5](#) shows eight maps divided into four categories: white males, white females, non-white or minority males, and non-white or minority females. The rate categories are the same as those listed in [figure 4.4](#) except for the lowest and highest categories, whose boundaries reflect the lowest and highest age-adjusted race-sex specific rates found within the state: 0.0, and 861.4, respectively. (These rates may not necessarily be stable due to small numbers—neither rate is found in ENC.)

Male mortality

Clearly, the largest contribution to cancer mortality rates is from males of both racial groups. Edgecombe County has the highest stable age-adjusted cancer rate for white males at 337.6 (188 deaths). For non-white males, the highest age-adjusted rate for cancer is found in Northampton County at 432.2 (118 deaths). The achievement of an age-adjusted rate similar to the HP 2010 objective target would mean a 63% reduction (74 lives over 5 years) in cancer mortality for non-white males in Northampton County. Non-white males in Tyrrell County have the highest rate among all race-sex groups, but with only 18 cancer deaths occurring over 5 years it is probably not a stable value.

Female mortality

Females, by contrast, appear to have low rates across the state. The 5 counties with the highest age-adjusted rates for white females in the three highest rate counties are all found in ENC. Among these counties, Dare has the highest rate at 192.7 (167 cancer deaths) over five years. Looking at age-adjusted rates for white females, 15 counties have rates that fall below the HP

objective target of 159.9. Of this group, Jones County has the lowest age-adjusted rate of 121.5 (27 deaths). In five years, this rate would have saved more than 10,400 lives in ENC. The highest age-adjusted rate categories for non-white females, like white females, are spread throughout the state rather than just in the east. Several of these high rate counties are found in the extreme western portion of the state, where small numbers and annual stochastic variation may account for these higher age-adjusted rates. In ENC, Dare County has the highest cancer mortality rate for non-white females at 259.3 age-adjusted deaths. However, only 6 deaths occurred for this group over the period, producing a potentially unstable rate. Washington County has the next highest rate at 229.0 with 43 age-adjusted deaths. A 30% reduction in the number of non-white female cancer deaths result if this county had achieved the HP 2010 objective target during the observation period. Sixteen ENC counties had non-white female cancer mortality rates below the HP 2010 objective target with the lowest stable rate found in Greene County at 131.7 (28 deaths). Statewide, age-adjusted mortality rates for both races and sexes combine in such a way that cancer deaths from all causes become concentrated in the eastern portion of the state.

Temporal Distribution of Cancer Mortality from All Causes

The temporal pattern of age-adjusted rates for all cause cancer mortality (1979 to 2004) vaguely resembles a flat epidemic curve (see [figure 4.6](#)). The peak year of this curve is 1993. Thereafter, a sharp decline in rates occurs for all regions with approximately 2.0 to 2.5 fewer deaths for each year. Nevertheless, the regional line equations from 1993 onwards suggests strongly that the HP 2010 target rate of 159.9 age-adjusted deaths per 100,000 from malignant neoplasms will probably not be met. (All line equations have relatively high R-squared values indicating a high degree of fit between the observed and expected values.) ENC clearly has the highest rates of all regions but a greater rate of decrease. Even so, this region is not projected to reach the HP 2010 target until sometime around the year 2023 if the current rate of decrease holds. The remaining counties of the state (RNC), with both the lowest rate in 1993 and the lowest rate of decrease, are not expected to achieve the target rate until around the year 2017. The US rates reach the target about a year later, with NC—a weighted combination of ENC 41 and RNC 59 rates—achieving the target around the year 2019. Together, recent trends for these regions point to a target date almost a decade beyond 2010.

As previously discussed, mortality rate patterns from cancer and heart disease are at a crossroads. For most of the 105-year span of time covered in [figure 1.1](#), heart disease has remained the leading cause of death for the nation with cancer emerging as the second leading cause by the late 1930s. This relationship has been maintained for well over 75 years with the greatest rate differences occurring in the 1950s and 1960s. A closer examination of crude rate patterns for these two causes based on data from the period 1979 to 2004 for all regions and the US⁴—shows trends converging between the years 2007 and 2016. Recalculating with an additional two years of data added to the series (1979 to 2006) produces a similar range of convergence years (2007 to 2014). The crossover period between heart disease and cancer mortality rates then shifts for each region a year or two earlier. In both series, RNC experiences the rate crossover sometime in 2007. In fact, RNC's observed crude mortality rate for heart disease was less than that for cancer for the first time in the year 2006. The updated crude rate series for ENC predicts crossover for this region will occur around the year 2010. Interestingly the US lags several years behind ENC 41 converging in the year 2014. This may be due to differences in age composition between the two regions and the relative differences in the rate of decline for the two causes of death. In any case, the time series evidence strongly suggests that cancers will contribute the largest share of the state's mortality burden a few years before the rest of the nation.

⁴ Figures 4.3a and 4.3b were calculated using more recent figures data than used in this Atlas. Nevertheless, the difference in rates for the 3-year shift in coverage period will be slightly different and highlights how extrapolating rates and dates of convergence and divergence can be affected by recent observations.

Age-adjusted mortality rates due to heart disease have been declining more than three times faster than all-cause cancer mortality rates (see [figure 3.8](#)). Based on the present time series data, converging age-adjusted rate trends will occur in 2013 for ENC, 2009 for RNC, 2010 in NC, and 2012 for the US. Age-adjustment here has the interesting effect of reversing ENC and the US in the timing of convergence (see above). This result suggests that ENC has a higher proportion of younger people than both the US and the standard million population model used in the age adjustment process. With crude and age-adjusted disease rate series thus considered, it is evident that a historical crossover is imminent for all regions discussed in the Atlas. At this time, heart disease will cease to be the definitive leading cause of death in ENC and malignant neoplasms will become the biggest killer in the region. By the time regional trends for cancer achieve the HP 2010 target; mortality from cancer will most likely be the leading cause of death across the nation.

Each of the four ENC race-sex groups shown in [figure 4.7](#) have declining age-adjusted cancer mortality rates with the most significant declines seen for both groups of males. The decreasing trends for males have fairly high R-squared values (0.73 for white males and 0.83 for non-white males) with 4.5 fewer deaths per annum for white males and 9.1 fewer deaths for non-white males. In spite of these high rates of decrease, the age-adjusted rates for males of both races will not reach the HP 2010 target rate (159.9) largely due to their initial high rates the time series. If the present rate trend holds, white males will reach the target in the year 2024. Non-white males, who currently possess the highest rate of decrease, may reach the target rate around the year 2021. Females belonging to both groups have experienced significantly lower rates over the time period when compared to their male counterparts. Since 1993, their rates have declined very slightly with a slope of -0.61 for white females ($R^2 = 0.11$), and a slope of -1.13 for non-white females ($R^2 = 0.16$). According to the trend lines, white females will achieve the HP 2010 rate target in 2007 and non-white females in the year 2014. Clearly, males from both racial contribute the largest share of the overall age adjusted cancer mortality rate and won't achieve parity with females for many years to come. The greater part of this temporal disparity reflects probable gender differences in occupational exposures and behavioral risk factors.

The emergent trends for malignant neoplasms and heart disease crude mortality rates ([figure 1.1](#)) are now just starting to be realized in North Carolina: heart disease and cancer have similar rates of mortality with rate trends pointing towards malignant neoplasms as the leading cause of death. Although mortality rates from malignant neoplasms are decreasing from their peak year in 1993, the descent is gradual and along a less stable path than those observed for heart disease mortality. The rate trends for malignant neoplasms indicate that the HP 2010 target rate (159.9) will not be met by any of the NC regions or the US and that the most likely period that regional rates will reach the target rate will occur many years after cancer mortality becomes the leading cause of death in North Carolina. The future trajectories of the present rate trends for cancer are somewhat questionable because fewer deaths from heart disease will certainly have some impact on the cancer mortality pattern over the next decade. Although the burden of mortality from malignant neoplasms is similar between ENC and RNC, age-adjustment of the rates exposes an underlying geographic disparity. Males of both races contribute nearly twice the amount of mortality from cancer than their female counterparts and won't (using present trends) achieve the HP 2010 rate target until the 2020s. Current observations and trends show that white females in ENC have achieved the target and that non-white females will achieve the target several years later. However, the female pattern for cancer rate decline is very gradual and not as stable as their male counterparts and therefore their future rates may potentially be more influenced by the decreased rates of mortality due to heart disease.

