Stroke Mortality in Tennessee: An Eco-epidemiologic Perspective

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Abstract: Prevention of stroke mortality in Tennessee is a statewide public health priority. These analyses describe how the distribution of Caucasian stroke mortality to be is greater among the state's Appalachian Counties. For the African-American residents of the state, the elevated stroke mortality risk is not distinctive for geographic regions, although Upper East Tennessee rates are quite elevated. Were Caucasian criteria for 'high' rates used with the African-American stroke mortality data, the entire state would be designed as having elevated levels for stroke mortality. Race-gender specific analyses at the county-level [ecological attributes] illustrate the greater risks for 'high' county-level stroke mortality rates are present for urban and poor communities in our state. African-American males are a conspicuous exception, where the poorer, urban communities show a protective effect for 'high' county-level stroke mortality rates. Examinations were made for a conceptually compatible measure of stroke mortality risk, e.g., behavioral survey data for respondents indicating they were that they have 'high blood pressure.' These finding were quite inconsistent with the geographic pattern for the observed stroke mortality patterns. We assert that these differences reporting of the prevalence of this risk factor [being today one has high blood pressure] in associated with specific ecologic attributes [e.g., urban, poor, Appalachian]. These differences between mortality and behavioral prevalence are a reflection of the participation distribution with the statewide survey. We call for the implementation of stroke prevention programming and public health interventions based upon the mortality data distributions. Happily, compatible statewide initiatives of this ilk are underway. We also ask for strategic over-sampling of the state's priority populations for stroke risk in order to facilitate the monitoring of prevention and intervention program impacts over time.

Introduction: Tennessee is found among the 'lowest' ranked states in the nation for many social and adverse behavior characteristics, e.g., income, education, smoking, obesity prevalence.[1] Correspondingly, southern states, and the Appalachian ones in particular share high rank status for unflattering health-related attributes, notably obesity and stroke [See Figure 1].[2] In this article, we describe the respective patterns for poverty, Appalachian status, and rural residence as they are associated in the state with elevated stroke mortality. Our aim is to call attention to opportunities to implement hypertension prevention programs, and to mount stroke-related interventions. As we began this study, we believed that the most conspicuous of these missed opportunities was the absence of strategic behavioral risk factor data that might be used for program planning among the populations selected: poor, rural, Appalachian, and African-American. Our perspective for racial disparities for stroke mortality was focus on the Upper East Tennessee region, the seven counties near the Virginia, Kentucky and North Carolina juncture, where our institution is located. Over the course of our analyses, we came to recognize quite a different ecologic perspective for the distribution of 'high' stroke mortality, within Tennessee.

Methods: We obtained ecological data from four sources, for the analyses of the distribution of stroke mortality in Tennessee. Foremost, we obtained race and gender specific stroke mortality data from the National Centers for Health Statistics for the most recently available period: 1999-2002.[3] Next, we obtained population-based data from the American Factfinder website for distribution of poverty and rural status among county-level populations by age, race, and gender.[4] Finally, we analyzed data provided

by the Tennessee Behavioral Risk Factor Surveillance System [BRFSS] survey conducted annually.[5] These BRFSS data were available for the period 1998-2003; we analyzed the 2003 data [1875 responses] specifically for this report.

