

CARDIOVASCULAR DISEASE MORTALITY

The biggest cause of death in both the United States and North Carolina continues to be from diseases of the circulatory system, commonly referred to collectively as cardiovascular disease. Cardiovascular disease (CVD) includes high blood pressure (hypertension), coronary heart disease, congestive heart failure, atherosclerosis, and stroke, conditions which often occur in combination. An estimate for the year 2004 indicates that 79 million adult Americans, about 1 of every 3, have one or more types of CVD and mortality from CVD comprises a little more than 36% of the 2.4 million deaths that occurred in the United States (Writing Group Members et al., 2006). In 2004, CVD in North Carolina accounts for almost 34% of the 72,000 resident deaths that year and in Eastern North Carolina more than 35% of its 22,000 deaths have been attributable to CVD. The impact and burden of CVD is so great that if all its forms were to be eliminated, life expectancy in the United States would rise by almost 7 years. For Americans born today, there is nearly a 50-50 chance that their eventual death will be due to CVD (Anderson, 1999).

In the present chapter, CVD mortality includes deaths due to heart disease (HD), coronary heart disease (CHD), and stroke, in addition to several other less prominent causes of the circulatory system.¹ The largest CVD mortality component is heart disease, which includes rheumatic heart disease, irregular heart rhythms, and diseases of the linings, valves, and vessels of the heart. The latter-most group generally pertains to blockages and constriction of the vessels that supply the heart and can lead to diseases like infarction and ischemia. Mortality from this group is a significant part of HD mortality and is considered separately as CHD. Stroke mortality is a distinct category within CVD that includes intracranial blockages (resulting in infarctions) and hemorrhages, and other cerebrovascular diseases. [Figure 3.1](#) summarizes the relationships of the TCVD mortality categories for the 41 counties of ENC during the period 2000 to 2004. For this 5-year period, heart disease and stroke comprise nearly 92% of all mortality attributed to TCVD, while CHD alone contributes slightly more than half of all CVD deaths. The less prominent CVD mortality category (All Other) is not considered in this chapter. A complete listing of ICD10 codes organized by the categories used here can be found in the appendix for this section.

¹ ICD9 Codes 390-459; ICD10 Codes I00-I99

CVD mortality and its three major component diseases discussed in this chapter can be accessed below.

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As can be seen from the chart *Six Leading Causes of Mortality in the US 1900 to 2001* ([figure 1.2](#)), heart disease has emerged as the nation's leading cause of death in the 1920s and continues to be the leading cause into the early 21st century. The chart also shows how the decline of infectious and communicable diseases in the first several decades of the twentieth century paved the way for this emergence. If both stroke mortality and HD mortality rates depicted in [figure 1.2](#) were combined, then the combined rate would account for the largest share of general mortality since the turn of the 20th century (with the exception of the influenza pandemic of 1918). The diminishing effect of infectious and communicable diseases on the mortality experience of the first half of the 20th century in the United States has given way to the rising prominence of death from heart disease in the latter half.

The Epidemiologic Transition (Omran, 1977) discussed in chapter one (introduction) describes the secular decline of infectious/communicable diseases and the concomitant rise of chronic disease mortality and its demographic consequences. The increase seen in HD mortality is more than likely the result of the rise in the proportion of people surviving the onslaughts of communicable diseases. Communicable diseases have their impact on both ends of the age

spectrum. Over time, survivors of childhood diseases swell older age groups which have increasing susceptibility to HD and other cardiovascular problems. This pattern is repeated wherever infectious/communicable diseases are brought under control with various public health measures and interventions. However, the demographic responses and outcomes can vary geographically and culturally. It is interesting to note that the states with the lowest rates, Minnesota, Alaska, and New Mexico are quite different in regard to their demographic attributes; investigation of the role of culture is suggested.

The US Department of Health and Human Service's document, *Healthy People 2010* (U.S. Department of Health and Human Services, 2000) provides target rates for the two major mortality categories of CVD: coronary heart disease, and stroke. Objective maps are included in this chapter for these two causes of death. Time series charts (1979 to 2004) are also included for each CVD mortality category (including total CVD). For the coronary heart disease and stroke mortality time series charts, the HP 2010 targets are indicated.

Spatial Distribution of Cardiovascular Disease Mortality

The 2002 age-adjusted mortality rate for CVD (ICD-10: I00-I99) for the United States is 319 deaths per 100,000 population but there is remarkable geographic variation across the nation. State rankings² (including the District of Columbia) place Minnesota, Alaska, and New Mexico first, second, and third with the lowest respective age-adjusted rates per 100,000 of 237.7, 242.1, and 255.9 per 100,000, respectively. The highest rates are found for Tennessee, Oklahoma, and Mississippi, (rates of 380.8, 398.8, and 420.7, which placed 50th, 51st, and 52nd respectively). The rate for North Carolina in 2002 was 327.0, ranking it 33rd in the nation. The 2002 average age-adjusted rate for the 41-county region within Eastern North Carolina (ENC) is 366.6. If this region were treated as a state, it would rank 45th. For the 5-year period 2000-2004, seven counties in ENC ranked worse than the state of Mississippi in 2002.³

The maps at the top of [figure 3.2](#) shows the spatial distribution of CVD crude mortality rates for the 100 counties of North Carolina and the 41-county ENC region. CVD crude mortality has its greatest impact in the northeastern part of the state in those counties that comprise the 29-county hospital service area and sub-region. (For county locations and names, see appendix A.) From [Table 3.1](#), three counties--Chowan, Perquimans, and Washington—have 5-year (2000-2004) crude rates above 500 per 100,000. This translates to an average of 5 CVD deaths per 1,000 people per year living in those counties. Many counties

² These rankings are based on calculations made at East Carolina University's Center for Health Services Research and Development. The data for combined state and regional comparisons are from the National Center for Health Statistics Compressed Mortality Files (1999-2002).