Over the course of the last century there has been a slow and steady rise of deaths in the US population due to malignant neoplasms. This slow curve reached its apex around the year 1993 and thereafter began a slow descent. This general pattern is the result of the natural histories and unique etiologies of many types of malignant tumor processes combined with the array of risk factors, behaviors, and exposures found in regional populations. Of this large set of malignant tumors, the leading four cancers that account for the greatest proportion of cancer deaths are

cancers of the trachea, bronchus, and lung; colon, rectum, and anus; the female breast, and prostate in males. We now turn our attention to these malignant neoplasms.

MORTALITY FROM CANCER OF THE TRACHEA, BRONCHUS, AND LUNG

Mortality from cancer of the trachea, lung and bronchus (TBL cancer mortality) accounts for more than 30% of all cancer deaths in ENC. For the years 2000 through 2004, it is ENC's third leading cause of death with 7,505 reported deaths. In 2002 ENC ranks 42nd out of 53 states and regions ([appendix X](#)) with Kentucky in last place. A visual inspection of TBL's age-adjusted mortality rate time series ([figure 4.11](#)) reveals sharp increase in rates between the years 1979 through 1993 and thereafter a moderately stable decrease in rates. With the greatest share of cancer deaths, the trends and patterns of TBL cancer mortality will have a strong underlying influence on the trends and patterns seen in general cancer mortality. Although the ill effects of tobacco have been understood for more than half a century it has taken several decades for behavioral changes to have an effect on the reduction of TBL cancer mortality. In this section we explore the spatial and temporal effects of TBL cancer mortality in ENC.

Progress towards TBL Cancer Mortality Reduction

[Figure 4.8](#) portrays the progress that has been made towards the reduction of TBL cancer mortality for the years 2000-2004. The HP 2010 objective target rate (age-adjusted) is 44.9 deaths per 100,000. From [table 4.2](#), the total number of deaths attributable to TBL cancer in ENC is 7,505 and for RNC, 16,981. Proportionally, ENC generated 451 more TBL deaths than RNC would have if that region had the same population. Adjusting for age structure, 618 ENC lives would have been spared over five years from TBL cancer if it had the same rate as RNC. If ENC had achieved the HP 2010 target by the year 2000, then 2,165 age-adjusted lives would not have been lost to this cancer. The state-wide counties map ([figure 4.8](#)) shows that only one county, Watauga, has achieved the target rate during the five year period. Several counties in the southern portion of the western Mountain province are within 10% of achieving the target. To contrast, 18 counties, representing 41% of ENC's population and 42% of its TBL cancer deaths, need to reduce their TBL age-adjusted mortality rates by 30-48%. More than 900 lives within these highest rate counties in the east would not have been lost if they were at or below the HP 2010 target rate. Death from TBL cancer is a significant component of ENC's cancer mortality picture.

Spatial Distribution of Mortality Due to TBL Cancer

Examination of the crude rate map for TBL cancer mortality located at the top of [figure 4.8](#) reveals a general pattern of low rate counties in central and southern ENC and extending into the Piedmont. In terms of excess deaths, the 17 ENC counties in the lowest two categories of TBL mortality rates produce about 800 fewer deaths from TBL cancer than would be expected given the regional rate. To contrast, the 9 counties in the highest category, 7 of which are concentrated in the northeast extremity, produce more than 800 TBL cancer deaths than would be expected at the regional rate. For ENC, age adjustment creates a more heterogeneous; less clustered, distribution of TBL mortality rates, and reduces excess mortality to 207 age-adjusted deaths over and above the age-adjusted deaths based on the regional rate. The high rate counties, as seen from the crude rate map, tend to be peripheralized towards the state's boundaries. Age-adjustment alters the high rate pattern of the crude map by further concentrating high rate counties in the region's south accompanied by a slight dispersal of high rates in the northeast of the region. Lower rates predominate in the western Mountain region. Age-adjustment can produce some interesting reversals in observed county rates.

Onslow County has the lowest 2000 to 2004 crude mortality rate for ENC at 42.6 TBL cancer deaths per 100,000 people ([table 4.2](#) and [figure 4.8](#)). Indeed, the crude rate is so low that if ENC had the same rate, the region's 7,505 TBL cancer deaths would be reduced to 5,198. However, Comparatively, Onslow County has a relatively young population age structure and correcting for this yields a much higher rate—the region's third highest age-adjusted rate of 75.9 per 100,000. (Other counties similar to Onslow County's situation include Harnett and Hoke counties.) On the other hand, a county like Perquimans with a crude rate of 81.3 (the upper limit of the second highest category in the crude rate legend) TBL deaths per 100,000, becomes a member of the lowest rate category (at 54.7) when its rate is age-adjusted. This reversal indicates that the county's age structure has a greater resemblance than Onslow's to the US Standard Million Population and that its TBL cancer mortality rate is actually relatively low given the age structure of the county's population. In ENC's southwest, Hoke County possesses the highest regional age-adjusted rate at 78.1 with 97 TBL cancer deaths over the five year period. If Hoke County experienced the regional rate, nearly 19 of these lives would not have been lost and if this county had the same rate as Pamlico County (50.9), then 34 lives would have been spared from TBL cancer. It can be seen clearly that while the regional TBL rate picture is not particularly good with respect to the HP 2010 target rate, there is considerable internal variation in rates suggesting geographic disparities. These disparities, as manifested on the map, are more than likely the result of inherent differences found in county populations to which we know turn our investigation.

Analysis by gender and race

[Figure 4.9](#) portrays a geographical breakdown of race-sex specific age-adjusted county TBL mortality rates. As with all race-sex specific rate maps, the category boundaries are fixed to the same category limits found in the crude and age-adjusted maps for the general population (the previous figure). For certain causes of mortality, adherence to this classification scheme has the immediate effect of dichotomizing the distribution of age-adjusted rates between males and females and age-adjusted TBL cancer mortality is no exception. Males of both races, as with cancer from all causes, show counties with high rates throughout the state. (There are concentrations of low [or zero] rate counties for non-white males in the far west of state, which is generally due very small numbers of minority populations in those counties.) A comparison of age-adjusted TBL cancer rates among ENC white males (93.0), white females (44.9), non-white males (106.8), and non-white females (26.7) yields the relationship among their respective rates as 3.4: 1.7: 4: 1. This relationship shows that a large disparity exists among these groups: non-white females are the least affected by TBL cancer. Non-white males are experiencing four times the mortality than non-white females and the white male rate is twice as great as that for white females. This picture has been changing over time, however, as the rates for males of both races have been declining since 1993 while the rates for females of both races have been continuously increasing since 1979 (see [figure 4.12](#)) with the disparity among the groups diminishing over the next decade or two. We now turn to describing the geographic aspects of this race-sex disparity in TBL cancer rates.

Like age structure, the racial composition of ENC and RNC is not the same. Cross-product calculations using the regional age-adjusted rates and death counts by race-sex groups ([table 4.2](#)) yields an excess TBL mortality of 666 deaths. The greatest excess mortality can be attributed to white males and the least to non-white females. This latter group actually has a more favorable mortality rate than their RNC counterparts: if RNC non-white females had the same age-adjusted rate as ENC non-white females, then 161 lives would have been saved in that region. Recalling that the category boundaries in [figure 4.10](#) are based on the scheme in [figure 4.9](#), there appears to be little rate heterogeneity within each race-sex group map, when in reality the differences among these maps are greater than the inter-regional difference, underscoring inherent demographic differences.

Male mortality

The highest age-adjusted county TBL rates for white males are found scattered about the 41-county region. Edgecombe County has the highest white mortality rate at 131.3 and 78 deaths.

Combined with the next four highest counties (with 5-year death totals ≥ 20): Hoke (125.5), Columbus (122.5), Bertie (119.7), and Greene (118.3), a total of 263 deaths among the five counties representing 8% of ENC white male TBL cancer deaths and 6% of the region's white male population. If these counties started out the 5-year study period with the HP 2010 target rate, then 159 lives would have been spared from TBL cancer. The five counties with more than 20 deaths each and possessing the lowest rates include Northampton (65.4), Pamlico (73.9), Craven (76.1), New Hanover (76.8), and Hertford (78.9) for a total of 451 deaths representing 13% of ENC white male TBL deaths and 14% of the region's white male population. Approximately 185 lives from these five counties would have been spared if the HP 2010 target rate had been achieved at the onset of the study period. Regionally, non-white males experience about a 15% greater TBL mortality than their white counterparts. The five counties with the highest rates (with 5-year death totals ≥ 20) for this group are Washington (161.9), Beaufort (154.7), Scotland (154.0), Bladen (145.4), and Hertford (135.4) yielding a TBL mortality count of 174. These deaths represent nearly 13% of the region's TBL mortality for non-white males and a little more than 11% of the region's non-white population. If this population group had started the study period with the HP 2010 target objective rate, then almost 100 non-white males would have survived this cancer in those counties. The five lowest rate counties for non-white (with 5-year death totals ≥ 20) are New Hanover (67.0), Cumberland (77.4), Sampson (90.5), Brunswick (93.6), and Edgecombe (94.6) producing 256 TBL deaths or more than 18% of all regional non-white male TBL deaths with nearly 27% of the region's non-white male population. If these lowest ranking counties had experienced the HP 2010 target rate at the onset of the study period, then about 112 lives would have been spared from this disease. ENC age-adjusted TBL rates for males of both racial groups are generally at least twice as great as the HP 2010 objective target: the county rates for these two groups are greater than the target rate, with the exception of Hyde County for non-white males (5-year total deaths = 2).

