

# Urban-Rural Differences in Coronary Heart Disease Mortality in the United States: 1999–2009

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## ABSTRACT

**Objective.** Coronary heart disease (CHD) mortality has declined in the past few decades; however, it is unclear whether the reduction in CHD deaths has been similar across urbanization levels and in specific racial groups. We describe the pattern and magnitude of urban-rural variations in CHD mortality in the U.S.

**Methods.** Using data from the National Center for Health Statistics, we examined trends in death rates from CHD from 1999 to 2009 among people aged 35–84 years, in each geographic region (Northeast, Midwest, West, and South) and in specific racial-urbanization groups, including black and white people in large and medium metropolitan (urban) areas and in non-metropolitan (rural) areas. We also examined deaths from early-onset CHD in females aged <65 years and males aged <55 years.

**Results.** From 1999 to 2009, there was a 40% decline in age-adjusted CHD mortality. The trend was similar in black and white people but was more pronounced in urban than in rural areas, resulting in a crossover in 2007, when rural areas began showing a higher CHD mortality than urban areas. White people in large metropolitan areas had the largest decline (43%). Throughout the study period, CHD mortality remained higher in black people than in white people, and, in the South, it remained higher in rural than in urban areas. For early-onset CHD, the mortality decline was more modest (30%), but overall trends by urbanization and region were similar.

**Conclusion.** Favorable national trends in CHD mortality conceal persisting disparities for some regions and population subgroups (e.g., rural areas and black people).

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Coronary heart disease (CHD) is the leading cause of death for most racial groups in the United States, accounting for approximately 600,000 total deaths annually.<sup>1</sup> CHD remains the leading cause of morbidity and mortality despite the fact that CHD death rates have declined by more than 30% since the 1990s.<sup>2</sup> This decline has been attributed to a combination of primary and secondary prevention efforts, with a reduction in the level of risk factors, such as blood pressure, smoking, and blood cholesterol, and continuing improvements in diagnosis and treatment.<sup>3–6</sup>

Although encouraging, the overall decline in CHD mortality rates in the U.S. may conceal less favorable trends in certain regions and demographic groups. Urbanization level is a key characteristic when studying health disparities. One-fifth of the U.S. population resides in rural areas, which rank poorly on 21 of 23 selected population health indicators, behaviors, and risk factors.<sup>7–9</sup> Urban-rural differences provide opportunities for optimizing health-care resources and improving prevention targeting areas of highest need.

Few previous studies have described regional differences in CHD mortality in the U.S. and trends over time in recent years.<sup>10–12</sup> There is an ongoing need to monitor the distribution of death rates from specific causes to help reduce preventable diseases and deaths and improve the health of all groups.<sup>13</sup> This study describes the pattern and magnitude of urban-rural differences in CHD mortality rates by geographic region in the U.S. from 1999 to 2009. The extent to which the decline applies to early CHD mortality is also examined. Deaths from early-onset CHD translate into a large number of years of potential life lost with substantial impact on families and society. Thus, the study of potential determinants of early-onset CHD is important but often neglected.

## METHODS

We obtained mortality data from the National Center for Health Statistics (NCHS) for non-Hispanic black and white Americans aged 35–84 years during 1999–2009. Mortality and population statistics are available on the Centers for Disease Control and Prevention's Wide-ranging Online Data for Epidemiologic Research (WONDER) website.<sup>14</sup> Since the 1980s, all deaths that occur annually in the U.S. are processed in these data files. Therefore, these data do not constitute a sample but, rather, a census of all deaths. The data on CHD mortality rates and urbanization level are available for all U.S. counties.

CHD deaths were defined as those with an underlying cause of death listed on the death certificate as isch-

emic heart disease (I20–I25) using the International Classification of Diseases, Tenth Revision (ICD-10) codes.<sup>15</sup> Place of residence was obtained from death certificate data and classified based on the 2006 NCHS urban-rural classification scheme for counties. We used a three-level categorization: large metropolitan areas (metros) and medium metros (both representing urban areas), and non-metros (rural areas).<sup>16</sup> Large metros included counties in a metropolitan statistical area (MSA) of  $\geq 1$  million people. Medium metros were counties with an MSA of 50,000–999,999 people. Rural or non-metros were counties with a population of 10,000–49,999 people. The analyses were limited to the years 1999–2009, as urbanization data were not available before this time period. Data with implausible age-adjusted mortality rate ( $< 20$  per 100,000 population), fringe-metro (suburban) areas, and non-core areas (counties with  $< 10,000$  residents) were excluded, as the goal was to compare urban and rural areas and to avoid the potential problem with unreliable statistics in non-core areas. Analyses were stratified by region (Northeast, Midwest, West, and South) and by race (black and white). Other races and Hispanic ethnicity were not included in the analysis because the data were either not available or were likely to be inaccurate. The definition of regions is consistent with that used for the National Health and Nutrition Examination Surveys and the U.S. Census Bureau definition. Early-onset CHD mortality was defined as death due to CHD in females aged  $< 65$  years and males aged  $< 55$  years.<sup>17</sup>