³ Calculations for county comparisons use primary data from North Carolina's State Center for Health Statistics via University of North Carolina—Chapel Hill's Odum Institute.

with relatively high observed crude rates also have relatively small numbers of people and may be proportionally older, which naturally leads to their increased susceptibility to more chronic conditions like CVD. Crude mortality rates are a kind of density measure—the number of deaths normalized (or divided by) the population of interest and do not account for age structure. Their depiction on maps is for the purpose of focusing the reader to areas where the mortality burden is greatest (see chapter 1 for more discussion). Maps of crude rates are useful in the development of policy, intervention measures, and determining the allocation of health care resources.

The age-adjusted mortality rate maps found at the bottom of [figure 3.2](#) permit comparisons among counties and population groups which may have different age structures (see chapter 1). The state map shows a sharper distinction in the disparity of county age-adjusted rates between the state's eastern 41 counties and the remaining counties to the west. As regions, 41-county ENC's age-adjusted rate of 367.3 is 19% greater than the 59-county region of NC at 308.0 deaths per 100,000 (see [table 3.1](#)). In 2002, the age-adjusted rate for the US was 319.0, less than 2% of the 2000-2004 rate for the state and less than 13% of ENC's rate. From another perspective, if ENC 41 had the same mortality rate as RNC 59 during the years 2000 to 2004, 6,590 lives would have been spared from death due to CVD.

[Figure 3.3](#) shows age-adjusted mortality by race and sex using the same rate classification cut points found in the age-adjusted map in [figure 3.2](#). These maps provide a visual sense of group contributions to the overall CVD mortality rate and distribution. For white males, the heaviest concentration of high rate counties is found in the east, while some metropolitan counties to the west and a chain of mountain counties tend towards lower rates. Within ENC, the county with the highest rate for white males is Hertford at 576.3 and 131 observed deaths ([table 3.1](#)). High rates are ubiquitous throughout the state for non-white males with the highest found in the ENC county of Currituck at 644.3 and 21 deaths. The highest rates for white females are found scattered throughout ENC with Washington County having the highest rate in this region at 374.6 (124 deaths). Currituck County also had the highest rate for non-white females at 528.2 (29 deaths). Statewide, ENC is home to the largest concentrations of high rate counties for these four demographic groups. For males of both races there appears to be little difference between ENC and the rest of the state. ENC becomes distinct as a high rate region because of the influence of regional white and non-white female rates.

Temporal Distribution of Cardiovascular Disease Mortality

The decline in CVD is hinted at in [figure 1.2](#) using the large proportional effects (72.1%) of HD mortality as a surrogate. This figure depicts the secular trend in heart disease (HD) mortality reaching its peak in the 1960s and soon after, crude stroke mortality rates begin to decline. (Together, these two diseases currently

comprise more than 90% [see [figure 3.1](#)] of CVD mortality and so gives a good approximation of the patterns of burden and progress made with respect to this disease.) [Figure 3.4](#) is a closer, comparative look at how ENC has been faring over time with respect to CVD mortality over the last two decades of the 20th century and the early years of the 21st. It charts the continuing decline in age-adjusted CVD mortality rates for ENC, the remaining 59 counties of North Carolina (RNC), North Carolina, and the United States, from 1979 to 2004 (US: 1979 to 2002). Within the 26-year period, ENC's annual rates are the highest, followed by the state, the nation, and the remaining 59-county region, each showing very similar patterns of decline. (The state values are a weighted average between ENC and RNC and will always have intermediate values.) The negative coefficients found in the equations of the lines, listed in the chart ([figure 3.4](#)), show that ENC's rate of decline is slightly greater than RNC's rate with the relative gap between the regions' *fitted rates* growing from 9% in 1979 to 13% in 2004. This represents a relative 44% increase in regional disparity for CVD mortality. In absolute terms, these same line equations show that the expected or *fitted rate differences* in age-adjusted death rates declined from 51 deaths per 100,000 in 1979 to 41 deaths per 100,000, which translates into a 24% decrease in regional disparity.

[Figure 3.5](#) depicts the 26-year trend of CVD mortality among the four major demographic groups in ENC. It is immediately apparent that the age-adjusted rates are declining for all groups. ENC white males show the greatest decreasing trend--a decrease of 52%, which on average saves 16.7 lives per annum. This compares favorably to the 42% decline for white females; a saving of 8 lives per year. With R^2 values around 0.90 one can make projection into the not-too-distant future with a fair amount of confidence. If the same trends continue, the age-adjusted CVD rates for white males and white females will converge around the year 2015 with an age-adjusted rate of approximately 184 per 100,000. The age-adjusted rates for both non-white men and non-white women are also converging but with their age-adjusted rate trends not projected to converge until sometime around the year 2030, when both non-white sexes attain the rate of approximately 188. In this scenario, it takes non-whites almost 15 years longer to achieve a projected rate similar to that of whites. Recall that the calculations are based on simplifying assumptions concerning the behavior of rates over time and any projections will have an increasing range of error as they move more distant in time from the last observed rate year. However such exercises can be viewed as another way of describing disparities and the amount of relative effort that would be required to achieve parity measured over time.

