Original Paper

The Impact of Changing *ICD* Code on Hypertension-Related Mortality in the Southeastern United States from 1994–2005

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Confusion surrounding cardiovascular disease trends arises when measurement and reporting of classification systems such as the International Classification of Diseases (ICD) *code are revised. The current study examined the impact of* ICD *code revision on mortality trends for heart disease, cerebrovascular disease, and diabetes in 16 Southeast states using data published in the 1994–2005 Centers for Disease Control National Vital Statistics Reports. Data were averaged by year and analyzed separately before (1994–1998) and after (1999–2005) the* ICD *code change, pooled across codes using comparability ratios (1994–2005), and further compared at the year of* ICD *code change using standard error of 1998 data to determine whether corresponding 1999 rates fell within 95% confidence intervals. The change in classification did not alter Southeast US trends regarding a decrease in heart disease and cerebrovascular disease rates and an increase in diabetes mortality in years 1994–2005. On the other hand, the change in* ICD *code classification systems did impact mortality rates for heart disease, cerebrovascular disease, and diabetes, suggesting that change in code to* ICD-10 *in 1999 underestimates heart disease and cerebrovascular disease and overestimates diabetes mortality rates in the Southeast United States. Health and disease burden profiles, which use mortality data to measure health status, need to carefully evaluate and report the influence of* ICD *code revisions as they draw conclusions. Primary care health providers should question the impact and comparability of* ICD *revision before accepting mortality trend conclusions.* J Clin Hypertens (Greenwich). *2010;12:213–222.*

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Between 1998 and 1999, the *International Classification of Diseases* (*ICD*) replaced the *ICD-9* revision with a new version of the code called *ICD-10*. The *ICD* is a coding system designed to promote international comparability of disease classification including mortality rate reports. Implementation of the *ICD-10* has had an important impact on the presentation and interpretation of mortality statistics since *ICD-10* differs from *ICD-9* in several aspects.[1] *ICD-10* is far more detailed, with 8000 categories arranged using alphanumeric code as compared with 5000

Table I. Heart Disease, Cerebrovascular Disease, Diabetes Mellitus *ICD-9* and *ICD-10* Codes

	ICD-9	*ICD-10*
Heart disease	390–398	I00–I09
	402	I111
	404–429	I113
		I20–51
Cerebrovascular disease	430–438	I60–I69
Diabetes mellitus	250	E10–E14

Abbreviation: *ICD*, *International Classification of Diseases.*

categories in numeric code used in *ICD-9*. Additionally, coding rules and results for selecting underlying causes of death have been revised along with additions and modifications made to chapters within the *ICD*.[1]

According to the Centers for Disease Control and Prevention (CDC) National Vital Statistics Reports, heart disease and associated comorbid diseases (cerebrovascular disease and diabetes mellitus), remain among the top 10 leading causes of death in the United States.[2,3] However, during the first year (1999) of implementation of *ICD-10* there was a reported switching of the order of leading causes of death. Diabetes mellitus, which ranked seventh in 1998, became the sixth leading cause of death replacing influenza and pneumonia.[4] Changes in the number of deaths by cause can be explained by two factors: (1) the introduction of *ICD-10* beginning with 1999 mortality data, and (2) an actual change in the mortality levels between causes.[4]

Being able to track mortality rates by cause over long periods of time is important toward assessing the impact of guidelines and policies advanced through government programs and health care organizations. To monitor and assess errors that the adoption of the new coding system could have on hypertension-related mortality trends over time, the current study evaluated the impact of *ICD* code changes on hypertension-related mortality causes including heart disease, cerebrovascular disease, and diabetes from 1994–2005 in 16 Southeast states (Alabama [AL], Arkansas [AR], District of Columbia [DC], Florida [FL], Georgia [GA], Kentucky [KY], Louisiana [LA], Maryland [MD], Mississippi [MS], North Carolina [NC], Oklahoma [OK], South Carolina [SC], Tennessee [TN], Texas [TX], Virginia [VA], and West Virginia [WV]). We hypothesize that the change in *ICD* code may account for recent reporting of a favorable decline in cardiovascular mortality in the Southeast, a region that has traditionally been found to have rates of cardiovascular mortality in excess of the national average.[5] To evaluate the impact of the *ICD* code on hypertension-related mortality causes in the Southeast, we employed a multistep analysis evaluating cerebrovascular disease, heart disease, and diabetes before (1994–1998), after (1999–2005), and across the *ICD-9* and *ICD-10* codes (1994–2005) using comparability ratios.