## Statistical analysis

The main outcome measure was the mortality rate due to CHD, defined as the number of deaths divided by the total number of people at risk. Rates were expressed as the number of deaths per 100,000 population. Crude and age-adjusted trends in CHD mortality rates were calculated in the overall population and in specific racial-urbanization groups (black and white people in large metros, medium metros, and non-metros). These results were additionally stratified by the four geographic regions. Crude and age-adjusted trends in early-onset CHD mortality rates were similarly calculated and stratified by sex because of recent reports of a possible lower decline of CHD incidence and mortality among young women.<sup>18,19</sup> All age-adjusted CHD mortality rates were obtained by standardizing CHD mortality rates to the 2000 U.S. Census population. Mortality rates were plotted against calendar year to examine trends from 1999 to 2009. Percentage change in mortality rates during the observation period was calculated by taking the difference between the 1999 and 2009 rates and dividing that result by the 1999 rate. We used Poisson

regression models on a log normal scale to describe trends in age-adjusted annual death rates and to assess the significance of the region-urbanization interaction.

We used the SAS<sup>®</sup> procedure (GENMOD) to model Poisson regression with a logarithmic function and a log offset term.<sup>20</sup> We used the number of CHD deaths as the response variable and added study year to the model as an independent variable. Interaction terms were applied to test whether the associations between CHD mortality and urbanization were dependent on sex, age, and race. The dispersion in CHD deaths with years followed the assumptions for Poisson models.

## RESULTS

From 1999 to 2009, among Americans aged 35–84 years, there was an overall 40% decline in age-adjusted CHD mortality rates, from 260 to 157 per 100,000 population. Although black and white Americans had a similar 40% decline, black people had higher CHD mortality than white people throughout this period (Figure 1). The age-standardized CHD mortality rates and the percent change comparing 1999 and 2009 are shown in the Table. CHD mortality declined in this period in all regions and urbanization levels for black and white people.

### Differences by urbanization and race

Age-adjusted CHD mortality declined within all levels of urbanization, but the decline was more marked in urban than in rural areas. These differences in trends resulted in a higher CHD mortality in rural areas in the latter half of the study period. CHD mortality declined by 42% in large metros (from 284 per 100,000 population in 1999 to 164 per 100,000 population in 2009), by 40% in medium metros (from 244 per 100,000 population in 1999 to 147 per 100,000 population in 2009), and by 35% in non-metros/rural areas (from 266 per 100,000 population in 1999 to 173 per 100,000 population in 2009) (data not shown).

Race and urbanization were independent predictors of CHD mortality. When considering race and urbanization jointly, there was a decline in CHD mortality in all six categories of white and black Americans living in large metros, medium metros, and non-metros, but the magnitude of decline was not uniform. CHD mortality declined the most for white Americans living in large metros (43%) and the least for white Americans living in non-metros (35%) (Figure 1). During the entire study period, mortality was higher in black people than in white people. Black people had higher CHD mortality than white people for any urbanization level; mortality was highest for black people in large metros

and lowest for white people in medium metros. In 2009, the mortality rate for black people in large metros was 215 per 100,000 population, while for white people in medium metros it was 143 per 100,000 population. Including non-core areas in a sensitivity analysis did not alter the observed trends.

### Differences by urbanization and region

Overall, all U.S. regions (Northeast, Midwest, West, and South) showed a similar CHD mortality decline of 40% (data not shown). However, important variations were observed in age-adjusted CHD mortality rates by urbanization and region. Non-metros had lower declines in CHD mortality compared with large and medium metros in all four regions. The greatest decline was for large metros in the Midwest region (44%) and the smallest decline was for non-metros in the West (32%). In all U.S. regions, except the South, urban areas had higher age-adjusted CHD mortality rates compared with rural areas. In the South, the age-adjusted CHD mortality rates in rural areas were higher than in urban areas ( $p < 0.01$  for the interaction between region and urbanization) (Figure 2). Upon examining these differences further by race, black people had higher mortality than white people at any urbanization level and in any U.S. region (Figures 3 and 4).