Female mortality

A completely different picture of TBL mortality rates emerges when age-adjusted rates for females of both races are considered. With a few exceptions, low rates for females are nearly ubiquitous throughout the state. Although low numbers of female TBL deaths contribute to the lower stability and high variation of age-adjusted mortality rates at the county level, the regional age-adjusted rate for white females is the same as the HP 2010 target rate (44.9) and the rate for their non-white counterparts is well below at 26.9 with only 543 deaths or 7% of all TBL deaths while sharing a little more than 18% of the regional population. For white females, the highest statistically stable county age-adjusted rates (total deaths ≥ 20) are found in Northampton (58.9), Onslow (86.2), Hoke (55.7), Cumberland (54.6), and Carteret (52.0). Among these counties, 481 white females died from TBL cancer. These deaths among high rate counties are nearly proportional for the region's white female population with more than 22% of this group's population experiencing nearly 22% of the region's white female TBL deaths. Almost 90 of these deaths could have been avoided if the HP 2010 target rate had been achieved before the onset of the study period. The counties with the lowest age-adjusted rates for white females are Duplin (32.9), Pasquotank (36.4), Pender (37.0), Wilson (37.4), and Pitt (37.6). The counties possess more than 14% of the region's white female population, but produced only slightly more than 11% of the region's TBL white female TBL deaths. Collectively, if these counties had either the regional or HP 2010 target rate of 44.9 per 100,000 at the onset of the study period, then 55 white female lives (over five years) would not have been lost to TBL cancer. While the regional white female age-adjusted rate for TBL cancer is the same as the HP 2010 target, the comparable rate for non-white females is substantially less. With 543 deaths over a 5-year period attributable to TBL cancer, non-white females experienced an age-adjusted rate of only 26.7. Non-white females comprise a little more than 18% of 41 county ENC's population and contribute just slightly more than 7% of the region's TBL deaths. The four counties with the highest age-adjusted and stable (total deaths ≥ 20) rates are New Hanover (41.3), Craven (38.6), Robeson (34.8), and Wayne (32.0) yield TBL cancer deaths below what would be expected if they had started with the HP 2010 target rate of 44.9. If regional non-white females had that rate, 37 more TBL cancer deaths would have occurred. Nevertheless, these counties possess 21% of the region's non-white female population, which in turn contributed a disproportionate share of more

than 27% of the region's TBL cancer deaths for this population group. The three counties with the lowest and most stable age-adjusted rates for TBL cancer in non-white females are Halifax (25.2), Nash (26.6), and Pitt (26.6). Again, these rates are well below the target rate and so generate 51 fewer deaths than if they had met the target rate. These three counties have a more proportional share of TBL deaths in non-white females, with nearly 14% of the region's population contributing a little more than 13% of the region's TBL cancer deaths in non-white females. Both regional white and non-white females are at or below the HP 2010 target rate of 44.9. Rates are ubiquitously low throughout the state and where they are extreme (e.g., Dare County) small numbers may be responsible. Interestingly, the ENC 41 age-adjusted TBL mortality rate for non-whites is much lower than the rate for their RNC counterparts.

The maps in [figure 4.10](#) are a snapshot of a much larger process occurring over time across the state and region. The snapshot indicates clearly that there is a substantial disparity between the sexes with regard to TBL cancer and that disparity is fairly uniform throughout the state. There also remains rate disparity between the races of each sex group with regional effects seen most clearly between ENC 41 and RNC for non-white females. However, a snapshot or map gives no indication of the evolution of TBL cancer rates, either regionally or by population groups. We now turn to a more temporal perspective of ENC's TBL cancer mortality rates.

Temporal Distribution of Mortality from Cancer of the Trachea, Bronchus, and Lung

The progression of regional age-adjusted mortality rates from TBL cancer closely resembles the pattern found for all malignant neoplasms (see [figure 4.11](#)). TBL cancer is the leading form of cancer mortality; with mortality counts between two and three times those attributable to cancer of the colon, rectum, and anus—the second leading cause of cancer deaths. The predominance of TBL cancer mortality undergirds the pattern observed for malignant neoplasms mortality rates (see [figure 4.6](#)) with the general rise in regional cancer mortality from 1979 to 1993 being driven by the steeply ascending rates of TBL cancer mortality followed by a more gentle decreasing gradient, indicating that declines in other areas of cancer mortality are also having a measurable effect on the overall pattern.

Like the pattern for all malignant neoplasms, regional age-adjusted TBL rates will not achieve the HP 2010 target rate of 44.9 until several years beyond the target year ([figure 4.11](#)). The projected trend for ENC has the year of target convergence sometime around the year 2021 and for RNC the current but weaker projection has that region achieving the target rate in the year 2038. For the state, which is a weighted combination of rates from both ENC and RNC, the target will be reached by the projected year of 2028. The US achieves the target in the year 2022. Although extrapolating rates beyond a few years with goodness-of-fit values below 0.95 is risky and little better than speculation, it strongly suggests that the 2010 target rate is not realistic given the regional trends series from the year 1993. Interestingly, ENC, a region that exemplifies poor health outcomes, may in fact achieve the HP 2010 target before the counties of the rest of the state. For example, ENC's rate of decrease is such that it will converge and overtake the rate for RNC sometime around the year 2010 if the linear trend from 1993 remains in tact. At that point in time both regional rates will be around 55 age-adjusted deaths per 100,000, approximately 22% higher than the target rate (44.9). To contrast, ENC will overtake the national projected rate 13 years later in the year 2023 with a rate 3% lower than the HP 2010 target rate (assuming present trends hold until that time).

Within ENC, a distinct mortality differential exists between the two sexes ([figure 4.12](#)), with rates for males of both races descending steeply from their plateau in the late 1980s and early 1990s, while rates for females of both races are slowly rising up to and beyond the HP 2010 target rate from their lowest point in the series, 1979. The steepest gradient is found for white males with a decline of slightly more than 3 age-adjusted deaths per annum and an R^2 value of 0.86. At this rate, white males will achieve the target rate around the year 2016. Non-white males lag somewhat further behind with a lower R^2 value; they will reach the target around the year 2023, a temporal displacement of 7 years. The observed TBL mortality rates for females of both races

exhibit a very different pattern than the pattern for their male counterparts. Although the trends are not nearly as strong as that for males, female TBL mortality rates are increasing. According to the trend line equations, ENC white females will experience a TBL mortality rate of almost 49 in the year 2010, about 9% greater than the target rate. Non-white females, who have experienced the least TBL mortality, are projected to remain well below the target rate and if the relatively weak trend line were to hold indefinitely, this group would reach the target in the improbable year of 2100. For TBL cancer mortality, the mortality experience between the sexes is quite distinct and can be attributed to underlying secular changes in behavioral risk factors related to this disease.

Mortality from cancer of the trachea, bronchus, and lung is the largest contributor accounting for a little less than one-third of all cancer deaths. Statewide, there is considerable variation in crude TBL mortality rates among counties but with age-adjustment, the higher rate counties tend to be more concentrated in ENC. ENC's age-adjusted rate is higher than the HP 2010 target and simple trend analyses suggest that regionally and demographically this target will not be reached for several years beyond 2010. The greatest disparity of rates exists between the sexes in terms of both rates and trends. Males of both races are dying at a significantly higher rate than their female counterparts but their rates are decreasing while female rates are increasing towards the HP 2010 target rate with white females overtopping the target rate by the year 2010. Although the decrease in TBL mortality rates in males is encouraging there is obvious concern about the trend observed in female mortality rates. Much of the observed TBL cancer mortality is avoidable. Exposure and behaviors linked to TBL cancer has occurred over many decades and to overcome their consequences to the people of ENC will take a not insignificant amount of time and effort in the form of continuing strong health promotion and prevention programs.

