

# Diabetes Mellitus Mortality

## Introduction

A growing awareness is emerging of the impact of diabetes mellitus on US mortality and an appreciation of the factors leading to diabetic conditions. There is also a greater awareness of the relationship diabetes has to other leading causes of death. Diabetes can be linked to a diverse array of diseases like heart disease, stroke, high blood pressure, blindness, kidney disease, nervous system disease, amputations, dental disease, pregnancy complications, and others such as increased susceptibility to infectious diseases (CDC, 2007). As the rates of death from heart disease and stroke begin to decline, death from diabetes becomes more prominent in the mortality profile of Eastern North Carolina.

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The impact of diabetes on mortality is clouded though by how it is recorded on the death certificate. Diabetes may be listed as one of many causes, a contributing cause, or an underlying cause of death. In this chapter, we consider diabetes as an underlying cause of death. An underlying cause is responsible for the condition that led to the apparent immediate cause of death. It is the first link in the causal chain that ultimately led to death. For example, complications from heart disease may have led to an individual's death--the apparent cause, but the disease that led to death was really the effect or the result of the individual having diabetes--the underlying cause of death. The publication, *Healthy People 2010* lists a target objective for diabetes mortality as a contributing cause of death. Contributing means diabetes may be listed anywhere on the death certificate and the disease has contributed to or exacerbated the conditions leading to an individual's death. Diabetes as an underlying cause of death can be thought of as a narrower subset of all deaths related in some way to diabetes. Because of the difficulty in discriminating diabetes as an underlying cause of death, diabetes mortality rates depicted here are probably an underestimate affecting all population groups and geographic regions equally.

The relative geographical importance of diabetes as an underlying cause of death can be appreciated by an examination of its relative rank as a leading cause of death in selected regions. Diabetes has been the 5<sup>th</sup> leading cause of

death in ENC and the US but the 7<sup>th</sup> for RNC from 2002 to 2005. In 2002, the US experienced 73,248 deaths while the regions of ENC and RNC experienced 771 and 1,435 deaths respectively. In 2005, 75,119 deaths occurred in the US, 881 in ENC, and 1,444 deaths in RNC. Two years later (2007) death totals from diabetes moved downward for ENC to 788 and for RNC to 1,362, but held the same relative rankings at 5<sup>th</sup> and 7<sup>th</sup>, respectively. This simple series of comparisons has shown that the impact of diabetes mortality is similar for both ENC and the US, while for the RNC region its impact is less acute.

The prevalence of diabetes in the population is difficult to establish but in the US for those 20 years of age and older in 2007 it is approximately 24 million, with another 57 million estimated to be in a pre-diabetic state. Based on estimates from the National Health Interview Survey<sup>1</sup>, 10.7% of the national population and 9.0% of North Carolina's population had diabetes (diagnosed and undiagnosed) in 2005. Dividing the state into regions, the prevalence rate for 41-county ENC is 10.0% and for the remaining counties of the state, 8.7%. The 29-county ENC prevalence rate is 10.4%, somewhat closer to the US figure, while the remaining 71 counties of the state has a prevalence rate of 8.8%. It is interesting to note that while North Carolina and its regions have estimated diabetes prevalence percentages lower than the national value, they have higher crude and age-adjusted mortality rates from this disease (see [table 5.1](#)).

At the sub-regional level, [figure 5.1](#) shows more than half of ENC41's counties with prevalence rates at least as high as the nation in 2005. [Figure 5.2](#) provides an overview of those counties with standardized prevalence percentages and age-adjusted mortality rates less than or more than  $\pm 0.5$  standard deviations (sd). Generally, higher prevalence rate counties correspond geographically to counties with higher diabetes mortality rates (see [table 5.1](#) and [figure 5.3a](#)) but there are two counties, Pitt and Onslow, with mortality rates higher relative to their respective prevalence percentages. Several explanations for this apparent disparity between prevalence and mortality levels are possible. First, some point value estimates may be artifacts originating from calculating percentages (and mortality rates) from smaller county population numbers. Second, there may be regionally varying differential diagnoses of diabetes as an underlying or contributing cause of death. Thirdly, differential mortality, where deaths from causes other than diabetes take their toll on individuals at younger ages, expose remaining older and more susceptible individuals to diabetes and its attendant effects and outcomes. Finally, higher rates of diabetes mortality in areas of relatively lower prevalence may signify disparities in access to appropriate treatment and care. Further study would be required to determine if these differences are the result of any one or combination of these possible explanations.

