

# Methods for Improving the Quality and Completeness of Mortality Data for American Indians and Alaska Natives

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Accurate health surveillance data are essential to address health disparities and to plan, implement, and evaluate disease prevention and control activities. Vital registration—the routine recording and monitoring of births and deaths within a population—provides a critical and ongoing picture of the health status of that population.<sup>1</sup> However, the goal of producing reliable mortality estimates for American Indian and Alaska Native (AI/AN) populations has been hampered by the misclassification of race that frequently introduces bias toward underestimation of death rates using Vital Statistics data.<sup>2</sup> Analyses that minimize misclassification of race have the potential to provide to tribes and their partners a more accurate description of the disease burden in AI/AN communities and, as a consequence, the tools to plan and implement more effective health promotion and disease prevention and control programs.

## BACKGROUND

In 2011, an estimated 6.2 million people reporting AI/AN ancestry alone or in combination with 1 or more other races lived in the United States—approximately 2% of the population.<sup>3</sup> These people are members of—or related to—1 or more of more than 560 federally recognized or more than 200 non-federally recognized tribes, and they represent communities with diverse languages, cultures, and histories.<sup>4</sup> The AI/AN population is younger and poorer and has attained less education than the White population.<sup>3</sup> Most of the AI/AN population resides west of the Mississippi River and makes up a greater proportion of the population in Alaska, Oklahoma, and other selected regions—the Southwest, the Northern Plains, and the Pacific Northwest (Figure 1). About 22% of AI/AN persons reside on tribal reservations, trust lands, or other tribally affiliated areas; approximately 59% live in urban areas.<sup>3</sup>

**Objectives.** We describe methods used to mitigate the effect of race misclassification in mortality records and the data sets used to improve mortality estimates for American Indians and Alaska Natives (AI/ANs).

**Methods.** We linked US National Death Index (NDI) records with Indian Health Service (IHS) registration records to identify AI/AN deaths misclassified as non-AI/AN deaths. Analyses excluded decedents of Hispanic origin and focused on Contract Health Service Delivery Area (CHSDA) counties. We compared death rates for AI/AN persons and Whites across 6 US regions.

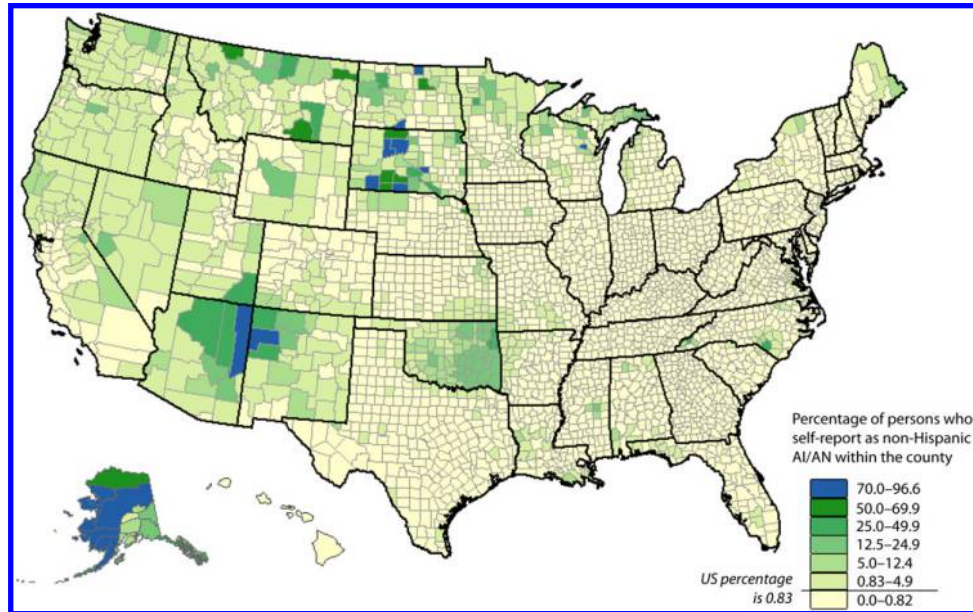
**Results.** IHS registration records merged to 176 137 NDI records. Misclassification of AI/AN race in mortality data ranged from 6.3% in the Southwest to 35.6% in the Southern Plains. From 1999 to 2009, the all-cause death rate in CHSDA counties for AI/AN persons varied by geographic region and was 46% greater than that for Whites. Analyses for CHSDA counties resulted in higher death rates for AI/AN persons than in all counties combined.

**Conclusions.** Improving race classification among AI/AN decedents strengthens AI/AN mortality data, and analyzing deaths by geographic region can aid in planning, implementation, and evaluation of efforts to reduce health disparities in this population. (*Am J Public Health.* 2014;104:S286–S294. doi:10.2105/AJPH.2013.301716)

The Indian Health Service (IHS) provides primary health care to approximately 2 million enrolled members of federally recognized tribes. The 168 IHS hospitals and clinics are located primarily on reservation lands and in a few cities with relatively large AI/AN populations. More than half of these health care facilities are managed by tribal governments under negotiated agreements with the federal government, and the rest of the facilities are operated directly by the federal government.<sup>5</sup> An additional 34 urban health centers receive some federal funding to provide health care to the urban AI/AN population.<sup>6</sup> Eligible AI/AN individuals can receive health care at any IHS facility, but complex rules govern and restrict delivery of contract health services for specialty medical care, such as cancer treatment, that is generally not available in IHS facilities.