MORTALITY FROM CANCER OF THE COLON, RECTUM, AND ANUS

Mortality from cancer of the colon, rectum, and anus (CRA) accounts for slightly more than 9% of all cancer deaths and is the second greatest contributor to cancer mortality. With 2,327 deaths from this disease, it is the ninth leading cause of mortality in ENC. In 2002, ENC ranked 25th out of 53 states and regions ([appendix X](#)) with the District of Columbia in last place. The temporal pattern of CRA mortality is different than the pattern observed for TBL pattern. North Carolina regions are fairly close together and relatively flat until the mid 1980s, when the rates begin to show more variation (and regional disparity). After 1993, CRA rates, like the rates for TBL cancer mortality, begin to decline. The US rates begin substantially higher in 1979, but in the late 1980s they drop into a similar pattern of that observed for NC's regions. We now turn to a geographical exploration of CRA cancer mortality and its impact on the people of ENC.

Progress towards CRA Cancer Mortality Reduction

[Figure 4.13](#) portrays the amount of rate reduction needed for NC and ENC counties to reach the HP 2010 objective 3-5 target rate of 13.9 age-adjusted deaths per 100,000. The observed rate for CRA cancer mortality in ENC during the years 2000 through 2004 is 20.1, nearly 45% greater than the target rate (see [table 4.3](#)). Regionally, this translates into 718 excess deaths due to CRA cancer for the five-year period. By comparison, the remaining counties of the state (RNC) have an age-adjusted rate of 18.5, about 33% greater than the HP 2010 target rate and resulting in an excess of 1,337 CRA cancer deaths. While three counties in RNC (the mountain counties of Alleghany, Madison, and Transylvania) have met or surpassed the HP 2010 target rate, the same cannot be said about the counties of the east. The lowest rate counties—within 15% of achieving the target—are Dare, Johnston, and Pender at 16.2, 15.8, and 15.7, respectively. The highest rate counties, which have rates that are greater than 45% of the target, are concentrated in ENC's northeastern corner. These counties include Bertie, Camden, Hertford, Hyde,

Perquimans, Tyrrell, and Washington at 31.4, 26.2, 31.9, 31.9, 27.1, 25.3, 30.6, and 27.2, respectively. Altogether, these counties experienced 151 CRA cancer deaths over the course of five years; more than twice the number of deaths they would have experienced if they had already achieved the HP 2010 target rate for this disease.

Spatial Distribution of Mortality Due to CRA Cancer

The maps at the top of [figure 4.14](#) show county crude CRA mortality rates and provide a visual impression of the spatial distribution of CRA cancer mortality burden. For the state, there appears to be three general concentrations of CRA cancer mortality burden areas. The first is located in the western mountain regions and the second is a less extensive concentration found in the southeast Piedmont. ENC has the most extensive concentration of high rate counties found in its northeast. The relative amount of CRA cancer mortality burden is nearly equally shared between the two regions with ENC claiming about 30% of the mortality from CRA produced by 29% of the state's population and RNC producing 70% of CRA cancer deaths with 71% of the state's population. The difference in crude rates between the two regions is about 4% (see [table 4.3](#)). Age-adjustment deemphasizes the concentration of rates in the state's mountain region and increases the concentration of high rate counties in ENC. With age-structure controlled the disparity in rates widens to almost 9%. This difference translates into about 185 excess CRA cancer deaths occurring in ENC over the five-year study period. By and large, the CRA cancer burden and rate disparity between ENC and RNC is similar to that seen in TBL cancer mortality as well as for all cancers (malignant neoplasms).

The maps at the bottom of [figure 4.14](#) show 14 counties in the highest rate categories with age-adjusted mortality rates at 22.2 per 100,000 and greater. This group of counties accounts for nearly 29% of all CRA cancer mortality in the region while possessing 22% of its population. With the exception of Wayne County, these counties are concentrated in the region's northeast. If counties in the highest rate category had shared the regional rate at the onset of the study period, 143 lives would have been spared. The county with the highest age-adjusted CRA cancer mortality rate is Hertford at 31.9 and 44 deaths. If this county had the regional rate, deaths from this disease would have been reduced to 28 over five years. If Hertford County had the same rate as Pender County, the lowest rate county in the region, then the number of deaths would have been reduced by half—from 44 down to 22. The lowest rate category accounts for a little more than 15% of all regional CRA cancer deaths with 18% of its population. If the entire region had the lowest age-adjusted ENC county mortality rate yet achieved (15.7) during the study period, then 509 lives would have been spared from CRA cancer, a reduction in mortality in nearly 28%. These calculations have been based on age-adjustment of county and regional age structures. The observed differences can be explained further when race and sex are taken into account, while still controlling for age.

Analysis by gender and race

[Figure 4.15](#) decomposes the age-adjusted map found at the bottom of [figure 4.14](#) into four race-sex groups. The break points used in the latter age-adjusted figure are used in the next figure, allowing the map user to see the relative contributions of each group to the spatial distribution of CRA mortality. Unlike, the race-sex distributions of TBL cancer mortality, high age-adjusted CRA mortality rates for females of both racial groups are more present in ENC. From the maps alone, it is difficult to discern any differences in concentrations of high rate counties between ENC and RNC although there are regional differences in rates for the race-sex groups (see [table 4.3](#)). White males, controlling for age, are the largest contributor to the small amount of regional disparity that exists at this time with an excess of 153 CRA cancer deaths produced in ENC. To contrast, there is a very slight favorable difference for non-white males living in ENC—with age-structure taken into account; this group would actually have fewer deaths than their counterparts in RNC. Within ENC there appears to be a visual cluster of contiguous high rate counties in the northeastern part of the region for both non-white males and females. There are several

contiguous high rate counties for white females within the region but this pattern is less extensive than for non-whites and for white males there is no corresponding concentration of high rate counties in northeastern ENC. In [table 4.3](#), the rates for the different age-sex groups in the 29-county sub-region of ENC (ENC-29) are higher than the 41-county region, suggesting that ENC's southern 12 counties would have even lower rates if calculated. We now turn to a discussion of the relative impact of CRA cancer mortality among ENC's race-sex groups.

Male mortality

Experiencing the greater share of deaths, white males make a significant contribution to the overall age-adjusted regional CRA cancer mortality. The top-left maps in [figure 4.15](#) portray a distribution that is difficult to characterize but ENC does possess relatively more counties in the highest mortality rate category and the regional comparisons at the bottom of [table 4.3](#) suggest that these higher rates are concentrated in the northern 29-county sub-region. The four highest rate counties for white males are Jones, Tyrrell, Perquimans, and Hyde, but each have five-year mortality counts less than 20, totaling just 24. The next five highest rate counties, Wayne (32.4), Beaufort (31.0), Robeson (30.0), Sampson (29.7), and Nash (28.6) have the largest share of white male CRA cancer deaths. Each county has more than 20 CRA cancer deaths with a total of 163 deaths or nearly 21% of all regional white male CRA cancer deaths being generated by only 15% of the region's white male population. If white males had achieved the regional 2000 to 2004 regional rate before the onset of the period, then 41 lives would have been spared and an additional 47 if they had achieved the HP 2010 target rate. For non-white males, the concentrations high rate counties are increased for both ENC and RNC. However, the county age-adjusted CRA mortality rates are even less stable than those for their white counterparts.⁵ Only three ENC counties have more than 20 non-white males dying of this disease. The five counties with the highest rate each have 5-year death totals less than 20, totaling 26 CRA cancer deaths. Pitt County, whose non-white male age-adjusted CRA rate (46.1) is the sixth highest for the region with 20 or more deaths (n = 31). The next highest stable rate is found in Robeson County, which ranks 23rd highest in the region, at 26.9 age-adjusted deaths per 100,000 and 26 deaths. Although this rate is in the lower 50% of the regional county rate distribution, it is nearly twice the HP 2010 target rate. Regionally, the non-white male rate is the highest among the four demographic groups in ENC, however, this rate is about two percent lower than that for their counterparts in RNC (see [table 4.3](#)). For the study period years 2000 to 2004, the number of ENC CRA cancer deaths (1,160) for males of both racial groups was just slightly less than the number of deaths (1,167) experience by females of both racial groups. However, given the relative sizes of their respective regional populations, males experience about 2% more mortality due to CRA cancer than females. The age-adjustment of CRA cancer mortality rates further widens the apparent gap between the sexes for each racial group. The 49% difference between male and female white rates and the 35% difference between male and female non-white rates ([table 4.3](#)) is the result of the differences in age structure and age-specific mortality.