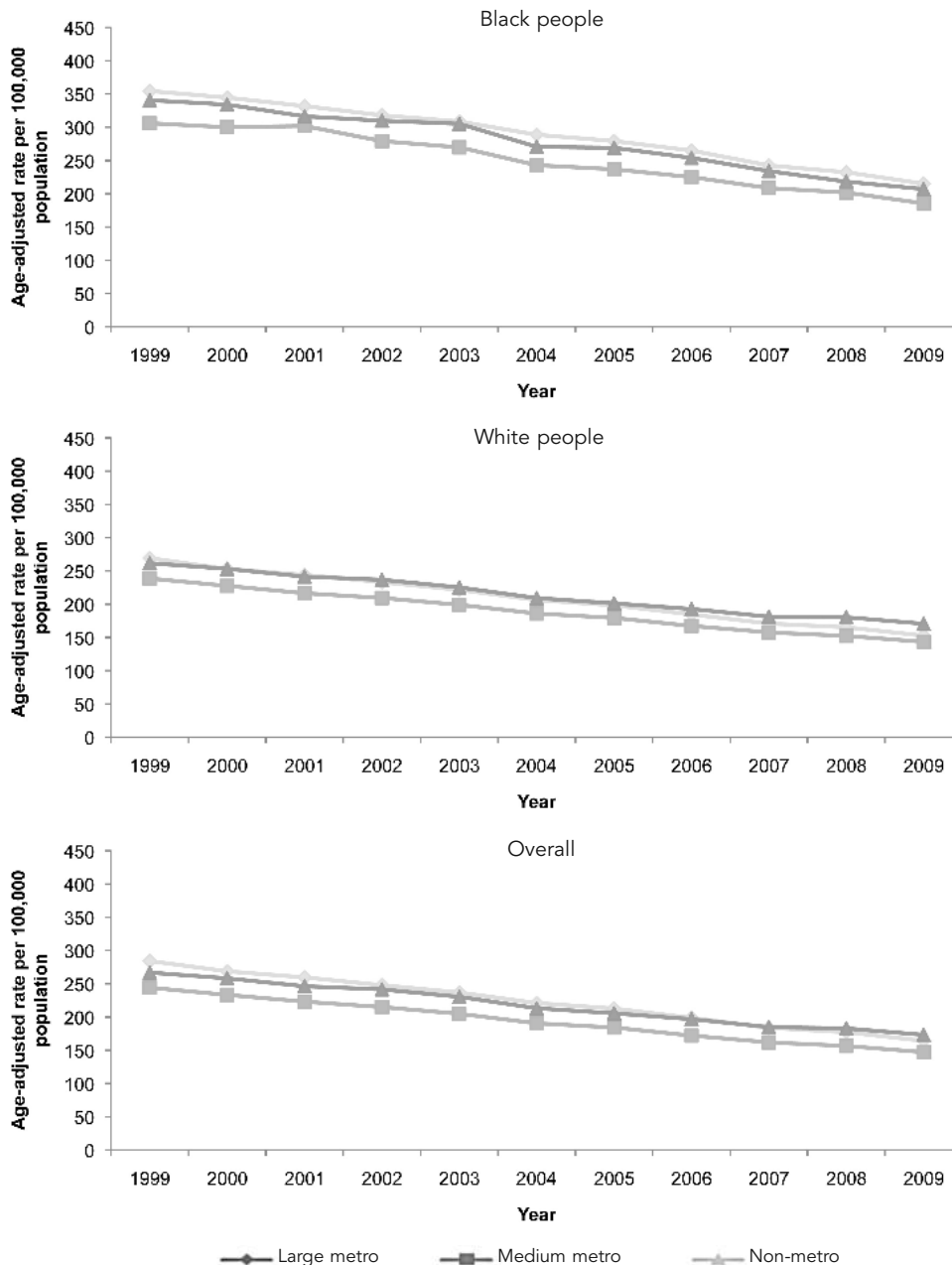
### Early-onset CHD mortality

From 1999 to 2009, there were approximately 500,000 deaths before age 65 years. The age-adjusted decline in CHD mortality was lower (30%) in this age group than in the whole population, with rates decreasing from 37 to 25 per 100,000 population. As in the overall sample, this decline was largest in urban metros (35%), intermediate in medium metros (28%), and smallest in rural non-metros (22%). Similar to the overall sample, early-onset CHD mortality was higher in black than in white people. In contrast to the overall sample, CHD mortality was higher in rural than in urban areas throughout the study period (data not shown). Black people in rural areas had the highest early-onset CHD mortality, followed by black people in large metros, while urban white people had the lowest rates. These trends were similar in both males and females (Figure 5). During the entire time period, early-onset CHD mortality was higher in black males and females compared with their white counterparts.

