

The Stroke Belt Enigma Continues: Reflections on the Geography of Stroke Mortality

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Suffering a stroke is devastating. The occurrence of this illness and the resulting loss of life in the U.S. are astronomical. While the mortality rates from strokes have plummeted dramatically over the last fifty years, especially in the Southeast, strokes continue to be menacing, as morbidity rates have remained virtually unchanged in decades. Current patterns of stroke mortality for whites, blacks, males, and females do support the notion that the stroke belt in the Southeast is becoming more fragmented and that a secondary stroke belt is becoming established along the Mississippi and Ohio River valleys. An examination of the literature on the geographic distribution of stroke reveals that physicians have written much of this research. While their interest in geography is to be applauded, the search for the stroke belt or belts would be best accomplished through multidisciplinary research teams consisting of physicians, epidemiologists, and geographers. Future studies on the geography of stroke should focus on morbidity, as these rates have remained stable for several decades.

Introduction

Physicians, epidemiologists, and other nongeographers have largely been responsible for identifying and exploring the stroke belt – a region of excessively high rates of stroke mortality occurring within the coastal plains of North Carolina, South Carolina, and Georgia. As yet, these studies have not been able to determine the causal factors responsible for this concentration. To their credit, physicians and epidemiologists have recognized the importance of a geographic perspective. Nevertheless, these same studies often fail to examine the appropriateness of the selected geographic techniques and concepts employed. Therefore, this article 1) examines risk factors, trends, and geographic distribution of stroke mortality and morbidity rates, 2) traces the origin and usage of the term “stroke belt,” 3) assesses the usage of such concepts and techniques as region, scale, data classification, choropleth mapping, autocorrelation, and mi-

gration effects from selected stroke studies, and 4) analyzes the current status of this stroke belt in North Carolina and the United States.

Risk Factors, Trends and Geographic Distribution

The primary risk factors for stroke are older age and hypertension. Other factors are relatively less important. However, among the more important of these secondary factors are high fat diet and lack of exercise that likely exert their effects through blood pressure and cholesterol levels. Socioeconomic status is likely to exert its effect similarly at least in part – it is a proxy for poor diet, hypertension, and no exercise. This link is supported by Meade’s (1979, 471) finding from Savannah, Georgia, “that the usual racial difference in blood pressure that has been repeatedly found when residences are classified only as urban, suburban, or rural disappeared when the teenagers were classified according to the land

use where they lived (i.e., blood pressure for whites and blacks living in a tract classified as 80% industrial did not differ significantly)."

The age-adjusted death rates from stroke experienced dramatic declines from 1950 to 1990 in the United States. Total age-adjusted death rates have plummeted from 88.8 per 100,000 to 27.7 per 100,000. Declines in these rates have been experienced by all sex/race groups, although blacks continue to experience higher death rates than whites. For example, the age-adjusted stroke mortality rate for white males was 87.2 per 100,000 in 1950 and 27.7 per 100,000 in 1990 while the rate for black males was 146.3 per 100,000 in 1950 and 56.1 in 1990. The phenomenon of declining rates may be ceasing in the 1990s as reflected by the minimal decreases in the age-adjusted death rates among whites and modest decreases among blacks from 1990 to 1995 (CDC 1997).

Since the 1960s, there have been numerous studies dealing with the geographic variation in deaths from strokes (see Table 1). Studies have been undertaken at the scale (i.e., the study area) of one or more states (Sauer et al. 1966; Siegel et al. 1992) or more commonly at the scale of the conterminous United States. Geographic units of analysis used in these studies included the individual states, the state economic areas (SEA), the health service areas (HSA), and the counties within each state. Time periods of interest ranged from 1939-1941 to 1988-1992 (Lanska 1993; Pickle et al. 1997). Further, mortality data for these studies were aggregated into one year (CDC 1992; Lanska and Kryscio 1994; Casper et al. 1995), three years (Sauer et al. 1966; Mason et al. 1981; Wing et al. 1988; Pickle et al. 1997), and five or greater years (Borhani 1965; Heyman et al. 1976; Fabsitz and Feinleib 1980; Siegel et al. 1992; Lanska 1993; Lanska and Peterson 1994; Howard et al. 1995; Pickel et al. 1997) for various race/sex groups (Jones et al. 2000; MMWR 2000). Such aggregations as quartiles, quintiles, deciles, and others were used to group data for the purpose of mapping stroke mortality rates (Table 1). A limited number of papers attempted to determine

the significance of disease clusters using autocorrelation area statistics (Borhani 1965; Lanska 1993; Lanska and Kryscio 1994; Lanska and Peterson 1994).