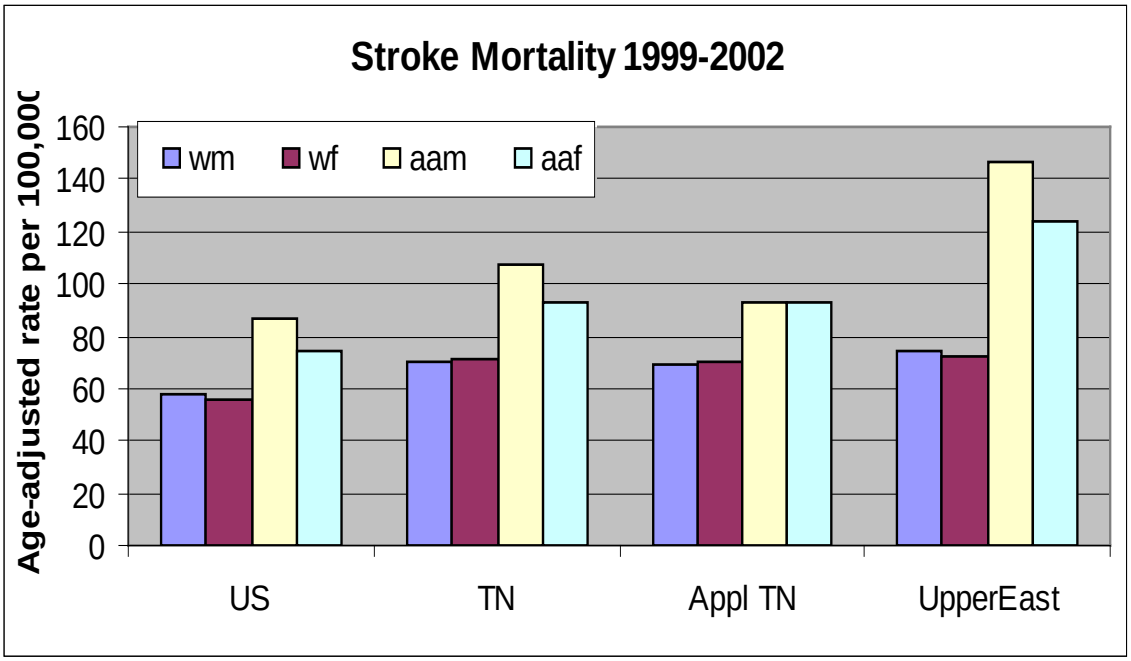
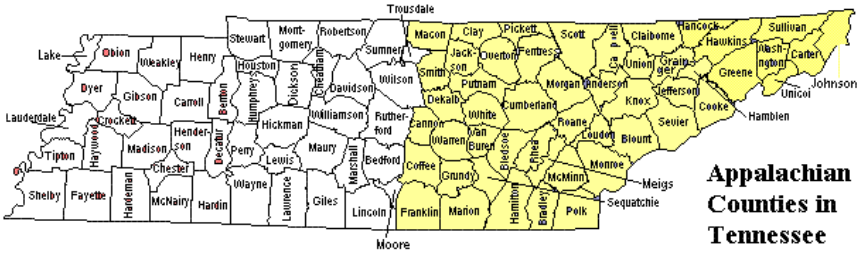
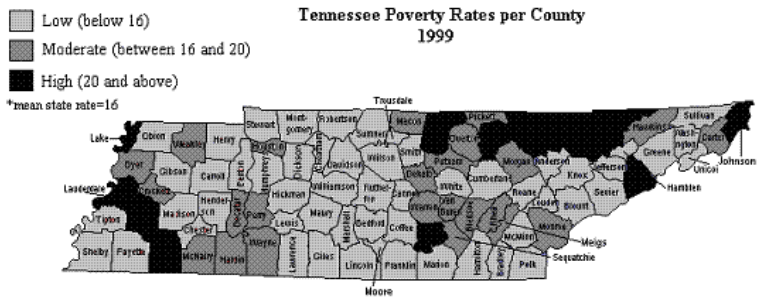


Figure 1: Stroke Mortality for the U.S., Tennessee, Appalachian TN, and Upper East Tennessee [Seven County Area].

For our analyses, we partitioned the county-level data for four race-and-sex categories: African-American Females, African-American males, Caucasian females, and Caucasian males. We chose these groups owing to the substantive differences for stoke mortality between these groups.[3] All of the mortality rates were age-adjusted to the 2000 U.S. Standard age-distribution. For the designations of Appalachia, we used the assignments for counties made by the Appalachia Regional Commission.[6] There are fifty **** Appalachian Counties in Tennessee [**See Figure 2**] and 45 non-Appalachian Counties. Designations of rural residence were based upon the classifications of the U.S. Census

[4]. There were forty rural counties designated in Tennessee, thirty-three suburban and 22 urban ones. Poverty was based upon the percent of county residents living below the national poverty level,[4] the state median of 16% was selected as the threshold for distinction, with one standard deviation as the 'high' designation on the maps.





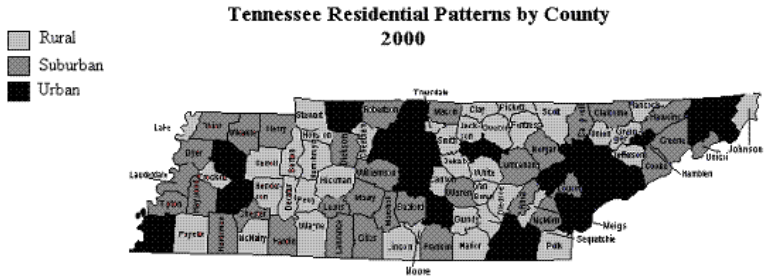


Figure 2: Appalachian, poverty status, and urban/suburban/rural county map here.

With the analyses of the Behavorial Risk Factor Information, we used the individual-level responses. [5] The distribution of responses for survey questions were maintained as percentages, for each race-gender sub-group. [5] We assigned rural and Appalachian status based upon the respondent's county of residence. We designated 'poor' as respondents indicating household incomes below $20,000 annually.