METHODS

Crude mortality rates (per 100,000 population) for the selected causes of death (heart disease, cerebrovascular disease, and diabetes mellitus) in each of the 16 selected Southeast states (years 1994–2005) were transcribed from the CDC National Vital Statistics Reports (http://www.cdc.gov/nchs/products/nvsr.htm) into an independent database for analysis. *ICD* codes contained under each cause of disease included are documented in Table I.

Results were individually examined by states over time, averaged among all 16 Southeast states, or divided into the following regions: (1) South Atlantic (DC, GA, FL, MD, NC, SC, VA, WV); (2) East South Central (AL, KY, MS, TN); and (3) West South Central (AR, LA, OK, TX). Disease trends were evaluated before the *ICD* code change (1994–1998), after the *ICD* code change (1999–2005), and pooled between *ICD* codes (1994–2005). Due to the revisions in code between 1998 (*ICD-9*) and 1999 (*ICD-10*), the most current cause-of-death data (1999–2005) were not comparable with years prior to 1999 without adjustments. To account for this, *ICD-9* rates (1994–1998) were modified to *ICD-10* rates using comparability ratios. The comparability ratio is a measure of the net effect of a new *ICD* revision on the rate and number of deaths attributed to that cause to measure the level of agreement between classification systems. Therefore, comparability studies providing a ratio for a given cause of death were determined between the "before" *ICD* coding system (*ICD-9*) and the "after" *ICD* coding system (*ICD-10*) for the disease types.

The comparability ratios utilized in this study are based on a study by Anderson and colleagues,[1] which coded the same deaths occurring in 1996 by both the Ninth and Tenth revisions of the *ICD* and measured the net effect of *ICD-10* by cause of death. Anderson and colleagues[1] suggested that a comparability ratio of 1.00 indicated that the same number of deaths was assigned to cause under both *ICD-9* and *ICD-10* denoting no effect of *ICD-10* on that particular cause of death. However, they also stated that a ratio showing perfect correspondence between the two revisions did not necessarily indicate that the cause was totally unaffected by

ICD-10 but that any increases in the allocation to the cause were completely offset by decreases in the allocation to the cause. A comparability ratio of <1.00 suggested fewer deaths being classified to the cause under *ICD-10* compared with the comparable cause under *ICD-9*.[1] The resulting ratios for the diseases selected in the current study were: heart disease, 0.99; cerebrovascular disease, 1.06; and diabetes mellitus, 1.01. These comparability ratios were multiplied by the mortality rate of each of the 16 states in years 1994–1998 to adjust the mortality rates so that data could be analyzed across the entire pooled (1994–2005) length of time.

After multiplying the death rates coded with *ICD-9* by comparability ratios to make them comparable to *ICD-10* death rates, rates from individual states were averaged together entirely or by region for the selected causes of death in each individual year. Comparisons of medians using unpaired Student *t* tests were made between reported *ICD-9* (before) rates, comparability-modified *ICD-9* (before [cm]) rates, and *ICD-10* (after) rates averaged across all 16 states. Since the change in *ICD* code occurred between years 1998 and 1999, averaged rates from all Southeast states for years 1998, 1998 (comparability modified), and 1999 were evaluated using a Student unpaired *t* test The standard error was then calculated[6] to obtain a more definitive estimate of whether the numbers for *ICD-10* years were different from those for *ICD-9* years:

$$\text{Comparability ratio} * \text{standard error} * 1.96* \\ \text{the comparability modified number.}$$

This respective number was then added to or subtracted from the comparability-modified rates for each year (1994–1998) to determine the upper and lower 95% confidence intervals. If the rate for the respective year falls within this confidence interval range, then there is a 95% probability that mortality due to that specific cause in that year was not substantially different from the mortality rates in the first year (1999) of the reported *ICD-10* rates.

RESULTS

Cerebrovascular Disease

Individual Southeast States. Cerebrovascular disease rates decreased in all Southeast states when comparing 1994 comparability-modified rates with crude rates reported in 2005. The 4 states reporting the largest decreases in crude rate cerebrovascular disease mortality in 2005 were DC, AR, NC, and FL, averaging 1.68-, 1.42-, 1.39-, and 1.39-fold below the comparability-modified rates reported in 1994, respectively.