Although mortality due to CVD is declining, its greatest impact is on the county populations of ENC. White males appear to do better in the large metropolitan counties of the Piedmont. However, these lower rates are comparable to the highest rates found in white female population. The highest rates for this latter group are concentrated in the counties of ENC. High rates of mortality for non-white males are nearly ubiquitous within the state, with low rates interspersed in

the mountain counties. (Low rates here are probably due to the small numbers of non-whites in this region.) For non-white females, high rates are concentrated in ENC, as well as the south-central portion of the state.

Trend analysis covering the period 1979 to 2004 show a dramatic 45% decrease in regional rates for CVD mortality ([figure 3.4](#)). The decrease in the age-adjusted rate for ENC roughly parallels the declining rates for the other regions, but there is a relative increase in regional disparity during this time—an artifact that results from using decreasing bases. When the CVD time series trend line for ENC is broken down into four race-sex trend lines, two patterns emerge: divergence in mortality rates between the two racial groups and convergence between the sexes for each racial group.

HEART DISEASE MORTALITY

Proportionally, heart disease (HD) comprises more than 70% of all TCVD deaths for the period 2000 to 2004 (see [figure 3.1](#)). The spatial and temporal patterns of HD mortality, therefore, should correlate strongly to those patterns observed for CVD. Any observable differences in these patterns will probably be due to the effects of stroke mortality, the next largest category outside of HD accounting for almost 20% of all CVD mortality. The ICD-10 definitions for HD can be found at the end of this section in [appendix B](#).

Spatial Distribution of Heart Disease Mortality

A comparison of the crude and age-adjusted maps for HD ([figure 3.6](#)) and CVD ([figure 3.2](#)) mortality does show strong similarities in patterns of mortality. (Note that the cut-points of HD mortality rate categories in the legends for both crude and age-adjusted maps are approximately 70% of the ranges observed for CVD mortality.) The crude map of HD mortality shows concentrations of higher rates in the extreme northeastern and western portions of the state, with smaller concentrations in the southeast and south. Age-adjustment produces a larger concentration of high rates in ENC, de-emphasizing HD mortality rates in the western region of the state.

Comparisons of regional age-adjusted HD mortality rates illustrate the continuing presence of geographic disparities. From [table 3.2](#), ENC's 2000-2004 age-adjusted rate (263.5) is 13% higher than the US rate (240.8) and 19% greater than the rate for RNC (221.9). The coastal counties of Dare and Pamlico possess the lowest rates at 187.9 (286 deaths) and 190.4 (174 deaths), respectively. (For county locations and names, see [appendix A](#)) These counties compare favorably to RNC's rate for the same period. Moving inland, the highest age-adjusted HD rates are found in two county clusters. The first cluster is found in the southern part of the 41-county ENC region. Here, the counties of Bladen (319.2), Columbus (347.5), Robeson (315.6), and Scotland (310.4) experience

12.7% of ENC's mortality attributable to HD while 10.1% of the region's aggregated estimated population from 2000 to 2004 lives in those counties. The proportional disparity grows when we move to the next high rate cluster of counties found in the northern part of the region. The high rates for Beaufort (309.1), Edgecombe (305.5), Martin (311.0), and Washington (314.8) counties comprise 8.2% of the region's HD deaths, but comprise only 5.7% of the region's population. Given their respective populations sizes, these two county clusters have a disproportionate share of ENC's HD mortality.⁴

Figure 3.7 depicts the spatial distribution of age-adjusted mortality rates for HD (2000-2004) broken down into four race-sex groups. The observed spatial patterns closely resemble those for CVD (**figure 3.3**) and indicate similar regional effects among the four groups: higher rates for females of both racial groups are again more concentrated in the eastern portion of the state, while high white male rates are found throughout the state with the exception of the Piedmont's metropolitan counties, and non-white male rates are ubiquitously high with the exception of several counties in the west. From **table 3.2**, the highest regional age-adjusted county rate for white males is Columbus at 424.1 with 335 dying from HD over five years. For the same period, Washington County is the deadliest for white females who experience 96 HD deaths and an age-adjusted rate of 294.0 per 100,000. Non-white males experience their highest rate of age-adjusted HD mortality in Currituck County at 480.7 per 100,000 but this is the result of only 16 individuals dying during that period—Perquimans County has the next highest rate at 441.1 and a more statistically stable death count of 32. In Columbus County, 189 non-white females died from HD producing the highest age-adjusted county rate of 339.1 during the years 2000 to 2004. The total age-adjusted HD mortality rate Columbus County is weighted largely by deaths contributed from females of both racial groups, although white males also make a significant contribution. The high CVD rate experienced by non-white males in Edgecombe County appears to be heavily influenced by the HD component for this race-sex group. Within ENC, the lowest statistically reliable age-adjusted rate for any race-sex group is that found for white females in Greene County at 165.0.