## DISCUSSION

Despite a continuing overall decline in CHD mortality in the U.S. from 1999 to 2009, this study shows important differences in CHD mortality trends by

**Figure 1. Trends in CHD mortality among white and black people aged 35–84 years, by urbanization<sup>a</sup> level: U.S., 1999–2009**



<sup>a</sup>Large metros were counties with  $\geq 1$  million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.  
Metro = metropolitan

urbanization, region, and race. First, the rate of decline was lower in rural areas than in urban areas in all four U.S. regions, resulting in a crossover around 2007, when rural areas began showing a higher CHD mortality than urban areas. Second, black people have

higher CHD mortality than white people regardless of region or urbanization level, and this disparity has remained unchanged over time. Third, the decline in deaths due to early-onset CHD (among females <65 years of age and males <55 years of age) was lower

**Table. Age-standardized CHD mortality rates for adults aged 35–84 years, by region and urbanization: U.S., 1999–2009**

Region	Urbanization <sup>a</sup>	Overall			Black people			White people		
		Rate <sup>b</sup>		Percent change	Rate <sup>b</sup>		Percent change	Rate <sup>b</sup>		Percent change
		1999	2009		1999	2009		1999	2009	
Northeast	Large metro	326	200	–0.39	344	222	–0.36	318	192	–0.40
	Medium metro	238	140	–0.41	268	175	–0.35	236	138	–0.41
	Non-metro	264	162	–0.39	365	147	–0.60	263	162	–0.38
Midwest	Large metro	295	165	–0.44	378	222	–0.41	272	146	–0.46
	Medium metro	248	151	–0.39	319	207	–0.35	244	147	–0.40
	Non-metro	258	167	–0.35	408	231	–0.43	256	166	–0.35
West	Large metro	262	148	–0.44	378	223	–0.41	253	141	–0.44
	Medium metro	221	135	–0.39	293	179	–0.39	219	134	–0.39
	Non-metro	222	151	–0.32	405	180	–0.55	221	151	–0.32
South	Large metro	268	158	–0.41	336	202	–0.40	250	145	–0.42
	Medium metro	256	155	–0.40	311	183	–0.41	248	150	–0.39
	Non-metro	289	189	–0.34	337	208	–0.38	281	186	–0.34

<sup>a</sup>Large metros were counties with  $\geq 1$  million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.

<sup>b</sup>Per 100,000 population

CHD = coronary heart disease

Metro = metropolitan

than the overall decline in CHD mortality (30% vs. 40%). Finally, rural areas in the South had higher age-adjusted CHD mortality compared with urban areas in the South, and this trend was the reverse of other U.S. regions (where urban areas had higher CHD mortality). These results suggest that factors influencing the rate of CHD mortality decline are not benefiting all populations of the U.S. equally.

Since the mid-1980s, trends in CHD mortality have been reported to diverge across race-sex subgroups.<sup>17,21</sup> Previous studies have shown that the rate of decline in CHD mortality has slowed for black people, women, and people of lower socioeconomic status.<sup>18,22,23</sup> Studies in several countries have also found urban-rural differences in CHD mortality rates.<sup>24–27</sup> About 70 million people in the U.S. (23% of the population) live in rural areas.<sup>28</sup> Previous studies have shown higher CHD mortality rates in urban than in rural areas.<sup>10,29–32</sup> Our results suggest that these differences are reversing nationally, as rural areas are experiencing a lower decline in CHD mortality and are already showing higher CHD mortality in the most recent years.