Southeast Regions. Cerebrovascular disease rates in 1994–1998 were comparability modified for comparison with 1999–2005 crude rates and yearly results per region were averaged across the entire 1994–2005 year spectrum. Cerebrovascular disease rates in all Southeast regions and in the entire United States decreased over time since 1994 (Figure 1A). Overall, the East South Central region of the Southeast United States reported the highest rates of cerebrovascular disease except in 1996, 1997, and 1998, when the West South Central region posted equal or higher cerebrovascular disease rates (Figure 1A). All Southeast regions had higher rates of cerebrovascular disease compared with the entire United States at all time points (Figure 1A).

Entire Southeast. When averaging mortality rates across all Southeast states using comparability indices, cerebrovascular disease declined 1.25-fold in the after period between 1999 and 2005 but did not change in the before period between years 1994 and 1998 (Figure 1B).

Heart Disease

Individual Southeast States. Heart disease mortality rates decreased in all Southeast states in 2005 compared with 1994. FL, NC, and GA reported the largest decreases in crude heart disease mortality rates, averaging 1.33-, 1.32-, and 1.29-fold lower in 2005 compared with 1994 comparability-modified rates, respectively.

Southeast Regions. Heart disease rates in 1994–1998 were comparability modified for comparison with 1999–2005 crude rates and yearly results per region were averaged across the entire 1994–2005 year spectrum. Heart disease decreased in all Southeast regions and in the entire United States throughout the reported time period (Figure 2A). Consistently, the East South Central region of the Southeast United States reported the highest rates of diseases of the heart throughout the 1994–2005 time period, followed by the West South Central region and the South Atlantic region (Figure 2A). All 3 Southeast regions had higher rates of heart disease at each recorded time point compared with rates within the entire United States (Figure 2A).

Entire Southeast. Collectively, when all Southeast states were averaged together, heart disease mortality rates did not substantially change (1.02-fold) during

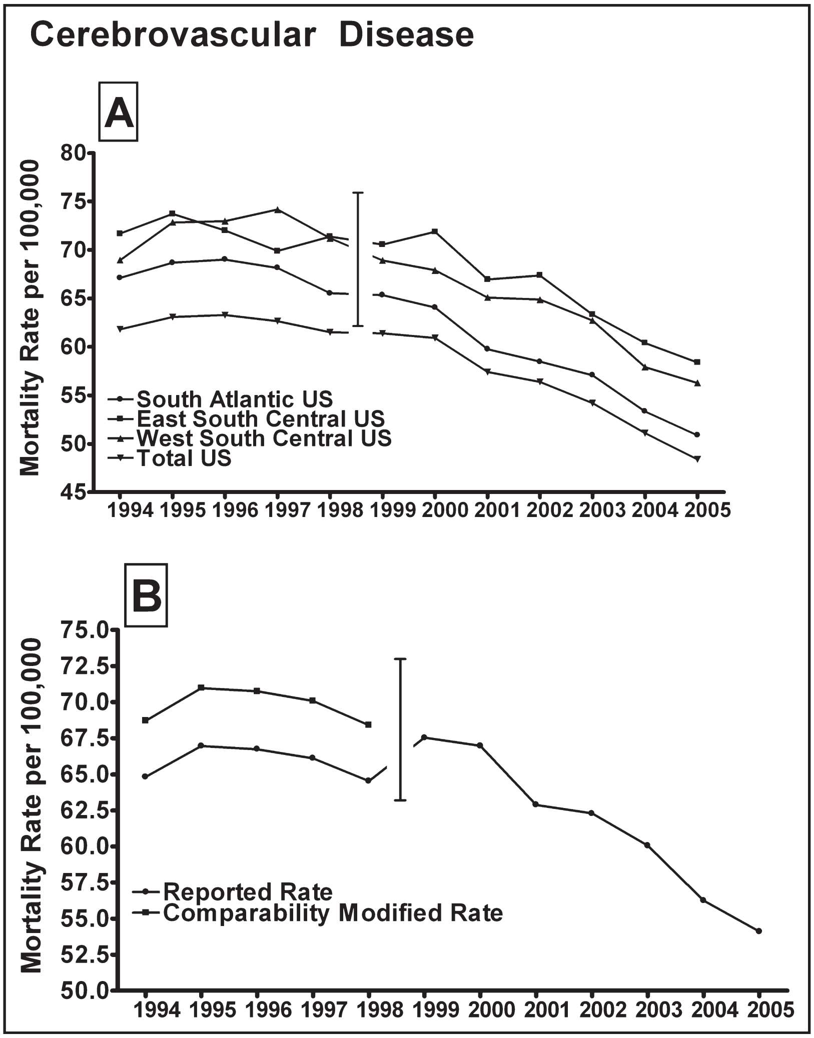

Figure 1. A. Cerebrovascular disease mortality rates (per 100,000 population) in Southeast United States regions as compared to the entire United States. B. Cerebrovascular disease trends using reported and comparability modified ICD-9 rates in 1994–1998 and ICD-10 reported rates in 1999–2005 averaged among all 16 Southeast states.

the before (1994–1998) period but fell by 1.18-fold in the after (1999–2005) period (Figure 2B).