Temporal Distribution of Heart Disease Mortality

Figure 3.8 shows trend lines for age-adjusted HD mortality among the four regions for the period 1979 to 2004. The slope of the lines all follow the same pattern of decline observed in **figure 3.4** for CVD. Closer observation shows, however, that with the exception of the ENC trend line, the relative positions of the other three regions have shifted slightly. For CVD (**figure 3.4**), North Carolina has been consistently above the US rate, but for HD the state emerges

⁴ Because age-adjusted rates can be used for making comparisons, they can be helpful in targeting areas where problems might exist. In this case, two county clusters have been identified and their count data are used to create proportions, which can be used to calculate the relative amount of mortality burden.

with rates slightly less than the nation. (This is probably due to the impact of stroke mortality in ENC, which tends to be higher and has a significant additive effect to the state rate for CVD.) Rates for RNC have been consistently below the declining trend for the US, whereas for CVD the trend lines closely matched one another. The impact of HD mortality on RNC's population is less than it is for the nation as a whole. ENC's age-adjusted mortality rates for HD are clearly higher throughout the 26-year time series with a slightly greater rate of decrease among all the regions. The pattern of HD mortality decline witnessed here is a good example of the secular trend in HD mortality burden observed during the 20th century ([see figure 1.2](#)).

Both observed and modeled trend lines for race-sex groups ([figure 3.9](#)) show patterns of decline similar to CVD ([figure 3.5](#)). What emerges in the present graph is the notable advantage in age-adjusted HD mortality rates that non-white males have over white males from the years 1979 to 1985. In 1986, the two trend lines intersect and then diverge. However, visual inspection of the last six or seven years of the observed rates in the series indicates that this divergence is probably an artifact of the trend line calculations, which weight historically distant and recent observations equally. A trend line calculated for the years 1998 to 2004 would probably show non-white male rates actually declining at a higher rate than the white male trend, which in turn suggests that the HD mortality burden for non-white males is lessening. To a lesser degree, the same patterns for observed and expected trends hold for white and non-white females. In the beginning of the series, their respective rates are very similar and divergence occurs sometime around 1983 and 1984. Non-white females experience substantially higher rates over the next 20 years. The rate gap begins to narrow around the year 2001 and visually the rates between white and non-white females are very similar for the year 2004. Altogether, the R^2 values are high allowing for a reasonably confident projection into the near future beyond the year 2004. In addition to the great decreases in age-adjusted HD mortality rates over the 26-year observation period, ENC should also begin to see much less disparity in HD mortality among the race-sex groups than it experienced over the last 20 years.

Because heart disease is by far and away the largest mortality component of CVD, spatial and temporal trends will be similar. The regional county maps show similar distributions and concentrations of high rates for both CVD and HD mortality. High age-adjusted HD mortality rates for non-white males are ubiquitous among NC's counties and it is the spatial patterns of rates for the other race-sex groups that underlie the distinctiveness of ENC as a relatively high rate region for HD. White males have made the greatest strides in the reduction of their HD mortality and visual inspection of recent trends suggest that non-white males are also beginning to show increased improvement. Residuals or differences (CVD – HD) in observed rates, whether mapped or charted as a data point, will largely be attributable to the effects of stroke mortality and other CVD mortality on a regional populations. However, within the HD component there is a large and significant contributor to CVD mortality—coronary heart

disease—that has a strong influence on the observed HD mortality. Spatial and temporal aspects of Coronary Heart Disease mortality are the next CVD mortality component to be considered.

CORONARY HEART DISEASE MORTALITY

For the years 2000 through 2004, Coronary Heart Disease (CHD) accounted for 70% of HD mortality and slightly more than half of all CVD mortality in Eastern North Carolina. Because CHD mortality comprises a large part of HD mortality, we can expect their spatial and temporal patterns to be similar to one another. Differences in observed mortality patterns (HD – CHD) would largely be attributable to rheumatic heart disease, irregular heart rhythms, diseases of the linings, and valves (see [appendix B](#)).

Progress towards Coronary Heart Disease Mortality Reduction

The two maps in [figure 3.10](#) show the amount of progress that has been made in the age-adjusted death rates for CHD towards *Healthy People 2010 Objective 12.1*. The 5-year CHD mortality rate (2000-2004) is compared to this objective's target of 166.0 age-adjusted deaths per 100,000 population. From the state map, 48 of the state's 100 counties have achieved the objective target rate, with 15 of those counties in ENC. Throughout the state, these counties are a mix of non-core, micropolitan, and metropolitan counties.⁵ Many of these counties possess large populations whose economies can support cardiac care centers. Counties with fewer people may be retirement community locations that have relatively easy access to these care centers. The underlying cardiac care landscape (which includes acute and preventive care programs and facilities), in conjunction with the geographic distribution of wealth (manifested by the presence of retirement communities and second homes), help explain the distribution of counties that have met or nearly meet the objective target.

Spatial Distribution of Coronary Heart Disease Mortality

A comparison of [figure 3.11](#) with [figure 3.6](#) shows that county CHD mortality pattern is very similar to that observed for county HD mortality. The crude rate maps in [figure 3.11](#) show a fairly dispersed pattern of low rate counties with concentrations of high rate counties in the western portion of the state, the southern Piedmont, and ENC. Age-adjusting CHD mortality rates shifts the pattern of high mortality away from the west with both the southern Piedmont and ENC seeing an increase in counties with comparatively higher rates. The ENC counties with the highest rates of age-adjusted CHD mortality—rates greater than 197.7—are arranged in three clusters in the interior of the region.

Almost 28% of ENC's population live in these county clusters and yet the same counties experienced almost 35% off all regional CHD deaths (see [table 3.3](#)).

