

General Mortality in Eastern North Carolina 2000 to 2004

The chapter on general mortality is divided into several topics related to mortality from all causes for eastern North Carolina. They can be accessed directly with the following links.

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Introduction

General mortality includes all causes of death over a specified time interval. Causes of death are further defined and classified into internationally recognized series of grouped codes, such as the *International Statistical Classification of Diseases and Disorders and Related Problems, 10th Revision* or ICD-10 (World Health Organization, 2004). (For the most recent revision of codes, see the electronic version at the World Health Organization's website (World Health Organization, 2006).) Periodically, revisions are made to incorporate changes in medical knowledge and to incorporate and facilitate improved coding rules (see U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, & National Center for Health Statistics, 2006). Standardized coding, in conjunction with using standard populations for age-adjustment, permits comparability of rates among different time periods and geographical units. Once the cause of death has been coded, each record is accumulated into a time and place-specific total number of deaths. The accumulated totals are then used to determine the relative ranking and importance of leading causes of death for a county or a region. [Figure 2.1](#) portrays the resulting 5-year totals for the ten leading causes of death proportionally to the total number of deaths in ENC from 2000 to 2004.

In this figure, two general classes of mortality causes dominate the mortality experience of ENC: Total Cardiovascular Disease (TCVD) and Malignant Neoplasms (All Cancers). From 2000 to 2004, more than 59% or 65,442 deaths have occurred due to these two disease categories. The remaining eight leading causes of death account for just 21.4% or 23,605 deaths during this same period. The number one leading cause of death in ENC for the study period is TCVD, which accounts for 37.0% (40,820) of the region's 110,390 deaths. (The TCVD category is based on the definitions proposed by the American Heart Association (American Heart Association, 2005) and includes mortality due to stroke.) Death from malignant neoplasms is the second of the ten leading causes of death and

accounts for 22.3% (24,622) of all regional mortality. A distant third leading cause is attributed to Chronic Obstructive Pulmonary Disease and Chronic Lower Respiratory Disease COPD/CLRD with 4.9% (5,384) of all deaths from this cause. Mortality from Diabetes Mellitus follows with 3.5% (3,904) of all ENC deaths. In fifth place, death from Unintentional Motor Vehicle Injuries (UMVI), accounts for 2.8% (3,047) of the region's deaths. Septicemia is the tenth ranking cause of death claiming 1.7% of all deaths. The ten leading causes of death are followed by a single category, All Other, which accounts for 19.3% (21,343) of General Mortality. Within this final category, 1,378 people have committed suicide, 1,193 people have died from chronic liver disease and cirrhosis, 1,104 people have been murdered, and 776 people have died from AIDS due to HIV (Human Immuno-deficiency Virus). Regionally, deaths from specific causes in the All Other category make up very small percentages within general mortality. Nevertheless, when counties are examined separately, the seemingly insignificant causes of death at the regional scale can be important causes of death at the more local county level scale. It is therefore important to monitor at the "basement" level so that emerging mortality trends at regional and local scales can be detected.

The present chapter is organized around three general topics. The first two topics describe patterns of mortality from all causes, but using two different approaches in its portrayal. The first approach examines the spatial and temporal patterns of two density measures: crude and age-adjusted general mortality rates. These two measures describe mortality quantities in relation to population sizes and their distributions in space and time. However, density measures do not provide information about what part of a population is being affected. Mortality, whether from specific or general causes, can affect populations in a differential manner across spatial and temporal dimensions. Measuring the cumulative differences of age-at-death of individuals that occur before an accepted standard age-at-death (say, 75 years) produces information about the level of premature mortality. Larger amounts of years of potential life lost in a population signify greater levels of mortality burden being shouldered by that population. The second topic covered in this chapter addresses the distributions of premature mortality in eastern North Carolina and the state. Finally, we move from empirical descriptions to a brief discussion of how patterns of general mortality can be explained by their relationships to other factors.

The Spatial Distribution of Crude and Age-Adjusted General Mortality Rates

A map of crude mortality rates will draw the map-reader's attention to those areas that are experiencing the highest numbers of deaths relative to their local populations. The crude mortality rate measures the density of resident deaths occurring in an area in relation to the population of that area. It is a summary measure representing the proportion of a population that has died over a given interval of time. Because this proportion is frequently a very small value, it is multiplied by a larger number (of persons) like 1,000, 10,000, 100,000, or even

1,000,000 for extremely rare causes of death. (This atlas will employ the multiple of 100,000 persons when discussing and comparing density measures.) Because age is the greatest risk factor for dying, the map of crude mortality rates is also, to some degree, a map of the underlying spatial distribution of population age structures. Controlling for the effects of age variation will permit the map reader to make comparisons of mortality rates among different areas on the map. This is accomplished through the technique of age-adjustment, which adjusts the observed number of deaths to an expected number of deaths if the population under study had the same age structure as some external reference population (Buescher, 1998). In this atlas, the US Standard Million for the year 2000 is employed (Anderson & Rosenberg, 1998). It is extremely important that the standard population used in each case is the same when comparing age-adjusted maps from one period of time to another, or when comparing maps of age-adjusted rates from other states. Different model or standard populations will generate different age-adjusted rates even when the actual or observed distribution of deaths across the population age distribution remains constant.