Female mortality

The ENC white female age-adjusted CRA cancer mortality rate of 15.3 is the lowest among the four demographic groups with 731 deaths. The rate is well below the regional rate, but if the HP 2010 target rate had already been achieved at the onset of the study period, the number of white females dying from this disease would have been reduced by 9% or 67 individuals. When compared to the other race-sex groups, the white female rate contributes significantly to the regional rate with 605 deaths in 31 counties with rates less than the regional value—the rates for the other three race sex groups are above the regional rate. The upper-right map in [figure 4.15](#)

⁵ As we proceed from the more common causes to less common causes of death, individual counties in ENC will begin to generate fewer numbers of deaths by a specific cause. Even over a period of five years many of ENC's less populated counties will begin to generate fewer deaths and will produce what we consider unstable rates when the number of events is less than 20. With CRA cancer mortality this has become a more prevalent problem for more specific geographic description and analyses when the county population is further sub-divided into four general race-sex categories. As diseases become rarer it will take increasingly larger populations to generate stable rates. In these cases, the strategy to be used in description and analyses will be more general, relying more on comparisons among counties as groups when the number of mortality events is less than 20.

shows a small cluster of the highest rate counties (, Hertford, Chowan, and Martin) in the central north of the region to the northwest of a group of counties possessing rates not as high but higher than the county median rate (Hyde, Beaufort, Craven, Pamlico, and Jones). However, many of the highest rate counties do not have sufficient numbers of death events to lend credence to their interpretation. The county with the highest stable rate is 9th ranking Beaufort at 21.0 with 26 deaths occurring in five years. Collectively, the seven counties that have 20 or more CRA cancer deaths and above the median age-adjusted county rate (i.e., Carteret at 21.4) experienced 221 deaths or 30% of ENC white females dying from CRA cancer.. Achievement of the HP 2010 target rate beginning in the year 2000 would have saved about 47 lives over the next five years in those seven counties. From [table 4.3](#), the regional rate for non-white females (21.4) is about 6% higher than the regional rate and almost 40% greater than the rate for ENC's white females. Of the 436 non-white females who died due to CRA cancer from 2000 to 2004, 153 would have survived if they had experienced the HP 2010 target rate at the onset of the study period. Geographically, the largest cluster of highest category rates for this group can be found in the northern half of the region. Almost 27% of the region's non-white female population live in this 14-county cluster and it produces a disproportionate share of CRA cancer deaths—173 (40%) of the regional total. The highest stable rate included in this cluster is 4th ranking Pitt County at 33.6—a lower rate than non-white males (46.1) but with a larger number of deaths, 36—which is due to a larger population of non-white females in this county and differences in age structure. If the 14 counties of this cluster had started out with the HP 2010 target rate in the year 2000, approximately 84 non-white female lives would have been spared; nearly half of deaths due to this disease. The relative impact of CRA cancer mortality in non-white females is similar to that of white males but significantly different than that for white females and non-white males. Regionally, white females contributed a disproportionately smaller share of CRA cancer deaths given their population size, while non-white females contributed slightly more deaths relative to their population size. Proportional shares of mortality and differences in age structure between the two populations would account for the nearly 40% gap between white and non-white female age-adjusted rates.

Temporal Distribution of Mortality from Cancer of the Colon, Rectum, and Anus

The regional times series plots for age-adjusted CRA cancer mortality ([figure 4.16](#)) and TBL cancer mortality ([figure 4.11](#)) are similar only with respect to their onset of declining rates in the early 1990s. For the CRA cancer mortality pattern, there is no rapid increase of rates from 1979 to the early 1990s. Instead the US rates are initially the highest and decline continuously from 1979, while the rates for the remaining regions appear to oscillate after this date up to the year 1993 and thereafter follow an unsteady declining trend. Generally regional CRA cancer mortality is about half that for TBL cancer in 1979. However, by 1993, regional TBL cancer mortality rates are nearly three times the rates for CRA cancer mortality and remained so, while declining, through 2004. Because the rate trends are decreasing at approximately the same rate, there no marked patterns of convergence or divergence among the regions. For all regions, the rates of decline are small and similar, with fairly high R^2 values (0.74 to 0.98). If the 12-year trend from 1993 to 2004 (2002 for the US) can be maintained for another dozen years then ENC and RNC may achieve the HP 2010 target rate of 13.9 age adjusted deaths per 100,000. Present trends (1993 to 2004) indicate that ENC will reach this rate sometime in the year 2014 and RNC in sometime in the year 2012. The state rate, a weighted average of these two regions, will achieve the target in the year 2013. Because the R^2 values are less than 0.95, indicating variability in the temporal sequence of observed rates, the target rate may be reached earlier or later than what the time series suggests. The national trend has the smallest beta coefficient (rate of change) but the largest R^2 value (0.98). The US, with its present trend, is not expected to arrive at the HP 2010 target rate until the year 2016. Although the target may not be reached until several years past the forecasted years of the other regions, the calculation can be treated with more confidence and it would be a fair assumption that at worst, the state regions would achieve the target rate by the year 2016, several years before the target rate for TBL cancer mortality.

When the ENC time series is broken down into individual series for the race-sex groups ([figure 4.17](#)), one is struck by the high degree of variation in the rates, which is also reflected in the lower R^2 values. The non-white female trend line has the smallest R^2 value and so the least amount confidence would be assigned to any forecast concerning the HP 2010 target rate for that group. The trend line for CRA cancer mortality in white females has the highest R^2 value at 0.62. At the terminal year for the 12-year trend (2004), white females have already achieved the target rate and the observed rate for that year is also below the target. (The 5-year rate found for white females in [table 4.3](#) is 15.3, about 10% higher than the target.) Males of both races will not achieve the target until sometime after the year 2010. Although lower confidence can be placed in the trend lines for males, if they continue into the foreseeable future, white males will achieve the HP 2010 target rate in the year 2016 and non-white males, who have had the highest rates from the beginning of the trend analyses, will not reach the target until ten years later. From the observed time series and their modeled trends it can be seen that the impact that CRA cancer mortality is least for white females, a group who started the series in 1979 with the lowest rates. Non-white females, however, began the series with nearly as low rates but after the first five years (the early 1980s) these rates had jumped up and have declined very unsteadily since 1993, which has contributed to the very low R^2 value for their trend line. Because of this low value, forecasting the year the target rate is achieved is not practicable. Non-white males, while having a comparatively low R^2 value also exhibit the highest rate of decline. With initial high rates in 1993, non-white males, even with the highest rate of decrease, will not achieve the HP 2010 target rate until many years after their white counterparts. White males, in turn, can expect to achieve the target several years after 2010.

Regionally, CRA cancer is the 9th leading cause of death and accounts for less than one-tenth of all cancer deaths. Even so, it is the second leading cause of cancer mortality in ENC after death from cancer of the trachea, bronchus and lung. While death from this disease ranks 12th among non-white males, they possess the highest CRA cancer mortality rates among the race-sex groups examined in this study. Although these rates are declining faster than for the other groups, the decline begins at a higher point in the mortality time series and proceeds in an unsteady manner and won't reach the HP 2010 target rate until sometime in the 2020s, if the 1993 to 2004 trend continues. Non-white female rates, on the other hand, have started at a relatively low rate in 1979 and continue the series in an oscillating and highly variable pattern—this form of cancer is the 8th leading cause of death for them. For ENC white males, CRA cancer is the 9th leading cause of death and for their female counterparts it is the 10th. Many lives can be spared from CRA cancer through regular screening, modifying diets, and a more active lifestyle.

MORTALITY FROM CANCER OF THE FEMALE BREAST

Cancer of the female breast accounts for 7.6% of all regional cancer deaths and is the 7th leading cause of death for ENC women with 1,867 dying from this disease between the years 2000 and 2004. In 2002, ENC ranked 52nd in mortality out 53 states and regions with the only the District of Columbia following with the worst rate. The 41 counties ENC have fared worse than those of the rest of the state, especially non-white females whose rates are about 25% greater than their counterparts in RNC. ENC white females, on the other hand, had slightly lower 5-year age-adjusted rates than US females. However, a large geographic disparity in rates is still found when a similar comparison is made between ENC and US non-white females (see [table 4.4](#)). Most people know of at least one person who has lived through or succumbed to this disease. Information, early detection, and access to care are extremely important in reducing this very significant cause of mortality in women. We now turn to a more detailed look at female breast cancer mortality in ENC.