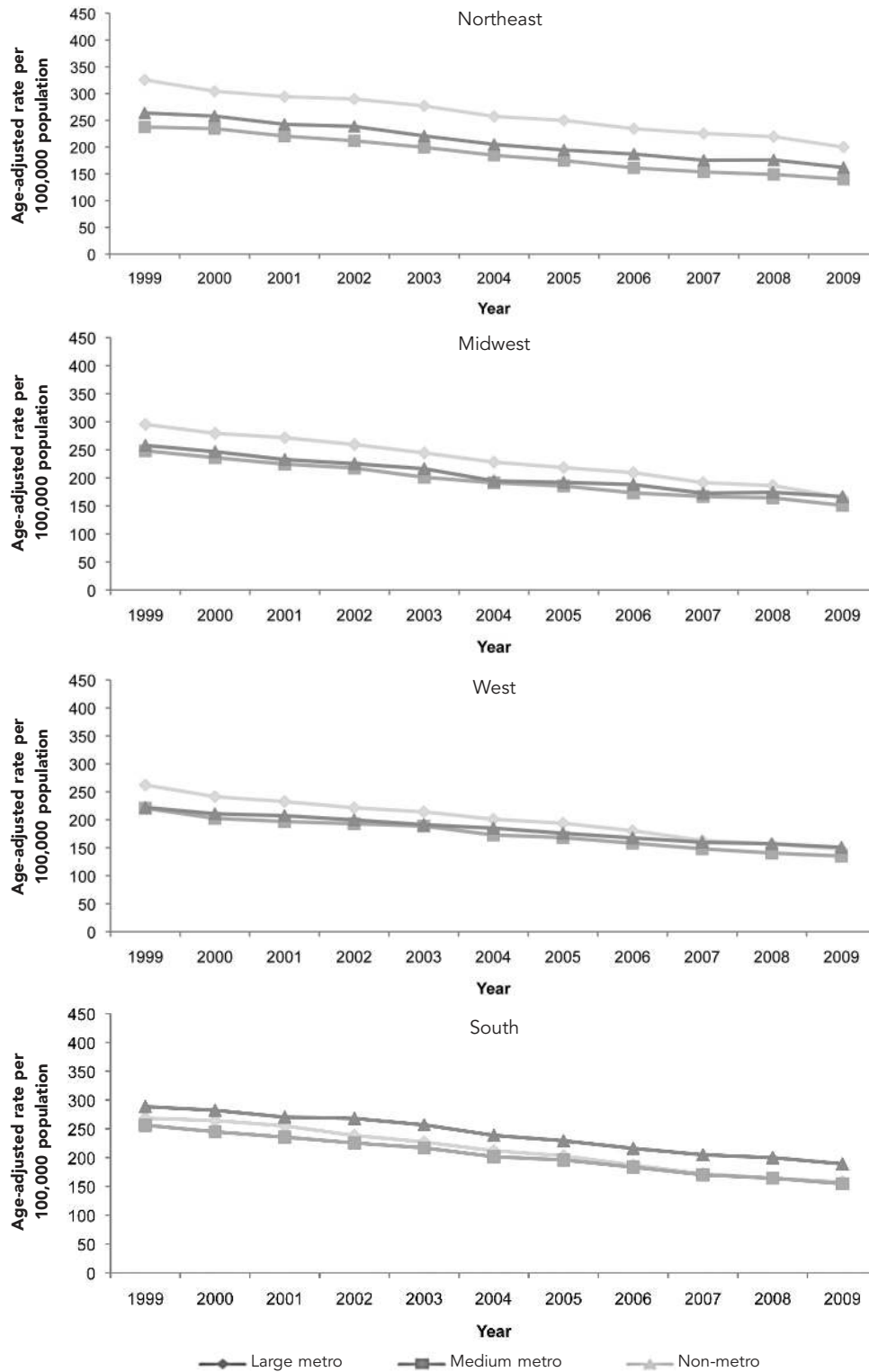
Our study shows that a higher CHD mortality in rural than in urban areas is particularly marked for early-onset CHD and in Southern regions. These data are consistent with a study of metros and non-metros within Appalachia, where rates of CHD mortality were consistently higher in non-metros compared with metros.<sup>33</sup> Gillum et al. recently showed that CHD mortality

declined more for white people than for black people, and the rates were greater in the Ohio and Mississippi River areas than in other geographic regions.<sup>12</sup> Our study examined a somewhat different population, as we excluded fringe metros and non-core areas; however, we showed similar trends continuing through 2009. These data suggest that the overall decline in CHD mortality in the U.S. may mask important differences in some geographic areas and subpopulations.

The reasons behind the mortality trends we observed may be complex and require further study. Several recent studies have shown that, compared with their urban counterparts, rural residents have experienced higher rates of CHD risk factors in recent years, particularly obesity and physical inactivity.<sup>34–37</sup> In rural communities, fewer healthy choices may be available for diet than in modern urban settings. Rural lifestyle has become increasingly sedentary because of the mechanization of farm work. Furthermore, some rural areas may suffer from lower access to affordable health care.

In recent decades, substantial declines in CHD mortality have occurred among both white and black people, but important racial differences persist.<sup>38–42</sup> During the period 1980–1993, black men experienced the slowest nationwide decline in CHD mortality.<sup>43</sup> Studies have also shown that the CHD epidemic disproportionately affects black people in rural areas.<sup>44</sup> These variations could be attributed to differences in lifestyle, quality of health care, risk factor prevalence, education

