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Kaustubh Dabhadkar 04/21/2011

Urban-Rural Disparities in Cardiovascular Disease Mortality Rates

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MBBS, Grant Medical College, 2009

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An abstract of

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

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in Epidemiology

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Abstract:

Background: Cardiovascular diseases (CVD) continue to be the most important cause of mortality throughout the United States (US). Although CVD mortality rates have declined over the past two decades, it is unclear if the decline has been uniform across all urbanization levels.

Objective: We evaluated mortality rates due to CVD over eight years (1999-2007) in predefined US urbanization categories.

Methods: We used national-level mortality and population statistics from the National Center for Health Statistics for years 1999-2007 among persons over 45 years. We calculated crude and age-adjusted mortality rates in three predefined urbanization categories (large metropolitan areas, small metropolitan areas, and rural areas) to study the effect of urbanization level on mortality rates. We further modeled crude rates using Poisson regression to compare rate ratios of mortality due to CVD in different urbanization levels.

Results: In rural areas, CVD mortality rate continues to be higher than in metropolitan areas (Adjusted RR 1.34; 95 % CI 1.33- 1.35). This has gone up from 1.27 (95 % CI 1.26-1.28) in 1999. Thus, urbanization level was found to be an independent predictor of mortality. Mortality rates in rural areas were higher than metropolitan areas in both genders as well as all age-groups. We also observed a decline in deaths due to CVD as a proportion of total deaths across the country, from 12.5 % in 1999 to 9.5 % in 2007. However, the decline in mortality was more in large metropolitan areas compared to small metropolitan and non-metropolitan areas. Age-group, race and gender differences in the population explain some of the excessive rate, but still a considerable portion remains unexplained.

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Literature review

Cardiovascular diseases (CVD) comprising of ischemic heart disease, chronic heart failure, and stroke are the leading causes of death in the United States (US). CVDs were responsible for over 831 thousand deaths in US in 2006 alone – towering in comparison to the 13 thousand deaths due to Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome (HIV/AIDS)(1-2). Over 151 thousand deaths caused by CVD were in people under the age of 65 – leading to lost outputs among the economically productive (1). Altogether, the cumulative direct and indirect costs in terms of premature death, disability, years of productivity lost, and healthcare costs make it a significant public health problem(3).

Hypertension, diabetes mellitus, smoking, obesity, and hyperlipidemia are some of the important risk factors which contribute to development of CVD, while unhealthy dietary habits and sedentary behaviors are upstream of many of these biochemical abnormalities. While positive actions in the form of risk factor control (e.g., tobacco prevention policies) and modern curative and rehabilitative advances (e.g., coronary artery bypass grafting, endovascular angioplasty procedures) have reduced mortality due to CVD, it still continues to be the leading cause of mortality and morbidity globally and in the US (4-5).

Understanding the impact and nuances of this condition in the US population is important to plan and develop appropriate public health interventions. Most of the available data from urban areas indicate that there is variability in CVD mortality rates by age, race, and gender. While most cases occur in people 65 years and older and the overall mortality rate for CVD has declined over the past four decades, the impact of this disease might increase due to an aging US population. There is also considerable mortality rate variability by race and gender.

The changes in mortality usually reflect changes in incidence and case-fatality rate. According to a study conducted in Worcester, the incidence and case-fatality rate of acute myocardial infarction has declined since 1975(6). The study attributes the decline partly to encouraging trends in the population awareness and control of high blood pressure, declining prevalence rates of cigarette smoking, and declines in average population serum cholesterol levels, as well as other unknown factors.

The American Heart Association's (AHA) strategic planning task force and statistics committee recommends a population goal of reducing cardiovascular mortality by 20 % by the year 2020(7). They define ideal cardiovascular health by the presence of both ideal health behaviors (nonsmoking, body mass index <25 kg/m2, physical activity at goal levels, and pursuit of a diet consistent with current guideline recommendations) and ideal health factors (untreated total cholesterol <200 mg/dL, untreated blood pressure <120/<80 mm Hg, and fasting blood glucose <100 mg/dL).