[Figure 2.2](#) shows the mapped distribution of crude mortality rates from all causes for counties in the contiguous US from 2001 to 2003. The category classification is based on the extension of the classification scheme used in the North Carolina mortality maps discussed later in this chapter.* Higher rates of general mortality in this map are concentrated in the central part of the nation, which includes the Great Plains and Midwest, the South, and the outlying high rate counties in the Far West. There is also a significant cluster of counties centered in mountainous West Virginia and eastern Kentucky. Recall that age is the greatest risk for dying. [Figure 2.3](#) is a map that shows the distribution of county level proportions of people 60 years of age and older for the 2000 US Census year. The distribution of the proportions of elderly is similar to the distribution of the higher crude mortality rates seen in the previous figure. Statistically, the relationship, measured as a correlation, results in an r-value of 0.81 and an R^2 of 0.66, which means that 66% of the variation in county crude rates of mortality is explained by just the proportions of individuals greater than 60 years of age. Although the

* The North Carolina rates (crude and age-adjusted) are based on more current numbers from the State Center for Health Statistics and State Data Center and use a five-year period such as 2000 to 2004. Because numbers for the entire US are usually available three years behind the state's and that there are a significant number of US counties that experience small numbers of mortality events, US county rates (crude and age-adjusted) in this work are based on three-year aggregations (2001 and 2003) from the National Center for Health Statistics' Compressed Mortality File (CMF) 1999 to 2003. The center point year or fulcrum year for the US county rate maps is 2002. That same year is the fulcrum for the period 2000 to 2004, which is the period used in the state and regional discussions throughout the Atlas. However, in the state and regional comparisons, the US value for one year is 2002, because their numbers are sufficiently large not to warrant aggregation. It should also be noted that the rates generated for North Carolina counties in the three-year US map will be slightly different than those generated for the five-year NC maps seen elsewhere in the Atlas. This is the result of using different numbers of data points (three and five) and slight differences found in the denominators (i.e., county populations) between the US (CMF 1999-2003) and NC (state demographic estimates) data sources.

crude mortality rate map depicts where mortality is occurring in relation to population age structure, this map cannot be used to make meaningful comparisons among individual counties because their respective age structures are different. [Figure 2.4](#) shows the effect that age-adjustment has on the county mortality pattern using an external standard population (US 2000 Standard Million). The high rate counties shift and concentrate their spatial distribution to the Ozarks, Lower Mississippi Valley, the southern Coastal Plain, and the south-central Appalachian region of West Virginia and eastern Kentucky. A few outlying high rate counties are found scattered throughout the west, which generally correspond to Indian reservations. The inset map in [figure 2.4](#) shows that ENC is a northern extension of the high rates of age-adjusted mortality found in the southern Coastal Plain. To contrast, the national age-adjusted map also shows that most of the remaining counties on North Carolina (RNC) are part of the southern extension of the much more favorable mortality conditions of the Northeast.

Maps showing the spatial distribution of crude and age-adjusted mortality rates from all causes in both NC and ENC for the years 2000 to 2004 are found in [figure 2.5](#). Individual county and regional mortality rates are listed in [table 2.1](#) and their locations can be found using the map in [appendix A](#) of this chapter. The state map for crude rates shows that the greatest mortality burden is experienced at both ends of the state. Western North Carolina (WNC) has the highest crude general mortality rate of 1,080 deaths per 100,000 people. The next highest crude mortality rate is found in the northeast 29-county region of North Carolina (ENC 29) with a rate of 967.7--7% higher than the 41-county ENC regional rate of 905.4. The highest county rates in ENC cluster together along a northwest-southeast axis. In this cluster, Hertford County experiences the highest rate of 1,330.6 and the second highest rate is found in its southern neighboring county, Bertie, at 1,313.3. Onslow County's rate is the lowest in the region (518.4), experiencing mortality at just 39% of Hertford's level. The greatest local impact of mortality from all causes is felt in the northern county cluster of ENC which also possesses an older aging-in-place population. This contrasts starkly to Onslow County where a significant portion of its population is made up of young, transient, military service-age people.