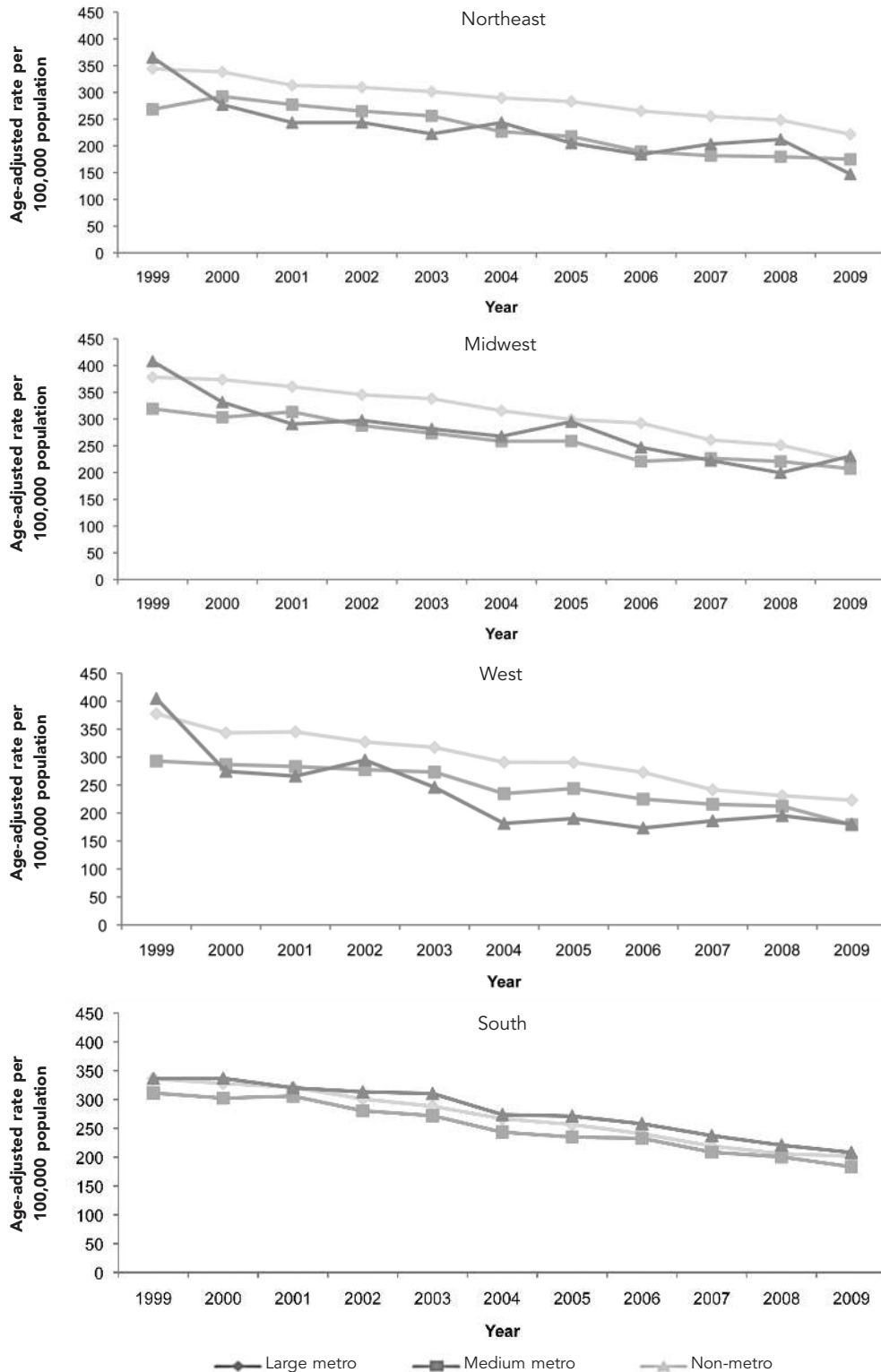
**Figure 2. Trends in CHD mortality among white and black people aged 35–84 years in U.S. regions, by urbanization<sup>a</sup> level: 1999–2009**



<sup>a</sup>Large metros were counties with  $\geq 1$  million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.