Progress towards Female Breast Cancer Mortality Reduction

[Figure 4.18](#) portrays the progress that has been made in rate reduction towards the HP 2010 target rate. The target rate is 22.3 age-adjusted deaths per 100,000 females. The 5-year regional rate for all females is 28.1 generated by 1,867 deaths from this disease (see [table 4.4](#)). A 21% reduction in its 2000 to 2004 rate is needed to achieve the HP 2010 target rate, while for RNC a reduction of 7% is needed. When white females are considered alone, the picture improves for both regions. The percent reduction needed for ENC white females is 10% and for RNC white females, 3%. The large shift in reduction percentage needed for ENC white females from the total strongly suggests that non-white females have a preponderant regional share of breast cancer mortality. ENC non-white females would need to reduce their age-adjusted rates by 63% to achieve the target rate, while non-white females in RNC would need to reduce their rates by 21%. The regional differences in percent reduction needed by racial categories indicate that in addition to a racial disparity there also exists a geographic disparity in breast cancer mortality. A greater effort in reducing non-white mortality for this disease is required.

If the ENC region met the target rate during all of the last five years, 385 lives would have been saved. For white females alone, 111 lives would have been spared and for non-white females, 461.⁶ Within the state, a number of counties have surpassed or are close to surpassing the HP 2010 target rate, indicating that an encouraging level of progress is being made at least for one population group. Twenty-six counties throughout the state have achieved the HP 2010 target rate during the years 2000 through 2004 (see [figure 4.18](#)). The six counties in ENC that have met the target are, in rank order, Chowan at 17.0 (8 deaths), Camden at 18.4 (4 deaths), Bertie at 20.7 (14 deaths), Pamlico at 21.1 (11 deaths), Onslow at 21.3 (52 deaths), and Pender at 21.4 (29 deaths). The top four lowest rate counties are considered unstable with 5-year total deaths less than 20. Pender and Onslow counties both have stable rates below the HP 2010 target rate. There are 10 counties that have age-adjusted rates that need to be reduced by at least 30% in order to achieve the target rate. These counties account for 305 breast cancer deaths and reducing their rates to the target rate would save 112 lives. Among these counties, Tyrrell is the highest at 68.4 and would require a reduction of 67%, but the rate is unreliable with only 8 deaths. The three highest reliable rates in the 30%-and-above category are found for 2nd ranking Greene County at 40.2 and 22 deaths, 3rd ranking Bladen County at 39.8 and 41 deaths, and 6th ranking Edgecombe County at 34.4 and 58 deaths. Reducing the rates for these three counties to the target rate would save 48 lives during the study period. The maps in [figure 4.18](#) portray a lot of variation in the percent reduction needed at the county level to achieve the HP 2010 target rate. Many counties have achieved or surpassed the target. Regionally, however, this success is unbalanced: less than 3% of the state's population live in ENC counties that have achieved the target, while almost 20% of RNC's population lives in counties that have met or surpassed the target.

Spatial Distribution of Mortality Due to Female Breast Cancer

The crude rate maps in [figure 4.19](#) portray two general concentrations of counties with high breast cancer mortality rates—one in the furthest western counties of the state and one in ENC. The mortality burden is about 14% greater in ENC when rates are compared in [table 4.4](#). Relative to its population size, ENC produces an excess of 227 deaths due to breast cancer when compared directly to RNC's population. However, this comparison does not account for the inherent difference in age structure between the two regions. Age-adjustment has the effect of shifting the high rate counties eastward, which implies significant inter-county differences in population structure and age-specific death rates. For ENC women, age-adjustment translates into 581 excess breast cancer deaths when compared to their counterparts in RNC. Although

⁶ The astute reader will notice that the total number of lives saved is not the same as the sum of the lives spared when white and non-white females are considered separately. The reason for this is that the rates used in this Atlas do not adjust for racial composition, only ages are adjusted for comparison. Nevertheless, the larger difference between the cross-product result for the total population and the sum of the two female population cross-product results underscores the impact breast cancer mortality has on the non-white female population.

there is a significant difference in age-adjusted rates between the two regions, there is also a large amount of variation of rates among ENC counties. This suggests that there are underlying differences in not just population characteristics but also different levels of success in programmatic efforts and accessibility to care.

Within ENC, there are 22 counties with age-adjusted rates above the regional rate (28.1, found in [table 4.4](#)), representing 50% of the population at risk and producing almost 56% of deaths from female breast cancer. The 15 counties in the highest rate category (30.1 to 68.4, from the bottom map in [figure 4.19](#)) represent 22% of the region's population and generating almost 28% (518) of its female breast cancer deaths. If these 15 counties had just the same rate as the regional rate during the study period, then 79 lives would have not been lost to this disease. If these counties together had the same mortality experience and age structure as the lowest stable rate ENC county—Onslow at 21.3 and 52 deaths, then 185 lives in these counties would have been spared from breast cancer. For the entire region, this would translate into a savings of 456 lives, a reduction of 24% in breast cancer mortality for all ENC women. The picture changes dramatically for breast cancer mortality when race is considered. We now turn to a discussion of the geographic distribution of breast cancer mortality by race.

In [figure 4.20](#) is a set of maps portraying the county distribution of age adjusted breast cancer mortality rates by race. For white females, there appears to be a slightly greater concentration of counties with the highest rates (i.e., rates greater than 26.3, which includes the highest two categories) in ENC. For non-white females, the concentration is much greater in ENC, with 35 counties possessing rates above 26.3 and 34 of those counties in one large cluster. There are also an increased number of high rate counties for non-white females in RNC, most notably a cluster in the far west and two clusters in the Piedmont's north and south. When county race-sex group populations and deaths are aggregated for the two highest rate categories (age-adjusted rates > 26.3), regional effects for breast cancer begin to emerge. For instance, ENC white females produce almost 17% more deaths than would be expected if population and deaths were uniformly distributed, while their counterparts in RNC experienced almost 29% more. Non-white females in ENC generated only 2% more, suggesting that deaths are proportional in size to the underlying population, and for their counterparts in RNC, the difference is almost 12% more than would be expected. These regional differences in the proportion of deaths to the underlying proportion of population (RNC > ENC) means that while a few county female populations in RNC experience high rates of mortality, the local higher rates are "swamped" by the more favorable experience elsewhere in the region. The same cannot be said for the female population in ENC, where high female breast cancer mortality rates are more ubiquitous and prevalent.

Regional difference and racial disparity in female breast cancer mortality can be further illuminated by additional consideration of the data found in [table 4.4](#). The RNC age-adjusted rate for regional white females is 22.9, a rate very close to the HP 2010 target rate of 22.3. If ENC white females were to share that same rate, 83 lives would have been spared from this particular disease. If ENC non-white females experienced this rate, 254 lives or 35% of those that died, would not have been lost in the 5-year study period. This contrasts to RNC non-white females, where a similar calculation yields a savings of 147 lives or just fewer than 19% of the non-white females who lost their lives to breast cancer in this region. Clearly, there is a regional effect to mortality with respect to this disease in non-white females that points to underlying regional differences in accessibility to care and perceptions about care. The map patterns observed in [figures 4.18](#) through [4.20](#) are really snapshots of the last several years of a disease process operating in regional female populations. In order to understand the most recent observed patterns and make judgments about rate improvements and where the process is leading, it is often useful to examine the history of the rates in question.

Temporal Distribution of Mortality from Cancer of the Female Breast

Generally, the pattern for the regional time series of age-adjusted female breast cancer mortality rates ([figure 4.21](#)) mirrors that observed for all cancer ([figure 4.6](#)). The chief difference is that the

peak years for breast cancer mortality are displaced a few years earlier than that seen for mortality from all malignant neoplasms (viz. US cancer mortality rates). The regional trend lines still begin in the year 1993 and so do not capture the effect of this displacement. However, the trend lines do accentuate the differences in the observed patterns for the last five years of the study. These last five years of age-adjusted rates in the time series are subsumed into one age-adjusted rate found in [table 4.4](#).