A study by Barnett and colleagues in 1996 indicated that coronary heart disease mortality in rural areas is higher than in urban areas(8). However, given the marked biomedical and public health advances in recent years, it is surprising that there has been no recent study examining trends in CVD mortality, nor investigations into the variability previously observed across different age, sex, race/ethnic, and rural-urban groups.

Urban- Rural Disparities in Cardiovascular Disease Mortality Rates

Kaustubh Dabhadkar, MBBS

Introduction:

Approximately 34 % of deaths in the United States of America (USA) are due to cardiovascular diseases (CVD). Heart failure, stroke, and myocardial infarction account for most of these deaths. Almost 1 in every 6 deaths due to CVD is due to coronary artery disease (9). However, heart failure, stroke and myocardial infarction are considered preventable causes of CVD mortality (10-11).

The decline in overall CVD mortality rates can be attributed to medical advances, reduction in risk factors like smoking, blood cholesterol levels, and blood pressure (owing to improved management guidelines, availability of newer drugs, and better access to healthcare), as well as increased awareness of healthy dietary habits(6). Similar reductions in mortality have been observed in European countries too (12-13). Despite these overall reductions in CVD mortality, CVD continues to remain a leading cause of death in the USA (9).

Moreover, many studies have noted race/ethnic disparities in CVD mortality (9). However, data regarding urban-rural disparities in CVD mortality and associated trends are sparse. Studies have shown that any relationship(s) between level of urbanization and CVD mortality is poorly understood (14).We therefore studied the differences in CVD mortality and their associated trends over eight years (1999-2007) in predefined urbanization categories in US adults over 45 years using National Center for Health Statistics (NCHS) data(15).

Methods:

Data source:

We used national-level mortality and population statistics for years 1999-2007 from the National Center for Health Statistics (NCHS) Office of Analysis and Epidemiology (OAE) at the Centers for Disease Control and Prevention (CDC). The data spanning the years 1968-2007 are made available as a Compressed Mortality File (CMF) on the CDC Wide-ranging Online Data for Epidemiologic Research (WONDER) website. The population estimates for the CMF are based on Bureau of the Census estimates of total U.S., State, and county resident populations. Mortality information is collected by state registries and is based on data from death certificates. The CMF is a county level national mortality and population database which also includes data on age-group, race, ethnicity, gender, cause of death, injury intent and mechanism, and urbanization. It was updated in November 2010 to include data on statistics from the year 2007. Data for the years 1999-2007 were used for this analysis.

Since we were interested in looking at covariate influences on preventable CVD in adults > 45 years, our outcome is a composite measure of mortality due to heart failure, stroke, and myocardial infarction. International Classification of Disease (ICD)-10 codes for conditions that were included in our analysis are listed below:

Heart failure: I11.0, I13.0, I13.2, I25.5, I42.1, I42.2, I42.5, I42.8, I50.0, I50.1

Stroke : I60.0, I60.1, I60.2, I60.3, I60.4, I60.5, I60.6, I60.7, I60.9, I61.0, I61.1, I61.2, I61.3, I61.4, I61.5, I61.6, I61.8, I61.9, I62.9, I63.0, I63.1, I63.2, I63.3, I63.4, I63.5, I63.6, I63.8, I63.9, I64, I67.8, I69.0, I69.1, I69.2, I69.3, I69.4, I69.8

Myocardial infarction: I21.0, I21.1, I21.2, I21.3, I21.4, I21.9, I22.0, I22.1, I22.8, I22.9, I24.1

For our analysis, we investigated death rates due to CVD per 100, 000 in a county. A death was assigned to a county if it was the person's place of legal residence at the time of death. In the CMF, underlying cause-of-death is selected from the conditions entered by the physician on the cause of death section of the death certificate. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications.