Simple descriptive reports are provided, e.g., figures and maps. Logistic regression was performed at both the county-level [ecologic] for counties whose race-sex-specific stroke mortality rates was greater than one-standard deviation above the respective statewide rate. We designated the county groups using the Poisson confidence limits methods of Frumpkin and Kantrowitz. [7] Our objective is to describe the risk that Tennessee's African-American populations hold for dying from a stroke. Similarly, we aimed to indicate how distinctly this risk distribution is borne by the poor, by rural and by Appalachian residents. As our analyses progressed, we found that the suburban strata of counties was 'not-linear' with the urban and rural. For each race-gender specific analysis, a regrouping of the three levels [urban-suburban-rural] was made to a dichotomy in order to obtain a 'best fit' for the regression solution. The format of these dichotomous grouping are described with each respective race-gender analysis. Statistical significance [$p < 0.05$] was only occasionally reached, our criterion for reporting results was simply that the model contain the fewest independent variables, that simultaneously provided the largest risk estimates for the remaining factors.

For the comparisons of proportions, we applied the conventional binomial formulae to test for significance.[8] All of our data-based interpretations are based on the $p < 0.05$ criterion, with no adjustment for multiple comparisons. Our gradients for shading of maps likewise reflect conventional statistical criteria, e.g., the 'low' category are those county rates below the statewide rate for that race-gender-specific group. Next, 'the moderate group' is the group of rates that were one-standard deviation above the statewide rate. Then, the counties with mortality rates between one and two standard deviations above the statewide rate were designated as high; this was a group for logistic analysis. The 'very high' designated levels [darkest shaded counties] are those that are 'statistically significant, $p < 0.05$ (two standard deviations above) the statewide values. Counties that are more than five standard deviations [$p < 0.0001$] above the statewide rate have been identified; these are communities potentially deserving particular public health attention for stroke risk-factor related interventions.

Results: We prepared simple maps of stroke mortality data for each race-gender group. See Figures 3-6 [attached at end of document]. These maps indicate the distribution of counties with 'higher' stroke mortality during the period 1999-2002. [3] We performed as series of logistic regression models to examine the 'ecologic' factors that may be related to a county having a 'high' stroke mortality rate. See Table 1. Our comparisons focused on Appalachia versus non-Appalachia counties, and ones designated urban or rural. As our analyses progressed, we found that the suburban strata of counties was 'not-linear' with the urban and rural. For each race-gender specific analysis, a regrouping of the three levels [urban-suburban-rural] was made to a dichotomy in order to obtain a 'best fit'

for the regression solution. This consideration [the distinctiveness stroke mortality rates for the 'suburban' counties] deserves further examination.

Table 1: Logistic Models for Race-Gender groups for 'elevated' stroke mortality rates, 1999-2002.

	Appalachia	Urban	Poor
Caucasian Males	1.80	2.98	
Caucasian Females	**3.28***	2.10	2.38
Afr-American Males		1.68	**0.346***
Afr-American Females		1.46	1.61

Only two values are statistically significant: $p < 0.05$.

Ecologic [County-level] Stroke Mortality Analyses: For Caucasian males, it was interesting that Appalachian counties represented a higher probability of having elevated stroke rates; odds ratio = 1.80 (not significant). We removed the suburban counties for the Caucasian male analyses, as their relationship was non-linear, and formed a distinctive gradient from both the rural and the urban groups. Thus, for the urban counties, there was nearly a three-fold likelihood (not significant) for the county having an elevated stroke mortality rate for Caucasian males. Poverty status was a negligible risk attribute, and the regression model was unchanged by exclusion of that variable, so the simpler model is reported. Urban Appalachian counties represent a priority population for reducing stroke risk among Caucasian males, of all income levels.

For Caucasian females, Appalachian counties showed a statistically significant elevation for stroke mortality risk [odds ratio = 3.28]. There was a two-fold risk (non-significant) for elevated Caucasian female stroke mortality rates for urban counties versus rural-and-suburban counties [these two categories were combined]. Similarly, counties that had 'proportion of residents living-in-poverty rates greater than the state median [16%] posed nearly 2.4-fold the risk for 'high' Caucasian female stroke mortality rates. (non-significant) Appalachian counties are clearly a focal area for prevention programming directed to stroke risk for Caucasian females in Tennessee. Urban residents and Caucasian females living in counties whose poverty level is greater than 16% are similarly at distinctive stroke mortality risk.

