Background—National vital event data suggest that cardiovascular disease (CVD) mortality rates are lower for American Indians and Alaska Natives (AIAN) than for the general US population, but these data are disproportionately flawed for AIAN because of racial misclassification.

Methods and Results—Vital event data adjusted for racial misclassification and published by the Indian Health Service were used to compare trends in CVD mortality from 1989 to 1991 to 1996 to 1998 between AIAN, US all-races, and US white populations. Without misclassification accounted for, AIAN initially had the lowest mortality rates from major CVD, but by the end of the study, their rates were the highest. Adjustment for misclassification revealed an early and rapidly growing disparity between CVD mortality rates among AIAN compared with rates in the US all-races and white populations. By 1996 to 1998, the age- and misclassification-adjusted number of CVD deaths per 100 000 among AIAN was 195.9 compared with age-adjusted rates of 166.1 and 159.1 for US all races and whites, respectively. The annual percent change in CVD mortality for AIAN was 0.5 compared with −1.8 in the other groups. Regardless of racial misclassification, the most striking and widening disparities were found for middle-aged AIAN, but CVD mortality among AIAN ≥65 years of age was lower than in the other populations.

Conclusions—A previously underrecognized disparity in CVD mortality exists for AIAN, particularly among middle-aged adults. Moreover, these disparities are increasing. Efforts to reduce CVD mortality in AIAN must begin before the onset of middle age. (Circulation. 2005;111:1250-1256.)

Key Words: cardiovascular disease ■ epidemiology ■ Indians, North American ■ Inuits

Several racial disparities in cardiovascular disease (CVD) mortality and health care have been documented in the United States. The Institute of Medicine reports that racial and ethnic disparities in health care are widespread, are associated with worse health outcomes, and occur independently of socioeconomic status.1

Nevertheless, national vital event data suggest that CVD mortality for American Indians and Alaska Natives (AIAN) is lower than in the general US population and has been for decades.2,3 Similar findings have been reported in other AIAN population-based studies using vital event data.4,5 These findings are somewhat puzzling because American Indians have for years had some of the nation’s highest prevalence rates of major CVD risk factors such as smoking, diabetes, and obesity. CVD is also the leading cause of death among AIAN and has been for decades. Furthermore, AIAN are among the most disadvantaged populations in the United States. Despite improvements in life expectancy and total mortality over the past century, disparities in these health status indicators remain for this population compared with the general population. Also, AIAN death rates for several major diseases, including cerebrovascular disease, increased during the 1990s, unlike rates in other racial and ethnic groups.3

Data from the nation’s only longitudinal epidemiological study of CVD and its risk factors among a diverse group of American Indians, the Strong Heart Study (SHS),13 suggest that CVD incidence and mortality rates are as bad as or worse than those in comparable general populations.14,15

The seemingly disparate findings between national data and the SHS may be explained by errors in national data resulting from racial misclassification and population estimates. These errors disproportionately affect AIAN and likely contribute to falsely low estimates of CVD. The Indian Health Service (IHS), the nation’s leading source of health care for AIAN, has compiled data since the 1950s on mortality rates for ≈60% of the US AIAN population. These rates are derived from the vital event and census data and are reported in the IHS Trends in Indian Health (Trends) series of publications. The IHS began to adjust for racial misclassification beginning with data from the early 1990s.

The present article uses data from the IHS to report trends in CVD mortality and to assess the impact of racial misclassification on an underrecognized CVD disparity among AIAN.

Methods


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Population Estimates
IHS obtains population estimates from the US Bureau of the Census and defines its service population as those persons who identified themselves as American Indian, Eskimo, or Aleut on the 1990 census and who resided in geographic areas “on or near” reservations or trust lands. Estimates of the IHS service population are census based, not “user” or clinic based. This population is also characterized by marked geographic and cultural diversity. The IHS service population from the 1990 census consisted of ~1.21 million AIAN, ~60% of the total AIAN population. CVD mortality rates for the IHS service population from 1989 to 1991 on have been corrected by the IHS for revisions in the census counts made by the US Bureau of the Census. Rates before 1989 to 1991 were not adjusted for changes in census estimates and therefore are not included in the present study. Population estimates for subsequent periods used consistent assumptions and projections obtained with linear regression techniques. By 1998, the IHS service population was estimated at 1.46 million.

Vital Event Data
Vital event statistics as reported in Trends were derived by the IHS from the National Center for Health Statistics (NCHS) publications and from unpublished data supplied by the NCHS. The NCHS compiles vital event data for all US residents on the basis of information reported on official birth and death certificates from state departments of health.

