

Hypertensive Heart Disease Mortality in Wisconsin, 1979-2004

Lynda Knobeloch, PhD; Pamela Imm, MS

ABSTRACT

Hypertensive heart disease (HHD) is a late complication of chronic high blood pressure. Each year HHD claims the lives of more than 20,000 people in the United States. Between 1979 and 2003, 8735 Wisconsin residents died as a direct result of the condition. While annual death rates were relatively stable over this time period, racial and regional variations were observed. Wisconsin's African American community had an age-adjusted death rate of 26.1 per 100,000 for HHD. In comparison, rates among whites and other races were 6.5 and 4.3 per 100,000, respectively. Regional rates were highest among residents of Milwaukee County. While additional research is needed to determine the cause of these disparities, our findings suggest that hereditary and environmental factors are important determinants of risk and demonstrate the importance of early screening and aggressive treatment of hypertension among high-risk populations.

INTRODUCTION

Between 1979 and 2003, 162,958 Wisconsin residents died of ischemic (154,223) or hypertensive heart disease (HHD) (8735). In 1990, the Wisconsin Department of Health and Family Services issued its Public Health Agenda for 2000 in which the agency set a 10-year goal of reducing cardiovascular mortality by 40%.¹ Two articles that appeared in a 2002 issue of the *Wisconsin Medical Journal* dedicated to cardiovascular disease evaluated progress toward this goal. Anderson and Commons² reported that death rates for ischemic heart disease declined 52% between 1979 and 1998. These authors found that death rates varied regionally and were

highest in counties that had lower education levels, lower household incomes, lower population densities and more non-white residents.² A companion article by Park, Safdar and Schmidt described a 49% decrease in the death rate for coronary heart disease (ICD-9 codes 410-414 and 429.9) over this time period and suggested that the improvement in mortality rates may have been due to major public health initiatives aimed at reducing tobacco use, high blood pressure rates, and high cholesterol levels.³ Although Wisconsin's public health agenda targeted hypertension as a cause of cardiovascular disease, neither of these studies evaluated HHD death rates.

As reported in the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, hypertension affects approximately 50 million individuals and claims the lives of more than 20,000 US residents annually.⁴ The majority of its victims are elderly white women. However age-adjusted death rates are highest among African Americans. Numerous risk factors including heredity, diabetes, alcohol, tobacco, caffeine, emotional stress, obesity, limited physical activity, high-sodium diets, and sleep apnea have been linked to the condition.⁵⁻¹⁰ Kidney function can also affect blood pressure regulation, and a 10-year follow-up study conducted in Beaver Dam, Wis, confirmed that elevated serum uric acid levels are predictive of the development of hypertension.¹¹

Certain environmental pollutants may also contribute to the risk. Early childhood exposure to lead from deteriorating paint, contaminated residential soils, and other sources can have long-term effects on blood pressure regulation.¹² Although blood lead levels have decreased significantly since leaded gasoline, lead paint, and the use of lead-based solders in household plumbing were phased out, childhood lead poisoning continues to occur. In Wisconsin, poisoning rates are highest in the inner city of Milwaukee where approximately 8% of the children tested in 2005 were found to have an unsafe blood lead level.¹³

Author Affiliations: Wisconsin Department of Health and Family (Knobeloch); Molecular and Environmental Toxicology Center, University of Wisconsin-Madison (Knobeloch); Bureau of Environmental and Occupational Health (Imm).

Corresponding Author: Lynda Knobeloch, PhD, Wisconsin Division of Public Health, 1 W Wilson, Rm 150, Madison, WI 53703; phone 608.266.0923; fax 608.267.4853; e-mail knobelm@dhsf.state.wi.us.

CDC WONDER

CDC WONDER (Wide-ranging OnLine Data for Epidemiologic Research) is an easy-to-use, menu-driven system that makes the information resources of the Centers for Disease Control and Prevention (CDC) available to public health professionals and the public at large. It provides access to a wide array of public health information.

The Compressed Mortality File (CMF) is a county-level national mortality and population data base spanning the years 1968-2003. On CDC WONDER, data are available for the years 1979-2003. The number of deaths, crude death rates or age-adjusted death rates can be obtained by place of residence (total US, state, and county), age group, race (white, black, and other), gender, year of death, and underlying cause-of-death (4-digit ICD code or group of codes).

The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979-1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Compressed Mortality Files are available at: <http://wonder.cdc.gov/mortSQL.html>.