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<sup>1</sup> Excel workbook downloaded from: Centers for Disease Control and Prevention: National Diabetes Surveillance System. Available online at: <http://www.cdc.gov/diabetes/statistics/index.htm>. Retrieved 1/27/2009.

## General Temporal Patterns and Perspectives

Figures 5.3a, 5.3b, and 5.3c show various temporal patterns of mortality due to diabetes from the perspectives of mortality burden, region, and population. The first pattern, shown in figure 5.3a, is the trajectory of underlying diabetes mortality for the US (crude rates) from 1950 to 2005 compared to stroke, and pneumonia and influenza. It shows an increasing prominence of diabetes mortality. As can be seen from the figure 5.3a, the crude mortality rate for diabetes is relatively constant—less than 20 deaths per 100,000 people—from 1950 to the early 1990s when a gradual rise continues until the end of the series. In comparison, stroke, for the period 2000 to 2004, is the third leading cause of death in the US after heart disease and malignant neoplasms. Its trajectory has remained relatively constant from 1900 until the mid-1970s, floating a little above and below 100 deaths per 100,000 people for much of the 20<sup>th</sup> century (see figure 1.1). In the following 15 years, crude mortality rates for stroke fell by 40% reaching a plateau around the year 1990. This plateau continues for about 10 years, when rates begin to decline once again. In 2005, the crude mortality rates for stroke are about twice that for diabetes mellitus. The national crude mortality rate for diabetes mellitus has exceeded the crude mortality rate for pneumonia and influenza since 1999.

The next chart, figure 5.3b, is a regional comparison of age-adjusted mortality rates for diabetes mellitus. North Carolina, and its two constituent regions ENC and RNC, follow a similar trajectory to that of the US but at different levels. The state and regional rates are extended to the year 2007 and show a decrease in mortality rates for the last four years of the series. During most of the 1980s, RNC's rates have been below that for the nation. A surge in both ENC's and RNC's rates occurs in the late 1990s and thereafter RNC's trajectory closely follows that for the nation. Visual inspection reveals a widening gap or disparity in mortality rates between ENC and RNC beginning in the late 1980s. By 2007, the age-adjusted rate disparity between the two regions has grown to be more than 47%. The higher rates of ENC have pulled the rates of the entire state upwards to a position greater higher than the US series from the late 1980s to 2004.

The regional disparity observed in figure 5.3b can be explained in terms of the rate disparities observed for each region. Figure 5.3c breaks down the previous regional series into two general racial/ethnic groups: white and non-white or minority populations. From 1980 to the latter part of the decade, the age-adjusted rates for whites in ENC track generally below their national counterparts. The ensuing years see ENC age-adjusted rates periodically exceeding those for the nation until 2000, when consistently higher rates are observed for the 2000 to 2004 study period. With the exception of the late 1980s RNC's age-adjusted mortality for white rates remain consistently below the national rates. Non-white or minority age-adjusted rates are significantly higher than the rates for their white counterparts, sometimes 2 to 3 times greater. The disparities between the two races appear to increase after the late 1980s. The

gaps between races are much more extreme for the two North Carolina regions than they are for the nation, which suggests a southern or at least a North Carolina effect on the rates for ENC and RNC minorities. The mortality from diabetes is disproportionately higher in minority populations, having a significant impact on overall regional rates.

In summary, mortality from diabetes mellitus is increasing and rising in rank among leading causes of death in both the US and North Carolina. Although the extended series for the regions (up to 2007) show a decrease in both regional and racial rates, disparities remain at their highest levels. The following section is an examination of the geographic patterns of diabetes mellitus mortality within Eastern North Carolina.

### **Spatial Distribution of Mortality Due to Diabetes Mellitus within Eastern North Carolina**

The maps in [figure 5.4](#) compare crude and age-adjusted regional and county diabetes mortality rate distributions. [Table 5.1](#) lists regional and county crude and age-adjusted rates used in making comparisons. The first general point to make is that both rate types for the remaining counties of NC (RNC) compare favorably the 2002 rates for the US. More specifically, the western mountain region of NC (WNC) compares the most favorably with its age-adjusted rate of 21.1. With the exception of WNC, there are only slight differences in regional values between crude and age-adjusted rates, indicating that age structure has little effect on the interpretation of rates. The greater difference between the two rates observed for WNC can be explained by the fact this region has a greater proportion of susceptible elderly whose effect is reduced by weighting to the standard population. The difference in rates for ENC when compared to other regions is not attributable to differences in age-structure.