Causes of death were identified by the NCHS from death certificates and coded with the International Classification of Diseases, ninth revision, definitions. The codes for categories of CVD were consistent throughout the study period and included the following: 390 to 448 for major CVD; 390 to 398, 402, and 404 to 429 for diseases of the heart; and 430 to 438 for cerebrovascular diseases.

The IHS uses 3-year averages to minimize the random fluctuations that may result from uncommon events. Rates for the US all-races and US white populations represent single years corresponding to the IHS service population from 1989 to 1991 on have been corrected by the IHS for revisions in the census counts made by the US Bureau of the Census. Rates before 1989 to 1991 were not adjusted for changes in census estimates and therefore are not included in the present study. Population estimates for subsequent periods used consistent assumptions and projections obtained with linear regression techniques. By 1998, the IHS service population was estimated at 1.46 million.

Adjustment for Racial Misclassification and Age
In the 1990s, the IHS conducted a study to determine the frequency of racial misclassification and to develop methodology for adjustment for underreporting of AIAN deaths. Briefly, records of the IHS user population were matched with data from the National Death Index (NDI) for the years 1986 to 1988. Adjustment factors were determined from the ratio of the actual number of AIAN deaths in the matched IHS NDI database to the number of AIAN deaths reported on state death certificates. Adjustment factors were developed for each of the 12 IHS regional administrative “areas” and the IHS overall and selected age groups; however, data were insufficient to reliably determine adjustment factors by subgroups within IHS areas.

Because misclassification rates varied more widely across the IHS areas, only the area-specific factors were chosen for use in the Trends publications (personal communication, Debra A. Heller, PhD, consulting statistician, IHS, December 2004).

Mismisclassification- and age-adjusted mortality rates in Trends were obtained as follows (personal communication, Debra A. Heller). First, the unadjusted number of total deaths from CVD, diseases of the heart, and cerebrovascular disease was adjusted by the IHS area-specific factor within age groups. These rates were subsequently applied to the 1940 standard US population for age adjustment using the direct method used by NCHS. The 2000 standard US population was not available at the time these data were prepared. Because the IHS service population was much smaller than the US white and all-races populations, misclassification of AIAN as another race on death certificate data has a negligible effect on mortality rates for these populations.

The IHS first reported misclassification-adjusted CVD mortality rates for data from 1992 to 1994. To estimate adjusted rates for earlier periods, the average percent differences between the unadjusted and adjusted rates for the periods 1992 to 1994, 1994 to 1996, and 1996 to 1998 were calculated. The average of these differences over the 3 periods was then applied to the rates from previous years.

The annual percent change in rates was also calculated by use of the midpoint years of the first and last time periods. Because these are census-level data and because denominator data were not available, statistical testing for significant differences in the annual percent change by race was not done.

Results
The Figure shows that, without adjustment for misclassification, a favorable gap in major CVD mortality rates at baseline existed for AIAN compared with the other groups, although this gap narrowed as a result of increasing rates in AIAN and decreasing rates in the other groups. In contrast, adjustment for racial misclassification, which resulted in a 16% increase in major CVD mortality rates, revealed a baseline and rapidly growing disparity in CVD mortality rates among AIAN compared with whites and, after the initial study period, US all races. The average annual percent change in major CVD mortality was 0.4 for AIAN rates compared with −1.8 for both the US all-races and white populations.
Table 1 presents mortality data for diseases of the heart and cerebrovascular disease for the total populations. Rates for diseases of the heart and cerebrovascular disease increased 18% and 11%, respectively, after adjustment for misclassification. Mortality rates from diseases of the heart were highest among AIAN after adjustment for misclassification, and the differences increased over time as a result of declines in the US all-races and white rates. The AIAN mortality rates from diseases of the heart changed minimally over the periods of study. Cerebrovascular disease mortality among AIAN rose during the study period but declined in the US all-races and white populations.

Diseases of the heart were the leading cause of death among AIAN beginning at 45 years of age for all periods reported in this study (data not shown). In contrast, diseases of the heart were not the leading cause of death for the US all-races or white populations until 65 years of age. Mortality rates from diseases of the heart and cerebrovascular disease stratified by age group are shown in Tables 2 and 3, respectively. Mortality rates among the 45- to 54-year-old AIAN group were dramatically higher than for the US all-races or white populations, regardless of adjustment for misclassification. Although decreases in the AIAN rates were found over time for diseases of the heart in this age group, the rate of decline was less than...
half that of the non-AIAN groups. In contrast, rates of decline were similar between populations in this age group for cerebrovascular disease. Among persons 65 years of age, AIAN had lower mortality rates from heart disease and cerebrovascular disease, regardless of adjustment for racial misclassification. Overall, heart disease mortality rates decreased and cerebrovascular disease mortality rates increased in this age group for each population, with roughly similar annual percent changes.