A recent study conducted in upstate New York linked exposure to organic contaminants to blood pressure levels. New York investigators found that hypertension rates were 19% higher among people who lived near a hazardous waste site that was contaminated with 1 or more persistent organic pollutants.¹⁴ Air quality may also play a role. In their landmark Six City Study, Dockery et al linked urban air pollution levels to cardiopulmonary disease death rates. Associations were strongest for fine particulates, including sulfate aerosols.^{15,16} While HHD was included in their analysis of cardiopulmonary death rates, these researchers did not evaluate it specifically. In an article titled "You Are What You Breathe," RD Brook provided evidence that particulate matter air pollution is capable of acutely increasing blood pressure and theorized that enhanced sympathetic tone and vascular dysfunction due to PM-induced systemic oxidative stress and inflammation might explain this effect.¹⁷

Not all chemical exposures are harmful, however. A 2004 report by the World Health Organization (WHO) concluded that consumption of water that is naturally high in calcium and magnesium can protect against the development of heart disease.¹⁸ Researchers in Taiwan and Finland have confirmed inverse associations between drinking water magnesium concentrations and mortality from cardiovascular disease.¹⁹⁻²⁰

Although many studies have evaluated coronary heart

disease mortality, our review of the literature found very little information on HHD as a cause of death. Compressed mortality records made available by the National Centers for Disease Control and Prevention list HHD as the underlying cause of 8735 Wisconsin deaths during the 25-year period from 1979 to 2003. Since hypertension can be controlled in most patients, many of these deaths may have been preventable. This article attempts to improve our understanding of HHD mortality in Wisconsin by summarizing these deaths and evaluating racial and regional disparities. The need for future research on environmental, genetic, and lifestyle risk factors for HHD is discussed.

METHODS

Death statistics reported in this article were obtained from compressed mortality files maintained by the US Centers for Disease Control and Prevention and made available to the public through their WONDER Web site (see box); or from an electronic death certificate registry maintained by the Wisconsin Department of Health and Family Services. Information from both of these sources is abstracted from death certificates completed by an attending physician or coroner. Death certificates can list only 1 underlying cause of death (UCOD), which is defined as the fundamental, original, foundational diagnosis or condition from which the remainder of the etiologic sequence springs. The UCOD for cases discussed in this article include ICD-9 codes 402.0 – 402.9 (1979 – 1998) and ICD-10 codes I11.0 to I11.9 (1999-2003). Rates based on fewer than 20 deaths are provided for comparative purposes, but are statistically unreliable and should be interpreted with caution.

The WONDER database allows deaths to be summarized by underlying cause of death, gender, age group, race, county and state of residence, and year of death. Deaths that occurred after 1998 can also be categorized by geographic region and urbanization level. The National Center for Health Statistics uses a classification scheme that divides the 3141 US counties and county equivalents into 6 categories, 4 metropolitan and 2 nonmetropolitan. The metropolitan categories are defined using population size cut points of 50,000 to 249,999; 250,000 to 999,999; and 1 million or more. The NCHS classification also subdivides counties in the largest metropolitan areas into 2 subcategories, central and fringe. The 2 non-metropolitan levels are designated as micropolitan if they have at least 1 urban cluster of 10,000 to 49,999 people; or noncore if they have no urban clusters with at least 10,000 residents.²¹

Since national compressed mortality files provide only

underlying causes of death and are reported at the county level, they cannot be used to evaluate the burden of HHD as a contributing cause of death or to examine regional rates within a county. Therefore, Wisconsin electronic death certificates for 1989 to 2004 were also reviewed. In addition to the UCOD, Wisconsin death certificates provide up to 20 contributing causes and were included in our analysis if the ICD 9 code for HHD was listed either as the UCOD or as a contributing cause of death.

RESULTS

Analysis of Compressed Mortality Records

Between 1979 and 2003, Wisconsin's age-adjusted HHD mortality rate for all races combined was 6.9 per 100,000. Annual age-adjusted rates ranged from a high of 8.5 in 1980 to a low of 5.0 in 1986, but have shown no consistent change over time. As shown in Figure 1, Wisconsin's HHD death rates were consistently lower than national rates, which ranged from a high of 11.3 in 1979 to a low of 8.3 in 1992 (mean 10.0). Within Wisconsin, age-adjusted death rates for HHD were highest in Milwaukee County, which is the state's only large, central metropolitan county.

Of Wisconsin's HHD deaths—including 35% of the deaths among whites and 93% of the deaths among African Americans—40% involved residents of Milwaukee County. In comparison, Milwaukee County is home to approximately 17% of Wisconsin's population, including 13% of the state's white residents and 76% of its African American population. Among those who died of HHD before reaching the age of 55, 63% were residents of Milwaukee County and half of the Milwaukee deaths in this age group involved African Americans.