Diabetes Mellitus

Individual Southeast States. Diabetes mellitus mortality rates increased in all Southeast states between 1994 and 2005 with the exception of MD. The Southeast states with the largest increases in diabetes mortality rates from 1994 to 2005 were OK, TN, and AR, which increased by 1.74-, 1.49-, and 1.34-fold, respectively.

Southeast Regions. Diabetes mellitus rates in 1994–1998 were comparability modified for comparison with 1999–2005 crude rates and yearly results per region were averaged across the entire 1994–2005 year spectrum. In 1994, the South Atlantic and the West South Central regions had the highest diabetes mellitus mortality rates (Figure 3A). The West South Central region surpassed other Southeast regions in having the highest diabetes mellitus mortality rates in the remaining years (1995–2005) (Figure 3A). The diabetes mellitus mortality rates for the entire United States remained lower than those in all 3 Southeast regions except in 1997. In 1997, there was a spike in diabetes mellitus mortality rates in the entire United States, making rates for the entire nation equal with those of the West South Central region in this year only (Figure 3A).

Entire Southeast. Among all Southeast states, diabetes mellitus mortality rates increased 1.15-fold in the before (1994–1998) period but did not

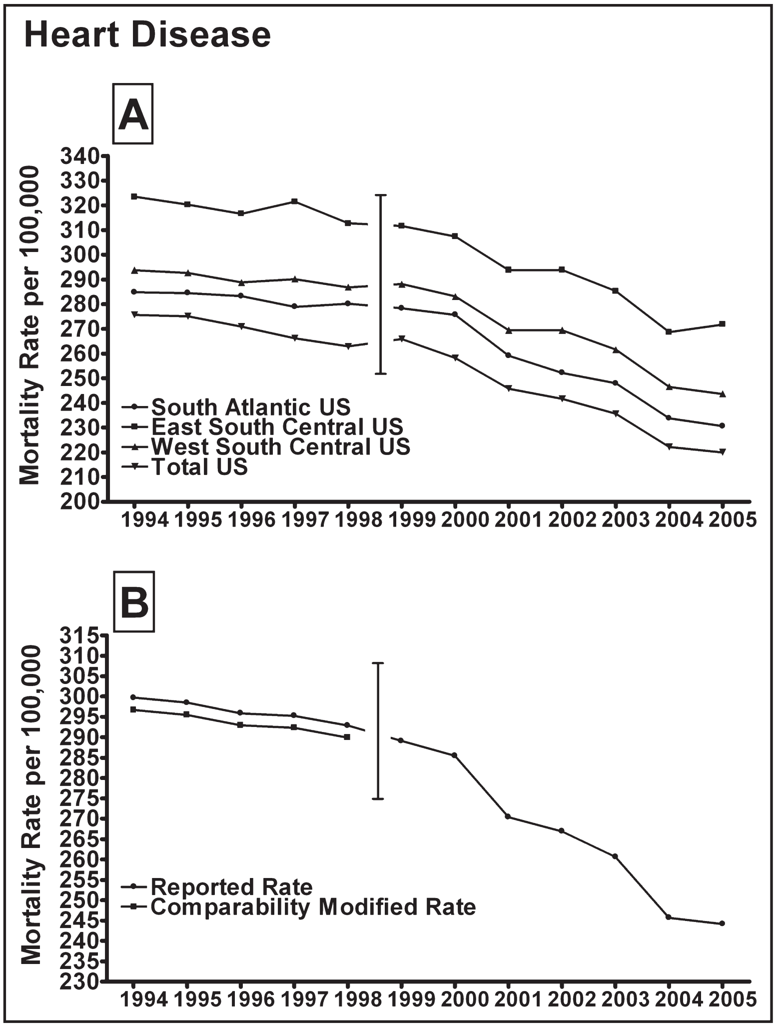

Figure 2. A. Heart disease mortality rates (per 100,000 population) in Southeast United States regions as compared to the entire United States. B. Heart disease trends using reported and comparability modified ICD-9 rates in 1994–1998 and ICD-10 reported rates in 1999–2005 averaged among all 16 Southeast states.

vary greatly in the after (1999–2005) period (Figure 3B).