The top pair of maps, NC and ENC, shows the distribution of crude mortality rates for counties. Visually, one can discern higher rate concentrations primarily in the upper coastal plain counties of ENC. There are small clusters of high rate counties interspersed throughout the RNC region. The crude rate for ENC during the 2000 to 2004 study period is more than 30% greater than the rate found for RNC (see [table 5.1](#)). This rate differential produces for ENC more than 900 excess deaths due to diabetes mellitus. The bottom pair of maps depicts the age-adjusted mortality rates from diabetes. Age-adjustment of rates has the effect of concentrating more ENC counties into higher rate categories. The smaller clusters of high rate counties remain in place for RNC. With a rate more than 37% greater than RNC, ENC experiences 1,056 more age-adjusted deaths than RNC. At the regional level, the difference between the crude and age-adjusted rates for diabetes mellitus is not as great as for other diseases (see [table 5.1](#)). In both cases, ENC does have a disproportionate share of diabetes as an underlying cause of mortality. This excess mortality can be equated to the

nearly complete depopulation of small towns in the East like North Topsail Beach, Maysville, or Manteo.<sup>2</sup>

In ENC, there is a wide range between minimum and maximum statistically meaningful (20 or more deaths) mortality rates (see [table 5.1](#)). Hyde County, with 21 deaths, tops the list with a crude mortality rate of nearly 74 per 100,000 and Dare County, with 24 deaths, has the lowest crude mortality rate of 15 per 100,000—a 5:1 difference in mortality burden due to diabetes. For age-adjusted mortality rates, both counties maintain their ranks. When the higher proportion of elderly is taken into account, Hyde County's age-adjusted mortality rate is reduced to 58.3 per 100,000, which contrasts to Dare County's rate adjusting downwards to just 14.1—a good indication that this county's age structure is not greatly different than the standard. With age-adjustment, the difference between the highest and lowest county rates reduces to a ratio of 4:1. These extreme differences in age-adjusted mortality rates for diabetes suggests a degree of heterogeneity and variation of rates based on population structure among ENC counties.

For both types of rates, ENC possesses a larger share of higher rate counties than the rest of the state. The crude rate map for ENC includes 14 of the 20 highest ranked mortality rates for the state. These 14 counties experienced 1,231 deaths due to diabetes during the years 2000 to 2004, comprising 11% of all diabetes deaths in the state and nearly 32% of ENC's diabetes deaths. The counties with the highest crude rates can be found in two clusters. The first cluster is located in the region's northeast and is comprised of Bertie, Chowan, Gates, Halifax, Hertford, Hyde, Martin, Northampton, and Washington, counties. This cluster accounts for almost 13% (497 deaths) of the region's diabetes mortality with less than 8% of the regional population; the cluster's crude mortality rate is 52.2 per 100,000. The second cluster is a less compact, more linear system of four contiguous counties: Bladen, Robeson, Sampson, and Scotland. This cluster also has a disproportionate regional share of deaths from diabetes with 15.3% of ENC's diabetes deaths (599) generated by slightly more than 10% of the population. The crude mortality rate for this cluster is 47.0. Lenoir County stands alone from either cluster, experiencing 135 diabetes deaths in five years, translating into a crude mortality rate of 45.8. The age-adjusted map for ENC ([figure 5.4](#)) shows 16 counties in the highest rate interval. Higher rate counties are in the interior, upper coastal plain area of ENC, although Hyde County remains the exception to this spatial trend as an outlying county along the region's coast. Those counties with rates equal to or higher than 37.2 age-adjusted deaths per 100,000 account for nearly half (48.8%) of ENC's diabetes mortality generated by 39% of the regional population. Using county populations as weights, these 16 counties have an average age-adjusted rate of 44.0 per 100,000—a rate 29% greater than that for the region. Like the distribution of crude mortality rates, the geographical distributions of the highest rate category counties are divided into two clusters. The first cluster, in ENC's north is

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<sup>2</sup> Municipal population data (2007) obtained from <http://www.osbm.state.nc.us/>. Viewed on 22 December 2008.

comprised of six counties: Bertie, Gates, Halifax, Hertford, Martin, and Northampton. Together these counties produced a five-year total of 417 (10.7%) diabetes deaths with 6.4% of the regional population. The weighted age-adjusted mortality rate for this cluster is 44.7 per 100,000. The second cluster is found in the interior south with an extension into the central part of ENC. Nine counties make up this cluster: Bladen, Greene, Cumberland, Hoke, Lenoir, Robeson, Sampson, Scotland, and Wayne. Together, these counties experienced 1,522 diabetes deaths from the years 2000 to 2004. This translates into nearly 39% of ENC's diabetes mortality produced by 33% of its regional population. The weighted age-adjusted mortality rate for the second cluster is 43.7. The overall patterns of the crude and age-adjusted diabetes mortality rates are similar, but age-adjustment shows more diabetes mortality in ENC while diminishing the distribution of comparably high rate counties along the coast (with the exception of Hyde County) and the region to the west. High mortality from diabetes, like many other causes of death, is one of the less favorable attributes of ENC's population health experience.