As shown in Table 1, death rates for HHD have decreased over the 25-year study period at the national level, but remained stable in Wisconsin and increased 28% in Milwaukee County. Age-adjusted HHD death rates were highest among African Americans at the national, state, and local levels. The greatest racial disparity was seen in data for Wisconsin between 1979 and 1988 when the death rate among African Americans was more than 4 times that of whites and nearly 7 times that of members of other races. From 1979 and 2003, age-adjusted death rates for residents of Milwaukee County were more than twice as high as gender- and race-matched rates in the remainder of Wisconsin (Table 2). Among African Americans, men who lived in Milwaukee county were nearly 4 times as likely to die of HHD as men who lived elsewhere (age-adjusted rates 37.9 versus 9.6). Milwaukee County death rates

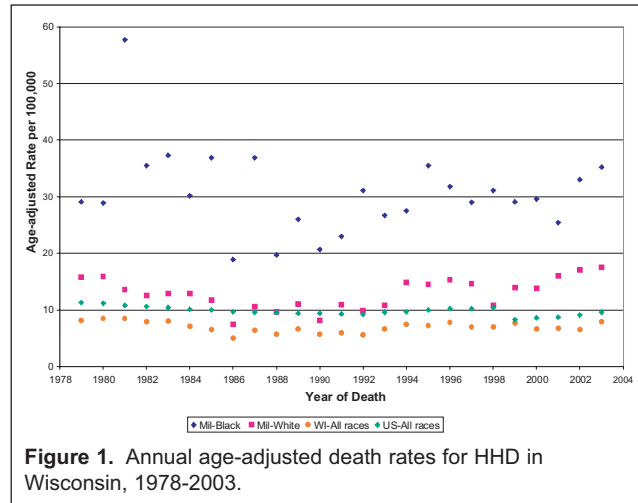


Figure 1. Annual age-adjusted death rates for HHD in Wisconsin, 1978-2003.

Table 1. Number of Hypertensive Heart Disease Deaths and Age-Adjusted Rates by Race, 1979-2003*

| Group | Number (Age-Adjusted Rate per 100,000) | | |
|-------------------------|--|---------------|---------------|
| | 1979-1988 | 1989-1998 | 1999-2003 |
| United States | | | |
| White | 153,071 (8.5) | 172,073 (7.9) | 92,737 (7.4) |
| African American | 53,067 (29.5) | 61,864 (28.7) | 30,798 (23.9) |
| Other | 2074 (7.1) | 3820 (7.4) | 2513 (5.9) |
| All Races | 208,212 (10.3) | 237,757 (9.8) | 126,048 (8.9) |
| Wisconsin | | | |
| White | 2892 (6.7) | 3175 (6.2) | 1875 (6.5) |
| African American | 246 (28.5) | 304 (26.0) | 208 (26.1) |
| Other | 11 (4.2) | 15 (4.9) | 11 (4.3) |
| All Races | 3149 (7.1) | 3494 (6.7) | 2094 (7.1) |
| Milwaukee County | | | |
| White | 1065 (12.3) | 1076(12.1) | 663 (15.6) |
| African American | 234 (32.7) | 277(28.6) | 196 (30.6) |
| Other | 4 (5.8) | 8(10.2) | 7 (10.1) |
| All Races | 1303 (14.0) | 1361(14.1) | 866 (18.0) |

*Rates based on fewer than 20 deaths are unreliable and should be interpreted with caution

Table 2. Hypertensive Heart Disease Deaths in Milwaukee and Other Wisconsin Counties, 1979-2003

| Group | Milwaukee County | | Remaining Wis Counties | |
|-------------------------|------------------|-------------------|------------------------|-------------------|
| | No. Deaths | Age-Adjusted Rate | No. Deaths | Age-Adjusted Rate |
| African American | | | | |
| Women | 343 | 25.5 | 25 | 10.6 |
| Men | 364 | 37.9 | 26 | 9.6 |
| White | | | | |
| Women | 1671 | 11.8 | 3327 | 5.6 |
| Men | 1133 | 13.7 | 1811 | 4.6 |