Most studies have reported high stroke mortality rates among populations within counties of the Southeastern Coastal Plain; hence, this region is often referred to as the "stroke belt." Recent studies, though, vary as to the current status of the stroke belt. Some investigators suggest that the stroke belt is shifting. According to Wing et al. (1988), high stroke mortality rates became less concentrated within the original stroke belt, whereas new areas of clustering of high rates became evident in areas adjacent to the southern Mississippi River and Ohio River from 1962 to 1982. Others suggest the stroke belt phenomenon persists. Pickle, Mungiole, and Gillum (1997) noted that although the rates for the Texas, Oklahoma, Arkansas, and Louisiana were high in 1988-1992, the Southeast still experienced high rates, especially for blacks. Howard et al. (1995) reported that the "relative increased risk of stroke death in the region has remained constant from 1968 to 1991" (p. 1153). It should be noted that these conflicting interpretations arise, in part, from the geographic unit and, more importantly, from the methods of data classification and spatial analytic techniques employed.

The Stroke Belt

The stroke belt is an ill-defined geographic region. For example, the National Heart, Lung, and Blood Institute considers states where stroke mortality rates are greater than 10% above the national average to be stroke belt states. Under this definition and using data from 1989, Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia would constitute the stroke belt (Lanska and Kuller 1995; Siegel et al. 1992). At the other end of the spectrum, many consider the traditional stroke belt as being a rather localized concentration of extreme rates among counties of the coastal plains of North Caro-

Table 1. Selected studies on geographic variations of stroke mortality

Author(s)	Geographic Unit	Time Period	Race/Sex Group	Data Classification	Statistics
Borhani	State	1949-1951, 1959-1961	WF, WM	Quartiles	Geary's C
Lanska	State	1939-1941, 1949-1951, 1959-1961, 1969-1971, 1979-1981	BF, BM, WF, WM	Significant deviations from the national level and 10th and 90th percentiles	Moran's I
Lanska and Kryscio	State	1989	Total population	Quartiles	Moran's I
Lanska and Peterson	State	1979-1981	W	Quartiles	Moran's I
CDC	State	1988	Total populaion	Quartiles	--
Casper et al.	State economic area	1962, 1975, 1988	BF, BM, WF, WM	Deciles (1, 2, 3-8, 9, 10)	--
Wing et al.	State economic area	1962-1968, 1969-1975, 1976-1982	WF, WM	Deciles (1, 2, 3-8, 9, 10)	--
Mason et al.	State economic area	1965-1971	NWF, NWM, WF, WM		
Heyman et al.	State economic area	1969-1971	BF, BM, WF, WM	--	--
Sauer et al.	State economic areas (NC, GA)	1950-1959	WM	Arbitrary (highest and lowest death rates)	--
Pickle et al.	Health service regions	1988-1992	BF, BM, WF, WM	Deciles (1, 2, 3-4, 5-6, 7- 8, 9, 10) and Quintiles	--
Fabsitz and Feinleib	Counties	1968-1971	BF, BM, WF, WM	Quartiles	--
Siegel et al.	Counties	1979-1981	Population	Exogenous	--
Howard	"stroke belt" counties	1968-1971, 1972-1975, 1976-1979, 1980-1983, 1984-1987, 1988-1991	BF, BM, WF, WM	--	--

Notes: BM= black males, BF= black females, WM= white males, WF= white females, W= white, NWF= non whit females, NWM= non white males

lina, South Carolina, and southern Georgia. Notwithstanding problems with its various definitions, Lanska and Kuller (1995) view the term "stroke belt" as a convenient buzzword for promoting stroke awareness and education.

Borhani (1965) was one of the first to document this clustering of stroke mortality for white men and white women for the years 1949-1951 and 1959-1961. How long it existed prior to that time is unknown. While the national age adjusted death rate for white males was 70.4/100,000, rates for the southeast Atlantic states ranged from 109.1 to 128.2/100,000 during 1949-1951. In other words, white males in the stroke belt states had a 1.5 to 1.8 greater risk of stroke mortality than the national average. Since then, numerous studies examining data across various geographic units, race/sex groups, and time periods have confirmed the existence of a stroke belt. Yet, the causal factors generating the stroke belt remain an enigma (Howard et al. 1995; Meade 1979). Repeated studies have indicated that the stroke belt is neither an artifact of systematic bias or error in diagnosis and death certificates (Casper et al. 1995) nor a result of variations in standards of care (Lanska and Kuller 1995). Other potential factors have been suggested including linkages to syphilis, alcohol consumption, elevated hematocrit, physical inactivity, obesity, and/or sickle cell disease. However, these factors either do not vary significantly or exhibit small variations regionally, have inconsistent associations with stroke, have affected just one race or gender, or have not been implicated with strokes (Lanska 1993). Connections between physical properties, such as selenium deficiency, water hardness, climate, and latitude and longitude, and the existence of the stroke belt have also not been confirmed (Fabsitz and Feinleib 1980; Meade and Earickson 2000).