⁵ Core Based Statistical Area (2003) designations

The cluster comprising Lenoir, Johnston, and Wayne counties has the largest population and the smallest disproportionate share of excess CHD deaths of the three high rate clusters with 12.5% of ENC's population experiencing 14.0% of all regional CHD mortality. The greatest burden relative to population is experienced by the high-rate cluster formed by Beaufort, Edgecombe, and Martin counties where 5.1% of the regional population lives, but where 7.0% of the regional deaths attributable to CHD occur. In absolute terms, the largest number of CHD deaths (2,860) within the region can be found in the southern part of ENC, where the share of CHD deaths in this county cluster is almost 37% higher than what would be expected for its population size.

A glance at the regional comparisons at the bottom of [table 3.3](#) shows that North Carolina's 2000 to 2004 CHD mortality rate is almost 6% less than the US 2002 rate of 170.9 age-adjusted deaths per 100,000, and about 3% less than the HP 2010 objective target of 166.0. ENC's CHD age-adjusted mortality rate is 8% greater than the US 2002 rate and 11% greater than the HP 2010 objective target rate. To contrast, RNC's 2000 to 2004 rate is almost 11% less than the US 2002 rate and more than 8% less than the HP 2010 target. If ENC had the same age-adjusted CHD mortality rate (and by extension, age structure) as RNC, ENC would have experienced 3,650 fewer CHD deaths over the five-year period. [Figure 3.12](#) shows the regional and county effects of age-adjusted CHD mortality among the four race-sex groups. Accounting for 709 deaths and 3% of all 41-county regional CHD mortality, Columbus County had the highest age-adjusted 5-year rates for white males, white females, non-white females, at the respective rates of 357.0, 213.9, and 252.1. The highest stable age-adjusted rate for non-white males is 338.8 in neighboring Bladen County. (With 11 deaths in the span of 5 years, Currituck County in the extreme northeast of the state has the highest rate of 347.7.) The Dare County CHD age-adjusted mortality is the most favorable, with white males (144.9 and 105 deaths) with the lowest rate, no deaths for non-white males, and two deaths for non-white females that produces an unstable rate of 100.3 for that group. (Low rates for non-whites in Dare County may be a function of the small number of resident non-whites.) White females experience their lowest 5-year age-adjusted rate in Chowan County at 69.0 (33 deaths). High age-adjusted rates for white and non-white males are widespread throughout the state. ENC becomes more distinct from the rest of the state when the distribution and contribution of high rate counties for females of both races is taken into account.

Temporal Distribution of Coronary Heart Disease Mortality

[Figure 3.13](#) portrays the decline over time of age-adjusted CHD mortality for all regions. The observed pattern of decline is similar to the HD pattern in [figure 3.8](#), only the rates are not as high. As with HD, ENC's CHD time series rates are consistently higher than those for other regions. In relative terms, the age-adjusted fitted rate gap between ENC and RNC from the years 1979 to 2004 doubles from 10% to 20%. However, the fitted rate differential or rate gap

between these two years decreases by 15%, indicating a significant diminishment of regional disparities. The time series also shows that RNC's rates compare favorably, if not better, to those of the US, while ENC's rates have remained higher than the other regions for the duration of the series period.

Included in [figure 3.13](#) is the HP 2010 objective target of 166.0 age-adjusted deaths per 100,000 population. All four regions have attained or surpassed this target rate by the year 2004. The R^2 values for each region's trend lines approach unity, indicating near perfect fits to the observed data points or rates, which provides us with a very high level of confidence that the trend will continue for the next several years and be well below the HP target in 2010.

[Figure 3.14](#) describes the observed and fitted trends for age-adjusted CHD mortality among the four race-sex groups in ENC from 1979 to 2004. The observed rates and fitted trend lines show a distinct advantage for non-white males up to the year 1990, and the year 1984 for non-white females. At these two points in time, there is a convergence of rates between the sexes in both race groups and the observed annual rates continue their decline approximately parallel to one another. The fitted rate or trend lines contradict these observations, suggesting that there will be some divergence in rates after these two years. However, a trend line fitted from the observed convergence years would probably show a narrowing gap in disparities between the two racial groups. With such a recent trends (1990 onwards) it is likely that ENC white and non-white males will be very close to attaining the HP 2010 target. Based on the trend line equations, ENC females from both racial groups have already surpassed the target: the year 1997 for white females and the year 2000 for non-white females.

The preceding discussion, with its accompanying charts and maps, makes the argument that both regionally and demographically, ENC is on track to meet and in some instances surpass the HP 2010 objective target of 166.0 age-adjusted deaths per 100,000 population. The maps and the regional trend chart illustrate that spatial disparities still exist and are likely to continue for the foreseeable future, albeit at rates below the HP 2010 objective target. Time series charts also show that non-whites were actually at an advantage from 1979 to the 1990s.

STROKE MORTALITY

Death from stroke comprises almost 20% of Eastern North Carolina's age-adjusted CVD mortality ([figure 3.1](#)). As shown in [figure 1.2](#), crude rates for stroke mortality, when compared to other causes of death like HD and cancers, have remained relatively stable throughout most of the 20th century. There is a slight depression in rates in the 1930s and a rebounding to a little more than 100 deaths per 100,000 in the 1950s. The proportion of crude stroke mortality in relation to crude HD mortality begins to decline in the 1920s with the dramatic

rise in HD mortality and as the prominence of mortality from communicable/infectious diseases recedes. Beginning in the early 1970s, crude stroke mortality begins to decline and continues to do so until the early 1990s, when crude rates reach a new level at some 40% to 50% lower than what they were for the first 70 years of the century.