When the county rates are age-adjusted ([figure 2.5b](#)), the high mortality categories become more concentrated in the east and less so in the state's mountainous west--where the relative older ages of those county populations played a role in that region's observed higher crude rates. The effect of age adjustment on relatively youthful county populations with low crude mortality rates can be quite dramatic. For example, when the crude rates for Cumberland and Onslow--two counties with large military aged populations--are age-adjusted, there is an apparent jump in mortality rates of 51% and 84%, respectively. At the regional level, age-adjustment widens the disparity for general mortality between ENC and RNC to more than 12% from the crude rate difference of 7%. Within the ENC region, counties with the highest age-adjusted rates form two centers,

one in the northeastern 29-county sub-region of ENC and the other in the remaining southern 12-county sub-region. In the 29-county sub-region, Edgecombe County possesses the highest rate (1125.6) among the eight county cluster found there. Other counties in this cluster include Halifax (1023.9), Northampton (1007.0), Hertford (1124.5), Gates (1061.1), Bertie (1111.2), Martin (1091.0), and Washington (1027.8).^{*} The highest age-adjusted general mortality rate is found in the southern sub-region. Robeson County with 1133.3 age-adjusted deaths per 100,000 has the highest general mortality rate in the state and forms the core of the southern-center-high-rate-county-cluster. This county cluster includes Scotland (1063.6), Hoke (1015.5), Bladen (1101.7), and Columbus (1069.9) counties. A north-northeast linear series of adjacent high rate counties (Sampson, Wayne, and Lenoir) continues from the northeastern border of Bladen County. Immediately adjacent to the east of the southern cluster is a three county cluster of the lowest age-adjusted general mortality rates found in the entire 41 county region. The counties in this cluster include New Hanover (832.7), Brunswick (842.8), and Pender (830.1). All three of these counties have rates that are more favorable than the RNC 59 county rate of 866.1 age-adjusted deaths per 100,000. The examination and comparison of crude and age-adjusted general mortality in North Carolina yields two conclusions. First, the higher crude rates found in the east like in the western counties, can partly be explained as a function of greater proportions of elderly. Second, when general mortality rates are adjusted for age, 16 of the 20 highest rate counties are found in ENC 41, which clearly demarcates this region as one experiencing a greater mortality burden in both an absolute and relative sense. Many of the counties in this discussion will be seen again in later sections of the Atlas when the geographic patterns of mortality from specific causes are explored.

Figure 2.6 shows the contributions that race-sex specific age-adjusted general mortality make to the overall pattern of general mortality in North Carolina seen in the age-adjusted map (fig. 2.5b). Applying the same age-adjusted rate category classification found in figure 2.5b to the rate distributions of each of the four demographic groups in **figure 2.6** produces four distinct map patterns. Males of both races have higher rates (i.e. they occupy the highest rate category: 1,004.3 to 2,107.8) of general mortality throughout the state. White males (fig. 2.6c) have a state rate of 1,034.0 and a regional (ENC 41) rate of 1,100.2 compared to nonwhite males whose rates are 1,336.2 and 1,406.0, respectively. Counties with larger proportions of retirement age populations, found within each of the state's three physiographic provinces, as well as the larger metropolitan counties of the Piedmont have lower rates of death from all causes for white males. For nonwhite males, 95 of the state's 100 counties are in the highest rate category. The remaining five counties are found in the westernmost portion of the state, and their lower rates for nonwhite males are probably the result of fewer people being in this race-sex group in the western region. The age-adjusted death rates

^{*} In the three year average (2001 to 2003) for the 3,100 plus counties of the US, Martin County ranked 15th highest in the nation at 1313 age-adjusted deaths per 100,000.

for females of either race are significantly less than their male counterparts. White females (fig. 2.6b) have a state rate of 720.4 and a regional (ENC 41) rate of 773.5 compared to nonwhite females (fig. 2.6d) whose rates are 857.3 and 891.6, respectively. White females have rates in the lowest map category throughout the state. Eight out of eleven of this group's highest rate counties are found in ENC. Nonwhite females have the most complex spatial distribution of mortality. A wide range of rates are observed throughout the state with the largest concentration of high rate counties found in ENC. Another large concentration of higher rate counties can be found along a north-south axis in the central Piedmont. In some counties, these high rates may be attributed to the smaller representation of this demographic group and thereby the potential effects of random variation of rates due to small numbers. Overall, there is very little geographic effect on nonwhite males with respect to the age-adjusted general mortality map patterns. White males, and females of both racial groups appear to shape or delimit the regional distribution of mortality from all causes, while the relatively greater proportion of nonwhite males in ENC further accentuates the high general mortality rates found in that region.

When general mortality rates for North Carolina are age-adjusted for the years 2000 to 2004, 35 of ENC's 41 counties (85%) emerge with rates above the state rate of 896.5, while 26 of RNC's 59 counties (44%) do so. Partitioning the general mortality map for the total population into four separate maps based on race and sex reveals how the distribution of rates for the total population is weighted and shaped by its constituent sub-populations. Later chapters of the atlas will show the impacts of specific leading causes of death on these sub-populations and their subsequent contribution to the observed spatial patterns of general mortality. The age-adjusted general mortality map of NC and ENC represents the integration of the patterns produced by component leading causes of death. It is also the culmination of many different mortality processes that have been operating at their own characteristic scales, tempos, and modes. The next section discusses how some of these processes have affected the observed pattern of mortality in ENC over time.