In order to analyze data by level of urbanization, we categorized urbanization into three levels (large metropolitan areas [metro], medium and small metros, and non-metros [i.e. rural areas]) based on the 2006 NCHS Urban-Rural Classification Scheme for Counties. Race and gender information in the census is collected by respondent self-report and on death certificates as reported by next of kin. The NCHS uses a direct method to standardize mortality rates to the US population in the year 2000. Our analysis did not include county-level rates if the death count for a year was < 20 or county census involved a sample population < 100,000 individuals.

Statistical analysis:

Analyses were performed using SAS statistical software version 9.2 (SAS Institute Inc, Cary, North Carolina). Age-group, race and gender were independently evaluated their association with outcome variable. Categories with less than 5 deaths or unreliable death counts were excluded from our analyses. Tests of normality were performed and where required, natural log transformation was applied to ensure the number of persons at risk was distributed normally. Analyses were performed using normally distributed data to satisfy the assumption of normality. Age-adjusted mortality rates were calculated as number of deaths due to CVD in an age-group divided by population under risk within each gender, race, and urbanization stratum with 95% confidence intervals calculated assuming a Poisson distribution.

The following equations describe our models for calculating the mortality rate:

Model 1: $Y_{mortality\_rate} = \beta 0 + \beta 1\ X_{urbanization\_level} + c$

Model 2: $Y_{mortality\_rate} = \beta 0 + \beta 1\ X_{urbanization\_level} + \beta 2\ X_{race} + c$

Model 3: $Y_{mortality\_rate} = \beta 0 + \beta 1\ X_{urbanization\_level} + \beta 2\ X_{race} + \beta 3\ X_{gender} + c$

Model 4:

$Y_{mortality\_rate} = \beta 0 + \beta 1\ X_{urbanization\_level} + \beta 2\ X_{race} + \beta 3\ X_{gender} + \beta 4\ X_{age\text{-}group} + c$,

where β1, β2, β3, and β4 are regression coefficients and c is a constant.

We performed multivariate regression analyses to calculate mortality rate ratios in each urbanization stratum with large metros as used as reference, while adjusting for gender and race. We also compared mortality rate ratios in different stratum separately for each gender. All statistical tests were 2-sided. A P value less than .05 was considered statistically significant.

The study was exempted from review by Emory Institutional review board.

Results:

Out of the total study population, 53.3 % were females. Race/ethnic groups were distributed across the population as follows: 85.5 % whites, 10.1 % African-Americans, 3.7% Asian or pacific islanders, and 0.75 % American Indians or Alaska natives. An estimated 4.54 % of the population was > 85 years of age and had the maximum mortality rate due to CVD.

[Table 1 here]

Table 1 shows crude mortality rates by 10 year age-group, gender, race, and by level of urbanization for the year 2007. An age trend was noted in mortality rates with the highest mortality rate in the group over 85 years. We consistently observed highest death rates by age-group, gender, and race in non-metro areas. The negative urban-rural gradient for death rates was statistically significant ($p < 0.001$) in all groups. Figure 1 shows that there has been an overall decline in mortality rates across all urbanization levels. However, age-adjusted mortality rates were consistently highest in non-metros and thus had the smallest relative decline.

[Figure 1 here]

[Table 2 here]

On univariate analysis, age-group, race and gender were significantly associated with mortality rate ($p <0.001$). Based on this observation, we included them in our multivariate model. In table 2, we present the adjusted rate ratio estimates by fitting age-specific Poisson models that included urbanization levels, age-group composition, ethnic composition, and gender as hierarchical covariates. Consistent urban rural patterns are evident. In particular, in the year 2007, adjusted for age, gender, and race, and compared to people in large metros, people in non-metros areas were 34 % more likely to die of cardiovascular causes. This likelihood has increased 7 %, as compared to 27 % increased rate in the year 1999. The mortality rate due to CVD has gone up to 12 % in small metros compared to large metros in 2007 compared to an 8 % increased likelihood observed in 1999. After we adjusted for age-group, gender and race, the rate ratio of mortality decreased with time, with the largest reductions being observed in large metros.