### **Analysis by Race and Gender**

[Figure 5.5](#) portrays age-adjusted diabetes mortality rates for the four race-sex groups. The legend in this figure maintains the age-adjusted category interval boundaries found in [figure 5.4](#). The minimum and maximum values in the legend reflect the increased range of values that occur when rates for individual race-gender groups are calculated and reflect either increased variation due to small numbers for certain counties or real differences in the diabetes mortality experience.

#### **Male Mortality**

Higher rates of white male mortality from diabetes are concentrated in the eastern part of the state with smaller clusters of high rate counties found in the Piedmont. [Table 5.1](#) lists ENC white males having the highest age-adjusted diabetes mortality rate among all regions at 28.7, but less than the overall rate for ENC. The ENC counties with the highest meaningful rates (diabetes deaths  $\geq$  20) are Cumberland, Halifax, Robeson, Sampson, and Scotland, which contributed more than 25% of regional white male diabetes deaths (252) with slightly more than 19% of the ENC white male population. The weighted age-adjusted white male rate for these five counties is 44.4 per 100,000, which translates into 59 excess white male deaths due to diabetes. With the exception of the mountain counties in the state's west, high rates of diabetes mortality can be found for non-white males in most of the counties of ENC and the Piedmont. Like their white counterparts, non-white males possess the highest age-adjusted mortality rate in the regional comparisons listed in [table 5.1](#) and it is more than twice the rate for ENC white males. The five highest rate counties (deaths  $\geq$  20) for non-white males are Cumberland, Halifax, Robeson, Sampson, and Scotland. Combined, these counties produced 250 (32.6%) non-white male deaths from

diabetes from approximately one-third of the region's non-white male population. This indicates a fair degree of proportionality between deaths and population for this group. The weighted age-adjusted average rate for these five counties is 66.8 per 100,000. If these counties had the same collective rate as that for ENC white males, then more than half (130) of the non-white male deaths for these five counties would have been averted. Underlying mortality from diabetes has a substantially greater impact on ENC's non-white males and compares unfavorably to the nation and other state regions.

### Female Mortality

The largest concentration of counties with high diabetes mortality rates for white females are found in the southern half of ENC with a smaller concentration located in the region's north. Relatively higher rate counties are generally distributed in the western portion of RNC, but a few counties in this region's east are contiguous with ENC's southern concentration. [Table 5.1](#) reveals that among regional white females, ENC possesses the highest mortality rate (21.6) from diabetes but remains substantially lower than the age-adjusted regional rate of 34.0 per 100,000. The five highest rate counties with 20 or more diabetes deaths ([table 5.1](#)) are Bladen, Cumberland, Lenoir, Robeson, and Wayne, producing a disproportionate 27% of ENC's diabetes deaths from slightly more than 21% of the region's white female population. The weighted average age-adjusted rate for these five counties is 30.0 per 100,000. When compared to the regional rate of diabetes mortality for white females, there is an excess of approximately 79 deaths over five years (2000 – 2004) in these counties. High age-adjusted county mortality rates for non-white females follow a similar geographic pattern to their male counterparts. With the exception of four coastal counties and several counties in the western portion of the state, the vast majority of counties statewide occupy the highest mortality interval for diabetes. [Table 5.1](#) shows that non-white females experience the highest rate of age-adjusted mortality among all regions with a rate between two to three times that of their white counterparts. The five counties with the highest non-white female age-adjusted mortality rates and diabetes deaths of 20 include Bertie, Duplin, Martin, New Hanover, and Sampson. These counties generated more than 19% (215 deaths) of all regional non-white female diabetes death with less than 11% of the regional population--the largest disproportionate share of diabetes mortality among the ENC population groups. The weighted age-adjusted average diabetes mortality rate for non-white females is 79.3 per 100,000. This translates into about 156 excess deaths if non-white females had the same regional age-adjusted death rate for diabetes deaths as white females. The high weighted age-adjusted rate for the five counties and the very disproportionate number of deaths relative to the underlying population indicates that mortality from diabetes is particularly acute for ENC non-white females.