In addition to the earlier start times for the general decline in female age-adjusted breast mortality rates, another noticeable pattern difference in rates can be found for the last five years of the series (see [figure 4.22](#)). With the exception of the US, there is an abrupt decline in rates from 1999 to 2000 followed by an equally abrupt rise in rates from the year 2000 to 2001 for North Carolina regions. After this rise, the rates appear to plateau and in ENC's case they appear to hover around values seen in the late 1990s. The abrupt rise is not seen for the US series and with its trend line established in 1993; the age-adjusted female breast cancer mortality rate is projected to have reached the HP 2010 target rate in the year 2005. For the state and RNC, the target rate (22.3) would be achieved, respectively, in the years 2006 and 2004, respectively. (The trend lines include the last five years of observations as well.) However, as can be easily seen in the case of RNC, the target has not been met: the observed age-adjusted rate for that year is 24.3, which is about 9% above the target rate. The ENC trend line, which includes the anomalous 2000 to 2004 observed age-adjusted rates, projects the year 2016 as the year the HP 2010 target rate is achieved. For all NC regions, it is clear that the last four years of observation points may forestall the currently predicted years at which NC regions achieve the target rate. The comparison between the predicted and the observed suggests that there is a likely set of underlying factors responsible for the shift in the last five years of rates. The abrupt change in the direction of age-adjusted rates also underscores the problem of putting too much credence in simple linear trends.

[Figure 4.22](#) breaks down the ENC age-adjusted time series trend and observation points from [figure 4.21](#) into two series: white females and non-white females. This chart provides further illumination on the source of the unpredicted regional rates for the last five years in the time series. Near the beginning of the time series, the year 1980 yielded an age-adjusted rate for non-white females that was actually lower than that observed for white females. From that year, their rates begin to diverge with age-adjusted rates increasing for both groups. The rates level off beginning in the late 1980s and continuing until the early 1990s, after which the rates for both groups diverge, forming a large gap, in two different directions: white female rates decline fairly steadily ($R^2=0.41$) and non-white female rates appear to increase very slightly and much less steadily, with a very slight positive slope (0.09) and an R^2 of 0.02. For both groups, the last five years of the time series show evidence of an abrupt rise. However, non-white female rates continue to increase dramatically from the year 2000, while rates for non-white females, increasing dramatically from 2000 through 2002 have reversed their trend for the last two years of the series. Both trend lines from 1993 through 2004 include the surge in rates for the last five years. The trend line for white females projects this group achieving the target rate in 2005, which is still possible given the amplitudes in age-adjusted rates observed historical series. For non-white females, the experience is vastly different. Visually, the long-term trend appears stagnant or stationary with a weak increase in rates between the years 1986 through 2004. Unless direct and strong measures are undertaken, it is likely that non-white females will not achieve age-adjusted mortality rates on par with their white counterparts for several decades.

The discussion and analysis of female breast cancer highlights three types of disparities. The first type of disparity is racial. Non-white female breast cancer is significantly higher than the rate for their white counterparts across all regions. The second type of disparity is geographic. Not only does race appear to matter in the chance of dying from this disease, but where a breast cancer victim lives can also increase that chance: a non-white female with breast cancer living in ENC has an increased chance of dying over their white counterparts living in the same region, whereas in RNC a non-white female chances of dying are 23% greater than their non-white counterparts living in the same region. This translates into an almost 90% increase in the chance

of dying if you have breast cancer and you are a non-white female living in ENC.⁷ Finally, there is a large temporal offset measured in decades in achieving both racial parity and the HP 2010 target rate: the current trend for non-white females is relatively flat, while the observed trends for white females gives every indication that the target will be met several years ahead of 2010.

Survivorship from cancer is largely a function of staging and treatment. Treatment is a function of access, which extends beyond financial means into the realm of the psychological. Both can be very effective barriers to female breast cancer survivorship. The information presented above demonstrates both numerically and graphically the effect such barriers can have (or not have) on the lives of women in ENC.

MORTALITY FROM CANCER OF THE PROSTATE

Prostate cancer is the fourth leading cause of cancer mortality and the 14th leading cause of all mortality in ENC, trailing behind female breast cancer. In 2002, ENC ranked 50th out of 53 states and regions in prostate cancer mortality, followed by Mississippi, Alaska, and Washington DC. For white males it is the 11th leading cause of death, but for non-white males it is the 5th. A quick glance at [table 4.5](#) reveals similar rates across NC regions for white males, but when they are compared to their non-white counterparts a large gap emerges: non-white males possess rates ranging from 67% to 279% greater than non-white males. During the study period years, 1,478 ENC males died from this disease. Of those who died, 738 were white males and 740 non-white males, a one-to-one relationship, while the population ratio of white males to non-white males is two to one. This translates into about twice as many non-white males dying from prostate cancer than would be expected given their relative population sizes. A cross-product comparison of the age-adjusted rates increases the difference ratio, that is, if ENC non-white males had the same age-adjusted prostate cancer mortality rates as white males, then only 265 individuals would have died—a third of the total. Prostate cancer, while not a major cause of death within the region, is clearly important for a large segment of the regional population. The very large racial differences and wide ranges of rates among regions indicate that accessibility to care and treatment, like the case with female breast cancer, is an important health issue.

While the age-adjusted mortality rate for prostate cancer exceeds that for female breast cancer by almost 37% (see [tables 4.4](#) and [4.5](#)), the actual burden of mortality due to breast cancer is greater for females because of age structure: females typically contract breast cancer and die from it at earlier ages. Prostate cancer, on the other hand, develops at later ages in men after surviving the gauntlet of other potential killers, particularly heart disease. Age-adjustment using the US 2000 Standard Million Population further inflates the expected number of deaths from prostate cancer because of the increased weight given to older age groups. Comparing the crude mortality rates between the two tables shows the effect the standard population has on a rate calculation. The crude rate is a better measure of the actual mortality experience or burden of disease, while age-adjustment corrects for differences in age structure and permits comparisons among areas and populations.

Progress towards Prostate Cancer Mortality Reduction

[Figure 4.23](#) portrays maps showing a number of counties having achieved the HP 2010 target rate for prostate cancer mortality of 28.8 age-adjusted deaths per 100,000 for the five-year study period. In ENC, eight counties with 25% of the regional male population have achieved the target rate and in RNC, 26 counties with 31% of that region's male population have achieved the target

⁷ The increased chance of dying by race and region is calculated by first comparing the ratio of non-white females to white females for both regions and then comparing them by forming another ratio based on the two regional results. The data are found in [table 4.4](#).

rate. The counties in the former region that have achieved the target are interspersed, while those in the latter are concentrated in the western portion of the state and the central and western Piedmont. The remaining 33 ENC counties that did not achieve the target rate represent an excess of 356 deaths that occurred during the 2000 – 2004 study period. For white males, achieving the target rate during this five year period would mean a savings of about 42 lives, which indicates that this population is relatively close to achieving the HP 2010 target. To contrast, no counties in the east have age-adjusted mortality rates for non-white males anywhere close to the target rate. The achievement of the target for this group alone would save 439 lives or a 59% reduction in mortality from this disease. (Recall that when making comparisons using age-adjusted rates, differences in age structure among population groups will yield numbers that may not be resolvable into a total number of deaths). Such a comparison demonstrates the need and effort that will be required to reduce the age-adjusted rates for non-white males. With a third of all NC counties having achieved the HP 2010 target rate during the study period, the future is encouraging but only if more resources and improved accessibility and treatment is afforded to a large minority population.

Spatial Distribution of Mortality Due to Prostate Cancer

[Figure 4.24](#) contains maps showing county distributions of crude and age-adjusted mortality rates. The crude maps portray the actual mortality or mortality burden experienced by the county populations of both regions. From [table 4.5](#), 1,478 males died from prostate cancer in ENC compared to the 3,045 deaths occurring from the same disease in RNC. In terms of population size alone, ENC males generate an excess 202 deaths due to prostate cancer. When the rates are age-adjusted there is an eastward shift of high rate counties with concentrations of these counties in the eastern Piedmont and the northern and southern portions of ENC. Age-adjustment makes both regions and counties comparable and it changes the number of excess deaths produced.. The age-adjusted prostate cancer mortality rate for ENC is 37.0 per 100,000, which is 25% higher than RNC's rate at 29.5, a rate occurring over the five year study period that is fairly close to the HP 2010 target (28.8). If ENC were to have the age-adjusted RNC rate during the study period, then 300 lives would have been spared—approximately 98 excess lives over and above the regional difference are attributable to age-structure differences between the two regional populations.