The Temporal Distribution of Age-Adjusted General Mortality Rates

The following two figures ([2.7](#) and [2.8](#)) show how mortality has evolved over the 26-year time period from 1979 to 2004. The last five data points (the years 2000 through 2004) in the ENC 41, RNC 59, and NC time series illustrate the amount of variation in annual rates that are subsumed into the single age-adjusted five-year (2000-2004) rate seen in the preceding table and maps. A trend line, shown by dashes in the figure, is fitted for each of the time series and extended to the year 2010. The trend line is calculated based on information from the entire series of data points (i.e., annual rates). Additional information about the trend line is also provided below the figure. This information includes the percent change in rates from the initial year to the latest year in the time series. The R^2 value is a measure of how well the fitted trend line corresponds to the observed

series. The equation of the line, also shown, generates the trend line that allows the investigator to calculate an expected value for a given point in time. Time series trend lines can diverge, converge, or run parallel to one another. To make analysis easier, linearity of the observed data is assumed for the 26-year period in these time series graphs. However, broader temporal scales of observation show that mortality from any number of causes is generally non-linear (see [figure 1.2](#)).

With the simplifying assumption of linearity, it is possible to calculate an approximate time when two series will have the same rate (convergence) or when two series began to separate (divergence) from each other by setting the two equations of the line equal to one another. However this should be done only when R^2 values are high (i.e., approaching 1.00) and when making projections into the near future or more recent past. Making projections too far into the future, or past, over-extends the more limiting and linear perspective of recent mortality trends, resulting in the danger of making spurious conclusions about long-term and, most, likely non-linear processes. For example, using the equations-of-the-line in the trends description section found in [figure 2.7](#), the age-adjusted general mortality rate for ENC 41 and RNC 59 will not be equal or converge until the year 2154! Clearly, the use of linear trend lines should only be used short term prognostication. Their utility lies in permitting the researcher to make summary assessments and examine potentially meaningful trends, emerging differences or improvements in rate disparities.

[Figure 2.7](#) illustrates four solid trends in regional declines of general mortality. The goodness-of-fit lines are all above 0.90, indicating that from 1979 to 2004 there are very tight fits to the modeled trend line and that predictions for the next several years could be reasonably and confidently made. Over this 26-year study period, age-adjusted mortality rates have declined by 16 and 17 percent for all four regions. The greatest decreasing coefficient belongs to the US (-7.75) and the least to RNC 59 (-6.34). This translates into an average growing disparity of age-adjusted general mortality rates of about 1.4 age-adjusted deaths per 100,000 per year over the course of the last 26 years. Although all trends are certainly favorable in absolute terms, the ENC 41 trend line stands out well above the others with the line equations demonstrating persistent relative disparity in mortality rate trends between this region and RNC 59.

A closer look at the mortality experience of ENC 41 reveals substantial differences by race and gender. [Figure 2.8](#) shows relatively flat trends (from negligible to 7% decrease) for females, with only a slight growth in disparity by race (see trend descriptions) over the 26-year period. White males have had the greatest amount of rate decline with a 28% decrease from 1979 to 2004. The trend for white males is very consistent over time and can probably be used reliably as an indicator of mortality scenarios in the near future. Nonwhite males follow with a more modest 16% decrease and a less confident trend line than their white counterparts. Although the trend lines for males from either racial

group are decreasing, the relative rate disparity between them, as measured by the equations-of-the-line, increases from 17% in 1979 to 37% in 2004. Since 1979, age-adjusted general mortality has been improving for all males in the region, while rates have remained relatively flat or changing little for regional females.

The female pattern suggests that mortality rates may reach an asymptotic level for a period of time. One reason for this flattening out might be that all benefits from current health technologies, innovations, knowledge concerning care and behaviors have been nearly realized for that group over the last two to three decades. There may also be a certain amount of intra-regional “balancing out” or counteracting of high and low rates among counties in different parts of ENC 41. The trend lines for males are converging on the trend lines for females—with white males approximating the mortality rates for nonwhite females some time around the year 2014 or 2015. It will be interesting to see if white males, and probably much later for nonwhite males, begin to approach a similar mortality asymptote as has been the case for females. It is likely that the reasons for the relatively low rates for females have yet to be completely realized for males, but the rates show that they are still in the process of responding to or adopting mortality reducing behaviors and technologies. Certainly the pattern between both female groups indicates that differential mortality remains even when rates are low and relatively stable. What accounts for this persistent differential forms the bulk of health disparities literature today.

The above discussion and description of the patterns of crude and age-adjusted mortality reveals that a geographic disparity exists between the 41 county (and 29 county) region of NC and the remaining counties of the state, with the east experiencing significantly higher rates than RNC. Within ENC, age-adjusted general mortality rates have been declining over the past three decades for the major demographic groups discussed in this chapter. For females of both racial groups the decline is relatively minimal, but for males the decline has been more dramatic, with nonwhite males having the sharpest decrease. Nonwhite males, although experiencing a larger decrease in general mortality rates have begun their downward trek at a much higher beginning rate so that the relative rate disparities between them and the other demographic groups will remain high for the foreseeable future.

As previously mentioned, density measures tend to mask other types of information that can be derived from mortality records. The next section focuses on the concept of mortality burden and its measurement. Understanding the impact of premature mortality on county populations can assist in discriminating where disparities of mortality burden are occurring.