Historically part of the stroke belt, the ENC region has exhibited some of the highest rates of age-adjusted stroke mortality in the US. Howard et al. (in Howard, Howard, Katholi, Oli, & Huston, 2001) discuss the changing pattern of stroke mortality in the US and suggest that stroke mortality has been declining throughout the nation and new patterns of high rate counties are beginning to emerge, possibly supplanting the historic stroke belt in the future. The authors also model one of the more interesting features of stroke mortality decline, the negative-exponential or reverse “S” curve, which describes a three-phase pattern with the first phase at a higher but stable rate pattern (upper asymptote) that remains until the late 1960s, followed by the second phase—a transition period of decreasing rates that lasts approximately 20 years, and then the third phase, which is characterized by a regime of lower but stable rates approaching a new asymptote. The new asymptote’s rates are approximately 40% lower than the rates for the initial phase. Although [figure 1.2](#) depicts crude rates, the pattern described by Howard et al. (Howard et al., 2001) is approximated for stroke mortality. The following is a discussion of the patterns of stroke mortality in ENC as it transits from the second phase to the current lower but stable rate phase.

Progress towards Stroke Mortality Reduction

[Figure 3.15](#) shows that only three counties in the entire state have achieved or have surpassed the HP 2010 objective (12.7) target for stroke: 48.0 age-adjusted deaths per 100,000 population. Twelve of the state’s 100 counties are within 15% of this target where another 12 counties have current rates of more than 45% than the target. Hyde County is the only county in ENC that has achieved the objective target, while Brunswick, Camden, Dare, and Hoke counties are the only counties within 15%. In the highest category (i.e., the counties with the greatest percent reductions necessary), 9 of the 12 counties are in ENC: Bertie, Bladen, Duplin, Edgecombe, Hertford, Nash, Robeson, Sampson, and Scotland. From [table 3.4](#), Edgecombe County experienced the region’s highest age-adjusted stroke mortality rate at 111.4 with 294 deaths over the 5-year time period. To reach the objective target, this county would require a rate reduction of 132%. If the county had experienced the target rate of 48.0 instead of 111.4 during those years, more than 120 lives in that county might have been spared from this disease.

Regionally, North Carolina and its three regions are well above the objective target rate and require significant amounts of reduction (see [table 3.4](#)). Western North Carolina (WNC) requires the least amount at 26% and the 29-county ENC region requires the most at 59%. ENC 41 would require a reduction of 54% in

order to achieve the objective target. This translates into more than 2,800 lives that could be saved if the target had been achieved in the year 2000. The state as a whole requires a reduction of 40%, while the nation in 2002 requires only 18%. Clearly, there is a significant amount of reduction and effort needed for North Carolina and its regions if the objective target is to be met by 2010; the dividends of achieving the HP 2010 goals for stroke will be many thousands of lives saved regionally and statewide over a relatively short period of time.

Spatial Distribution of Stroke Mortality

Figure 3.16 illustrates the county distribution of both crude and age-adjusted stroke mortality rates. The county distribution of stroke mortality parallels that of the other cardiovascular diseases discussed in the present chapter. The crude mortality rates show concentrations of high rate counties throughout the state, particularly in the west. In ENC there is a large amount of heterogeneity among counties with respect to stroke mortality. There is a disproportionate share of stroke deaths in the highest rate category in the crude rate version of the map—25% of all stroke deaths in the region are produced by 17% of its population, while the lowest rate category accounts for 27% of the deaths produced by 40% of ENC's population. Although the crude rate map shows which counties are experiencing the greatest amount of stroke death burden, it should be kept in mind that this burden is most likely the result of underlying differences in age structure among county populations.

Age-adjusted rates can be used to compare and contrast excess mortality across counties and regions. **Table 3.4** lists Edgecombe County with the highest stable age-adjusted rate (number of deaths ≥ 20) at 111.4 and Brunswick County with the lowest age-adjusted stable rate at 52.6. If Edgecombe County with 294 stroke deaths had the same age-adjusted rate as Brunswick County (223 stroke deaths), then 155 lives over the course of five years would have been spared. A similar comparison at the regional scale shows that age-adjusted rate differentials for ENC and RNC yield a difference of 984 lives. With the effects of age controlled, this simple comparison shows again that race and socio-economic factors must be at work to produce such a difference in mortality between two places.

The relative proportions of demographic groups vary from one region to another. If factors and behaviors to mortality from a particular cause are operating uniformly across regions, then there should be very little difference in race specific rates or excess (disproportionate) mortality among them, that is, rate disparities should be about the same. Any significant differences in mortality must therefore be attributable to differences in health behavior, health literacy, access and treatment. For example, **table 3.4** compares the age-adjusted race-sex specific rates between ENC 41 and RNC 59. A comparison of rates between non-white and non-white males in ENC shows that non-white males suffer stroke mortality at a rate 54% higher than their white counterparts. The same comparison in RNC yields a 47% difference—a rate disparity that is about 15%

less than what is found in ENC. For females, a race comparison yields a 32% in ENC and a 26% difference for RNC. The regional disparity between white and non-white females is about 23%, a more elevated difference than that found for regional males. One can conclude from this simple comparative analysis that there is a measurable geographic effect at work producing differences and disparities in mortality. The geographic effect could be thought of as regional assemblages of risk factors, behaviors, accessibility, and inherent socio-economic characteristics operating at varying tempos and scales, together producing their differential effects on the mortality map.