[Figure 2 here]

While the age-adjusted all cause mortality rate has declined from 2306.7 in 1999 to 1984.9, the age-adjusted CVD mortality rate has declined from 449.8 in 1999 to 293.4 in 2007(15). Thus, the proportion of CVD deaths has gone down from 12.5 % in 1999 to

9.5 % in 2007. As seen in Figure 2, the proportional mortality has declined across all urbanization levels. However, the decline has been more pronounced in large metros and non-metros compared to small metros.

Discussion:

Advances in healthcare and introduction of more rigorous early intervention and risk factor control have most likely contributed to major changes in CVD mortality trends. The availability of NCHS data allowed us to study these trends from an ecological perspective. We found that CVD mortality rates vary according to level of urbanization, with the largest disparity being observed between non-metros and large metros (see Table 1). Our results highlight the importance of need to focus on non-metros to reduce the cardiovascular mortality disparity. Prior studies have focused on age, race and gender related differences in CVD mortality rates. However, very few studies have studied the urban-rural disparities in CVD mortality. .

Large metros accounted for 47 % of total deaths. This finding is not surprising since 52 % of US population over the age of 45 years is inhabitant of large metros. We observed a similar pattern in CVD mortality rate in rural areas in comparison to large metros. CVDs seem to have more serious outcomes amongst people residing in rural areas. Although there has been a trend toward decreasing contribution of CVD to all cause mortality rates, the decline has been the least in rural areas (Figure 2).

The availability of NCHS data allowed us to study these trends from an ecological perspective. Thus, our study is unlikely to be affected by ecological fallacy or bias. We stratified all US counties into three urbanization levels to study the effect of urbanization on cardiovascular disease mortality. The results of this study show that although CVD mortality rates have declined overall in the US during study period, the gap in rate ratio of mortality in urban-rural areas has widened. Particularly noticeable is the gap between large metros and rural areas which has increased from 1.27 to 1.34 after adjusting for age-group, gender, and ethnic differences in the population.

CVDs were traditionally considered diseases of affluent urban populations. However, since the past 2-3 decades, the disease pattern has undergone transformation such that rural areas have witnessed higher mortality rates. These differences might reflect differences in incidence and case-fatality rate (16). However, solid data regarding incidence of CVD in rural populations throughout US is lacking. A similar declining trend has been observed in all-cause mortality rates as well. Thus, there has been a shift towards non-metropolitan mortality penalty from urban mortality penalty(17). Pearson has proposed that rural areas are 'late adopters' of health behaviors (18). This might also explain the change in mortality penalty.

A few commonly-cited factors that may contribute to these differences in rural-urban mortality are the lack of access to healthcare, shortage of trained healthcare workers in rural areas, and lack of awareness of risk (19-20). Lower socioeconomic status in rural areas might contribute to low levels of awareness and knowledge about health maintenance, poor access to and adoption of preventive care and behaviors, and reliance on emergency departments or other episodic, discontinuous sources for primary care(21). Also, low socioeconomic status is associated with higher prevalence of coronary heart disease risk factors, such as cigarette smoking, poor dietary habits, and sedentary lifestyles(22).

According to a report, the ratio of physicians to population in urban counties is 136% higher than that in rural counties(23). The disparity is also an indication of lack of equitable access to good healthcare facilities. In general, the significant differences have been observed in availability and level of response of rural emergency services, transit time and communication gaps between local emergency department and tertiary care centers and inadequately trained healthcare staff in rural areas(24). Also, in general it has been observed that general practitioners and nurses in rural areas lack the skills and confidence required to encourage health promotion activities(25). This issue is further compounded by lack of availability of screening tests in rural areas which in turn leads to poor risk perception in rural population (26).

There are some limitations to our study though. We modeled variations in CVD mortality rates primarily as a function of an ecological variable, level of urbanization, which is not quite reducible at and may have limited effect on the individual level. Previous studies have demonstrated that mortality due to CVD is associated with socioeconomic factors and access to healthcare. So the difference in county characteristics in terms of socioeconomic status, access to healthcare and education levels, in addition to age group, ethnic, and gender composition could have contributed to differences in mortality. Bias is also possible from undercounts of some population groups in the census, particularly young black males, young white males, and elderly persons, resulting in an overestimation of death rates. However, since the study involved sample populations that are representative of the entire US population, the effect of bias is likely to be very small.