Metro = metropolitan

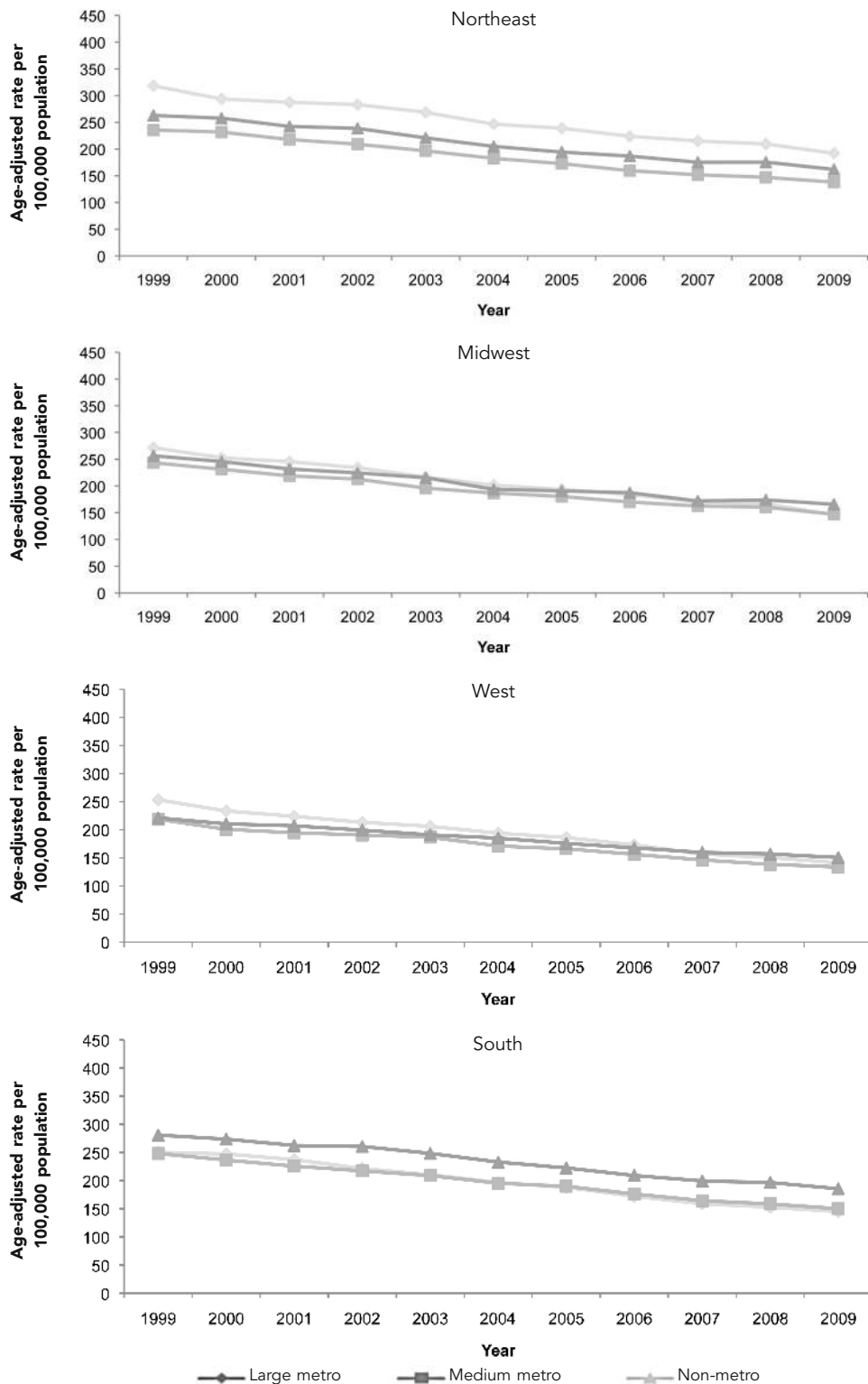
**Figure 3. Trends in CHD mortality among black people aged 35–84 years in U.S. regions, by urbanization<sup>a</sup> level: 1999–2009**



<sup>a</sup>Large metros were counties with  $\geq 1$  million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.

Metro = metropolitan

**Figure 4. Trends in CHD mortality among white people aged 35–84 years in U.S. regions, by urbanization<sup>a</sup> level: 1999–2009**