Table 3. Hypertensive Heart Disease Death Rates by County

| County | No. of Deaths (Age-Adjusted Rate per 100,000) | | | | County | No. of Deaths (Age-Adjusted Rate per 100,000) | | | |
|----------------|--|--------|-----------|--------|-----------------------------|--|--------|-----------|--------|
| | 1979-1998 | | 1999-2003 | | | 1979-1998 | | 1999-2003 | |
| Noncore | | | | | Micropolitan | | | | |
| Adams | 10 | (2.5) | 7 | (5.3) | Dodge | 99 | (5.7) | 35 | (6.3) |
| Ashland | 21 | (4.7) | 7 | (5.3) | Dunn | 12 | (1.8) | 4 | (1.7) |
| Barron | 18 | (1.8) | 5 | (1.6) | Florence | 2 | (1.6) | 0 | (0.0) |
| Bayfield | 28 | (8.3) | 9 | (9.3) | Grant | 60 | (5.2) | 13 | (3.9) |
| Buffalo | 22 | (6.1) | 2 | (2.0) | Green | 57 | (7.9) | 14 | (6.7) |
| Burnett | 11 | (3.0) | 4 | (3.3) | Jefferson | 51 | (4.0) | 17 | (4.2) |
| Clark | 10 | (1.2) | 7 | (2.6) | Lincoln | 21 | (3.2) | 4 | (2.1) |
| Crawford | 12 | (3.1) | 3 | (2.5) | Manitowoc | 49 | (2.6) | 24 | (4.4) |
| Door | 14 | (2.2) | 9 | (4.3) | Marinette | 50 | (4.8) | 18 | (5.5) |
| Forest | 6 | (2.9) | 1 | (1.5) | Portage | 60 | (6.2) | 13 | (4.0) |
| Green Lake | 36 | (6.8) | 6 | (3.6) | Sauk | 37 | (3.2) | 9 | (2.6) |
| Iron | 9 | (4.2) | 2 | (3.0) | Walworth | 47 | (3.0) | 18 | (3.4) |
| Jackson | 24 | (5.8) | 1 | (0.7) | Wood | 51 | (3.2) | 19 | (3.5) |
| Juneau | 20 | (3.7) | 0 | (0.0) | Small Metro | | | | |
| Lafayette | 9 | (2.6) | 3 | (3.7) | Calumet | 27 | (5.0) | 4 | (2.2) |
| Langlade | 18 | (3.2) | 7 | (4.1) | Chippewa | 19 | (1.7) | 5 | (1.5) |
| Marquette | 14 | (4.5) | 3 | (2.9) | Eau Claire | 90 | (5.9) | 14 | (2.9) |
| Menominee | 4 | (10.9) | 0 | (0.0) | Fond du Lac | 236 | (12.2) | 59 | (9.7) |
| Monroe | 37 | (4.7) | 17 | (6.9) | La Crosse | 123 | (6.5) | 20 | (3.5) |
| Oneida | 36 | (4.6) | 10 | (3.9) | Marathon | 117 | (5.5) | 58 | (8.1) |
| Pepin | 4 | (2.0) | 1 | (1.5) | Outagamie | 73 | (3.2) | 19 | (2.4) |
| Polk | 46 | (5.4) | 15 | (5.5) | Racine | 189 | (6.2) | 38 | (4.0) |
| Price | 18 | (4.2) | 9 | (6.5) | Rock | 148 | (5.7) | 36 | (4.5) |
| Richland | 10 | (2.3) | 2 | (1.7) | Sheboygan | 215 | (9.7) | 24 | (3.5) |
| Rusk | 8 | (2.3) | 3 | (2.6) | Winnebago | 102 | (3.8) | 154 | (18.5) |
| Sawyer | 19 | (5.2) | 1 | (1.0) | Medium Metro | | | | |
| Shawano | 71 | (7.4) | 9 | (3.0) | Brown | 143 | (4.7) | 54 | (5.0) |
| Taylor | 36 | (8.3) | 14 | (10.3) | Columbia | 31 | (2.9) | 14 | (4.4) |
| Trempealeau | 26 | (3.8) | 11 | (5.2) | Dane | 232 | (4.5) | 75 | (4.2) |
| Vernon | 56 | (7.7) | 11 | (5.1) | Iowa | 5 | (1.3) | 2 | (1.6) |
| Vilas | 22 | (3.8) | 5 | (2.8) | Kewaunee | 33 | (7.5) | 17 | (12.1) |
| Washburn | 13 | (3.6) | 3 | (2.4) | Oconto | 28 | (4.0) | 13 | (6.1) |
| Waupaca | 80 | (6.1) | 7 | (1.9) | Large, Fringe Metro | | | | |
| Waushara | 14 | (2.8) | 5 | (3.1) | Kenosha | 178 | (7.8) | 49 | (6.8) |
| Noncore | NA | NA | 199 | (3.6) | Ozaukee | 83 | (7.6) | 28 | (6.7) |
| Micropolitan | NA | NA | 188 | (4.1) | Pierce | 61 | (11.5) | 8 | (5.4) |
| Small metro | NA | NA | 431 | (6.2) | St Croix | 14 | (1.6) | 12 | (4.2) |
| Med metro | NA | NA | 181 | (4.6) | Washington | 109 | (7.4) | 31 | (5.5) |
| Lg. fringe | NA | NA | 229 | (5.7) | Waukesha | 291 | (6.2) | 101 | (5.5) |
| Lg. central | NA | NA | 866 | (18.0) | Large, Central Metro | | | | |
| Wisconsin | 3979 | (5.2) | 1228 | (4.9) | Milwaukee | 2664 | (14.1) | 866 | (18.0) |

*Rates based on fewer than 20 deaths are unreliable and should be interpreted with caution.

were also higher among African American women (25.5 versus 10.6). Age-adjusted HHD death rates were also higher among white residents of Milwaukee County compared to gender-specific rates for residents of other counties (13.7 versus 4.6 in men and 11.8 versus 5.6 in women).