The association of urbanization level with CVD mortality suggests that strategies that address risk factors at all levels of urbanization are necessary. In general, our findings indicate that further research to understand the causes of this disparity is required. This can help us further reduce CVD mortality by optimizing interventions at national level with specific focus on rural areas.

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Tables

Table 1: CVD Mortality Rates for US Population by urbanization categories, 2007

	All USA		Large metros		Small metros		Non-metros	
	Deaths	Mortality rate (per 100,000)	Deaths	Mortality rate (per 100,000)	Deaths	Mortality rate (per 100,000)	Deaths	Mortality rate (per 100,000)
45-54 years (38.81 %)	161569	44	71916	37	49582	47	40071	64
55-64 years (26.68 %)	296119	118	128547	99	89862	122	77710	165
65-74 years (17.75 %)	543674	325	241329	293	163306	325	139039	404
75-84 years (12.21 %)	1112603	969	513340	908	335112	959	264151	1124
85+ years (4.54 %)	1327650	3097	611034	2924	395861	3100	320755	3523
Female (53.23 %)	1894603	374	875592	333	567835	381	451176	481
Male (46.27 %)	1547012	355	690574	308	465888	362	390550	472
American Indian or Alaska Native (0.75 %)	12288	172	2763	108	3354	162	6171	253
Asian or Pacific Islander (3.7 %)	57734	165	40886	153	13352	198	3496	237
Black or African American (10.13 %)	359946	377	204729	329	90133	413	65084	574
White (85.5 %)	3011647	374	1317788	333	926884	375	766975	475

Data source: National Center for Health Statistics (Compressed Mortality File 1999-2007)

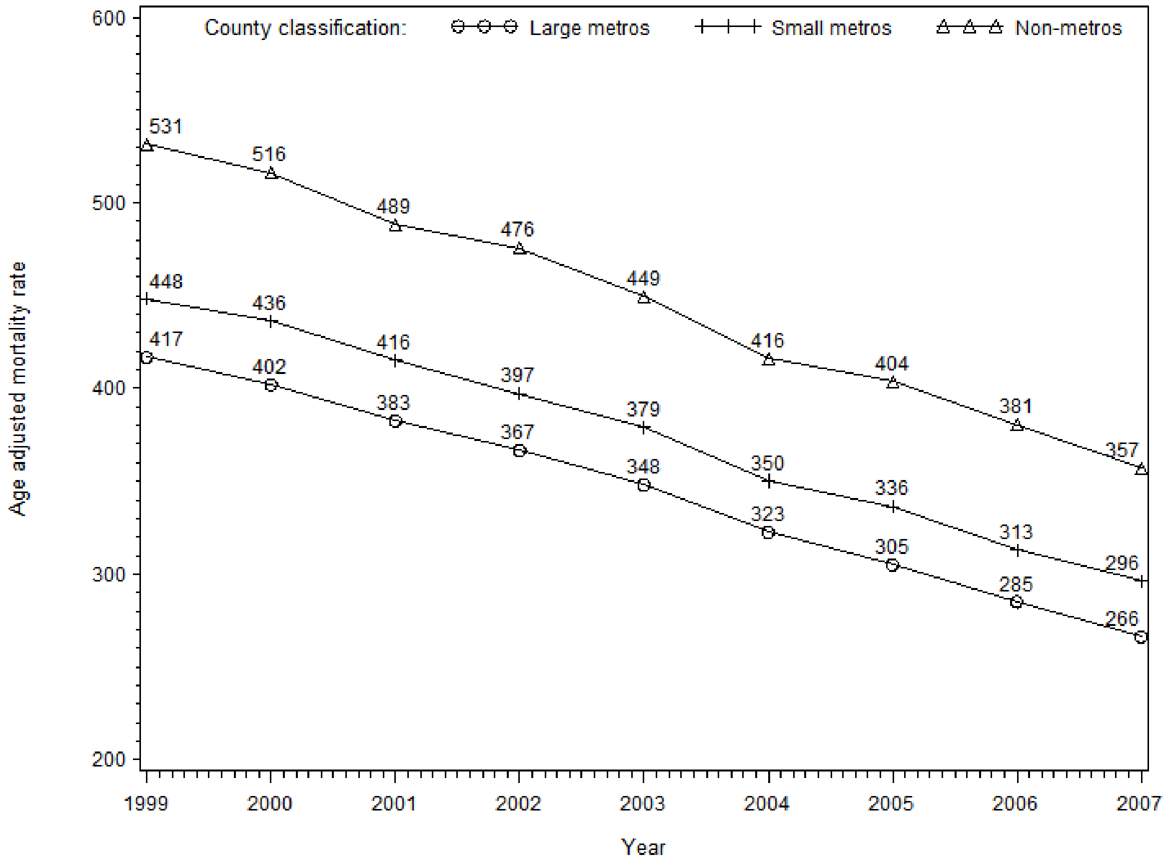
Table 2: Rate Ratio Estimates of CVD mortality From Poisson Regression Models by Urbanization categories, Age group, Gender, and Race in United States, 1999 and 2007