In the ENC map found in the bottom half of [figure 4.24](#), 27 counties have prostate cancer mortality rates in the highest two categories, with all rates for these counties above 35.7 age-adjusted deaths per 100,000. These counties account for 61% of the regional male population and contribute 67% (994) of all the region's deaths due to prostate cancer (i.e., approximately 10% more than expected). Whereas RNC counties with rates above 35.7 represent just 15% of that region's male population and generate about 19% of the prostate cancer deaths, or about 27% more than expected. In relation to population, a smaller portion of RNC's population is generating a more disproportionate number of deaths: the mortality burden is concentrated into fewer counties and a smaller segment of the regional population. Most of this region's counties are adjacent, or nearly so, to the western-most boundary of ENC. In ENC, The higher production of prostate cancer mortality is more widely distributed across the region's counties and population. If ENC's 27 highest rate counties started the measurement period (2000 through 2004) with the ENC 5-year rate of 37.0, then 758 regional males would have died translating into a reduction of 234 deaths (or 24%). If the RNC rate was realized for these counties, an additional 153 lives would have been saved for a total reduction of prostate cancer mortality of 39%. Although the foregoing calculations are based on the control of age structure, they illuminate the regional differences in the prostate cancer mortality experience of the state. We now turn to a consideration of racial differences in rates both regionally and among counties.

[Figure 4.25](#) is a set of maps portraying the distribution of age-adjusted mortality rates for prostate cancer by race. The difference in rates between the two races is evident in this figure. Higher rates for white males appear scattered across the state with a weakly discernable concentration of these rates in the east. Using [table 4.5](#), the white male age-adjusted rate for ENC is 25.3 per

100,000 with 738 white males dying from this disease between the years 2000 and 2004. This rate is only slightly higher than the rate experienced by RNC over the same time, 24.5 with 2,195 deaths. ENC white male mortality is about 5% less than their counterparts in RNC. However, when age is controlled for the regional male populations, the situation reverses slightly with a 3% reduction (23 deaths) in ENC white males needed to achieve parity with RNC white males. Clearly there is not much difference between white males in either region. Regionally, there are contrasts in the mortality burden due to prostate cancer for the state's non-white males. Counties in the highest rate category, however, are distributed almost ubiquitously throughout the state, with the exception of several western counties, which have smaller minority populations. On a crude, proportional basis, ENC generates nearly 30% more prostate cancer deaths for non-white males than RNC. In terms of population proportion we would expect about 569 deaths from this disease—about 23% less than the observed number of deaths. Differences in age structure for non-white males in both regions account for about 60 (35%) of the 171 excess deaths experienced by ENC non-white males. Therefore, about 121 non-white deaths in ENC are due to regional effects, a situation similar to the breast cancer mortality experience.

The age-adjusted prostate cancer rate of 25.3 per 100,000 for white males in ENC is below the HP 2010 target rate (28.8). The age-adjusted rate for non-white males contrasts sharply to that of ENC white males. Here, the age-adjusted non-white rate is nearly three times that for white males. Given their respective regional population sizes, we would expect only 370 deaths for non-white males over the 5-year study period—about half the number observed. If regional non-whites had the same population age structure as their white counterparts at the beginning of the study period, then a dramatic reduction of 475 deaths would have resulted—producing a number of deaths fewer than observed for white males! This suggests that age structure has a strong effect on the experience of prostate cancer mortality. A similar situation for age-adjusted rate differentials is found for RNC (see [table 4.5](#)).

Spatially, the higher rate counties for white males tend to occupy the central portion of ENC, while for non-white males high prostate mortality rates are found in all counties (see maps in [figure 4.25](#)). For ENC white males, the county with the highest stable rate is ninth ranking Carteret at 30.7 per 100,000 and 47 deaths. Other higher ranking counties with statistical stability in prostate cancer deaths include Harnett at 30.5 (30 deaths), Pender at 30.5 (20 deaths), Halifax at 30.2 (20 deaths), and Sampson at 30.1 (21 deaths). If the 20 counties with white male rates above 25.3 had this rate at the beginning of the study period, then the number of white male deaths would have been reduced by 44. To contrast, the highest rate county for non-white prostate cancer mortality is Northampton at 114.0 per 100,000 and 29 deaths. (The absolute highest rate is found for Tyrrell County, but with just 6 deaths, the rate cannot be considered stable.) Northampton County is followed by three counties with high and stable rates: Sampson at 101.3 (35 deaths), Wayne at 93.9 (50 deaths), and Nash at 89.0 (33 deaths). The regional age-adjusted rate for non-white males is 70.7 per 100,000 and 740 deaths. If non-white males from the highest rate county had achieved the regional rate at the onset of the study period, then more than 400 non-white male lives would have been saved. (These calculations are based on controlling for age structure and should be interpreted as the number of lives saved if county populations, white, and non-white, had the same age-compositions.) The primary value of these calculations is to illustrate the large discrepancies that exist among counties and populations. We now turn an examination of the temporal patterns underlying the differences observed on the maps.

Temporal Distribution of Mortality from Cancer of the Prostate

The temporal pattern found in [figure 4.26](#) approximates the form seen in [figure 4.6](#). The regional patterns are not only similar but maintain their relative positions throughout the 26-year series. There is a strong and consistent decline in age-adjusted prostate cancer mortality rates from 1993 to 2004 as measured by the R^2 values and all regions are expected achieve the HP 2010 target rate before the year 2010. The US is expected to reach the target in 2001, RNC in 2001 or 2002, NC in 2003, followed by ENC in 2005. While these declines are very encouraging for regions as a whole, not all populations within these regions will achieve the target rate in 2010.

[Figure 4.27](#) illustrates the temporal pattern and differences in age-adjusted prostate cancer mortality rates between white and non-white males. ENC white males achieve the HP 2010 target rate in 1999 using the expected value from the equation-of-the-line formula. On the other hand, non-white males do not achieve the target rate until sometime in the year 2016. The R^2 values for these series are high enough to project several years into the future, but in the case for white males the subsequent observed data points bear out the prediction based on the equation. For non-white males we can have some confidence that reaching the HP 2010 target rate won't occur until well into the next decade. According to the charts, the prognosis for prostate cancer mortality in ENC non-white males is much more favorable than it is for breast cancer in non-white females. However, this may not be necessarily due to better access to care and treatment, but may be the effect of age-specific mortality differences (prostate cancer mortality occurs at higher ages) and the differential survivorship from other causes of death.

Progress is being made in prostate cancer mortality in ENC, although it is not equitably shared between the two racial groups. The picture is much more favorable to ENC white males than their non-white counterparts. This disparity can be seen easily from both the map and the time series chart. For non-white males county age-adjusted rates above 35.7 are ubiquitous, while white males these rates are limited to three counties throughout the state. ENC white males have already achieved the HP 2010 target rate prior to the 5-year study period, while ENC non-white males may not achieve this target until some 16 or more years later, reflecting a temporal offset or disparity with respect to the HP 2010 objective.

CONCLUSION

Mortality from malignant neoplasms is rising in relation to heart disease mortality and evidence is mounting that death from cancer will become the leading cause of death. Among malignant neoplasms, cancer of the trachea, bronchus and lung is the most prominent in ENC, shaping the temporal rate pattern for cancer mortality. Only one county (Watauga) has achieved the HP 2010 target rate with other counties still requiring a high percentage of reduction. While mortality rates for males have been declining for the last several decades, it will be many years after 2010 when the objective target is finally reached. TBL mortality for females, on the other hand, has been slowly increasing since 1979. White females are projected to reach and exceed the target a year or two before 2010 and non-white females may reach and surpass the target many years after. The trend lines for both female groups are relatively weak, indicating a high likelihood that these trends can be reversed. Cancer of the colon, rectum, and anus is a distant second in terms of leading cause of cancer mortality. Again, not very many counties have achieved the HP 2010 objective target, with counties in ENC still requiring more percent reduction. White females tend to have lower rates of mortality from this disease compared to the other three groups. Female breast cancer mortality is the third leading cause of cancer mortality. The study period witnessed a curious rise in rates departing from the overall declining pattern observed for all regions. However, more than a quarter of all NC's 100 counties have already achieved the HP 2010 target rate. There appears to be regional differences in rates for non-white females that suggest underlying disparities in access to care and treatment. Extrapolating from the trend line, ENC is the only region not expected to reach the HP 2010 target rate. Following female breast, mortality from prostate cancer is the next leading cause of death from malignant neoplasms. While mortality rates tend to be higher than those seen for female breast cancer, it should be remembered that most deaths from prostate cancer occur at much later ages than death from female breast cancer, which affects the comparison of age-adjusted rates. More than a third of NC's counties have achieved the HP 2010 target rate. Most of this achievement has been accomplished by the numerically larger white male population. Death from prostate cancer is a very prominent cause of cancer mortality among non-white males, with rates often 2 to 3 times that of their white counterparts. These four leading cause of cancer deaths comprise about 50%

of all cancer deaths. The remaining share of cancer mortality is caused by a very wide array of malignant neoplasm sites affecting a spectrum of ages and populations.. Because of the inherent diversity of cancer sites and their complex etiologies, cancer will remain a leading cause of death well into the future.

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