Table 3 lists the number of deaths and age-adjusted rates for HHD by Wisconsin counties and level of

urbanization. From 1979 to 2003 age-adjusted death rates have tended to be higher in counties designated as large fringe-metropolitan or large central-metropolitan. Notable exceptions include rates for Fond du Lac and Winnebago Counties, which are higher than expected based on their urbanization designation, and the lower than expected rate for St Croix County, which is designated as a large, fringe metropolitan county due to

its location across the Mississippi River from St Paul, Minn. The pattern of higher rates in large metropolitan areas was also observed at the national level where age-adjusted death rates for African American and white residents of large, central metropolitan counties were nearly twice as high as rates observed in the most rural, noncore counties (see Table 4). Between 1999 and 2003, age-adjusted HHD death rates among African American residents of large central metropolitan counties, which ranged from 27.5 to 31.4, were roughly twice as high as rates observed among African Americans who lived in noncore counties (15.4 to 18.9); 3 times as high as rates for white residents of large metropolitan counties (8.6 to 10.7); and 5 times as high as rates seen among white residents of noncore counties (5.2 to 6.4)

Analysis of Electronic Death Certificate Data

A review of Wisconsin electronic death certificates for 1989 through 2004 identified 8901 certificates that included an ICD-9 code for HHD. HHD was listed as the underlying cause of death (UCOD) on 6142 (69%) of these and as a contributing cause on the remaining certificates. Other frequently reported underlying causes of death included acute myocardial infarction (574 deaths), coronary atherosclerosis (584 deaths) and unspecified hypertensive heart and renal disease (268 deaths). The average age at death for African Americans was 61 years among men and 64 years among women. White men and women succumbed to this condition much later in life, dying at average ages of 72 years and 81 years, respectively.

As was observed in the national death records, a disproportionate number of HHD deaths occurred in Milwaukee County (3381 of 8901 or 38%). The age-adjusted death rate in Milwaukee County of 22.0 per 100,000 was more than twice the statewide rate of 10.5. To further explore HHD mortality in Milwaukee County, age-adjusted death rates were calculated for each of its ZIP codes. Table 5 provides death rates along with demographic and environmental data for 10 ZIP codes that had the 5 highest and 5 lowest age-adjusted HHD death rates within Milwaukee County. ZIP code areas with the highest death rates were clustered in the central city of Milwaukee while areas with the lowest rates were located in suburban areas in southern Milwaukee County. (See also Figure 2.) High death rates were associated with large African American populations, higher population densities, more remediation and redevelopment sites per square mile, older housing stock, and lower household incomes compared to areas with the lowest rates.

Table 4. Age-adjusted HHD Death Rates by Race and Urbanization Level in the United States

| Year of Death | 1999 | 2000 | 2001 | 2002 | 2003 |
|-------------------------|------|------|------|------|------|
| White | | | | | |
| Large Central Metro | 8.6 | 8.7 | 9.3 | 10.6 | 10.7 |
| Large Fringe Metro | 6.4 | 6.6 | 6.7 | 6.5 | 7.1 |
| Medium Metro | 7.1 | 7.7 | 7.4 | 7.5 | 7.9 |
| Small Metro | 6.1 | 6.5 | 6.4 | 6.6 | 7.4 |
| Micropolitan | 6.0 | 5.8 | 6.1 | 6.2 | 6.3 |
| Noncore | 5.2 | 5.4 | 5.4 | 6.1 | 6.4 |
| African American | | | | | |
| Large Central Metro | 27.5 | 28.4 | 28.9 | 31.4 | 31.3 |
| Large Fringe Metro | 17.9 | 17.1 | 15.7 | 16.8 | 18.1 |
| Medium Metro | 21.9 | 24.6 | 20.5 | 20.2 | 21.1 |
| Small Metro | 18.5 | 17.9 | 19.9 | 19.6 | 21.0 |
| Micropolitan | 18.1 | 18.7 | 17.6 | 16.7 | 18.7 |
| Noncore | 15.4 | 15.4 | 16.6 | 18.6 | 18.9 |

DISCUSSION

Based on national and state death certificate data, HHD death rates among residents of Milwaukee County have been significantly higher than rates observed in other parts of Wisconsin. Between 1999 and 2003, the age-adjusted HHD death rate for Milwaukee County (18.0 per 100,000) was nearly 3 times higher than the statewide rate (6.9 per 100,000). This disparity, which has existed for at least 25 years, was most striking among African Americans but was also significant among white residents. The reasons for the higher mortality rates observed in Milwaukee are not known. One hypothesis might be that physicians and coroners in Milwaukee are more aware of hypertension as a cause of death and more likely to include it among the causes of death on the death certificate. This possibility merits additional investigation and should be considered in future research studies.

Other potential reasons for these disparities could lie in environmental, genetic, socioeconomic, and lifestyle differences between Milwaukee, which is Wisconsin's most urban and most racially diverse county, and the rest of the state, which is largely white and made up of small to medium-sized cities, towns, and villages that are surrounded by farming areas and native forests. Within Wisconsin, Milwaukee County is unique in that most of its residents live in a densely-populated urban area. According to the 2000 US Census, Milwaukee County has a population density of 3892 people per square mile—a density 40 times higher than the statewide average.²² Counties that had HHD mortality rates of <2 per 100,000 tended to be rural and have very low population densities and small minority populations.