Non-metros (Ref.: Large metros)						
	1999			**2007**		
	Estimate of adjusted mortality RR	95 % CI		Estimate of adjusted mortality RR	95 % CI	
Model 1	1.43	1.42	1.44	1.57	1.56	1.59
Model 2	1.40	1.39	1.41	1.54	1.53	1.55
Model 3	1.40	1.39	1.41	1.54	1.53	1.55
Model 4	1.27	1.26	1.28	1.34	1.33	1.35
Small and medium metros (Ref: Large metros)						
	1999			**2007**		
	Estimate of adjusted mortality RR	95 % CI		Estimate of adjusted mortality RR	95 % CI	
Model 1	1.13	1.12	1.13	1.21	1.20	1.22
Model 2	1.11	1.10	1.12	1.19	1.18	1.20
Model 3	1.11	1.10	1.12	1.19	1.18	1.20
Model 4	1.08	1.07	1.09	1.12	1.11	1.13

Data source: National Center for Health Statistics (Compressed Mortality File 1999-2007)

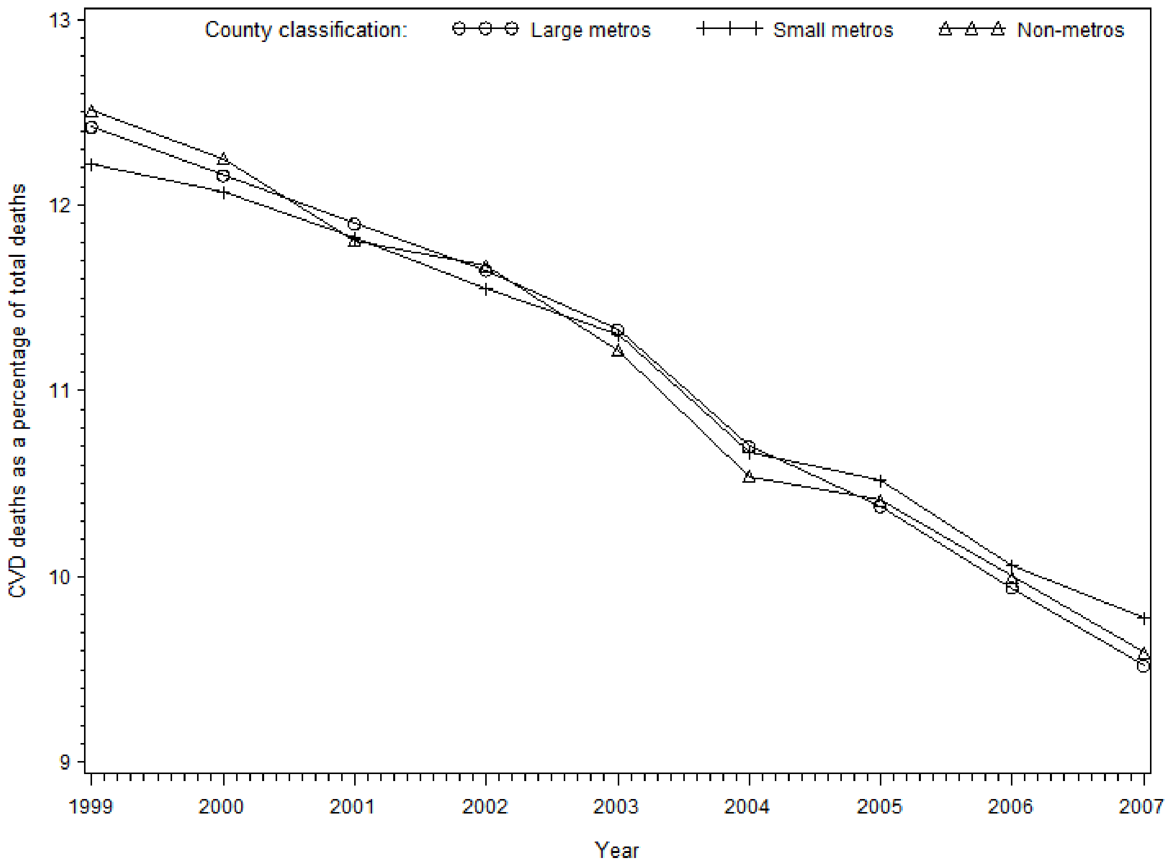
Figures

Figure 1: Age-adjusted US CVD mortality rates by Urbanization Level, 1999-2007



Data source: National Center for Health Statistics (Compressed Mortality File 1999-2007)

Figure 2: CVD deaths as a percentage of total deaths, 1999-2007



Data source: National Center for Health Statistics (Compressed Mortality File 1999-2007)

Public Health Implications and future directions

The urban-rural disparities observed in this study are important considerations for policy makers as well as healthcare providers. While CVD mortality has declined over the past two decades, there have also evidently been some epidemiological transitions. CVDs, which were earlier considered an urban disease, now have higher incidence and mortality in rural areas. Our findings indicate that people living in non-metros are at a higher risk compared to those living in metropolitan areas. Among people in rural areas, the mortality rate was 1.34 times higher in the year 2007.