Recently there has been disagreement as to whether the location of the originally identified stroke belt is stable or becoming less concentrated and shifting elsewhere. For example, Howard et al. (1995) asserted that the relative risk of stroke mortality among populations of the coastal plain of North Carolina, South Carolina, and Georgia

remained constant from 1968 to 1988. Pickle, Mungiole, and Gillium (1997) suggested that the rapid decline in stroke mortality rates for whites in the Southeast has left the West South Central states with relatively high mortality rates. Wing et al. (1988) mentioned that the stroke belt has become less concentrated in the coastal plain areas of the south Atlantic states and has become more pronounced along the Mississippi and Ohio River valleys.

Geographic Considerations

What exactly is the stroke belt? Answering this question is problematic. First, the stroke belt is arbitrarily defined as an area of the country in which there is an excess of stroke mortality as compared to the national average. The stroke belt sometimes refers to a broad region encompassing the southeastern states and at other times to the coastal plain counties of North Carolina, South Carolina, and southern Georgia. Too often the stroke belt is viewed as a fixed geographic region. As geographers know, one of the characteristics of regions is that they change over time. Others suggest that the borders of this region are indeed shifting (Casper et al. 1995) or that there are multiple stroke belts corresponding to the various categories of stroke. These different perspectives contribute to the current confusion about the areas that define the stroke belt.

Choropleth maps are the most common map type used to present stroke mortality data. However, there have been no attempts to promote optimal methods of classifying stroke data. The variety of classification methods used to develop categories to map stroke mortality rates is mind-boggling. These range from using quartiles, quintiles, standard deviation, percentiles, deciles, and other, sometimes arbitrary methods. Virtually all studies have neglected to indicate the appropriateness of their choice of data classification. Dent (1985) recommends appropriate data classification methods for specific data distributions. For example, he suggests using standard deviation units for data with normal distributions, equal class intervals for uniform distribu-

tions, geometric progressions for J-shaped distributions, and natural breaks or the iterative method for multi-modal distributions (data with two or more clusters of observations).

Two problems arise if data classification methods are chosen haphazardly. First, it is difficult to compare across studies that use a wide range of classification methods. Second, and probably more serious, employing autocorrelation statistics to test for clusters derived from less than optimal classification methods is inappropriate. That is, the finding of positive autocorrelation is meaningless when the pattern being tested is the result of an inferior or inappropriate classification. Uses of autocorrelation statistics by some authors have perhaps led to erroneous conclusions on the clustering of stroke (Lanska 1993; Lanska and Kryscio 1994; Lanska and Peterson 1995).

Probably the most exciting contributions regarding the stroke belt have been studies concerning the potential effects of international and interstate migration on the geographic distribution of stroke mortality (Lanska and Peterson 1995; Lanska 1997). Comparison from 1979 to 1981 found that "immigrants had markedly and highly statistically significant lower age-adjusted stroke mortality rates than either the entire US-born resident population or the US-born inter-regional migrant population" (Lanska 1997, 53). Similarly, comparisons were made between states' stroke mortality rates for native and resident populations. States either benefited or suffered from the influx or exodus of migrants. Although their study found that migration alone couldn't explain the existence of the stroke belt, Lanska and Peterson indicated that some states were strongly influenced, either in a positive or negative manner, by the effects of migration. Lanska and Peterson (1995) went on to identify Colorado and DC as benefiting from the migration of whites. In these two entities, out-migrants with high rates were improving the remaining population's stroke mortality rate. Conversely, they found that in states like California, Idaho,

Oklahoma, and Nevada, the mortality rates suffered from white migration, the first three states because of an influx of higher rate in-migrants and Nevada because of the exodus of lower rate out-migrants. For blacks, only Colorado benefited from the migration effects, whereas 21 states suffered.