Mortality Burden

Mortality burden can be viewed at different scales of impact. Within a family there is the obvious psychological, social, and economic impact of a member's death. The decedent's stage in the life cycle, occupation, resources, and position in society also has relevance in broader local and community scales of social relationships. Implicit in any decedent's age at death is the tangible and intangible cost, benefit, and potential contribution of that individual's life to both family and friends, and to the larger extended communities to which he or she belonged. Collectively these mortality experiences can be summarized into one point value: crude mortality rate. This density measure indicates the direct arithmetic impact or burden actual deaths can have on a population. However, a population with an older age structure will naturally have more individuals at risk of dying as they enter the latter stages of their life cycle during a given time interval and so that population may appear to be experiencing a higher burden of mortality. Another way to look at mortality burden is to look at how much potential life is lost, which is a comparison of an observed age-at-death against some expected or standard age at death. Instead of one point value, two point values are used, with greater differences between corresponding to increases in mortality burden.

Age-at-death can be used to measure the amount of life lost prematurely from a standard number of years of life that an individual can be expected to live in the population of interest. The typical standard age used in current research is 75 years, which is close to 77.5 years, the life expectancy at birth (e_0) for the US in 2003 (Arias, 2006) and nearly identical to the mean age of death in North Carolina. The number of deaths and their ages of occurrence before the age of 75 can be accumulated, age-adjusted, and normalized by the underlying population. Greater differences mean greater years of life lost, when calculated in this manner, and indicates a greater level of mortality burden being experienced prematurely.

The meaning of a premature mortality rate or years of life lost rate as described above is qualitatively different than for the more commonly used density measures. To illustrate, the age-adjusted mortality rate in North Carolina for female breast cancer was 25.6 per 100,000 and for prostate cancer in males it was 29.1 per 100,000 in 2004. A comparison of these two rates would lead one to the conclusion that prostate was a slightly bigger killer of men than breast cancer is in women. However, when the premature mortality rates* for these two causes of death are compared, the number of years of life lost before age 75 is 33.9 years per 10,000 for female breast cancer and 6.4 years for prostate

* Currently premature mortality is typically measured by the number of years of life lost (YLL) before age 75 per 10,000 people. Each death is aggregated into an age category and the total number of deaths in that category is multiplied by the difference between the age category mean age at death and age 75. The resulting age category YLLs are then summed, divided by the population, and then multiplied by 10,000 to make interpretation easier. The YLL-75 (premature mortality) measure can either be crude or age-adjusted.

cancer. These values indicate that males tend to die at much later ages from prostate cancer and not prematurely relative to the age of 75. Females tend to die from breast cancer at earlier ages, suffering a greater mortality burden than their male counterparts for a sex-specific disease, with perhaps a greater impact on families and communities.

The Spatial Distribution of Premature Mortality from All Causes

The national age-adjusted premature mortality rate for the year 2002 is 751 years of life lost per 10,000 people. The lowest state premature mortality rate in this same year is found in Vermont at 568, while the worst state rate belongs to Mississippi at 1088. If the District of Columbia is added as a state it would fall behind Mississippi ranking a distant 51st with a rate of 1323. Within the state rankings, North Carolina is 39th with a rate of 833, and with the exception of Florida and Virginia, has the lowest premature mortality of the remaining southern states. If the 41 county region of ENC is entered into the state rankings, it would rank 47th at 959, with Arkansas, Alabama, Louisiana, Mississippi, and the District of Columbia trailing in the lowest ranks.[†] The 29-county region of ENC would rank 48th at 975, ousting Tennessee, which moves up to 47th. The Piedmont region compares more favorably as a state with a premature mortality rate of 774 placing it 29th among the states. The Western NC region has a more intermediate premature mortality rate of 805 and ranks 34th. [Figure 2.9](#) is a map of the United States that shows the age-adjusted premature mortality rates for the states with North Carolina's three regions mapped as "states". From this national context we now move to a more specific in-depth discussion of how premature mortality varies by sub-region and county within North Carolina.

[Figure 2.10](#) portrays both crude (fig. 10a) and age-adjusted (fig 2.10b) premature mortality rates measured as years of life lost before the age of 75 years (YLL-75). The maps in this figure describe the distribution of mortality burden for counties. Unlike the maps in [figure 2.5](#), age-adjusting the rates (i.e., the expected number of deaths) has very little effect on the map pattern of premature mortality. The ENC 41-county region stands out distinctly relative to the other regions of the state with its large number of high premature mortality counties. [Table 2.2](#) bears this out with the age-adjusted rate for premature mortality 22% higher than RNC, and when compared to PNC and WNC, the region is 23% and 17% higher, respectively. Finally, the age-adjusted premature mortality rate for ENC is 27% higher than the rate for the nation, which for the year 2002, is 751.0.