Table 5. 1989-2004 HHD Death Rates vs Demographic Variables in 10 Milwaukee County ZIP Codes

| ZIP Code | City | Age-Adjusted Death Rate* | % African American | % Housing Built Before 1950 | Median Household Income | Remediation and Redevelopment Sites per Sq Mile† | Persons Per Sq Mile |
|----------------|-----------|--------------------------|--------------------|-----------------------------|-------------------------|--|---------------------|
| Highest | | | | | | | |
| 53205 | Milwaukee | 55.78 | 87 | 37 | \$14,660 | 40 | 7768 |
| 53210 | Milwaukee | 51.51 | 70 | 71 | \$32,340 | 43 | 12,200 |
| 53206 | Milwaukee | 46.16 | 96 | 68 | \$20,787 | 17 | 12,173 |
| 53233 | Milwaukee | 45.07 | 34 | 46 | \$13,140 | 78 | 8603 |
| 53212 | Milwaukee | 42.02 | 63 | 68 | \$23,523 | 55 | 7512 |
| Lowest | | | | | | | |
| 53110 | Cudahy | 13.29 | <1 | 38 | \$40,017 | 21 | 3487 |
| 53154 | Oak Creek | 12.64 | 2 | 7 | \$53,870 | 9 | 1012 |
| 53228 | Milwaukee | 11.97 | <1 | 10 | \$64,186 | 4 | 2892 |
| 53129 | Greendale | 11.41 | <1 | 13 | \$64,943 | 4 | 2529 |
| 53132 | Franklin | 9.32 | 5 | 7 | \$64,822 | 2 | 846 |

Demographic data are from the US Census Bureau at <http://factfinder.census.gov> and reflect 2000 census data.

*Age-adjusted rates per 100,000 were calculated using population data from the 2000 US Census.

† Of 63,922 hazardous waste sites managed by the Wisconsin Department of Natural Resources' Remediation and Reclamation Program, 9754 (15%) are located in Milwaukee County.²⁷

Iowa County, which had only 7 HHD deaths during the 25-year study period, is 98.7% white and has a population density of 26 per square mile – less than 1% that of Milwaukee. Other counties with HHD death rates of <2 per 100,000 included Barron, Chippewa, Clark, Dunn, Florence, and St. Croix. These counties also have small minority populations and low population densities that range from 10 to 87 people per square mile. Dane County, Wisconsin's second most populous county, is 89.4% white and has a population density of 355 people per square mile. Between 1999 and 2003, its age-adjusted HHD death rate was 4.2 per 100,000.

At the state and national levels, annual HHD death rates between 1999 and 2003 were highest in large central metropolitan counties and lowest in rural and suburban areas. This pattern is consistent regardless of race or gender, suggesting that something in the urban environment may be contributing to the risk of HHD mortality. HHD death rates are increasing each year in our cities, while rates in rural and suburban areas remain stable. While race and lifestyle are well-known risk factors for HHD, the influence of the physical living environment on the etiology of hypertension and HHD is not well understood. Population density, for example, may be serving as an indicator of an urban environment with higher potential for exposure to vehicle exhaust and industrial emissions, as well as potential lifestyle differences and emotional stressors. Milwaukee's inner-city neighborhoods are characterized by older housing stock with lead paint hazards, heavy traffic volumes, poverty, and indus-

trial pollution. Residential instability, traffic congestion, long commute times, and noise may contribute to stress among residents of these areas and increase their risk of stress-related illnesses such as hypertension.

Associations between exposure to particulate air pollutants and cardiovascular mortality have also been reported. Due to heavy traffic, a large regional airport, and a thriving industrial sector, Milwaukee County suffers from significant air quality problems. In their State of the Air Reports for 2004²³ and 2005,²⁴ the American Lung Association concluded that Milwaukee residents breathe some of the unhealthiest air in Wisconsin and gave Milwaukee failing grades for ozone and fine particulate air pollution. While ozone problems exist in most counties that border Lake Michigan, Milwaukee was the only Wisconsin county that received a failing grade for particulate pollution.