African-American males represent a high risk population for stroke mortality all across Tennessee, not in Appalachia in particular. Notice in Figure 5, how the African-American males 'low' rate is higher than the corresponding 'very high' rate for Caucasian males [Figure 3]. For urban-and-suburban counties [these two categories were combined] counties, there is nearly 70% greater likelihood of elevated stroke mortality for African American males compared to that for rural. For counties with greater than 16% living in poverty, the risk of elevated stroke mortality rates for African-American males was nearly one-third ($p < 0.05$). Therefore, the counties whose fraction of residents living in poverty is less than the state, and for the counties designated as urban/suburban: resident African-American males are a priority population, for stroke-directed intervention programming in Tennessee.

The distribution of stroke mortality risk at the county-level for African-American females is again, statewide in distribution, not for Appalachian counties distinctively. Urban-and-suburban counties [these two categories were combined] and those counties with higher percentages of residents living in poverty have higher stroke mortality rates for African-American females; odds ratios 1.46 and 1.61 respectively (both are not statistically significant). This means that for African-American women residing in poverty and in urban counties in Tennessee the community-level risk for elevated stroke mortality is greater, whether they reside in Appalachian or non-Appalachian regions.

Behavioral Risk Factor Survey Analyses: Next, we endeavored to examine a corollary with stroke mortality risk, that is the diagnosis of high blood pressure. We analyzed BRFSS data for the distribution of self-reported "being told by a health professional that you have high blood pressure' on the Behavioral Risk Factor Surveillance Survey for Tennessee, in 2003. These data were analyzed on individual level, and as unweighted extrapolations [the form for the national data] they are not representative of the state's population.[1] This unrepresentativeness if a result of a disproportion of respondents being urban dwelling, female, and Caucasian. About equal proportions are Appalachian residing and non-Appalachian residing.

A multivariate logistic model was prepared for the attributes of: poor [defined as household income < $20,000]; race; gender; urban, suburban, and rural status, and residence in an Appalachian county versus residence in a non-Appalachian county. For the Urban/Suburban/Rural and Appalachian categories, the same criteria for assignment

was applied as with the county-level, cause-specific mortality rate analyses [described above].See Table 2 for these results.

TABLE 2 : Logistic model of reported ‘ever told you had high blood pressure.’

Logistic Regression Affirmative answer	Poverty (< $20,000)	Race (White)	Gender (Male)	Urban	Appalachia
Odds Ratio	0.94	1.18	0.74*	0.92	1.02

* chi-square 9.43 $p < 0.002$

Only gender was statistically significant and this showed a protective effect for males [odds ratio 0.74, chi-square 9.43 1 df, $p < 0.002$.]. The race effects were elevated [odds ratio 1.18 for Caucasian to have a greater likelihood to report having been told they had high blood pressure] but negligibly. We performed a set of these analyses without the suburban counties being included, in light of the [non-linear] findings with the county-level mortality findings, yet these results were essentially unchanged. Finally, the risks for ‘being-told-that-you-have-high-blood-pressure’ is essentially the same for Appalachian residence versus non-Appalachian residence; the odds ratio 1.02.

Curious about the race and gender-specific effects found for the stroke mortality rate analyses at the county level, we repeated these BRFSS respondent analyses by for Appalachia versus Non-Appalachia Counties, and then by the respective race-gender sub-group. See Tables 3a and 3b for these results.

	Poverty (< $20,000)	Race (White)	Gender (Male)	Urban
Appalachia	0.99	0.76	0.85	0.95
Non-Appalachia	0.90	1.32	0.65*	0.89

* chi-square 9.75, $p < 0.002$

Table 3a: Odds ratios for Appalachia and Non-Appalachia-specific regression models for 'ever told you had high blood pressure.'

The male protective risk for being 'told-that-you-have-high-blood-pressure' seen in Table 2 was most implicit with the non-Appalachia males, when the two regions were partitioned [e.g., protective odds ratio for males was 0.65, chi-squared 9.747 and $p < 0.002$]. Correspondingly, the negligible elevated risk for Caucasians was raised [still non-significantly], with Non-Appalachian respondents. Examined as single effects, these risk patterns for African-Americans reporting having been told they had 'high blood pressure' were essentially unchanged, for both Appalachia and non-Appalachia.

This dynamic of the 'race' odds ratio converting from elevated to protective for Caucasians in Appalachia was examined by a series of race-gender specific logistic models with Appalachia, rural/urban, and poor status included. See Table 3b.

	Appalachia	Urban	Poor
Caucasian males	1.08	1.45	0.63
Caucasian females	0.86	1.23	0.81

African-American males	1.01	0.34	2.03
African-American females	2.26	0.29	0.70

None of the regression coefficients were statistically significant.

