Stroke Mortality and Its Socioeconomic, Racial, and Behavioral Correlates in Florida

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Synopsis

Stroke mortality is associated both with being black and with having low socioeconomic status. However, it is uncertain to what extent that increased risk is related to rates of behavior-related risk factors, such as hypertension, cigarette smoking, obesity, or alcohol consumption. The investigators performed an ecologic analysis to estimate the contributions of behavioral risks, socioeconomic status, and black race to regional variations in stroke mortality rates among persons 55–84 years of age in Florida. They used data from the 1980 census and from the Behavioral Risk Factor Surveillance System (BRFSS) for 1986 through 1988.

Weighted multiple linear regression models indicated that regions in Florida with high stroke mortality rates were characterized by high prevalences of poverty, obesity, and hypertension. Although limited by its ecologic design, this study suggests that socioeconomic status and prevalence of behavioral risks contribute independently to interregional disparities in stroke mortality rates in Florida. BRFSS data, now available for more than 45 States, can be used to help clarify the relative contributions of behavioral and other risks to population-based mortality rates.

DESPITE A DRAMATIC DECREASE in the death rate from stroke in the United States, from 71.5 per 100,000 persons in 1968 to 30.1 per 100,000 persons in 1987, stroke remains the third leading cause of death, accounting for about 7 percent of all deaths (*1*).

Behavior-related risk factors for stroke are preventable. They include hypertension, cigarette smoking, and obesity (*2*). Some evidence indicates that chronic consumption of alcohol, as well as binge drinking, may increase the risk of stroke (*3*).

Blacks are known to be at greater risk of death from stroke than whites (*4*). High stroke mortality rates have been shown to be associated with low socioeconomic status (*5, 6*), as well as measures of social instability (*5*) and social disorganization (*7*). It is not known to what extent high stroke mortality rates associated with those groups may be related to high prevalences of behavioral risks.

Several behavior-related cardiovascular risk factors are more prevalent among blacks and persons with low income than among whites and persons with high income. For example, blacks, persons with low income, and persons with less than a high school education are more likely to be overweight than are whites, persons with high income, and high school graduates *(8)*. Smoking is more common among high school nongraduates than graduates *(8)*. Low levels of physical activity are more common among blacks, persons with low income, and high school nongraduates than among whites, persons with high income, and high school graduates *(8)*. Hypertension, in part behaviorally determined, is known to be more prevalent among blacks than whites in the United States *(9, 10)*.

In our ecologic analysis, we assessed the population-based stroke mortality risk in Florida that is associated with socioeconomic status, black race, and behavioral risks, using readily available data sets. This research method can be replicated for other States and applied to a broad range of public health problems.

Methods

Geographic unit. The geographic reference unit chosen for the study was the labor market area (LMA). A LMA is a county, or a group of contiguous counties, whose population constitutes an economic unit, identified by commuting patterns reported in the 1980 census (*11*). Each LMA has at least 100,000 inhabitants, and some LMAs are divided into subareas. Florida contains 26 separate LMA subareas. We grouped contiguous LMA subareas into 17 regions to provide completed risk factor surveys for a minimum of 100 persons for each of the regions.

Outcome measure. We chose as an outcome measure the average annual stroke mortality rate per 100,000 Florida residents ages 55–84 years during the 8-year period 1980–87. Most preventable stroke deaths occur in this age range. We obtained yearly population estimates, stratified by age, race, and county, from the State of Florida, Office of Planning and Budgeting. Records of deaths from stroke, categorized under the International Classification of Diseases (ICD-9) (*12*), codes 430–434 and 436–438, were obtained from the State's Vital Statistics Services master death tape, which contains coding for the underlying cause of death, as well as data fields for age, race, sex, county of residence, and year of death.

We calculated age-stratified mortality rates for the 55–64-, 65–74-, and 75–84-year age groups, and standardized against the 1980 U.S. population for the same age groups. Mortality rates were weighted proportionately to the population for each study year.

Socioeconomic and demographic variables. Values of socioeconomic variables for each county were extracted from the 1988 County and City Data Book (*13*), produced by the Bureau of the Census. Socioeconomic variables and reference years included

- percentage of the population with incomes below the poverty line (1979),
- percentage of the adult population with at least 12 years of school (1980),
- number of physicians per 100,000 population (1985), and

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- number of hospital beds per 100,000 population (1985).

We used State population data to calculate one demographic variable, the percentage of blacks among residents ages 55–84. For each socioeconomic and demographic variable, we calculated a value for each geographic region by weighting the values for each component county proportional to the county population.