Race misclassification of AI/AN persons has been reported in various public health data sets. Thoroughman et al.<sup>7</sup> described substantial underreporting of sexually transmitted infections in Oklahoma resulting from race

misclassification. Similar linkages of IHS registration records with state death records indicated a similar problem of race misclassification in mortality data.<sup>8,9</sup> Compelling findings from the National Longitudinal Mortality Study (NLMS) have described marked race misclassification of AI/AN decedents compared with other racial groups.<sup>2</sup> The NLMS allows investigators to compare self-identified race for a participant in the US Census Bureau's Current Population Survey with the race classification recorded by the funeral home director at the time of death.<sup>10</sup> It demonstrated race misclassification of nearly 30% for AI/AN decedents in comparison with other race groups.<sup>2</sup> A previous study linking IHS patient registration records with the National Death Index (NDI) also found substantial underreporting of AI/AN race on death certificates, and the IHS uses these findings to adjust agency mortality reports.<sup>11,12</sup> Multiple investigators have described misclassification in central cancer registries using linkages between registry records and patient registration records from the IHS.<sup>13–17</sup> The use of such linkages has been integrated into national reporting for cancer



Source. 2013 intercensal bridged single-race population estimates, US Census Bureau/Centers for Disease Control and Prevention/National Cancer Institute, (<http://seer.cancer.gov/popdata>).

**FIGURE 1—Percentage distribution of American Indian/Alaska Native (AI/AN) population, by county: United States, 2009.**

incidence as a means for correcting misclassification of AI/AN race in central cancer registries.<sup>18</sup>

In this article, we describe methods used to mitigate the effect of race misclassification in mortality records and the data sets used to improve mortality estimates for AI/AN persons, including secular trends from 1990 to 2009, for the AI/AN population overall and by geographic region, reported in the individual articles in this supplement.

## METHODS

### Data Sources

**Population estimates.** This study includes population estimates and reported deaths from 1990 to 2009. Population estimates used as denominators in the rate calculations in this supplement are based on the annual time series of July 1 estimates of county populations by age, sex, race, and Hispanic origin produced by the US Census Bureau's Population Estimates Program.<sup>19</sup> Before 2000, the Office of Management and Budget required that federal agencies report 4 single-race categories: White, Black or African American, Asian or Pacific Islander, and AI/AN. Starting in 2000, the US Census Bureau developed annual county-level

population estimates for 31 possible racial groups (5 single race and 26 multiple race) to include people who select 1, 2, 3, 4, or all 5 of the race categories. Corresponding multiple-race information was not uniformly available in state vital records (mortality data), especially in the years immediately after the transition to multiple-race reporting.<sup>20</sup> Therefore, the US Census Bureau and the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS) developed a method for bridging the 31 multiple-race categories used in the 2000 Census to the 4 single-race categories used in the 1990 Census by using information from the pooled 1997 to 2000 National Health Interview Surveys.<sup>20</sup> The bridging method takes responses to the 2000 Census' questions on race and reclassifies those responses to approximate the responses the individuals would hypothetically have given using the old single-race categories. Updated bridged single-race estimates that take into account the 2010 decennial census and population migrations during and after Hurricanes Katrina and Rita in 2005 were included as denominators in the calculations of death rates appearing in this supplement.<sup>21</sup> Development of the bridged single-race data also makes the post-2000 race/ethnicity population

estimates comparable to the pre-2000 race/ethnicity estimates and enables the reporting of a combined rate spanning 2000 as well as trend analyses.<sup>20</sup>

**Death records.** According to state laws and regulations, each death that occurs in that state must be registered and reported on a death certificate. For each death, a physician, coroner, or medical examiner typically provides clinical information documenting the cause of death. The funeral home director provides demographic and personal information, such as race and ethnicity. Death certificates are compiled at the state level yearly and are sent to the NCHS, where the data are edited for consistency and personal identifiers are removed. NCHS then makes this information available to the public in published reports and to the research community by providing the raw data (without identifiers) in electronic format as part of the National Vital Statistics System, which, in addition to deaths, includes births, marriages, divorces, and fetal deaths.<sup>1</sup> The mortality data available for analysis via the National Vital Statistics System include, but are not limited to, cause of death, state of residence, age, gender, race, and ethnicity. For the years 1990 to 1998, the underlying cause of death was coded according to the *International*

*Classification of Diseases, Ninth Revision (ICD-9).*<sup>22</sup> From 1999 to 2009, the *International Classification of Diseases, 10th Revision (ICD-10)* was used.<sup>23</sup> Trend analyses spanning ICD-9 and ICD-10 reporting years took into account comparability of cause-of-death records between the 2 revisions.<sup>24</sup> NCHS applies a bridging algorithm nearly identical to that used by the US Census Bureau to assign a single race to decedents with multiple races reported on death certificates after 2000 such that they can be compared with deaths occurring from 1990 to 1999.<sup>25</sup>