Table 3b: Odds ratios for race-gender specific regression models for 'ever told you had high blood pressure.'

For Caucasian males, the risk of respondents reporting they had been told they had high blood pressure was essentially non-differential for Appalachian versus non-Appalachia. Urban respondents were more likely to report having been told they had high blood pressure. Poor respondents were less likely to report being told of this diagnosis.

For Caucasian females, Appalachian women were less likely to report having been told they had high blood pressure. Urban Caucasian females were more likely to have been 'told-they-have-high-blood-pressure.' But for women whose household incomes was less than $20,000, they were less likely to have been told they had high blood pressure.

For African-American Males, the Appalachian versus non-Appalachian differences were non existent. But urban residents were nearly one-third as likely to say they had been told-they-have-high-blood pressure [that is rural residents were three-times as likely to have been told this diagnosis], and respondents whose household income was greater then $20,000 were twice as likely to report that diagnosis. This pattern for rural, poor respondents being more likely to report that they had been told they had high blood pressure suggests an awareness of hypertension risk among this group.

For African American females, Appalachian females were twice a likely to report having been told-they-have-high-blood-pressure. Urban residing African-American female respondents to this telephone survey were one third as likely to report they had been told they had high blood pressure as rural residing respondents [alternatively, one may say that rural residing African-American females were over three-times as likely to report this diagnosis]. Poorer African American females were 30% less likely to report they had been told-they-have-high-blood-pressure than those with household incomes greater than $20,000 a year.

These data give evidence to the pronounced selection forces present with the Tennessee BRFSS telephone survey [5]. The Non-Appalachian resident's proportion [52.8%] in the 2003 survey is very close to that for Appalachian residents [47.2%]. See Figure 7. The respondents to the telephone survey over represent female residents of urban centers. The African-American proportion is small compared to the state population 11.6% in the BRFSS overall versus 16.6 % of the state's residents. And, the intersection of the under-representation for African-American respondents, with that for the Appalachia residents, is a tiny fraction: only 4% of the entire statewide survey. Similarly, the statewide sample for African–Americans tends to over represent poor persons, ones whose house-hold incomes are less than $20,000 per year.

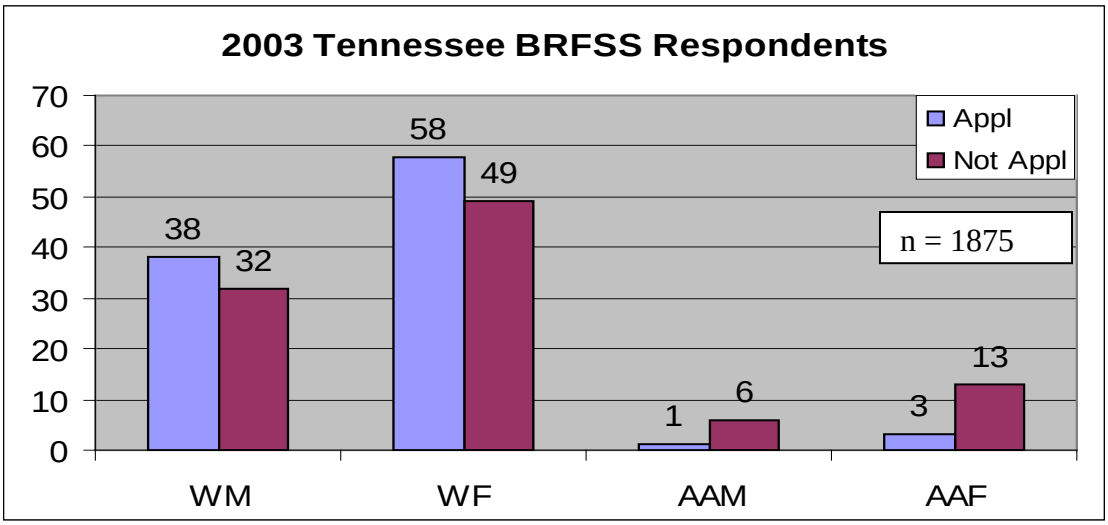


Figure 7. Proportion of Respondents to the Behavioral Risk factor Surveillance Survey in 2003, for Appalachia versus Not Appalachia residents, by race and gender groups.

Discussion:

Our aim is to call attention to opportunities to implement hypertension prevention programs, and to mount stroke-related interventions in Tennessee. As we began this study, we believed that the most conspicuous of these missed opportunities was the absence of strategic behavioral risk factor data that might be used for program planning among the populations selected: poor, rural, Appalachian, and African-American. Over the course of our analyses, we came to recognize quite a different ecologic perspective for the distribution of 'high' stroke mortality.