When premature mortality is compared on a national and regional level, the counties of North Carolina and ENC do not fare well. Only 14 NC counties in the state have premature mortality rates less than the US 2002 rate, with New

[†] ENC 41 and 29 county regional rates, as well as other NC regional rates, are calculated using the National Center for Health Statistics' Compressed Mortality File series data for the year 2002.

Hanover, at 705.6 years of life lost per 10,000, being the only county in the east to do so. Regionally, 36 of the 41 counties in ENC (84%) have rates above the North Carolina rate, while 27 of the 59 counties of the remaining NC counties (46%) have rates greater than the state. In terms of population exposed to risk of dying prematurely at a rate higher than the state, the difference between the two regions becomes even more dramatic. In ENC, 84% of the region's population who are under the age of 75 years live in those counties that have higher rates than the state, while 27% of RNC's population under 75 live in counties with a higher rate than the state. Moving to the individual county comparisons, Wake County experiences the least years of life lost in the state for the 2000 to 2004 period with a rate of 564.8 years per 10,000, which is 32% lower than the state rate. Robeson County has the least favorable rate for this study period at 1,234.7 years of life lost, 119% greater than the rate for Wake County.

When the age-adjusted map for premature mortality for all causes is decomposed into maps focusing on the four demographic groups, differences in their contributions to the overall rates emerge (see [figure 2.11](#)). The greatest contribution to the overall rate is made by nonwhite males (fig. 2.11b). Like age-adjusted mortality rates, high county rates for this group are a ubiquitous feature throughout North Carolina, with the exception of a few counties in the western part of the state. (For county locations, see the map in [appendix A](#).) Duplin County, in southern ENC had the highest premature mortality rate in the state at 2,133.4 years of life lost per 10,000 (see [table 2.2](#)). To contrast, white females (fig. 2.11b) have ubiquitously low county rates with the highest state-wide county rate found in an ENC county, Northampton, at 803.4. Regionally, the lowest rate for white females is found in New Hanover County at 412.4, slightly more than half of the Northampton rate. Overlaying these two contrasting map patterns, are the rate distributions of white males (fig. 2.11a) and nonwhite females (fig. 2.11d). Both of these map patterns are more variegated than the previous two. The mapped distribution for white males, though heterogeneous, is weighted more by the higher rate categories concentrated primarily in ENC, but also found distributed throughout the peripheral non-metropolitan counties of the Piedmont, and the western counties. The highest rate for white males, 1,563.0 years of life lost, is found in Robeson County located in southern ENC on the South Carolina border. Like white males, the distribution of high rate categories for nonwhite female culminates in the east, while high rate counties are found scattered to the west of the region. For this group, the highest rate--1,517.3 years of life lost--is found in Perquimans County. While the highest rates for each of the four demographic groups are found in ENC, the lowest rates for any of these groups are located outside of ENC. For white males and females (fig. 2.11a—b), the lowest premature mortality rates are found in Wake County at rates of 578.1 and 352.9, respectively. The lowest meaningful rates (i.e., rates calculated from deaths numbering 20 and more) for their nonwhite counterparts are found in McDowell County with nonwhite males at 977.8 years and nonwhite females at 494.0 years in Wilkes County. Both of these counties are found in the western portion of the state. To conclude, there is a discernable geographic difference in

mortality burden between ENC and RNC that is driven by the mortality experience of white males and nonwhite females

The Temporal Distribution of Premature Mortality from All Causes

[Figure 2.12](#) is a comparison of premature mortality trends among regions from the years 1979 to 2004 (2002 for the US). Premature mortality for all four regions is declining at approximately the same rates. The relationships among the trends, in terms of their relative ranking in years of life lost rates, remains constant throughout the time series study period. ENC consistently experiences the highest rates of age-adjusted premature mortality but the trend line indicates an approximate 27% decrease from the beginning of the study period in 1979 to 2004, slightly less than the other regions. All regions show a similar pattern of decline, including the gentle oscillations of observed values about their respective trend lines. For the first five or six years, the decline in trends is steeper than any other interval in the series. Thereafter, the observed regional rates decline less steeply and fluctuate very little from their respective trend lines. This suggests that there may be emerging countervailing trends in premature mortality from specific causes, which either balance each other out or have become more stable over time.

When ENC's observed premature general mortality rate series is decomposed into four separate premature mortality series corresponding to each of the four demographic sub-groups, several distinct patterns emerge ([figure 2.13](#)). The greatest decline in premature mortality is experienced by white males at 34%. Although nonwhite males have the largest negative coefficient (-30.35), indicating the steepest rate of decline, they begin the series with an expected or modeled premature mortality rate (the intercept) at a level some 72% greater than their white counterparts. The pattern of decline for this group is very similar to the one observed for regions and it may be that the nonwhite male experience is what is driving the patterns seen in the previous figure. The trend line for white males is decreasing more than twice as fast as the trend for nonwhite females and overtakes the latter sometime around the year 2002. The observed rate patterns suggest a convergence—a convergence that has been evident for the 10 years prior to 2002. For the last two or three years of the series the rates appear to be diverging but it is probably not indicative of a reversal in trends. The last demographic group, white females, shows the least amount of decrease (17%) over the 26-year period and like the age-adjusted mortality rates for this group they appear to be approaching a rate asymptote. If present trends continue for the four demographic groups, the next convergence of premature mortality rates will occur between white males and females around the year 2030. As with age-adjusted mortality, decomposing the general premature mortality rate by demographic groups reveals differences and potential disparities among them.