*National Death Index.* The National Death Index (NDI) is a central electronic repository maintained within the NCHS of death record information on file in individual state vital statistics offices.<sup>26</sup> NCHS works with state offices in establishing the NDI as a resource to aid epidemiologists and other investigators in the ascertainment of vital status and circumstances and cause of death. The NDI is a file of national death record information (beginning with 1979 deaths) containing personal identifiers compiled from electronic files submitted by individual state vital statistics offices. Death records are added annually, approximately 12 months from the end of the calendar year. NDI users submit as many of the following data items as possible for each study participant: first and last name, middle initial, father's surname, Social Security number, birth date, race, sex, marital status, state of residence, and state of birth. The NDI aids investigators in determining whether individuals in their database submitted to the program have died, the state in which those deaths occurred, the date of death, the death certificate number, and cause of death.<sup>26</sup>

*Indian Health Service patient registration database.* In the mid-1980s, the IHS developed the Resource and Patient Management System to electronically capture clinical and public health data in IHS facilities.<sup>27</sup> By the early 1990s, it was widely used in IHS and IHS-funded tribal facilities, many of which have now gathered personal health information for decades. Commissioned Corps officers of the US Public Health Service or non-native spouses of AI/AN persons who seek medical services at IHS facilities are excluded from the registration database by applying the IHS "Indian Status" algorithm, based on 3 variables: beneficiary

code, tribal code, and blood quantum (representing the proportion of native ancestry). Individual tribes determine the degree of tribal ancestry necessary for tribal membership, which, in turn, determines eligibility to receive services from the IHS.<sup>28</sup>

### Data Linkage

We submitted the IHS patient registration database to the NDI program for linkage to identify AI/AN deaths misclassified as non-AI/AN deaths. NDI conducted the linkages using a 2-step process. In the first step, the NDI program selected potential death record matches on the basis of a set of 7 matching criteria using key patient identifiers (Social Security number, first name, last name, middle initial, date of birth, sex, and date of death). The second step involved a procedure resulting in a probabilistic score or weight of a potential match pair and a suggested determination of final match status by NCHS.<sup>29</sup> After the linkage, NDI staff sent the results to Centers for Disease Control and Prevention project staff assigned to the IHS Division of Epidemiology and Disease Prevention in Albuquerque, New Mexico, for review. Two reviewers independently examined pairs with intermediate final weights (designated as "clerical reviews"). Each reviewer assigned a status of match or non-match by comparing personal identifying fields in each record. Any discrepancies between these 2 reviewers were adjudicated by a third reviewer.

### Analytic Data Set

*AI/AN Mortality Database.* The AI/AN Mortality Database (AMD) includes all deaths for all races reported to NCHS from 1990 to 2009. After the linkage of IHS patient registration data with NDI and the completion of the clerical review process, we returned the state death certificate number and year of death of IHS clients to NCHS to merge back to the National Vital Statistics System mortality file. NCHS added a variable to indicate linkage to the IHS registration file (IHS link), which served as a supplemental indicator of AI/AN ancestry to the death certificate race. NCHS stripped this file of personal identifiers and death certificate numbers, and we combined the resulting file with the updated bridged single-race intercensal population

estimates as denominators, thus creating the AMD.

*Classification of race and ethnicity in the AI/AN Mortality Database.* Current Office of Management and Budget standards include the following minimum categories for the collection of race information: AI/AN, Asian, Black or African American, Native Hawaiian or other Pacific Islander, and White.<sup>30</sup> These race categories represent social, cultural, and political characteristics as well as ancestry and are not genetically or biologically based.<sup>30</sup> The current Office of Management and Budget standards also allow multiple-race data collection and reporting by federal agencies.<sup>30</sup>

The reporting of decedents' race and Hispanic ethnicity is the responsibility of funeral home directors, and NCHS has issued guidelines for the collection of this information.<sup>10</sup> Race categories used by state vital statistics offices are specified by NCHS and correspond to the race categories used by the US Census Bureau to allow calculation of race-specific death rates. A 2003 revision to the US Standard Certificate of Death allowed the reporting of more than 1 race.<sup>31</sup> In the AMD, we considered decedents AI/AN if they were classified as such by the NCHS in the National Vital Statistics System file or if there was a positive IHS link. Race is coded independently of Hispanic/Latino origin, and race and ethnicity are not mutually exclusive categories.<sup>30</sup> Hispanic origin became a part of the US Standard Death Certificate in the 1989 revision. Before this revision, some states collected Hispanic origin on the death certificate; however, missing information for this item was common.<sup>2</sup> By 1990, only Louisiana, New Hampshire, and Oklahoma were not including Hispanic origin on death certificates, and most other states had missing rates well below 1% for this field. State coverage was complete beginning in 1997.<sup>2</sup> All of our analyses exclude data from those states for the years in which they were not reporting Hispanic ethnicity.<sup>2</sup>