Behavioral risk factors. We used the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System (BRFSS) to estimate the prevalence of behavior-related cardiovascular risk factors in each of the study regions. BRFSS uses a random-digit-dialed, population-based telephone survey in estimating the prevalence of behavioral risk factors associated with the leading causes of premature death among persons 18 years and older (*14*). Cardiovascular disease-related BRFSS data items include

- current smoker status, having smoked a lifetime total of 100 cigarettes and being a smoker now;
- obesity, being 120 percent or more of ideal body weight, according to the 1959 Metropolitan height-weight tables;
- dietary salt intake, adding salt to one's food at the table most of the time;
- binge alcohol consumption, consuming five or more alcoholic drinks at one occasion, one or more times in the past month;
- chronic alcohol consumption, consuming an average of 60 or more alcoholic drinks a month;
- sedentary lifestyle, participating in less than 20 minutes of leisure-time physical activity three times per week; and
- hypertension, ever having been medically advised about being hypertensive.

We aggregated BRFSS data for Florida for the 3-year period 1986–88, a total of 3,922 responses.

Table 1. Socioeconomic, demographic, and behavioral risk factor prevalences for Florida and 17 Florida regions, by percent of the specified population group

Variable	17 Florida regions: Minimum percent	Maximum percent	State percent
Socioeconomic variables:			
High school education[1]	59	73	67
Poverty[2]	9	23	14
Demographic variable of percentage black[3]	7	24	14
Behavioral risks:[4]			
Current smoking	18	33	27
Obesity	18	33	23
Dietary salt	16	34	23
Binge drinking	9	20	15
Chronic drinking	4	17	9
Sedentary lifestyle	49	64	57
Hypertension	17	27	23

[1] Adults ages 25 years and older, 1980.
[2] Population below poverty threshold income, 1979.
[3] Weighted average, 1980–87.
[4] Adults aged 18 and older, 1986–88, weighted to Florida's 1987 population according to age, race, and sex.

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The combined data set was then weighted against the Florida population for 1987 to correct for overrepresentation or underrepresentation of age, race, or sex groups in the sample. Details of this method have been described *(14)*.

Regression analysis. We performed a forward multiple linear regression analysis, using the REG procedure in SAS *(15)*, with values weighted to the number of BRFSS respondents in the respective regions. The *P*-value criterion, set to 0.05, was used for entry into the regression model. We compared the model obtained to the models produced by the all subsets regression option.

Results

Age-adjusted stroke mortality rates per 100,000 residents ages 55 to 84 years ranged from 148 to 248 among the 17 geographic regions; the rate for the entire State was 175. Table 1 shows the substantial interregional variation in risk factor prevalence, in most cases the highest prevalence being more than 50 percent higher than the lowest. Age-adjusted stroke mortality rates statistically were significantly associated with poverty and obesity ($P < 0.01$). Regression coefficients are shown in table 2.

Weighted multiple regression analysis. Poverty was the most important predictor variable ($P < 0.01$), followed by obesity ($P < 0.05$) and hypertension ($P = 0.05$) (table 2). The coefficients for those variables yielded the following regression model: stroke mortality = 4.35*poverty + 3.45*obesity + 3.45*hypertension −0.36. Stroke mortality is expressed in annual stroke deaths per 100,000 population ages 55 to 84 years; poverty, obesity, and hypertension are expressed as population prevalence.

This regression model explained 71 percent of the total variation in stroke mortality rates among the 17 regions ($R^2 = 0.71$). All subsets regression confirmed that this model had the highest R^2 of all models for which the *P*-value of each variable was less than or equal to 0.05.

Pearson correlation coefficients indicated that none of the predictor variables in the model was highly correlated with another (table 3). The percentage of black residents was, however, highly correlated with the percentage of residents whose family income was at the poverty level or below.

Discussion

The results of this study support and expand current knowledge about correlates of stroke mortality. Socioeconomic status, hypertension, and obesity are all documented correlates of stroke mortality *(2, 4, 6, 16)*. Obesity and hypertension reportedly are responsible for more stroke deaths in the United States than any other behavioral risks *(17)*. Otten and coworkers have shown that behavioral risk and family income factors contribute independently to excess all-cause mortality among black adults; however, they did not comment on cause-specific mortality *(18)*. Our study is the first, to our knowledge, to provide evidence that socioeconomic status and prevalence of behavioral risks are independently associated with stroke mortality.