Stroke risk in the state is greatest for African-Americans. If the Caucasian stroke mortality rate designations were used with the African-American, all the counties of Tennessee would be shaded as 'very high.' This implication represents a well recognized (national-level) racial risk for stroke mortality.[3] It was a surprise for our perspectives

that in Tennessee the 'Appalachian' risk for stroke mortality was found among the Caucasians alone; however, this simply implied that the African-American stroke mortality risk is statewide in distribution.

Among Caucasian women, the Appalachian counties represent a significant risk for 'high' stroke mortality. This pattern was true for the urban and the poor counties. With the 'high' stroke mortality rates in Tennessee, among the African-American the risk for males is among the urban counties and counties that are below the median state proportion of persons living below the poverty level. That is the African-American male risk for urban counties [not-statistically significant] is contrary to the pattern for Caucasian females, it is for the 'richer,' not the poorer counties. Perhaps this distribution reflects a competing cause of death effect, as earlier deaths from diabetes, myocardial infarction, etc. among this race-gender group may make for this discordant finding from African-American females. More study of this distinction is warranted.

African-American females follow the urban and poor county pattern of the Caucasian females, but less robustly. The guidance for planning and conducting stroke-related programming and interventions suggest that the greatest need in Tennessee is among African-Americans foremost, then Appalachian Caucasians focused on the urban residents, and counties with relatively large proportions of persons living in poverty. The exception to this pattern is with African-American males, where the risk of 'high' stroke mortality is for counties with lesser proportions of persons living in poverty.

Similarly, we have endeavored to show the manner in which stroke mortality risk is not well represented via the statewide data surveillance efforts for behavioral risks. Urban Caucasian respondents reflect the increased likelihood of having been told-they-have-high-blood-pressure, while the urban African-Americans do not, despite those profiled counties possessing the 'higher' stroke mortality rates for the state. Also, notable is that Non-Appalachian males are less likely to report having been told-they-have-high-blood-pressure than Appalachian males, while this region's Caucasians are more likely to report this diagnosis. Likewise, the greater likelihood of this diagnosis for Appalachian African-American females, but a one-third likelihood for the respondents from urban counties to report that they have been told-they-have-high-blood-pressure. These sorts of conflicting distributions are indicative how the participation patterns for the statewide survey are pose a gap in the characterization of communities in Tennessee that are at risk for 'high' stroke mortality.

The mortality data shows a conspicuous distinction for stroke mortality risk from that implicated via the behavioral risk survey. However, the survey responses [e.g., being less likely to have been told-they-have-high-blood-pressure] is distressingly demonstrative of the absence of knowledge of this stroke-related diagnosis risk. Therefore, we call for greater public health programming emphasis for African-Americans, poor persons, and for Appalachian residents. Foremost among these steps is a measure that several other Southern states have taken, that is over-sampling of strategic populations with their BRFSS survey. This involves the systematic collection of regional behavioral data to underpin programmatic emphases toward high-risk populations. Statewide data

collection efforts should be organized to adequately represent African-Americans and Appalachian regions in particular, so that monitoring of disease risk impacts from the targeted stroke mortality prevention programming may be monitored over time.

Tale of the Tail: As a conclusion for this work, we elected to examine 'extreme' stroke mortality rates. We did this in only an 'excess' perspective; as some counties has very few stroke deaths [by rage-gender groups], so that 'zero' deaths in a single year was quite common, across the state. We regard it is useful for public health practice to consider the extreme values for a distribution.[9] Such 'outliers' may signal a *bona fide* exorbitant disease risk, or more often a systematic distinction for selective case referrals, or data coding, etc. In this case, we chose values of stroke mortality that were more than five-standard errors above the statewide rate, by race-gender group.

Among the African-Americans, there were a dozen or so counties with these extreme values, but we selected for identification only those that: [a] were present for both genders, or [b] occurred for the Caucasian rates in the County as well. There were three counties identified: Johnson, Jefferson, and Sevier. See Figure 5 for the icons (four-point stars) that indicate these three counties. For the preceding four-year period [1995-1998], only Johnson County also had such an extreme value, and that was for African American males alone. That these three counties are adjacent warrants closer examination.

Two counties were found to have 'extreme' stroke mortality rates for both African-American genders, and for Caucasian males. These counties were Grangier and Dickson.

In the 1995-1998 period, the Grangier County stroke mortality rates were so excessive, solely for African American males. For the earlier period, both the African-American gender-specific rates were similarly elevated, and the Caucasian male rate was greater than four standard errors from the statewide rate. Grangier and Dickson County are marked with five-point stars in Figures 5. That three of these counties are adjacent warrants closer examination.