During preliminary analyses, we learned that the updated bridged intercensal population estimates significantly overestimated AI/AN persons of Hispanic origin.<sup>32</sup> Therefore, to avoid underestimating mortality and cancer incidence in AI/AN persons, reports in this supplement based on the AMD and cancer registry data linked to IHS are limited to

non-Hispanic AI/AN persons. Non-Hispanic White was chosen as the most homogeneous referent group. Henceforth, the term “non-Hispanic” is omitted when discussing both groups, as has been done previously.<sup>33</sup>

**Geographic Coverage**

Most of the analyses in this supplement were restricted to IHS Contract Health Service Delivery Area or Tribal Service Delivery Area counties (CHSDA counties) that, in general, contain federally recognized tribal reservations or off-reservation trust lands or are adjacent to them (Figure 2). For death rates restricted to CHSDA counties, data from counties within 35 states were included. CHSDA residence is used by the IHS to determine eligibility for services not directly available within the IHS. IHS also uses CHSDA designation for routine mortality reporting.<sup>12</sup> Linkage studies involving IHS patient registration records as well as National Longitudinal Mortality Study data indicate less misclassification of race for AI/AN persons in these counties.<sup>2,34</sup> The CHSDA counties also have higher proportions of AI/AN persons in relation to total population

than do non-CHSDA counties, with 64% of the US AI/AN population residing in the 637 counties designated as CHSDA (representing 20% of the 3141 counties in the United States; Table 1). Although less geographically representative (Figure 2), analyses restricted to CHSDA counties are presented for death rates in this article for the purpose of offering improved accuracy in interpreting mortality statistics for AI/AN individuals.

We completed analyses for all regions combined and by individual IHS region: Northern Plains, Alaska, Southern Plains, Southwest, Pacific Coast, and East (Figure 2). Identical or similar analyses using these regions have been conducted for other health-related publications focusing on AI/AN populations.<sup>35-37</sup>

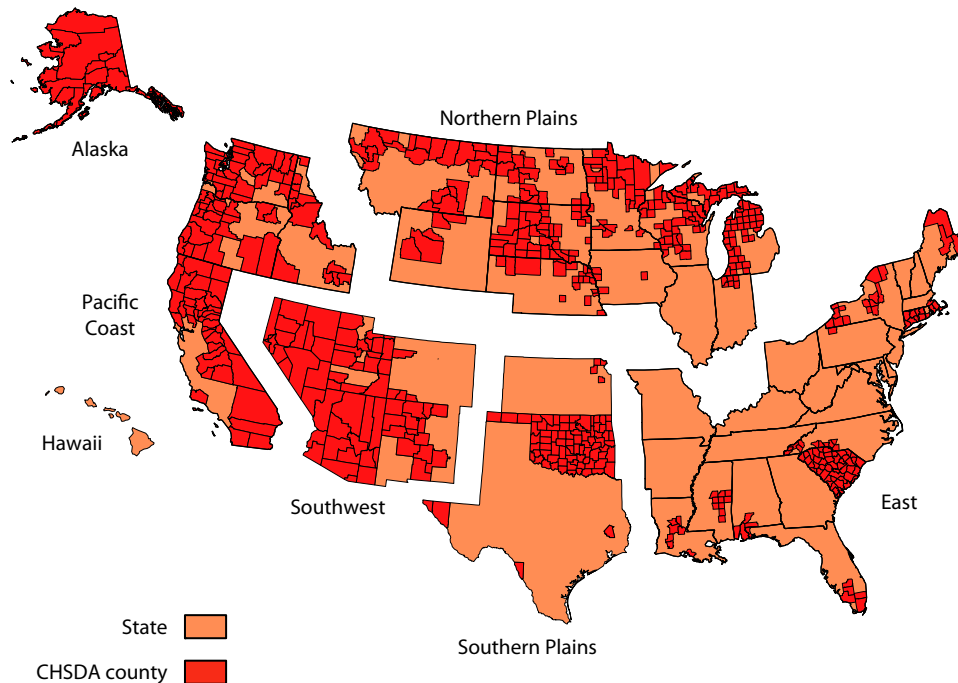
**Statistical Methods**

All rates, expressed per 100 000 population, were directly age adjusted, using SEER\*Stat software, version 8.0.4 (National Cancer Institute, Bethesda, MD),<sup>38</sup> to the 2000 US standard population and using, except where otherwise noted, 11 age groups (> 1 year, 1–4 years, 5–14 years, 15–24 years,

25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, 75–84 years, and ≥ 85 years) in accordance with a 1998 US Department of Health and Human Services recommendation.<sup>39,40</sup> Readers should avoid comparison of these data with published death rates adjusted using a different standard population.

Using the age-adjusted death rates, we calculated standardized rate ratios for AI/AN populations using White rates for comparison. Rate ratios calculated by the reader from rounded rates presented in the tables may not correspond to the rate ratios calculated by SEER\*Stat before rounding. We calculated confidence intervals for age-adjusted rates and standardized rate ratios on the basis of methods described by Tiwari et al.<sup>41</sup> using SEER\*Stat 8.0.4 and presented them in these reports to the second decimal point.