Otten and coworkers pointed out that a comprehensive approach to the national problem of differential all-cause mortality in subgroups of our population must address behavioral risks, and that further research is needed to identify factors associated with income that may be subject to intervention *(18)*. Our results reaffirm those ideas in the context of a single cause of death in a single State.

The "percent black" variable did not enter into the best regression model; however, it was highly correlated with poverty ($P < 0.01$). Because high correlation between independent variables can confound their relationship with the outcome variable, it is not possible, with the data used, to determine which of those variables might be independently associated with stroke mortality.

Morgenstern described how linear regression coefficients from ecologic analyses can be used to estimate the expected rate of a disease outcome in a population, given a specified prevalence of a risk factor *(19)*. By applying this method to the current study, we would expect each percentage point change in risk factor prevalence to change annual stroke mortality by the value of the regression coefficient for that risk factor. For example, using the regression equation, we can predict that, for each percentage point decrease in the prevalence of obesity, the expected stroke mortality among adults ages 55 to 84 years would decrease by 3.45 per 100,000 population.

Siegel and coworkers have shown that stroke mortality rates in north Florida are similar to those in the group of southeastern States known as the "Stroke Belt" *(20)*. The relationship of stroke mortality rates with socioeconomic status, race or ethnicity, and prevalence of behavioral risks seen in the current study may be generalizable to other States with high stroke mortality rates. Since BRFSS is active for more than 45 States, data are available to test that hypothesis.

The basic methods used in this study can be applied to a variety of related questions. One example would be to test whether regional variations in stroke mortality among blacks at the national level can be explained in terms of either socioeconomic status or prevalence of behavioral risks. As of now, there is no clear explanation of why the stroke mortality rate for black men in the Southeast is almost 44 percent higher than that for black men in all other regions *(10)*.

Ecologic analysis is inherently limited by the use of aggregate-level data rather than individual-level data. This method can result in substantial bias known as the "ecologic fallacy" *(19)*. In addition, the limited amount of behavioral risk factor data available for the current study warrants caution in drawing inferences *(21)*. As additional years of BRFSS data become available, however, it will become possible to assemble data sets with larger numbers of respondents. This, in turn, will make it possible to divide States into larger numbers of regions and to perform more powerful ecologic analyses. Larger samples will allow for more powerful analyses of race or ethnicity effects.

Table 2. Unadjusted and adjusted regression coefficients for stroke mortality predictor variables, Florida, 1986–88

Variable	Regression coefficients: Unadjusted	Regression coefficients: Adjusted[1]
Poverty	[2]5.53	[2]4.35
Obesity	[2]5.25	[3]3.45
Hypertension	2.53	[3]3.45
Percent black	2.50	...

[1] Best regression model. [2] *P*-value < 0.01. [3] *P*-value < 0.05.

Table 3. Correlation matrix of stroke mortality predictor variables, Florida, 1986–88

	Hypertension	Obesity	Poverty	Percent black
Hypertension	...	0.04	−0.09	0
Obesity	0.04	...	0.40	−0.06
Poverty	−0.09	0.40	...	[1]0.71
Percent black	0	−0.06	[1]0.71	...

[1] *P*-value < 0.01.

Another limitation of this study is that all the variables do not represent the same age groups. The outcome data are for persons ages 55–84 years, the risk factor data are for those 18 years and older, and the poverty level data are for persons of all ages. Several influences on Florida's population structure could affect the results of this study. These include deaths of part-year residents and immigration from regions with lower or higher stroke mortality rates or prevalence of a stroke risk factor. Those demographic phenomena underscore the importance of replicating this study for other States.

The self-reported behavioral data used are subject to respondent error. For example, self-reported data for height and weight have been shown to underestimate by several percentage points the prevalence of overweight *(22)*. Such bias in self-reported data would result in bias at the ecologic level only if it were inconsistent across the regions included in the study. Since not every household has a telephone, lack of telephone coverage is another source of potential bias. However, this is unlikely to introduce substantial bias, because more than 90 percent of households have telephone service (*23*).

Geographic variation in the prevalence of diabetes might be responsible for some of the interregional variation in stroke mortality rates. Because a question on self-reported diabetes was added to the Florida BRFSS questionnaire in 1987, such an analysis could be incorporated into future studies.

Although subject to the limitations mentioned, we believe that our study is the first to assess independent effects of socioeconomic, race or ethnicity, and behavioral risk factors on population-based stroke mortality rates. The high degree of consistency with current knowledge about correlates of stroke mortality gives confidence in the general validity of the method.