**Discussion**

This report assesses recent trends in CVD mortality for the >1 million AIAN residing on or near reservations and trust lands. Findings suggest that total CVD mortality for AIAN is higher, not lower, than in the rest of the nation and may have been higher for more than a decade. Furthermore, CVD mortality is increasing in this population but decreasing in the general population, widening a previously unrecognized disparity. National vital event data had consistently suggested that CVD mortality rates among AIAN compared favorably to the general population, even to the present2,4,5,23–25; however, prior studies did not account for the effect of racial misclassification.

This study also reveals differences in CVD mortality among adults by age groups. The marked disparity in CVD mortality between middle-aged AIAN and the US all-races and white populations is striking and is increasing. Other studies have also recently demonstrated a higher burden of premature heart disease mortality for AIAN.26,27 In contrast, lower rates of heart disease and cerebrovascular disease mortality occurred among AIAN compared with US all-races and white populations 65 years of age, even after adjustment for racial misclassification. This finding is also consistent with some other studies27,28 but not all.14,15 In addition, heart disease mortality rates for AIAN ≥65 years of age decreased and cerebrovascular mortality rates increased. Although it is tempting to speculate that the lower mortality from diseases of the heart, coupled with a rising prevalence of hypertension,29 increased the number of AIAN elders at risk for dying of stroke, reasons for this pattern are not clear. Similarly, the increasing trend in mortality from diseases of the heart among middle-aged AIAN compared with the decreasing trend in older AIAN cannot be explained by this study. This may reflect the birth cohort effects of diabetes and smoking, which have increased markedly in prevalence among younger AIAN in recent decades. Additional evidence that the burden of CVD among AIAN was not as low as suggested by national vital event data can be found in previous studies. The 1987 Survey of American Indians and Alaska Natives found that the self-reported percent prevalence of CVD was nearly equal to that reported for the general US population.28 Among AIAN in Washington State, heart disease and cerebrovascular mortality did not differ significantly between urban AIAN and urban whites, but rural AIAN had significantly higher mortality than either of these 2 groups.10 Other smaller, tribally based studies in the late 1980s also suggested that AIAN heart disease rates rivaled or exceeded rates in the general population or were rising rapidly.6

Findings from the largest study of CVD among American Indians provide even stronger support for a growing burden of CVD. The SHS is an epidemiological study of CVD among a well-defined but culturally diverse population of American Indians 45 to 74 years of age residing in Arizona, Oklahoma, and North and South Dakota.13 The SHS included a population-based survey to estimate CVD mortality rates in these communities for 1984 to 1988.14 Major CVD mortality
rates were determined from death certificate data and confirmed by independent review of medical records. In contrast to studies using national event data, the SHS found that CVD mortality rates were close to the US averages in Arizona and Oklahoma and >2 times higher in North and South Dakota for persons between 45 and 64 years of age. Furthermore, American Indian CVD mortality rates were often higher than the respective state rates for most age and sex groups.

The SHS also longitudinally ascertained CVD morbidity and mortality from medical record review, clinical history, and physical examinations in a cohort of 4549 American Indians 45 to 74 years of age in the 3 regions described above. Lists of tribal rolls were used to identify eligible persons, thus eliminating racial misclassification.13 Medical records and death certificates were independently reviewed by 2 physicians to determine whether the deaths were due to CVD. After 7 years of follow-up, combined coronary heart disease incidence rates were nearly twice as high as those reported in the national Atherosclerosis Risk in Communities study cohort.14 This finding suggests that rates of coronary disease in this cohort exceed those of other US populations.

Racial Miscoding and CVD
Several studies support the use of adjustment for racial miscoding in reporting AIAN mortality rates. The National Center for Health Statistics evaluated the quality of the national death rates and found a markedly disproportionate underestimation of AIAN total mortality rates compared with other races.16 Specifically, the study found that death rates for AIAN were underestimated by nearly 21% compared with 11% for Asians and 2% for Hispanics. In contrast, death rates for black and white populations were overestimated by 5% and 1%, respectively. In the miscoding study of death certificate data for the IHS user population, AIAN race was misidentified an average of 10.9%, with rates varying widely from 1.2% to 30.4% across the different service units and age groups.22 Also, in Washington State, nearly 15% of AIAN were misclassified as a different race.30

Racial miscategorization among AIAN has resulted in substantial underestimation of cancer mortality,12 injury rates,32 and prevalence of end-stage renal disease.33 Furthermore, mortality from “signs, symptoms, and ill-defined conditions” was a disproportionately leading cause of death among American Indians in New Mexico,34 likely leading to underestimation in rates of death from CVD.