Lanska and Peterson (1995) noted three effects that can influence mortality rates. These include the selection, origin, and destination effects. The selection effect is represented by the migration of healthy retirees to the Sun Belt; whereas, the movement of blacks from the South to the North in the 1920s and 1940s through the 1970s illustrates the origin effects. The destination effects are the lifestyle changes that people might make on moving to a new region. Another example of such a migration effects is illustrated by Florida's elderly population. Siegel et al. (1992) identified much of north Florida as part of the stroke belt using data from 1979-81. They found that a continuing in-migration of healthy, upper income, and educated elderly with a low stroke risk to central and southern Florida kept its stroke rate below the national average. Further, Florida's out-migrants were more likely to be disabled elderly returning to be close to their children in other states. Florida's patterns of in- and out-migrations have left the counties of north Florida with rates of stroke similar to the adjacent stroke belt.

There are several other geographic or medical considerations in demarcating the stroke belt. These include comparing the geographic patterns of diabetes, ischemic heart disease, cigarette smoking, diet, and socioeconomic status, which are known to have some association with stroke. Lanska noted that the pattern of ischemic heart disease is focused on the Northeast and therefore does not correlate with the stroke belt. He also observed that the pattern of diabetes is "only loosely similar to that for stroke." (Lanska 1993, 1847). However, rates of cigarette smoking do exhibit a similar pattern as that of stroke – the Southeast with high rates. Diet is another con-

sideration. The traditional diet of the Southeast consists of corn bread, beans, lard – a high grain, low protein diet similar to that of Japan. Strokes were the leading cause of death in Japan from 1950 to 1980 until a dramatic lowering occurred in the early 1990s (Kinyo et al. 1999; Sarti et al. 2000). Since the rise of the South, diets have become more similar to that of the rest of the United States. Improvements in socio-economic status (SES) and access to health care services and treatment for diabetes and hypertension might have the effect of producing milder strokes that people have better chances of surviving. A more developed health services network also increased survivability and lowered stroke mortality in the stroke belt. Add the recent large immigration of northerners to the South and this might partly explain the declining stroke rates in the stroke belt states.

Current Pattern

The *Atlas of United States Mortality* devotes eight pages to stroke mortality, two pages each for white males, white females, black males and black females. These pages can be viewed or downloaded from <http://www.cdc.gov/nchs/products/pubs/pubd/other/atlas/atlas.htm>. The first page (plate) includes a color choropleth map produced using age-adjusted rates for 1988-92 by health services area. The classification method used to categorize the data is based on percentiles. Its legend lists seven rate categories: 10 percent (category 1- lowest), 10 percent (category 2), 20 percent (category 3), 20 percent (category 4), 20 percent (category 5), 10 percent (category 6), and 10 percent (category 7 – highest) of the rate distribution. The legend is also referenced with a comparative mortality ratio “defined as the HSA age-adjusted rate divided by the U.S. age-adjusted rate” (Pickles et al. 1996, p. 10). A graph showing the distribution of health service area (HSA) death rates is also included on this plate. The second plate includes three maps and a graph: death rates of each HSA compared to the US rate, smoothed death rates for age 40, smoothed death rates for age 70, and predicted regional

rates for smoothed rate maps.

For white males a tenuous and sometimes fragmented string of HSAs from North Carolina have a 1.36 to 2.31 greater risk for stroke mortality than the United States. There also appears to be a secondary string of HSAs in this highest category within the Mississippi River Valley, particularly in Arkansas and Tennessee. Smoothed death rates for the age 40 suggest a splitting or shift in the stroke belt toward Arkansas, Louisiana, Texas and Oklahoma. White women have a similar geographic pattern of stroke mortality as white men.

Some of the highest rates of stroke are for black men. These high rates are clustered within the eastern coastal plains of the Southeast; however, the focus tends to be on South Carolina and the immediate adjacent North Carolina HSAs. Other high rates for black men in North Carolina and Georgia appear to be more isolated. A secondary cluster of the highest rates is found in the HSAs on either bank of the Mississippi River from Louisiana, Mississippi, and Arkansas. Again, the pattern for black females is similar to that of black males, except to note that the cluster of HSAs with high rates in South Carolina and Georgia appear to be less fragmented, whereas the high rates along the Mississippi Valley appear to be a bit more scattered than for black males.