In addition to lack of access to healthcare services and poor physician to population ratio, there are many other obstacles that hamper optimum CVD prevention interventions in rural areas. These include low population density, transportation issues, lack of access to grant funding , difficulty in recruiting staff to rural areas and fragmentation of resources(27). Thus, we cannot directly use models that have been found to be useful in urban areas. We will have to develop models that will suit the healthcare needs of rural America by taking into account the difference in cultures.

Much of the excessive CVD mortality risk in rural areas still remains unexplained. In order to develop such models, additional studies are needed to understand reasons for excessive risk of cardiovascular mortality in rural areas. In order to reduce overall mortality rates due to CVD, greater attention must be paid to these potential underlying reasons. Further investigation is needed to tease out the drivers of these outcomes disparities – in other words, are these rural-urban differences rooted in system-level issues (infrastructure, personnel), provider-level barriers (awareness, clinical inertia, or other causes) or patient-level challenges (e.g. awareness, accessibility, acceptability)? Utilizing these findings would permit policy-makers to devise policies and programs that focus on reducing urban-rural disparities. For example, policies and programs that specifically focus on health promotion activities in rural areas, decreasing thresholds for detection, increasing provider awareness, provision of algorithms and guidelines, instituting quality of care standards, and enhancing existing infrastructure (buildings, transfer/referral systems, etc.) may all prove beneficial. Improved interventions in rural areas have the potential to considerably reduce the national CVD mortality rates. The US Department of Health and Human Services has taken important steps towards this by identifying reducing health disparities as one of its goals in 'Healthy People 2010'.