Study Limitations
The adjustment factors developed by IHS were based on racial miscategorization of deaths from all causes in the IHS user population from 1986 to 1988. Although overlap exists between the IHS user-defined population and the census-defined IHS service population, miscategorization may be greater in the wider service population. Because adjustment factors by both age group and IHS area could not be determined, only the area-specific adjustment factors were applied, forcing the assumption that rates of miscategorization across age groups were uniform. Also, rates of miscategorization of AIAN race may be increasing.30 Finally, disease-specific miscategorization rates have not been determined for the IHS populations. Still, miscategorization might vary by cause of death, with racial miscategorization occurring less often for conditions well known to affect AIAN such as alcoholism than for conditions such as cancer.35 Because CVD has not been widely recognized as disproportionately affecting AIAN, it may be subject to greater rates of miscategorization. Mortality from ill-defined causes is also markedly disproportionate for some American Indians,34 leading to undercounting of CVD as a cause of death. The combined effect of these biases may result in conservative estimates of CVD mortality among AIAN; therefore, the disparities in the present study may be greater than demonstrated.

Data were not available for a sensitivity analysis of CVD-specific adjustment factors. The adjustment for miscategorization led to a 16% increase in total CVD mortality rates, which, as discussed above, may be conservative. If the overall correction of the miscategorization of CVD deaths had resulted in only a 10% increase in mortality rates, the disparity would be apparent only 2 years later.

Another limitation in the IHS data is the use of the standard 1940 population rather than a more recent standard population for age adjustment. It is unlikely, though, that the observed disparities would be substantially affected by use of a different standard population.

The lack of sex-specific age-adjusted CVD mortality rates is another limitation of the IHS data. Such information would contribute to a better understanding of the disparities demonstrated in this study, especially if the disparities affect men and women differentially.

Despite these limitations, the data clearly show an enlarging disparity in CVD mortality among AIAN compared with the US white and all-races populations. These disparities are particularly marked among middle-aged AIAN even without adjustment for racial miscategorization.

Reasons for the widening disparities in CVD mortality cannot be determined from the present study. One factor may be the severe epidemic of diabetes mellitus, which is markedly disproportionate among AIAN30,36,37 and may be exacting its toll. Diabetes mellitus is the most common modifiable CVD risk factor for many AIAN populations38,39 and is one of the strongest risk factors for incident CVD among participants in the SHS.15 Indeed, diabetes is a stronger risk factor among the SHS cohort than among the Framingham cohort.40 The role of socioeconomic status and access to specialty care cannot be assessed with these data but could also account for some of the disparities found here. For instance, in the 1990 census, 31.6% of the AIAN living in states with reservations lived below the poverty level compared with 13.1% of the US all-races population.20 Also, in 2000, the IHS annual per capita healthcare spending was $1430, less than one half that for the general US population ($3766),41 raising the specter that some of the observed disparities could be due to underfunding of the IHS.

Although >1.2 million AIAN were included in this study, the extent to which these data can be generalized to other AIAN populations is unknown. Many AIAN may have different access to health care or different risk profiles compared with the IHS service population. Furthermore, marked heterogeneity in CVD risk factors,29 mortality,42 and
racial misclassification exists among AIAN.42 The present report cannot provide region- or tribe-specific information.

Conclusions and Future Directions

Unfavorable and widening disparities in CVD mortality for AIAN have been largely unrecognized because of errors in national vital event data that disproportionately affect AIAN. Even without misclassification accounted for, disparities in CVD are most marked among middle-aged AIAN, which in turn suggests an even higher burden of chronic disease among younger AIAN. Rigorous data collection efforts to ensure accurate and adequate representation of AIAN in national data sets are required. Reassessments of national rates of racial misclassification should be conducted periodically to help ensure the accuracy of CVD mortality data. IHS should be commended because it is the only federal healthcare agency to routinely account for misclassification of AIAN in its health status reports. Researchers using national event data to assess trends in the health of AIAN should follow its lead.

This study shows an alarming increase in CVD mortality among middle-aged AIAN and a growing disparity in CVD mortality for AIAN compared with the general population. Further research is needed to discover the root causes of these disparities and to identify persons at high risk. Although the premature CVD deaths may be attributable in part to the disproportionate and rising scourge of diabetes among younger AIAN, this hypothesis has not been tested. How AIAN men and women are affected differently by CVD mortality needs further elucidation. Also, manifestations of CVD among AIAN may differ from the general population or may be less recognized. To best address these questions, future research should include longitudinal comparative epidemiological studies of AIAN and non-AIAN men and women before the onset of middle age. Finally, AIAN communities should be alerted to the increased risk of early CVD mortality so that they can develop programs targeted at decreasing this risk.

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Racial Misclassification and Disparities in Cardiovascular Disease Among American Indians and Alaska Natives
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