The Impact of *ICD* Code

Disease rates from years 1994–1998 were modified using comparability ratios to transform crude *ICD-9* rates to comparability-modified *ICD-9* rates. Comparisons were then made between: (1) the *ICD-9* crude rates and the *ICD-9* comparability modified rates, (2) the *ICD-9* crude rates and the *ICD-10* crude rates, and (3) the *ICD-9* comparability modified rates and the *ICD-10* crude rates.

ICD-9 comparability-modified rates were significantly different than *ICD-9* crude rates for cerebrovascular disease only (Figure 4). Cerebrovascular disease had the comparability ratio furthest away from 1.00 with a value of 1.06. The cerebrovascular disease rate averaged across Southeast states in the after (1999–2005) period was significantly decreased only when compared with the comparability-modified before (1994–1998) rate (Figure 4). The cerebrovascular disease rate averaged across Southeast states in the after (1999–2005) period was not changed as compared with the crude before (1994–1998) rate (Figure 4). The heart disease mortality rate averaged across Southeast states was significantly decreased in the after (1999–2005) period as compared with the before (1994–1998) period regardless of whether the *ICD-9* before (1994–1998) rate was comparability modified or reported normally as a crude rate (Figure 4). Diabetes mellitus mortality rates averaged across Southeast states were significantly increased in the after (1999–2005) period as compared with

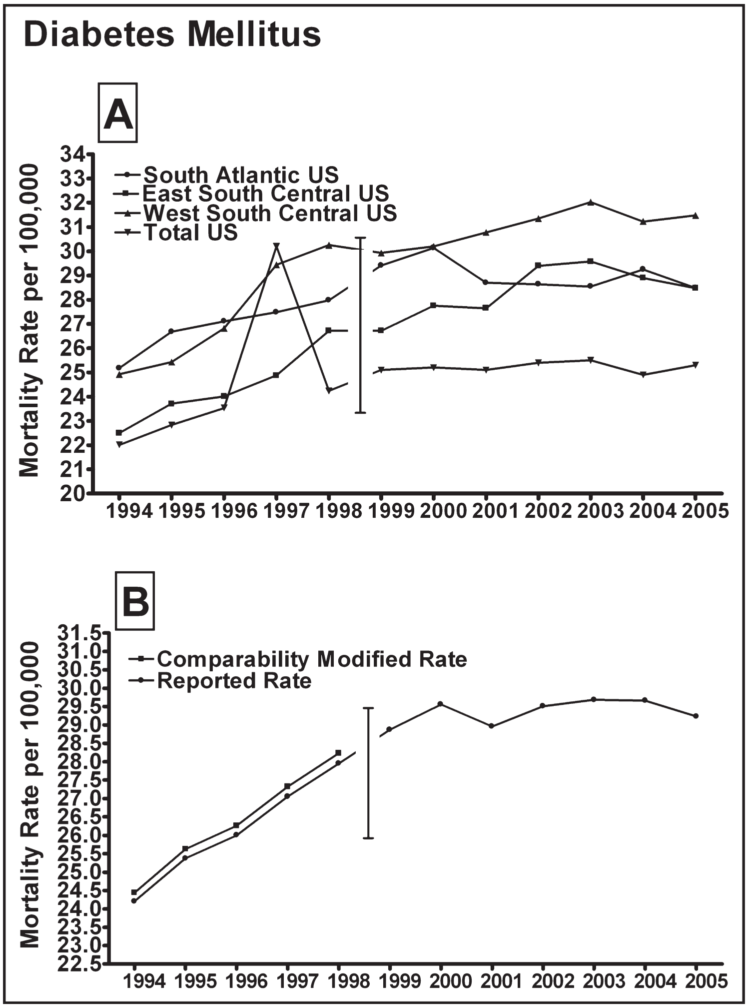

Figure 3. A. Diabetes mellitus mortality rates (per 100,000 population) in Southeast United States regions as compared to the entire United States. B. Diabetes mellitus trends using reported and comparability modified ICD-9 rates in 1994–1998 and ICD-10 reported rates in 1999–2005 averaged among all 16 Southeast states.

the before (1994–1998) period regardless of whether the *ICD-9* before (1994–1998) rate was comparability modified or reported normally as a crude rate (Figure 4). These results suggest that the changes in *ICD* code could, in some cases, such as cerebrovascular disease, effect mortality trends.