Figure 3.17 depicts the age-adjusted rate distributions for the four race-sex groups. Visually, white and non-white males have large concentrations of high rate counties in ENC. For white and non-white females, high rates are nearly ubiquitous with the exception of the extreme western counties of the state. From **table 3.4**, the highest stable (deaths ≥ 20) age-adjusted rate for white males is found in Hertford County at 137.5 with 31 stroke deaths over the five-year period. Neighboring Bertie County possesses the highest stable age-adjusted rate for white females at 95.9 with 34 deaths. Edgecombe County had the highest stable age-adjusted rates for both non-white males and females at 149.0 (64 deaths) and 117.2 (100 deaths), respectively. Stable age-adjusted rates for Brunswick County white males and Northampton County white females have declined to the point where they have surpassed the Healthy People 2010 objective target at 45.3 and 42.6, respectively. No comparably stable age-adjusted rates are found for non-white males and females that surpass the HP 2010 target. ENC remains a region of relatively high stroke mortality in the face of national decline, particularly when rate and excess differentials are examined among race-sex groups and regions. Unlike CHD mortality, very few counties within the state have met the HP 2010 objective target during the period 2000-2004.

Temporal Distribution of Stroke Mortality

Towards the end of the twentieth century, the prominence of the stroke belt has been diminishing as other relatively high-rate focus areas have been emerging among US counties (Howard et al., 2001). Nevertheless, as stroke mortality rates have declined across the nation, the stroke belt and ENC still remains regions of concern, especially in light of the progress made in other cardiovascular diseases. With this in mind, we now turn to a discussion concerning the unfolding of ENC's stroke mortality pattern over time.

Figure 3.18 portrays the temporal distribution of age-adjusted stroke mortality among the four regions. A decline in rates is strongly evident for the first years of the series portrayed—a decline that has already been underway during the previous decade. (see **figure 1.2**). The series represents the last two phases described by Howard et al. (Howard et al., 2001). The second phase, 1979 to about 1990, is characterized by a rapid decline in rates. This general decline ends in the early 1990s and by the middle of the decade there begins a period upswings and downswings of diminishing amplitudes. These dampening

oscillations of declining rates characterize the third phase of the time series (1990 to 2004). Fitted trend lines for the third phase would more than likely result in smaller negative slope coefficients approaching zero. The US series is the best example of this pattern, with stroke mortality becoming nearly stationary in magnitude or asymptotic. This pattern suggests that a new level of stroke mortality rates may have been achieved given the current state-of-the-art for prevention and amelioration, or perhaps the rise in the exacerbating problems of obesity and diabetes are beginning to any gains in this area.

The regional trend lines fitted around the 26-year series in [figure 3.18](#) shows ENC, RNC, and NC converging to a rate very close to the HP 2010. The US rate for the year 2010 is projected to be approximately 42.0, about 13% less than the target rate. However, if recent, rather than long term, trends hold for the US this target may not be achieved (see the above discussion). Nevertheless, for all regions a significant decrease in age-adjusted rates for stroke mortality has occurred from 1979 to 2004 (US: 2002). ENC experienced the greatest decrease in rates over the period (47%) with an average of almost 2.5 deaths avoided each successive year. During these years, the relative rate gap or rate disparity between ENC and RNC has shrunk from 19% to 12% and if the 26-year trend holds, the regional disparity in 2010 will be reduced to 7%. The US currently shows the slowest rate of decline at 1.6 age-adjusted deaths per year from the line equation based on the US 24-year series, but the rates from 1992 onward suggest that the number of lives spared is approaching zero. This suggests that age-adjusted stroke mortality rates for the US will be somewhat above the HP 2010 target rate. If the recent US trend is a harbinger of future patterns for regions within the country, , then it is not likely that ENC, RNC, and NC will be as close to the HP 2010 target as their long term trend lines predict.

[Figure 3.19](#) is a refraction of ENC's age-adjusted stroke mortality time series ([figure 3.18](#)) into for each of the four race-sex groups. The flattening out of rates in the early 1990s appears to hold for all race-sex groups except for non-white males whose 26-year series shows a constant decreasing trend. The temporal pattern for white females is the closest to the last two phases of US pattern. White males show a rate series that closely matches their female counterparts and the longer term trend lines indicate a convergence for these two groups very close (47.5) to the HP 2010 target (48.0) sometime in the year 2009, decreasing to 46.0 the following year. The longer term fitted-rate trends for nonwhite males and females indicate that they will not achieve the HP 2010 target. The years 1979 through 2004 has seen significant decreases in the fitted age-adjusted mortality rates for all demographic groups. White males experienced the largest relative decrease between with a 52% reduction. White females and non-white males both experienced a 46% decrease and non-white females decreased by 43%. In 1979 the greatest relative rate gap or rate disparity is between white females and nonwhite males at 65%. This relative disparity grows slightly to 68% in 2004. Non-white males currently have the greatest rate of decrease (from the equation of the line) and do not, at least visually, appear to be undergoing a third-phase leveling of rates like those witnessed in either the regional time series

([figure 3.18](#)) or in the time series for white females. If the recent third-phase pattern continues, then it is promising that non-white males may at long last overcome this “temporal offset” of stroke mortality.