The majority of Milwaukee County residents consume water drawn from Lake Michigan while most Wisconsin families consume water from underground aquifers. These source water supplies differ markedly in their chemistry. Water drawn from Wisconsin aquifers, many of which are in limestone bedrock, tends to be high in dissolved calcium and magnesium—2 essential minerals that have been shown to be protective against heart disease and contribute to water hardness.¹⁸⁻²⁰ Based on public water supply data maintained by the Wisconsin Department of Natural Resources, the average calcium level in Wisconsin's community water supplies is 100 mg/L.²⁵ The average magnesium level is 51 mg/L. In compari-

son, calcium and magnesium levels in Milwaukee's drinking water average 34 and 10 mg/L, respectively. Based on recommended intake levels established by the National Academy of Sciences, daily ingestion of 2 liters of water that has a magnesium concentration of 50 mg/L would provide a third of the recommended daily intake (RDI) for an adult woman. Two liters of water with a calcium level of 100 mg/L would provide about 20% of the RDI for this beneficial mineral.²⁶

Lifestyle and socioeconomic indicators, such as nutrition, body weight, physical activity, emotional stress, family income, and the use of caffeine, alcohol, and tobacco have all been linked to the risk of hypertension and cardiovascular disease. Since this study was conducted using national mortality data, it did not include an assessment of personal risk factors for HHD. Despite these weaknesses, the racial and geographic disparities reported in this article support the need for additional research. Future studies should evaluate regional cause of death reporting practices as well as the importance of genetic, lifestyle, and environmental risk factors for HHD. Our findings also suggest the need for early screening and treatment of hypertension throughout Wisconsin. Since HHD takes many years to develop, early diagnosis and treatment has the potential to prevent hundreds of premature deaths.

Financial Disclosure: None declared.

Funding/Support: None declared.

REFERENCES

1. Wisconsin Department of Health and Social Services. Healthier People in Wisconsin: A Public Health Agenda for 2000; 1990.
2. Andersen D, Commons JL. Regional variations in coronary heart disease mortality in Wisconsin, 1979-1998. *WMJ*. 2002;101:16-22.
3. Park H, Safdar N, Schmidt H. Decline in mortality of coronary heart disease among whites and blacks in Wisconsin 1979-1998. *WMJ*. 2002;101:23-27.
4. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 Report. *JAMA*. 2003;289:2560-2572.
5. Whelton PK, He J, Appel LJ, et al. Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. *JAMA*. 2002;288:1882-1888.
6. Sacks FM, Svetkey LP, Vollmer WM, et al. for the DASH-Sodium Collaborative Research Group. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *N Engl J Med*. 2001;344:3-10.
7. Mahmud A, Feely J. Effect of smoking on arterial stiffness and pulse pressure amplification. *Hypertension*. 2003; 41:183-187.
8. Artinian NT, Washington OG, Flack JM, Hockman EM, Jen KL. Depression, stress, and blood pressure in urban African-American women. *Prog Cardiovasc Nurs*. 2006;21:68-75
9. Higdon JV; Frei B. Coffee and health: a review of recent human research. *Crit Rev Food Sci Nutr*. 2006;46:101-123.
10. Puddey IB, Beilin LJ. Alcohol is bad for blood pressure. *Clin Exp Pharmacol Physiol*. 2006;33:847-852.
11. Shankar A, Klein R, Klein BE, Nieto FJ. The association between serum uric acid level and long-term incidence of hypertension: population-based cohort study. *J Hum Hypertens*. 2006 [Epub ahead of print].
12. Hu H, Aro A, Payton M, Korrick S, Sparrow D, Weiss ST, Rotnitzky A. The relationship of bone and blood lead to hypertension. The Normative Aging Study. *JAMA*. 1996; 275:1171-1176.
13. The State of Environmental Health in Wisconsin, 2005: An Environmental Health Indicators Report. Wisconsin Dept of Health and Family Services, Madison, Wis.