Yet, our observation is most conspicuous for the single county Henderson, where all race-gender groups were extremely elevated. In fact, these rates were double digit standard deviations from the state rate [e.g., 13-SE for Caucasians]! In the preceding interval, three of the four race-gender rates were likewise greater than five standard errors above the state rate, only African-American females was closer to the state rate [albeit, still somewhat elevated]. Henderson county is also marked [eight-point star] in Figure 5. Such profound differences of stroke mortality rates are indicators justifying public health follow-back studies.[9]

Tennessee is a state of great stroke mortality. We believe it is a priority for public health practice in the state. These data identify communities of greatest risk, and so greatest need for public health action. Strategic data collection to sufficiently represent these priority populations with the statewide data surveys are needed to permit tracking of progress made in the state for stroke mortality risk.

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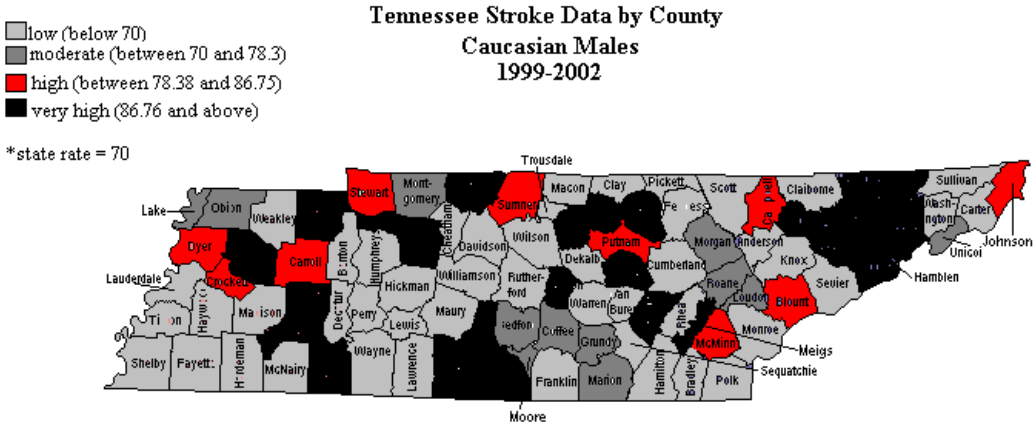
Figures 3 – 6


Tennessee Stroke Data by County
Caucasian Males
1999-2002
low (below 70)
moderate (between 70 and 78.3)
high (between 78.38 and 86.75)
very high (86.76 and above)
*state rate = 70
Trousdale
Lake
Obion
Weakley
Stewart
Mont-
gomery
Sumner
Macon
Clay
Pickett
Scott
Claiborne
Sullivan
Carter
Johnson
Unicoi
Hamblen
Dyer
Carroll
Davidson
Wilson
Putnam
Morgan
Anderson
Knox
Cumberland
Dekalb
Lauderdale
Crockett
Hickman
Williamson
Rutherford
Roane
Loudon
Blount
Sevier
Madison
Perry
Lewis
Maury
Warren
Van Buren
Rhea
Monroe
Meigs
Sequatchie
Shelby
Fayette
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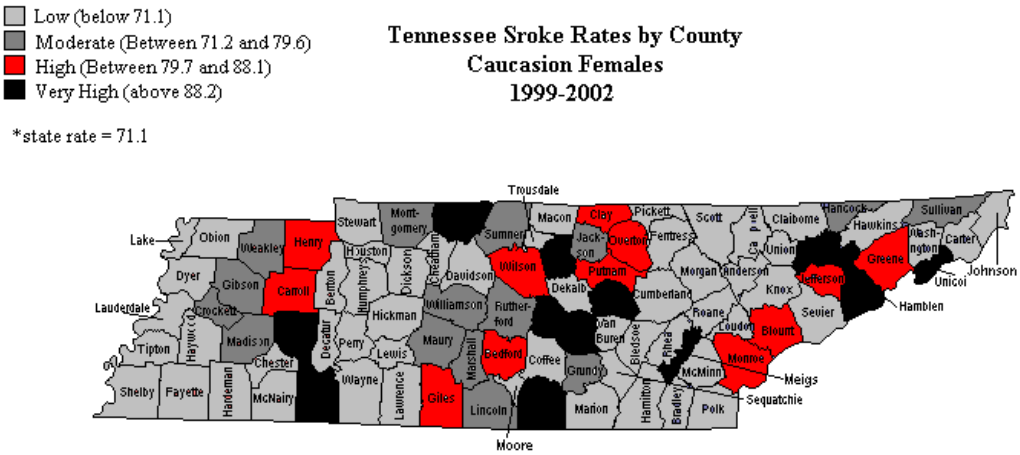
Wayne
Laurence
Bedford
Coffee
Grundy
McMinn
Franklin
Marion
Hamilton
Bradley
Polk
Moore