The spatial and temporal pattern of stroke mortality in ENC is part of the secular change witnessed at the national scale in the latter third of the 20th century. Regional differences in rates between ENC—which is part of the traditional stroke belt—the buckle—and RNC have been decreasing since 1979 as high rate clusters have begun to emerge in other parts of the country. The differences between ENC and RNC are largely attributable to a combination of race and age structure. A spatial comparison shows that non-whites in ENC experience an excess of mortality and temporally, non-white males have not yet “caught-up” to the recent rate trends seen for the other race-sex groups. The trends for these latter groups appear to be approaching a new level or asymptote—a lower limit that represents a new phase in the secular pattern of stroke mortality. Visual inspection indicates that the new lower level for the national age-adjusted stroke mortality rates will be slightly above the HP 2010 objective target of 48.0 age-adjusted deaths per 100,000. Recent trends for ENC, RNC, and NC also indicate that these regions still have several years to reach the flattening level of rates achieved at the national scale. If ENC were to reach the 2002 fitted rate for the US rather than the HP 2010 target, a significant savings in lives (385) would be realized.

SUMMARY

Cardiovascular disease (CVD) has been the greatest leading cause of death throughout most of the 20th century and remains so into the early 21st. Like other chronic and degenerative diseases, it became prominent in the first third of the last century as infectious and communicable diseases receded in importance. Mortality from Heart Disease (HD) makes up the bulk of CVD and peaked nationally during the late 1950s through the 1960s. Thereafter, crude mortality rates for HD declined. There is a very slight rise in an otherwise long term era of stability in crude rates for stroke (cerebrovascular disease) mortality paralleling that of the HD peak, but its magnitude is no greater than that witnessed for the first 10 years of the 20th century. By the mid-1970s mortality rates for stroke decline in tandem with HD and CVD mortality rates and then around 1990, stroke mortality appears to level off into a new stable and lower regime of rates. Basic spatial and temporal analyses indicate that the mortality picture for CVD is generally improving for regions and their populations, albeit at different rates that result in continuing disparities.

Eastern North Carolina (ENC) and the rest of North Carolina (RNC) have participated in the national decline of CVD mortality. For CVD, the time series for age-adjusted mortality shows RNC experiencing lower rates than the US, while ENC’s rates are far and away higher but with a slightly greater rate of decline. The apparent gap in rates does not appear to be closing anytime in the near

future, signifying a continuing geographic disparity. Race-sex disparities also continue to exist but recent trends for non-white males suggest a greater acceleration of decline than the other groups. A similar scenario exists for HD among regions and for race-sex group comparisons. Time series analyses show that, like CVD, non-white males have recently demonstrated a stronger rate of decline. Interestingly, in the beginning of the series (1979-1983), non-white males had more favorable age-adjusted rates for HD than their white counterparts, after which their rates begin diverging. The Coronary Heart Disease (CHD) age-adjusted mortality rates show the continued presence of a rate gap, but here the US rate pulls away from RNC in the direction of ENC. Within ENC, the Healthy People 2010 (HP 2010) target of 166.0 age-adjusted deaths per 100,000 population has already been met during the years 2000 through 2004 for white and non-white females. Recent trends for white and non-white males suggest visually that the HP target will be close to being met.

The stroke mortality picture is somewhat different than the others. Fitted-rate trend lines indicate that the US will meet the HP 2010 target (48.0) and the other regions will approach very close to it in the year 2010. Again, an examination of recent trends shows that the US rates may have already begun to level and at rates higher than the target. Although this leveling is not as apparent for the other regions, the recent observed rates give some indication, at least visually, of maintaining their rates at a higher level than the HP target. For ENC's race-sex groups the fitted-rate trend lines suggest that white males and females will reach the HP target, while visually, the observed rates will be close to the target in 2010. There is little evidence that non-white males and females will achieve the HP target. Overall, the level of progress has been very positive for most cardiovascular diseases, with stroke mortality showing a quick and relatively large percent decline only to flatten at rates that will probably not achieve the HP 2010 objective target.

In spite of progress in CVD, ENC remains behind the rest of the state with respect to excess deaths. If ENC had the same age-adjusted rate as RNC, then ENC would have experienced 6,590 fewer deaths over the 5-year period, 2000 - 2004. For the state, HD mortality is the largest component (70%) of CVD mortality and the same type of comparison yields an excess number of deaths for ENC of almost 4,650 with CHD contributing about 2,548 of those deaths for the 5-year interval. The similar and lower age-adjusted rates for stroke produce a smaller number of excess deaths for ENC—430. In addition to a consideration of rate disparities and excess deaths, we can also entertain the question of how long it will take for ENC to “catch-up” to RNC's rates by algebraically manipulating the line equations for the 26-year trends. For example, the equations for the 26-year trend lines for CVD suggests that it will take more than 90 years for ENC to reach a convergence of their respective rates or parity with RNC. Obviously this result is spurious because of not only the assumption that such a linear trend will continue for that length of time, but also the algebraic solution produces a negative age-adjusted rate sometime in the year 2102!

However, such a result does provide a strong indication that for CVD, HD, and CHD, parity will not be reached in the foreseeable future. The picture is significantly brighter for stroke, however. Even though recent trends suggest that the Healthy People 2010 targets for stroke mortality may not be achieved, these same trend line equations do not preclude the possibility of parity between the two regions in the very near future. The 26-year age-adjusted trend suggests that rate parity could be achieved around the year 2014 at a rate 42, belatedly lower than the Healthy People 2010 target of 48.0.

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