We assessed temporal changes in annual age-adjusted incidence and death rates with joinpoint regression techniques using statistical software developed by the National Cancer Institute (Bethesda, MD).<sup>42</sup> Joinpoint analyses spanning ICD-9 and ICD-10 were conducted



Note. CHSDA = Contract Health Service Delivery Area.

**FIGURE 2—States and Contract Health Service Delivery Area counties by Indian Health Service Region: United States, 2009.**

**TABLE 1—Population Coverage of Mortality Data for AI/AN Persons and Whites, by Geographic Area: Contract Health Service Delivery Area Counties and All Counties, United States, 2009**

Area	AI/AN			White			
	AI/AN Population in All Counties	AI/AN Population Resident in CHSDA Counties	% AI/AN Population Resident in CHSDA Counties	% All Races Population That is AI/AN in CHSDA Counties	White Population in All Counties	White Population Resident in CHSDA Counties	% All Races Population That is White in CHSDA Counties
Northern Plains	439 445	284 560	64.8	3.1	37 452 086	7 857 893	21.0
Alaska	114 207	114 207	100.0	16.3	471 660	471 660	100.0
Southern Plains	468 408	357 204	76.3	7.5	16 494 077	2 939 922	17.8
Southwest	543 851	496 480	91.3	4.3	11 890 700	6 842 577	57.5
Pacific Coast	390 765	278 583	71.3	1.2	25 232 525	13 891 541	55.1
East	595 475	108 286	18.2	0.5	108 389 242	13 757 313	12.7
Total	2 552 151	1 639 320	64.2	2.3	199 930 290	45 760 906	22.9

Note. AI/AN = American Indian/Alaska Native; CHSDA = Contract Health Service Delivery Areas. Analysis excludes all Hispanics. Indian Health Services regions are defined as follows: Alaska;<sup>a</sup> Northern Plains (IL, IN,<sup>a</sup> IA,<sup>a</sup> MI,<sup>a</sup> MN,<sup>a</sup> MT,<sup>a</sup> NE,<sup>a</sup> ND,<sup>a</sup> SD,<sup>a</sup> WI,<sup>a</sup> WY<sup>a</sup>); Southern Plains (OK,<sup>a</sup> KS,<sup>a</sup> TX<sup>a</sup>); Southwest (AZ,<sup>a</sup> CO,<sup>a</sup> NV,<sup>a</sup> NM,<sup>a</sup> UT<sup>a</sup>); Pacific Coast (CA,<sup>a</sup> ID,<sup>a</sup> OR,<sup>a</sup> WA,<sup>a</sup> HI); and East (AL,<sup>a</sup> AR, CT,<sup>a</sup> DE, FL,<sup>a</sup> GA, KY, LA,<sup>a</sup> ME,<sup>a</sup> MD, MA,<sup>a</sup> MS,<sup>a</sup> MO, NH, NJ, NY,<sup>a</sup> NC,<sup>a</sup> OH, PA,<sup>a</sup> RI,<sup>a</sup> SC,<sup>a</sup> TN, VT, VA, WV, DC).

Source. County-level population files, single-year age groups, 1990–2011, expanded races by origin. US Census Bureau/National Center for Health Statistics, Centers for Disease Control and Prevention/National Cancer Institute (<http://seer.cancer.gov/popdata>).

<sup>a</sup>Identifies states with at least 1 county designated as CHSDA. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: Northern Plains = 64.8%; Alaska = 100%; Southern Plains = 76.3%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; total US = 64.2%.

only for cause-of-death recodes with comparability ratios close to 1.<sup>24</sup>

**Analysis for Cancer Articles**

Data sources and analytic methods for cancer incidence and stage at diagnosis in the supplement articles addressing cancer burden in AI/AN persons are explained in the cancer overview article by White et al.<sup>18</sup>

**RESULTS**

Summary results of the linkages are presented in Table 2. Briefly, for the 176 137 decedents whose record linked to the IHS patient registration database for the period

1990–2009, misclassification of AI/AN persons as another race on the death certificate for all regions combined was 17.7% and ranged from 6.3% in the Southwest to 35.6% in the Southern Plains.<sup>34</sup>

We demonstrate the impact of restricting analyses to non-Hispanic AI/AN persons in Table 3, in which the difference for all-cause death rates in non-Hispanic AI/AN decedents and all AI/AN decedents from 2000 to 2009 is shown by region and gender. The percentage of change between the 2 methods for both sexes combined ranges from a 0.6% increase in Alaska to a 25.8% increase in rates in the Pacific Coast. Similar changes between the 2 methods are also reflected in the rate ratios

comparing AI/AN individuals with Whites. The time period for Table 3 begins in 2000 to match the year of onset of the overestimation of Hispanic AI/AN persons described earlier.

Analyses in CHSDA counties resulted in overall higher death rates for AI/AN persons than did analyses for all counties combined (Table 4). Excluding the Alaska region, which is entirely CHSDA, increases ranged from 1.8% in the Southwest region to 39.1% in the East region. The change for all regions combined was 20.9%. Updating the race field on the basis of the linkage results increased the all-cause death rates for the period 1999 to 2009 in CHSDA counties in all regions combined from 964 deaths to 1166 deaths per 100 000, a 17.3% difference.<sup>34</sup> The largest change, 40.9%, was noted in the Southern Plains region, where the rate increased from 932 deaths to 1313 deaths per 100 000.