For several reasons, we expect that BRFSS will become an increasingly important epidemiologic tool for the study of stroke and other health problems. First, it is a population-based data set with State-specific estimates for the prevalences of risk factors associated with leading causes of death and disability. Second, by aggregating data from multiple years, investigators can provide stable prevalence estimates at sub-State levels and for selected age-race-sex strata. Because of the limited amount of stroke mortality data available from cohort studies, ecologic analyses may play an important role in clarifying etiologic differences between the two major pathologic groups of stroke, hemorrhagic and thrombotic.

References

1. Progress against mortality from stroke. Stat Bull Metrop Insur Co 70: 18-28, April-June 1989.
2. National Institutes of Health: The stroke belt. Data Fact Sheet. National Heart, Lung, and Blood Institute, Bethesda, MD, October 1989.
3. Klag, M. J., and Whelton, P. K.: Stroke and nutrition: a review. Clin Nutr 8: 34-41 (1989).
4. Gillum, R. F.: Stroke in blacks. Stroke 19: 1-9 (1988).
5. James, J. A., and Kleinbaum, D. G.: Socioecologic stress and hypertension related mortality rates in North Carolina. Am J Public Health 66: 354-358 (1976).
6. Pincus, T., Callahan, L. F., and Burkhauser, R. V.: Most chronic diseases are reported more frequently by individuals with fewer than 12 years of formal education in the age 18-64 United States population. J Chron Dis 40: 865-874 (1987).
7. Neser, W. B., Tyroler, H. A., and Cassel, J. C.: Social disorganization and stroke mortality in the black population of North Carolina. Am J Epidemiol 93: 166-174 (1971).
8. National Center for Health Statistics: Trends in smoking, alcohol consumption, and other health practices among U.S. adults, 1977 and 1983. Advance Data from Vital and Health Statistics, No. 118. Centers for Disease Control and Prevention, Hyattsville, MD, June 30, 1986.
9. Cornoni-Huntley, J., LaCroix, A. Z., and Havlik, R. J.: Race and sex differentials in the impact of hypertension in the United States. Arch Intern Med 149: 780-788 (1989).
10. Roccella, E. J., and Lenfant, C.: Differences between blacks and whites in high blood pressure control, the United States experience. Cardiologie Tropicale 13: 33-44 (1986).
11. Tolbert, C. M., and Killian, M. S.: Labor market areas for the United States. U.S. Department of Agriculture, Economic Research Service, Washington, DC, 1987.
12. International classification of diseases: manual of the international statistical classification of diseases, injuries, and causes of death. 9th revision. Clinical modification. DHHS Publication No. (PHS) 91-1260. Centers for Disease Control, National Center for Health Statistics, and Health Care Financing Administration, Hyattsville, MD, 1992.
13. Bureau of the Census: County and city data book (diskette). U.S. Government Printing Office, Washington, DC, 1988.
14. Gentry, E. M., et al.: The Behavioral Risk Factor Surveys: II. Design, methods and estimates from combined state data. Am J Prev Med 1: 9-14 (1985).
15. SAS/STAT guide for personal computers, version 6. SAS Institute, Cary, NC, 1985.
16. Kannel, W. B.: Current status of the epidemiology of brain infarction associated with occlusive arterial disease. Stroke 2: 295-318 (1971).
17. Hahn, R. A., et al.: Excess deaths from nine chronic diseases in the United States, 1986. JAMA 264: 2654-2659 (1990).
18. Otten, M. W., Jr., Teutsch, S. M., Williamson, D. F., and Marks, J. S.: The effect of known risk factors on the excess mortality of black adults in the United States. JAMA 263: 845-850, Feb. 9, 1990.
19. Morgenstern, H.: Uses of ecologic analysis in epidemiologic research. Am J Public Health 72: 1336-1344 (1982).
20. Siegel, P. Z., Wolfe, L. E., Wilcox, D., and Deeb, L. C.: North Florida is part of the Stroke Belt. Public Health Rep 107: 540-543, September-October 1992.
21. Harrell, F. E., Lee, K. L., Matchar, D. B., and Reichert, T. A.: Regression models for prognostic prediction: advantages, problems, and suggested solutions. Cancer Treat Rep 69: 1071-1077 (1985).
22. Rowland, M. L.: Reporting bias in height and weight data. Stat Bull Metrop Insur Co 70: 2-11, April-June 1989.
23. Glossary handbook: a survey researcher's handbook of industry terminology and definitions. Survey Sampling, Inc., Fairfield, CT, 1992.