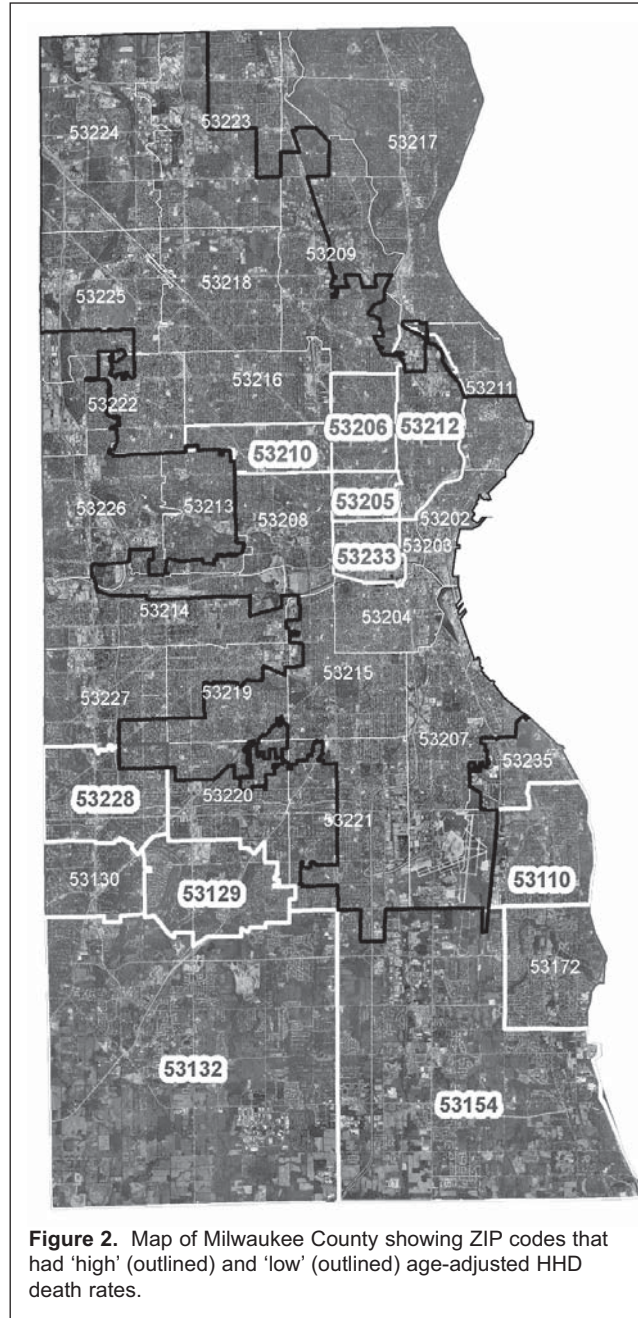


Figure 2. Map of Milwaukee County showing ZIP codes that had 'high' (outlined) and 'low' (outlined) age-adjusted HHD death rates.

14. Huang X, Lessner L, Carpenter DO. Exposure to persistent organic pollutants and hypertensive disease. *Env Res.* 2006;102:101-106.
15. Dockery DW, Pope CA, Xu X, et al. An association between air pollution and mortality in six US cities. *N Engl J Med.* 1993;329:1753-1759.
16. Laden F, Schwartz J, Speizer E, Dockery DW. Reduction in fine particulate air pollution and mortality. Extended follow-up of the Harvard Six Cities Study. *Am J Respir Crit Care Med.* 2006;173:667-672.
17. Brook RD. You are what you breathe: evidence linking air pollution to high blood pressure. *Curr Hypertens Rep.* 2005;7:427-434.
18. WHO. Nutrients in Drinking Water and the Potential Health Consequences of Long-Term Consumption of Demineralized and Remineralized and Altered Mineral Content Drinking Waters. Consensus of Meeting Report; 2004.
19. Yang CY, Chiu HF. Calcium and magnesium in drinking water and the risk of death from hypertension. *Am J Hypertens.* 1999;12:1894-1899.
20. Kousa A, Havulinna AS, Moltchanova E, et al. Calcium: magnesium ratio in local groundwater and incidence of acute myocardial infarction among males in rural Finland. *Environ Health Perspect.* 2006;114:730-734.
21. Ingram DD, Franco S. NCHS Urban-rural classification scheme for counties. Atlanta, GA: NCHS; 2006.
22. US Census Bureau. Census 2000 Gateway. Available at: <http://quickfacts.census.gov/qfd/states/55000.html>. Accessed May 18, 2007.
23. American Lung Association. 2004. State of the Air Report. Available at: <http://lungaction.org/reports/stateoftheair2004.html>. Accessed May 18, 2007.
24. American Lung Association. 2005. State of the Air Report. Available at: <http://lungaction.org/reports/stateoftheair2005.html>. Accessed May 18, 2007.
25. 1985 Public Water Supply Data Book. State of Wisconsin. Department of Natural Resources. Madison, Wis.
26. Otten JJ, Pitzzi-Hellwig J, Meyers LD. *The Dietary Reference Intakes: The Essential Guide to Nutrient Requirements, 2006.* Washington, DC: National Academies Press; 2006.
27. WI DNR. Remediation and Redevelopment Tracking System (BRRTS). Available at: <http://dnr.wi.gov/org/aw/rr/index.htm>. Accessed May 18, 2007.

Wisconsin Medical Journal

The mission of the *Wisconsin Medical Journal* is to provide a vehicle for professional communication and continuing education of Wisconsin physicians.

The *Wisconsin Medical Journal* (ISSN 1098-1861) is the official publication of the Wisconsin Medical Society and is devoted to the interests of the medical profession and health care in Wisconsin. The managing editor is responsible for overseeing the production, business operation and contents of the *Wisconsin Medical Journal*. The editorial board, chaired by the medical editor, solicits and peer reviews all scientific articles; it does not screen public health, socioeconomic or organizational articles. Although letters to the editor are reviewed by the medical editor, all signed expressions of opinion belong to the author(s) for which neither the *Wisconsin Medical Journal* nor the Society take responsibility. The *Wisconsin Medical Journal* is indexed in Index Medicus, Hospital Literature Index and Cambridge Scientific Abstracts.

For reprints of this article, contact the *Wisconsin Medical Journal* at 866.442.3800 or e-mail wmj@wismed.org.

© 2007 Wisconsin Medical Society