**DISCUSSION**

The methods used in this supplement enhance AI/AN mortality surveillance by addressing race misclassification and by including analyses by geographic region. Linkages of IHS registration data to death records in the NDI and restriction of analyses to CHSDA counties are efficient ways of reducing the proportion of AI/AN decedents misclassified as

**TABLE 2—Percentage of Misclassification as a Non-AI/AN Person of NDI Decedents Linked With the IHS Patient Registration Database, by IHS Region: United States, 1990–2009**

Region	AI/AN Decedents, No.	Non-AI/AN Decedents, No.	% Misclassification
Northern Plains	34 731	4033	10.4
Alaska	12 888	894	6.5
Southern Plains	22 196	12 247	35.6
Southwest	49 945	3338	6.3
Pacific Coast	19 333	7413	27.7
East	5909	3210	35.2
Total	145 002	31 135	17.7

Note. AI/AN = American Indian/Alaska Native; NDI = National Death Index; IHS = Indian Health Service.

**TABLE 3—All-Cause Death Rates for Non-Hispanic AI/AN Persons and All AI/AN Persons Compared With Non-Hispanic Whites, by IHS Region and Sex: CHSDA Counties, United States, 2000–2009**

IHS Region and Sex	Non-Hispanic AI/AN <sup>a</sup>					All AI/AN <sup>b</sup>					% Change in Non-Hispanic AI/AN vs All AI/AN
	AI/AN Count	AI/AN Rate	White Count	White Rate	AI/AN:White RR (95% CI)	AI/AN Count	AI/AN Rate	White Count	White Rate	AI/AN:White RR (95% CI)	
<b>Northern Plains</b>											
Male and female	21 388	1449.9	714 793	765.6	1.89* (1.86, 1.92)	21 635	1411.4	714 793	765.6	1.84* (1.82, 1.87)	2.7
Male	11 666	1737.0	351 148	920.3	1.89* (1.84, 1.93)	11 823	1683.5	351 148	920.3	1.83* (1.79, 1.87)	3.2
Female	9722	1232.0	363 645	645.5	1.91* (1.87, 1.95)	9812	1203.3	363 645	645.5	1.86* (1.82, 1.91)	2.4
<b>Alaska</b>											
Male and female	7939	1219.0	21 785	735.3	1.66* (1.61, 1.71)	8019	1211.2	21 785	735.3	1.65* (1.60, 1.69)	0.6
Male	4400	1431.2	12 530	853.2	1.68* (1.61, 1.75)	4449	1421.0	12 530	853.2	1.67* (1.60, 1.74)	0.7
Female	3539	1040.4	9255	625.5	1.66* (1.60, 1.73)	3570	1034.4	9255	625.5	1.65* (1.59, 1.72)	0.6
<b>Southern Plains</b>											
Male and female	28 039	1317.6	326 476	927.5	1.42* (1.40, 1.44)	28 442	1288.0	326 476	927.5	1.39* (1.37, 1.41)	2.3
Male	14 717	1572.8	160 136	1098.3	1.43* (1.41, 1.46)	14 962	1534.7	160 136	1098.3	1.40* (1.37, 1.42)	2.5
Female	13 322	1121.0	166 340	791.0	1.42* (1.39, 1.44)	13 480	1096.9	166 340	791.0	1.39* (1.36, 1.41)	2.2
<b>Southwest</b>											
Male and female	30 615	1015.6	613 792	786.4	1.29* (1.28, 1.31)	32 218	944.1	613 792	786.4	1.20* (1.19, 1.22)	7.6
Male	17 332	1252.3	318 295	920.3	1.36* (1.34, 1.38)	18 337	1151.5	318 295	920.3	1.25* (1.23, 1.27)	8.8
Female	13 283	823.8	295 497	668.9	1.23* (1.21, 1.25)	13 881	772.6	295 497	668.9	1.16* (1.13, 1.18)	6.6
<b>Pacific Coast</b>											
Male and female	19 259	1097.5	1 329 768	791.8	1.39* (1.36, 1.41)	20 608	872.1	1 329 768	791.8	1.10* (1.08, 1.12)	25.8
Male	10 049	1242.4	657 797	927.5	1.34* (1.31, 1.37)	10 857	972.3	657 797	927.5	1.05* (1.02, 1.07)	27.8
Female	9210	978.8	671 971	680.9	1.44* (1.41, 1.47)	9751	786.4	671 971	680.9	1.16* (1.13, 1.18)	24.5
<b>East</b>											
Male and female	5707	826.0	1 415 749	791.3	1.04* (1.01, 1.07)	5779	719.8	1 415 749	791.3	0.91* (0.88, 0.94)	14.8
Male	2978	928.1	681 805	951.1	0.98 (0.94, 1.02)	3024	797.7	681 805	951.1	0.84* (0.80, 0.87)	16.3
Female	2729	737.3	733 944	667.9	1.10* (1.06, 1.15)	2755	649.8	733 944	667.9	0.97 (0.93, 1.01)	13.5
<b>Total</b>											
Male and female	112 947	1165.3	4 422 363	794.7	1.47* (1.46, 1.48)	116 701	1064.6	4 422 363	794.7	1.34* (1.33, 1.35)	9.5
Male	61 142	1381.3	2 181 711	942.4	1.47* (1.45, 1.48)	63 452	1250.3	2 181 711	942.4	1.33* (1.31, 1.34)	10.5
Female	51 805	990.9	2 240 652	675.8	1.47* (1.45, 1.48)	53 249	912.0	2 240 652	675.8	1.35* (1.34, 1.36)	8.7