## Temporal Distribution of Mortality Due to Diabetes Mellitus

In the beginning of the time series ([figure 5.6](#)) there is very little difference among the regions with respect to diabetes as an underlying cause of death. Calculated from the trend line equations, the North Carolina, RNC, and the US age-adjusted rates are 15 per 100,000. ENC begins the series at 16 per 100,000, which is about 6% greater than the other region's rates. The first nine years of the series sees a relative flattening of trends with no discernable trend among the observed annual rates. Between the years 1986 and 1988, a marked increase in regional rates becomes apparent and thereafter distinct slow rising regional trends arise for the remaining 16 years of the series. The rise in regional diabetes mortality rates has not occurred uniformly among the regions. The regional disparity in diabetes mortality between ENC and RNC has grown to almost 24% in those 26 years. The trend lines for the expected rates for all regions in the figure are relatively strong suggesting that this regional disparity will continue for some time.

The ENC trend line can be thought of as a composite of individual trend lines for the four population groups: white males and females, and non-white males and females (see [figure 5.7](#)). For white males and females, there is little initial change in the rates for the first nine years in the series (11 and 12 age-adjusted deaths per 100,000, respectively). Thereafter, an increase in rates is evident for both groups and at the end of the series in 2004, their expected age-adjusted rates have increased more than two-fold to 29 and 27 per 100,000 respectively, but the relative gap in the two rates has actually decreased to 8% from 6% over the course of the series. For the non-white population groups, the male series begins at a lower rate (1979) with a mortality rate of 20 compared to the female rate of 28. This difference translates into a relative gap of almost 29%. Within the first nine years of series for these two groups, there is a noticeable decline in rates reaching a nadir around the years 1983 and 1984. From that point, there is a steeper gradient of increasing rates, especially when compared to their white counterparts. In the years 1997 and 1998, the trend lines for non-white males and females converge and intersect. For the next six years, divergence between the two groups continues and by 2004, with non-white males experiencing rates 5% higher than non-white females. Stark disparities among groups have been maintained while age-adjusted death rates have only increased. In 1979 the largest difference in rates was between white and non-white females at 61%. In 2004, while the relative gap has decreased slightly to 58%, this still translates into an expansion in the absolute numbers of deaths for each population group.

Diabetes mortality rates have been increasing for all populations considered in this study. The rate disparity in absolute terms has also increased steadily between the two race groups. The rate increase has been similar for both white males and females, while rate increases between non-white males and females have been unequal with regional minority male rates moving to a higher level than their female counterparts.

## Conclusion

As mortality rates for heart disease, cancer, and stroke decrease, death from diabetes mellitus has moved towards the center stage in the mortality profile for both the US and ENC. In the first half of the present decade, diabetes has been the 5<sup>th</sup> leading cause of death for these two regions. Among the regions considered in this study, diabetes mortality has increased over the course of twenty-six years time interval (1979 through 2004), with the rate for ENC growing more than 50% of its initial rate by the final year of the series. At the regional level, age-adjustment appears to have little effect on crude mortality rates, suggesting that mortality from diabetes is occurring in age groups in the same proportion as the population used in standardization. This observation is further borne out by the ranking of premature mortality measured as years of life lost before age 75 (discussed elsewhere).<sup>3</sup> While diabetes is the 5<sup>th</sup> leading cause of mortality, it is the 10<sup>th</sup> leading cause of premature mortality. More deaths are occurring in the older age groups rather than in younger groups for this disease. In terms of prevalence estimates, ENC is similar to that of the US as a whole, but mortality is substantially higher. Where prevalence of diabetes within counties does not correspond to their mortality rates we should consider whether disparity in access and quality of care might be the cause. Those counties and regions within North Carolina that have higher rates tend to have greater proportions of minorities. An examination of the temporal dimension has also shown that increasing diabetes mortality rates are underpinned by the disproportionate share of deaths experienced by non-whites.

## References and Additional Reading

### American Diabetes Association

<http://www.diabetes.org> (accessed 12/3/2008)

*Complication of Diabetes in the United States*  
*Direct and Indirect Costs of Diabetes in the United States*  
*The Dangerous Toll of Diabetes*  
*Total Prevalence of Diabetes & Pre-diabetes*

### Centers for Disease Control

<http://www.cdc.gov/diabetes> (accesses 12/3/2008)

*National Diabetes Fact Sheet, 2007—General Information*  
*National Diabetes Fact Sheet, 2007—Data Sources, References, and Methods for Estimates of Diabetes*

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<sup>3</sup> Premature mortality used in ranking is calculated by simply aggregating the number of years of life lost before age 75 for decedents by cause of death.