The shift in the county distributions from crude premature mortality rates to age-adjusted premature mortality rates is minimal when compared to west-to-east

shift in distributions of the density measures. One reason for this difference in pattern shifting is that ages at death close to 75 years have a small negative impact on the premature mortality outcome measure and a zero impact when deaths occur after that age. Larger numbers of deaths occurring at ages several years prior to 75 indicate a population experiencing a greater share of mortality burden as an outcome. For example, the accumulation of years of life lost due to high infant mortality rates, and earlier ages at death from cardiovascular diseases and cancer can reflect inherent problems with access to appropriate healthcare. (Density measures essentially treat all deaths as equal in impact and cannot be used to measure the depth of mortality burden.) Regionally, this suggests that although the western region of the state possesses populations with higher relative proportions of elderly, their respective mortality burdens are not greater than expected. This contrasts to what the measure portrays for the eastern 41 counties of the state—a region that not only has a high proportion of elderly population with its attendant mortality but it is also a region that has a disproportionate number of its population dying prematurely.

From Empiricism to Explanation: General Mortality Disparities

The numerical evidence tells us that mortality is not experienced equally between ENC and the 59 remaining counties of North Carolina (RNC). From 2000 to 2004, 110,390 deaths occurred in ENC and 249,278 deaths occurred in RNC. The latter region's population is larger with a 5-year population-at-risk of 29,349,691 individuals compared to ENC's 12,192,418. Proportionally, the expected number of deaths for ENC numbers would be 103,555. Subtracting the proportionalized mortality from the observed value of 110,390 yields an excess of 6,835 deaths (6.6% more) carried by ENC-- a crude measure of a geographic disparity for general mortality between the two regions. However, this does not account for the probable regional differences in age structure. (Recall that age is the greatest risk factor for any individual dying during a specified time interval.) If age structure is controlled for the two regions, the difference in the number of deaths between the two regions grows to 12,924 (12.2% more), nearly twice the observed value and further exacerbating the apparent geographic disparity between the two regions. ENC experiences a greater burden of mortality--almost 2,600 more deaths per year than would be expected given its population size and its age-structure.

Characteristics other than population size and age may affect the observed and adjusted mortality disparity between the two regions. We can hypothesize (or speculate) that there may be other factors or covariates at work with mortality rates that are also geographically distributed. For illustrative purposes, explanatory variables might include underlying racial and ethnic diversity, poverty, and rurality. The rationale or assumption for the choices of these variables is that income distribution (related to racial/ethnic diversity) and measurable financial and physical (distance) access to health care have some discernable effect or relationship to mortality. However, one can further

speculate that these covariates are associated with many other measurable variables such as educational attainment, occupation and associated social relations (including peer pressure), risky or health promoting behaviors, the value and awareness of health as a personal and social good, and so on. The first three covariates introduced can be thought of as surrogate measures—they are meant to capture and simplify a complex series of relationships among a spectrum of factors that are operating at different scales. Surrogate measures are used to assist the students of public health and mortality in focusing on those relationships with the most explanatory power and in the construction of the most parsimonious ecological model of mortality.

Racial/ethnic diversity, poverty, and rurality can be measured like age-adjusted mortality at the county and county-based regional level. For example, ENC's county populations are more racially and ethnically diverse when compared to the counties of the rest of the state (RNC). According to the US Census atlas, [*Mapping Census 2000: the Geography of U.S. Diversity*](#) (see page 22 in Brewer & Suchan, 2001), 26 of ENC's 41 counties have diversity index values at or above the US value of 0.49, with a regional index of 0.52. (The diversity index is a measure of the probability that any two random people chosen from a county's population will be of a different race.) Only 13 of RNC's 59 counties are more diverse than the US, with a regional index of 0.39. From the US Census year 2000 (1999) data, a little more than 16.0% of ENC's population is below the poverty line for that census year, which is almost 50% greater than the 10.7% reported for RNC's population. Rurality is another attribute that distinguishes ENC from RNC. Slightly less than 49% of ENC's population is classified as rural by the US Census Bureau, which contrasts to slightly more than 36% of RNC's population being rural. The next step is to determine what influence or how well these proposed variables explain the county distribution of general mortality.

To assess the relationships and associations between any two of these variables, we employ a methodology similar to that used in studying the temporal trends of general mortality. The following discussion will describe the linear relationships between the dependent (age-adjusted mortality from all deaths) variable and each of the independent variables: the diversity index, poverty, and the proportion of rural population.. The interrelationships among the independent variables will also be examined. Exploring the strengths and weaknesses of association among variables is fundamental to hypotheses testing and the development of explanatory models.