Note. AI/AN = American Indian/Alaska Native; CHSDA = Contract Health Service Delivery Areas; CI = confidence interval; IHS = Indian Health Service; RR = rate ratio. AI/AN race was created using death certificate race and IHS link. Rates are per 100 000 people and are age adjusted to the 2000 US standard population (11 age groups; Census P25-1130). RRs calculated in SEER\*Stat before rounding of rates and may not equal RRs calculated from rates presented in table. IHS regions are defined as follows: Alaska;<sup>c</sup> Northern Plains (IL, IN, IA, MI, MN, MT, NE, ND, SD, WI, WY); Southern Plains (OK, KS, TX); Southwest (AZ, CO, NV, NM, UT); Pacific Coast (CA, ID, OR, WA, HI); and East (AL, AR, CT, DE, FL, GA, KY, LA, ME, MD, MA, MS, MO, NH, NJ, NY, NC, OH, PA, RI, SC, TN, VT, VA, WV, DC).

Source. AI/AN Mortality Database (1990–2009).

<sup>a</sup>Includes only AI/AN of non-Hispanic origin.

<sup>b</sup>Includes all AI/AN, regardless of Hispanic origin.

<sup>c</sup>Identifies states with at least 1 county designated as CHSDA. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: Northern Plains = 64.8%; Alaska = 100%; Southern Plains = 76.3%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; total US = 64.2%.

\*P < .05.

non-AI/AN and reducing bias toward underestimation in mortality data among AI/AN persons. The supplement also includes data from 50 state cancer registries and the District of Columbia, including 35 of the 50 states containing CHSDA counties, and is therefore the most comprehensive

analysis of cancer incidence in AI/AN populations to date.

Findings from the articles in this supplement indicate that wide regional variation is characteristic of AI/AN mortality and that region-specific data are essential to characterize AI/AN mortality patterns and disparities. In

general, death rates among AI/AN populations in CHSDA counties were highest in Alaska and the Northern and Southern Plains. The wide regional variations may, in part, reflect geographic variations in environmental, social, and personal determinants of health.<sup>43</sup> Research designed to understand regional variations in

**TABLE 4—All-Cause Death Rates for American Indians/Alaska Natives Compared With Whites, by IHS Region and Sex: United States, 1999–2009**

IHS Region and Sex	CHSDA Counties					All Counties				
	AI/AN Count	AI/AN Rate	White Count	White Rate	AI/AN:White RR (95% CI)	AI/AN Count	AI/AN Rate	White Count	White Rate	AI/AN:White RR (95% CI)
<b>Northern Plains</b>										
Male and female	23 331	1461.8	786 392	770.6	1.90* (1.87, 1.93)	31 188	1242.9	3 843 218	787.1	1.58* (1.56, 1.60)
Male	12 709	1748.8	386 164	927.4	1.89* (1.84, 1.93)	16 812	1484.9	1 846 384	947.8	1.57* (1.54, 1.60)
Female	10 622	1243.4	400 228	649.2	1.92* (1.88, 1.96)	14 376	1064.5	1 996 834	666.6	1.60* (1.57, 1.63)
<b>Alaska</b>										
Male and female	8616	1218.6	23 621	738.2	1.65* (1.61, 1.70)	8616	1218.6	23 621	738.2	1.65* (1.61, 1.70)
Male	4771	1431.6	13 600	856.8	1.67* (1.61, 1.74)	4771	1431.6	13 600	856.8	1.67* (1.61, 1.74)
Female	3845	1041.2	10 021	627.3	1.66* (1.60, 1.73)	3845	1041.2	10 021	627.3	1.66* (1.60, 1.73)
<b>Southern Plains</b>										
Male and female	30 421	1313.1	358 711	928.7	1.41* (1.40, 1.43)	35 130	1159.6	1 758 152	859.7	1.35* (1.33, 1.36)
Male	15 946	1568.7	175 778	1102.2	1.42* (1.40, 1.45)	18 391	1359.5	858 447	1018.7	1.33* (1.31, 1.36)
Female	14 475	1116.3	182 933	790.9	1.41* (1.39, 1.44)	16 739	1001.1	899 705	733.6	1.36* (1.34, 1.39)
<b>Southwest</b>										
Male and female	33 325	1017.8	669 622	789.7	1.29* (1.27, 1.30)	35 366	1000.0	1 052 569	776.8	1.29* (1.27, 1.30)
Male	18 836	1251.4	347 628	926.2	1.35* (1.33, 1.37)	19 916	1218.4	536 547	909.7	1.34* (1.32, 1.36)
Female	14 489	828.1	321 994	670.4	1.24* (1.21, 1.26)	15 450	821.5	516 022	664.2	1.24* (1.22, 1.26)
<b>Pacific Coast</b>										
Male and female	20 779	1091.5	1 459 406	796.0	1.37* (1.35, 1.39)	27 339	953.5	2 711 044	781.0	1.22* (1.21, 1.24)
Male	10 875	1238.3	721 856	933.7	1.33* (1.30, 1.36)	14 379	1088.3	1 327 483	916.5	1.19* (1.16, 1.21)
Female	9904	971.1	737 550	683.8	1.42* (1.39, 1.45)	12 960	842.9	1 383 561	671.4	1.26* (1.23, 1.28)
<b>East</b>										
Male and female	6172	828.7	1 559 313	795.7	1.04* (1.01, 1.07)	24 738	595.7	12 136 547	824.8	0.72* (0.71, 0.73)
Male	3231	939.1	750 611	957.7	0.98 (0.94, 1.02)	13 095	691.7	5 872 696	988.2	0.70* (0.69, 0.71)
Female	2941	735.4	808 702	671.0	1.10* (1.06, 1.14)	11 643	518.3	6 263 851	698.3	0.74* (0.73, 0.76)
<b>Total</b>										
Male and female	122 644	1165.9	4 857 065	798.8	1.46* (1.45, 1.47)	162 377	964.4	21 525 151	812.2	1.19* (1.18, 1.19)
Male	66 368	1381.8	2 395 637	948.8	1.46* (1.44, 1.47)	87 364	1135.2	10 455 157	969.1	1.17* (1.16, 1.18)
Female	56 276	991.5	2 461 428	678.6	1.46* (1.45, 1.47)	75 013	827.3	11 069 994	689.9	1.20* (1.19, 1.21)