When comparing the mortality rates averaged across all 16 Southeast states in the last year of the *ICD-9* code (1998) and the first year of the *ICD-10* code (1999), there is no significant difference between the mortality rates for cerebrovascular disease, heart disease, or diabetes mellitus whether the *ICD-9* rates are comparability modified or reported in their original crude format (Figure 5). There was also no significant difference between the crude *ICD-9* 1998 rates and the comparability modified *ICD-9* 1998 rates for cerebrovascular disease, heart disease, or diabetes mellitus (Figure 5). These data suggest that there is no difference in disease rates when the years (1998 and 1999) surrounding the change in *ICD* code are examined. Thus, it appears more important to assess the effects of the *ICD* code change when trends are evaluated over periods of time before and after the *ICD* code change as compared with the years surrounding the change in code itself. To obtain a more definitive comparison between *ICD-9* and *ICD-10*, the first year (1999) of the *ICD-10* code was compared with the confidence interval for *ICD-9* in years 1994–1998. The 16 Southeast states 1999 *ICD-10* rate averages for cerebrovascular disease, heart disease, and diabetes mellitus were 67.54, 289.09, and 28.96, respectively. These Southeast state-averaged mortality rates for cerebrovascular disease (Table II) and heart disease (Table II) fell below the 95% confidence intervals for 1998 and years prior

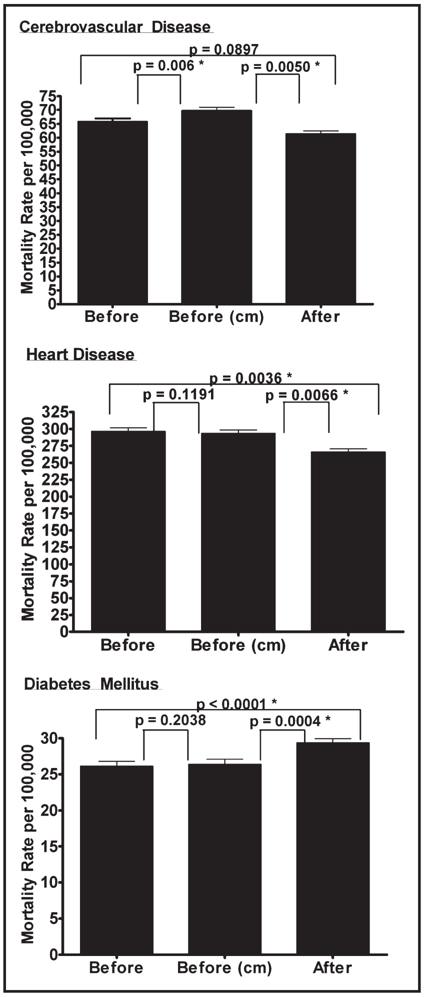

Figure 4. The comparison of reported before (1994–1998), comparability modified before (1994–1998), and reported after (1999–2005) mortality rates (per 100,000 population) averaged among the 16 Southeast states for cerebrovascular disease, heart disease, and diabetes mellitus.

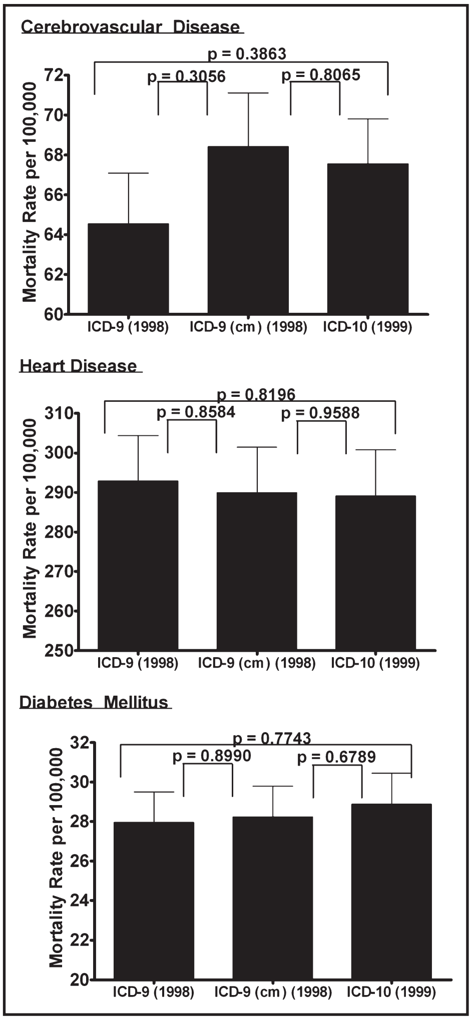

Figure 5. The comparison of reported ICD-9 1998, comparability modified ICD-9 1998, and reported ICD-10 1999 mortality rates (per 100,000 population) averaged among the 16 Southeast states for cerebrovascular disease, heart disease, and diabetes mellitus.