The North Carolina Center for Health Statistics publishes on-line *The North Carolina Health Atlas*. County-level data from 1994 through 1998 were used to construct age-adjusted mortality rates per 100,000 population for cerebrovascular diseases (Figure 1, <http://www.schs.state.nc.us/maps/atlas/vstats98/cerebro.html>). Seven counties including a cluster of five were classified into the highest category with rates ranging from 112.1 to 121.5. From northeast to southeast, this cluster consists of Lenoir, Jones, Duplin, Sampson, and Bladen Counties. These counties are ranked low for median family income (2000) and population per physician. For context, compare the ex-

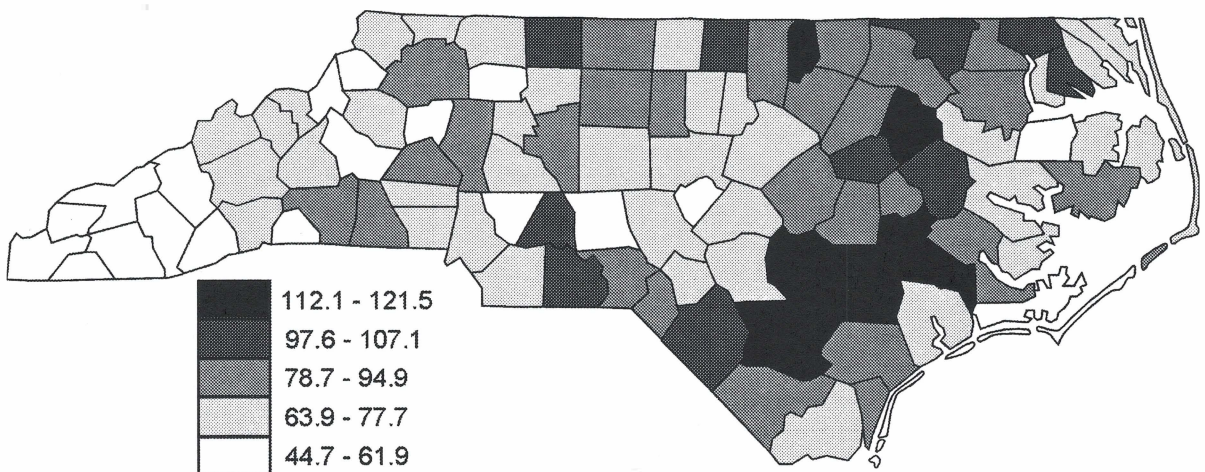


Figure 1. Age-adjusted mortality rates per 100,000 population North Carolina 1994-1998. Data from The North Carolina Health Atlas, North Carolina Center for Health Stateistics (1998).

treme differences that exist between Bladen County and Wake County for median family income and population per physician (Table 2).

Conclusions

Suffering a stroke is devastating. The occurrence of this illness and the resulting loss of life in the US are astronomical. While the mortality rates from strokes have plummeted dramatically over the last fifty years, especially in the Southeast, strokes continue to be menacing, as morbidity rates have remained virtually unchanged in decades. Current patterns of stroke mortality for whites, blacks, males, and females do support the notion that the stroke belt in the Southeast is becoming more fragmented and that a secondary stroke belt is becoming established along the Mississippi and Ohio River valleys. An examination of the literature on the geographic distribution of stroke reveals that physicians have written much on this topic. While their interest in geography is to be applauded, the search for

the stroke belt or belts would be best accomplished through multidisciplinary research teams consisting of physicians, epidemiologists, and geographers.

Traditionally, epidemiologists use geographic distributions of disease to infer etiology. For stroke, we know the major etiology: uncontrolled hypertension and age. Hence, the mapping of the stroke belt could prove useful for health care planning and intervention. Future research could seek to identify (predict) emerging regions of concern. Another research focus could be to verify the reasons for the higher rates of stroke with emphasis on the hypertension hypothesis. For this, one might want to focus on the emerging regions to identify what changes have occurred in terms of the regional population's health characteristics and behaviors. Third, there is an intervention agenda for future research. Specifically, the stroke belt could be targeted for community-based interventions: stroke awareness (signs of stroke so the victim gets to the hospi-

Table 2. Median Family Income and Population/Physician Ratio for North Carolina Counties with Highest Stroke Mortality Rates for 1994-1998.

Counties	Median Family Income (2000) Rank N=100	Population/ Physician Ratio
Vance	77	769
Edgecombe	40	1,501
Lenoir	59	594
Jones	No Data	No Data
Duplin	80	1,171
Sampson	70	1,259
Bladen	99	1,628
Wake (for comparison)	1	446

Source: Economic Development Information System, NC Department of Commerce <http://cmedis.commerce.state.nc.us/countyprofiles>.

tal sooner-this is actually the brain attack campaign of the National Stroke Association); promoting of prevention activities (i.e., exercise, diet); and especially medical treatment to control hypertension. Continued mapping, then, may be a cost-effective mechanism to monitor intervention impacts. Future studies on the geography of stroke

should also focus on morbidity rather than mortality rates, as the former rates may be more indicative of etiology than access to health care.

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