Tennessee Sroke Rates by County
Caucasion Females
1999-2002
Low (below 71.1)
Moderate (Between 71.2 and 79.6)
High (Between 79.7 and 88.1)
Very High (above 88.2)
*state rate = 71.1
Trousdale
Lake
Obion
Weakley
Henry
Stewart
Mont-
gomery
Sumner
Macon
Clay
Pickett
Scott
Claiborne
Hancock
Hawkins
Sullivan
Carter
Johnson
Unicoi
Hamblen
Dyer
Gibson
Carroll
Houston
Humphreys
Dickson
Cheatham
Davidson
Wilson
Putnam
Morgan
Anderson
Knox
Jefferson
Greene
Cumberland
Dekalb
Lauderdale
Crockett
Hickman
Williamson
Rutherford
Roane
Loudon
Blount
Sevier
Madison
Perry
Lewis
Maury
Van Buren
Rhea
Monroe
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Coffee
Grundy
McMinn
Shelby
Fayette
Hardeman
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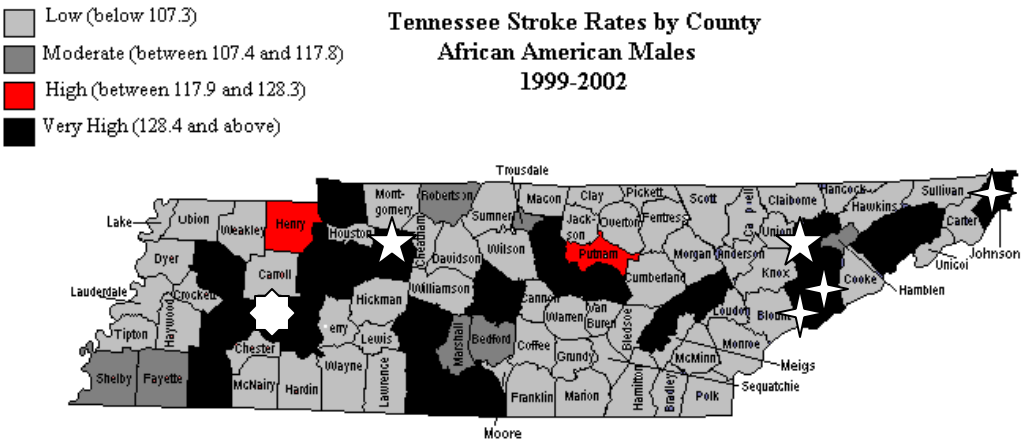
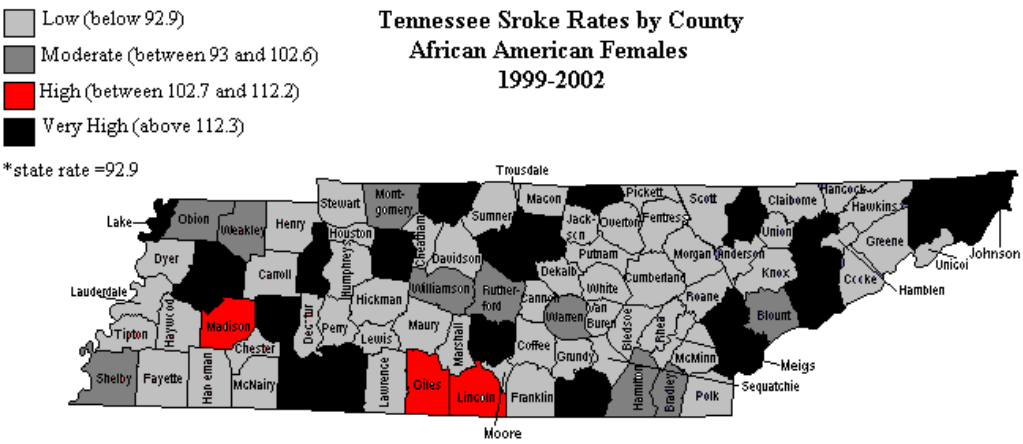
Polk
Moore





Source [3]: Compressed Mortality Data Request Screen for the years 1999-2002 with ICD 10 Codes. At http://wonder.cdc.gov/wonder/