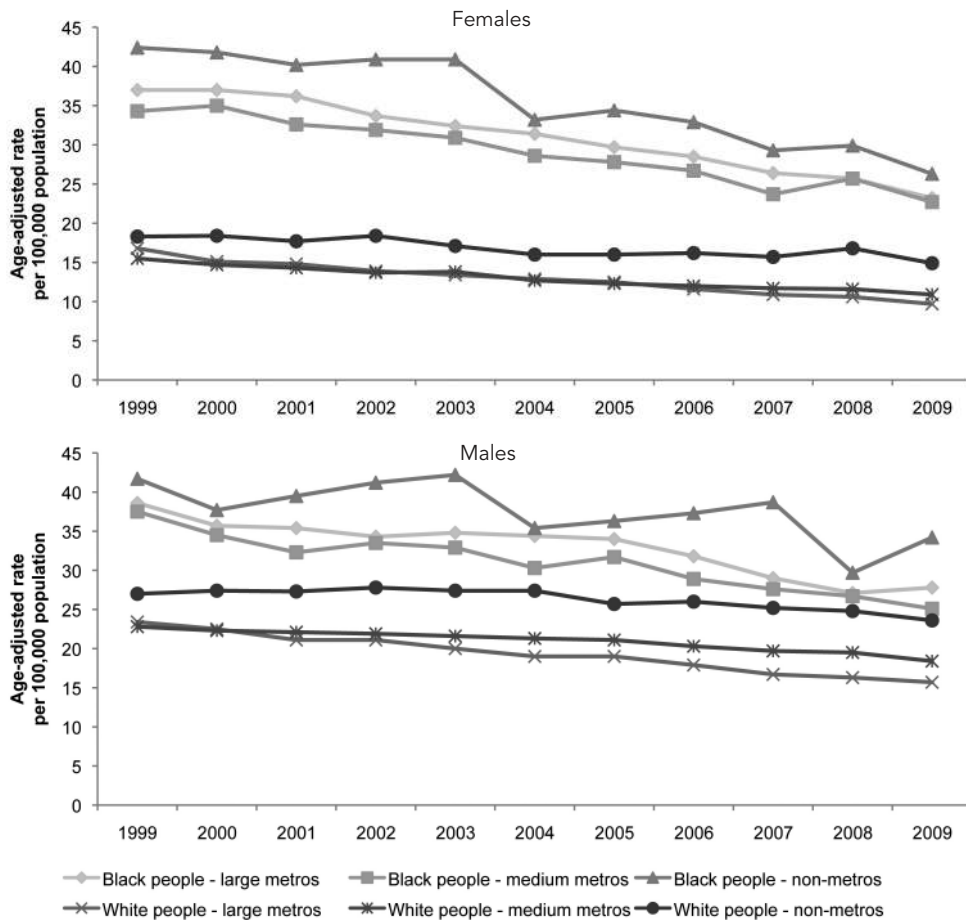


<sup>a</sup>Large metros were counties with  $\geq 1$  million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.

Metro = metropolitan



**Figure 5. Trends in early-onset CHD mortality among black and white females aged <65 years and males aged <55 years, by urbanization<sup>a</sup> level: U.S., 1999–2009**



<sup>a</sup>Large metros were counties with ≥1 million people, medium metros were counties with 50,000–999,999 people, and non-metros (rural areas) were counties with 10,000–49,999 people.

Metro = metropolitan

level, and other socioeconomic characteristics.<sup>45,46</sup> We found a 26% difference in age-adjusted CHD mortality rates in 2009 between black and white people. Black people continued to have a higher age-adjusted CHD mortality than white people at any urbanization level and in any region. These differences were similar when early-onset CHD mortality was examined. However, there was one important difference between early-onset CHD and the overall sample: black people in rural areas had the highest early-onset CHD mortality, while in the overall sample, black people in urban areas had the highest CHD mortality.

An excess in CHD mortality in the South has been reported in studies from previous decades.<sup>47,48</sup> Ingram and Gillum examined trends from 1968–1985 and showed that the South had higher rates of CHD mor-

tality in rural areas compared with urban areas, and that these rates differed from other U.S. regions.<sup>12</sup> The current data show that this reverse trend of higher CHD mortality in rural areas in the South continues in the recent decade. Several reasons have been hypothesized, but the persistence of these trends remains largely unexplained. For example, rural residents in the South may have lower levels of physical activity as a result of the transition from agricultural to low-level services employment.<sup>49,50</sup> Analysis of the Behavioral Risk Factor Surveillance System data found that physical activity levels were lower in rural areas compared with urban areas, and this difference was most prominent in the South.<sup>51</sup> A study of white men living in the South reported higher levels of blood pressure among residents of rural vs. urban counties.<sup>52</sup>

These geographic differences could be due, in part, to dietary patterns and the disproportionate consumption of processed, high-fat, and high-salt foods in rural areas of the South.<sup>53</sup>

### Strengths and limitations

Our study had several notable strengths. The study provides a comprehensive graphical description of CHD mortality trends during a 10-year period in different regions of the U.S. We used ICD-10 coding for all the years and, thus, avoided misclassification because of changes in ICD versions. To obtain better characterization across the urban-rural continuum, we excluded fringe metros as, for a number of health measures, residents of fringe metros fare substantially better than residents of other urbanization levels.<sup>54</sup> We also excluded non-core areas to provide us with more reliable estimates of CHD mortality in rural areas.

This study also had several limitations. First, it is not possible to differentiate between CHD deaths that represent incident cases and those that do not. Unfortunately, data about the incidence of CHD in the U.S. are not readily available; using hospitalizations as a proxy has its own limitations.<sup>55,56</sup> Second, potential inaccuracies on death certificates regarding cause of death in urban vs. rural areas could lead to misclassification bias. Third, this study lacked data on possible confounders or explanatory factors for the differences found, such as socioeconomic factors, health behaviors, and health-care factors. Geographic variations in socioeconomic status, access to health care, and education levels could be the primary factors leading to differences in CHD mortality.<sup>57</sup> Finally, because Hispanic ethnicity on death certificates is likely to be misclassified, we restricted our analyses to non-Hispanic people to avoid bias.<sup>58</sup>

### CONCLUSIONS

This study demonstrates enduring differences in CHD mortality trends by urbanization and geographic region in the U.S. during the past decade. The slower decline of CHD mortality in rural areas is concerning and warrants further study. There is a need to explore and quantify the relationship between CHD mortality and risk factor trends in population subgroups to explore possible reasons for differences in CHD mortality trends and optimize preventive strategies. Further research is needed to ascertain whether urban-rural differences result from differences in lifestyle factors, environmental factors, and/or quality of health care. Understanding reasons for these disparities will allow policy makers to design more effective CHD prevention

programs targeted toward disadvantaged populations and regions.

This study was considered exempt from Institutional Review Board (IRB) approval by the Emory University IRB. The authors thank Avina Goel, MD, MPH, for her help with the figures.

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