(1994–1998). The Southeast state average for diabetes mellitus mortality rates fell above (Table II) the 95% confidence intervals for 1998 and years prior (1994–1998). Interpretation of these results reveals underestimation of 1999 mortality rates for cerebrovascular and heart disease and overestimation for diabetes mellitus mortality change due to the change in *ICD* code. While there appears to be no change in 1999 mortality rates for cerebrovascular disease, heart disease, and diabetes as compared with 1998 rates (Figure 5), this more definitive comparison of 1999 rates to those of 1998 (and before) using the confidence interval method show otherwise (Table II). These data suggest that mortality data need to be carefully evaluated by all potential methods such that disease trends over *ICD* code changes can be more accurately evaluated.

DISCUSSION

The current study demonstrated a decline in Southeast US cerebrovascular and heart disease mortality rates and an increase in diabetes mellitus mortality rates from 1994 to 2005. These results are consistent with previous accounts showing a 56% decline in age-adjusted heart disease death rates between 1950 and 1996.[7] On the other hand, death rates attributed to heart disease and cerebral circulation were no longer declining between 1990 and 1994, with the Southeast having higher numbers of deaths attributable to myocardial infarction, stroke, and renal failure.[5] The current study confirms a decline

Table II. Cerebrovascular Disease, Heart Disease, and Diabetes Mellitus Rates, Comparability-Modified Rates, Standard Error, and 95% Confidence Intervals Averaged Among 16 Southeast States in Years 1994–1998

	1994	1995	1996	1997	1998
Cerebrovascular disease					
ICD-9 rate	64.41	66.55	66.38	65.85	64.26
ICD-9 (cm) rate	68.71	70.98	70.75	70.09	68.41
Standard error	0.114	0.118	0.118	0.116	0.114
Confidence interval (low)	68.60	70.86	70.63	69.97	68.30
Confidence interval (high)	68.83	71.10	70.87	70.20	68.52
Does the 1999 *ICD-10* rate (67.54) fall within, above, or below the *ICD-9* 95% confidence interval?	Below	Below	Below	Below	Below
Heart disease					
ICD-9 rate	299.71	298.48	295.89	295.29	292.88
ICD-9 (cm) rate	296.71	295.50	292.93	292.33	289.95
Standard error	0.115	0.115	0.114	0.113	0.113
Confidence interval (low)	296.59	295.38	292.82	292.22	289.83
Confidence interval (high)	296.82	295.61	293.05	292.45	290.06
Does the 1999 *ICD-10* rate (289.09) fall within, above, or below the *ICD-9* 95% confidence interval?	Below	Below	Below	Below	Below
Diabetes mellitus					
ICD-9 rate	24.20	25.37	26.00	27.05	27.95
ICD-9 (cm) rate	24.44	25.62	26.26	27.32	28.23
Standard error	0.053	0.056	0.057	0.059	0.061
Confidence interval (low)	24.39	25.57	26.20	27.26	28.17
Confidence interval (high)	24.50	25.68	26.32	27.38	28.29
Does the 1999 *ICD-10* rate (28.96) fall within, above, or below the *ICD-9* 95% confidence interval?	Above	Above	Above	Above	Above

Abbreviation: *ICD*, *International Classification of Diseases.*

in heart and cerebrovascular disease mortality rates in Southeast states during 1999–2005, with little change in rates during the 1994–1998 period. This suggests that the halt in decline previously reported in years 1990–1994 has been reversed. Historically, the Southeast has been associated with higher mortality rates from congestive heart failure and heart disease[8] and a greater prevalence of hypertension among black females[9] and black and white men.[10] States in the Southeast have also had the highest overall stroke mortality rates since the 1970s for both men and women and for blacks and whites.[11,12.]

The current study shows that the increased trend for diabetes mellitus in the southeast United States has been prevalent especially in years 1994–1998. Although the nationwide prevalence of patients diagnosed with diabetes has increased 61% since 1990,[13] we now show that diabetes mellitus mortality rates have recently leveled off in years 1999–2005, discontinuing the upward slope seen in the early 1990s. These data suggest that increased mortality due to this comorbid disease in the early 1990s could have contributed to the reported halt in decline in heart disease and cerebrovascular disease mortality rates. As diabetes rates leveled off in years 1999–2005, mortality rates for heart disease and cerebrovascular disease in the Southeast commenced again with a continued downward trend.