The correlation coefficient between mortality and the diversity index is 0.61. The adjusted R^2 value is 0.365, which translates into more than 36% of the variation in mortality is explained by the variation found in the diversity index alone. The correlation coefficient between mortality and poverty is 0.63 and has an R^2 of 0.385. More than 38% of the variation in mortality is explained by poverty alone—about 2% more than the diversity index. The least amount of explanation (0.0%) can be attributed to the measure of rurality. The correlation coefficient is

only 0.046, which produces the negligible R^2 of 0.002. These simple analyses show that ethnic/racial diversity and poverty have a substantial and direct effect on mortality. The next step would be to determine if there was any direct relationship between diversity and poverty and whether at some indirect level, rurality having some effect. A relationship among these variables would indicate that their effects on mortality were not independent.

To get a handle on the amount of interaction between diversity and poverty (collinearity) we can apply the same method used in the preceding example. Lower R^2 values will suggest smaller amounts of collinearity, less association, and more independence among the independent variables. For rurality and poverty the R is 0.344 and the R^2 is 0.118, which means there is a small level of rurality and poverty associated with each other at the county level. Next, the diversity index and poverty measure yield an R of 0.531, with an R^2 of 0.27, which means that racial/ethnic diversity is more related to poverty than the degree of county rurality. How related is a county's racial and ethnic diversity to its level of rurality? The R for this comparison is 0.186 with an R^2 value of just 0.025. Recall that poverty, in this simple example, offers the greatest explanation of mortality. We now know that while rurality has some effect on poverty, diversity has an even greater effect on this variable. In more elaborate models of explanation, the rurality measure (as devised here) would not contribute much to explanation and could probably be excluded.

The foregoing discussion is meant as a simple example of how empirical descriptions of mortality can provide a basis for research questions and the building statistically oriented explanatory models. However, numerical and graphical descriptions of mortality can also stimulate further research or thinking in non-statistical ways. For example, thoughtfully publicized rate increases in mortality due to automobile accidents or diabetes will raise the awareness of policy makers and citizenry and help promote interventions, funding, and other ameliorative measures. Empirical description and explanatory models each have their own place and can be useful adjuncts to each other in the presentation and understanding of public health and demographic problems.

Conclusion

Geographically, different ways of measuring and describing general mortality demonstrates that the eastern 41 counties of North Carolina experience both higher comparative levels of death from all causes and a disproportionate share of mortality burden in regional and national contexts. When general mortality rates for ENC 41 are decomposed into four major demographic groups, rate differentials (or disparities) emerge. The distributions of age-adjusted general mortality rates also have unique characteristics for each of the race-sex sub-populations. Time series depictions (1979 to 2004) for both regions and race-sex sub-populations also show that there has been progress, but relatively large gaps or "disparities" continue to exist. For sub-populations, males of both racial

groups have greater relative declines in their rates compared to their female counterparts. All measures, spatially and temporally, indicate that although absolute differences in general mortality has been declining among regions and sub-populations, relative disparities will continue for some time to come. A description and examination of general mortality, which reveals the great disparities observed in our region of interest, naturally leads to further questions about how and why such disparities exist. With this in mind, we enter into the realm of explanation and can begin to consider the relationships and associations of covariates and mortality. Explanatory models are valuable aids for determining where changes can be effected and where healthcare resources can best be allocated.

General mortality encompasses a myriad of causes of death, all which have been classified and coded. In this regional atlas of mortality, the subsequent chapters will address the ten leading causes of death as shown in [figure 2.1](#). These ten leading causes of death account for more than 80% of deaths occurring in ENC 41 during the years 2000 through 2004. It is our hope that a consideration of each of these will lead to an increased understanding in the exceptional character of the region's mortality experience.

References

- American Heart Association. (2005). *Heart disease and stroke statistics--2005 update*. Dallas, Texas: American Heart Association.
- Anderson, R. N., & Rosenberg, H. M. (1998). Age standardization of death rates: Implementation of the year 2000 standard. *National Vital Statistics Reports*, 47(3)
- Arias, E. (2006). United states life tables, 2003. *National Vital Statistics Reports*, 54(14)
- Brewer, C. A., & Suchan, T. A. (2001). *Mapping census 2000: The geography of U.S. diversity*. Washington, D.C.: U.S. Government Printing Office.

- Buescher, P. A. (1998). *Age-adjusted death rates* (13th ed.). Raleigh, North Carolina: North Carolina Center for Health Statistics.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention & National Center for Health Statistics. (2006). *International classification of diseases, tenth revision (ICD-10)*. Retrieved 10/20, 2006, from <http://www.cdc.gov/nchs/about/major/dvs/icd10des.htm>
- World Health Organization. (2006). *International statistical classification of diseases and disorders and related problems 10th revision for 2006*. Retrieved 10/20, 2006, from <http://www.who.int/classifications/apps/icd/icd10online/>
- World Health Organization. (2004). *International statistical classification of diseases and related health problems* (10th revision, 2nd ed.). Geneva: World Health Organization.