With mortality data spanning over many decades and across *ICD* modifications, the overall impact and ranking of specific mortality causes can become difficult to evaluate. For example, a 2005 report[14] stated that heart disease death rates were falling faster than cancer in individuals younger than 85. If age was ignored, heart disease outranked cancer as the number one killer of Americans. But if age was a limiting factor, cancer would oust heart disease from being the leading cause of death for all but the very elderly.[15] Analyzing results from all angles such as by age is a necessity, but results cannot be accurately evaluated over time unless strides are made to eliminate the impact that *ICD* code change and restructuring can have on these trends.

To measure the comparability between *ICD* revisions, many comparability studies have been published in the United States since the *ICD Fifth Revision*.[16,17] In the current study, cerebrovascular disease was the only hypertension-related *ICD* coded disease that possessed an *ICD-9* to *ICD-10* comparability ratio that departed from 1.00 by at least 3%. This departure suggests a moderate to substantial classification difference between the successive revisions and a potential discontinuity in trending patterns.[18] The comparability ratio for cerebrovascular disease was 1.06, allocating a 6% increase with the implementation of *ICD-10*. It has been argued that this increase is due to deaths added to cerebrovascular disease in the *ICD-10* from the pneumonia code in the *ICD-9*.[18] In the current study, changes in *ICD* coding rules affected the Southeast cerebrovascular rates such that there was no change in cerebrovascular disease in the before (1994–1998) and after (1999–2005) periods unless values were comparability modified. If researchers neglect examination of the code revisions over time, trends may be skewed and either false-positives noted or real changes neglected.

The most important mortality rate comparisons in attempts to track disease mortality changes over time are often not between individual years but across years. Comparability ratio studies focus on 1 year of data in a specific *ICD* code and re-evaluate values with the new standards of a different *ICD* code to determine comparability ratios. Upon examination of the CDC Web site (http://www.cdc.gov), we only find one preliminary report published in 2001[1] that examines comparability between *ICD-9* and *ICD-10*. This comparison between *ICD* codes used 1996 data, making the comparability ratios only completely accurate back to 1994.[6] The years between the adoption of *ICD-9* in 1979 and 1994 cannot be accurately converted and thus leaves a time gap where there is no way to accurately compare the mortality trends over time.

The ability to accurately understand by all possible methods the impact of *ICD* changes from version to version appears to be even more essential based on results from the current study. For Southeast states, the 1999 mortality rates for heart disease, cerebrovascular disease, and diabetes mellitus fell outside the 95% confidence intervals calculated with *ICD-9* codes in 1998 and years prior. Our findings suggest an underestimation of cerebrovascular and heart disease and an overestimation of diabetes mellitus. Studies conducted in England and Whales have shown that number of deaths assigned to circulatory diseases as a whole increased by 3% to 4% purely as a result of the introduction of *ICD-10* replacing *ICD-9*. Griffiths and colleagues[19] concluded that results need be revised to adjust for changes in code when examining trends from circulatory diseases across the introduction of *ICD-10*.

In summary, the current study demonstrates that in the Southeast United States, cerebrovascular and heart disease mortality rates have decreased and diabetes mellitus mortality rates have increased between years 1994 and 2005. However, based on confidence interval study analysis of the change in *ICD* code between years 1998 and 1999, there appears to be an underestimation of cerebrovascular and heart disease and an overestimation of diabetes mellitus trends with this change in *ICD* code. Potential biases such as this one to mortality trends over time need to be carefully evaluated and reported. While changes in *ICD* code are necessary to stay abreast with medical advances, these revisions do not come without consequences. To more accurately compare mortality trends over times, additional comparability studies need to be completed within a given *ICD* code to allow for more accurate comparability ratio modification of all data within a code. Until such time that these studies are complete, researchers, health care professionals, and users of mortality data should exercise caution when reporting mortality statistics and should evaluate by all methods possible the impact of *ICD* code on their respective results of interest.

From the mortality trend data presented in the current study, primary care health providers should recognize that: (1) cerebrovascular and heart disease rates have declined throughout the United States including the Southeast since 1994; and (2) improvements still need to be made in reducing the excess prevalence of cerebrovascular disease and heart disease in the Southeast and the rates of diabetes nationwide. When presented with mortality trends over time requiring data points across *ICD* revisions, primary care health providers should question whether the appropriate steps including confidence interval testing were completed to ensure rates comparability before accepting conclusions made as a result of this data.

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