Note. AI/AN = American Indian/Alaska Native; CHSDA = Contract Health Service Delivery Areas; CI = confidence interval; IHS = Indian Health Service; RR = rate ratio. Includes only AI/AN and Whites of non-Hispanic origin. AI/AN race was created using death certificate race and IHS link. Rates are per 100 000 people and are age adjusted to the 2000 US standard population (11 age groups; Census P25-1130). RRs calculated in SEER\*Stat before rounding of rates and may not equal RR calculated from rates presented in table. IHS regions are defined as follows: Alaska;<sup>a</sup> Northern Plains (IL, IN,<sup>a</sup> IA,<sup>a</sup> MI,<sup>a</sup> MN,<sup>a</sup> MT,<sup>a</sup> NE,<sup>a</sup> ND,<sup>a</sup> SD,<sup>a</sup> WI,<sup>a</sup> WY<sup>a</sup>); Southern Plains (OK,<sup>a</sup> KS,<sup>a</sup> TX<sup>a</sup>); Southwest (AZ,<sup>a</sup> CO,<sup>a</sup> NV,<sup>a</sup> NM,<sup>a</sup> UT<sup>a</sup>); Pacific Coast (CA,<sup>a</sup> ID,<sup>a</sup> OR,<sup>a</sup> WA,<sup>a</sup> HI); and East (AL,<sup>a</sup> AR,<sup>a</sup> CT,<sup>a</sup> DE, FL,<sup>a</sup> GA, KY, LA,<sup>a</sup> ME,<sup>a</sup> MD, MA,<sup>a</sup> MS,<sup>a</sup> MO, NH, NJ, NY,<sup>a</sup> NC,<sup>a</sup> OH, PA,<sup>a</sup> RI,<sup>a</sup> SC,<sup>a</sup> TN, VT, VA, WV, DC).

Source. AI/AN Mortality Database (1990–2009).

<sup>a</sup>Identifies states with at least 1 county designated as CHSDA. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: Northern Plains = 64.8%; Alaska = 100%; Southern Plains = 76.3%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; total US = 64.2%.

\*P < .05.

disease risk may help identify appropriate prevention and control strategies.

**Limitations**

Several limitations should be considered when interpreting the results presented in this supplement. First, although linkage with the IHS patient registration database improves the classification of race for many AI/AN decedents, the issue is not completely resolved

because AI/AN people who are not members of federally recognized tribes are not eligible for IHS services and are therefore not represented in the IHS registration database. Additionally, some decedents may have been eligible for—but never used—IHS services and were therefore not included in the IHS registration database. Second, the findings from CHSDA counties highlighted in this supplement do not represent all AI/AN populations in

the United States or in individual IHS regions (Table 1, Figure 2). In particular, the CHSDA portion of the East region includes only 18.2% of the total AI/AN population for that region. Furthermore, the analyses based on CHSDA designation exclude many AI/AN decedents in urban areas that are not part of a CHSDA county. AI/AN residents of urban areas differ from other AI/AN persons in poverty level, health care access, and other factors

that may influence mortality trends.<sup>44</sup> Third, these analyses revealed less variation for White than for AI/AN death rates by IHS region using data from CHSDA counties only. Perhaps alternative groupings of states or counties would reveal a different level of variation for Whites. Fourth, federally recognized tribes vary substantially in the proportion of native ancestry required for tribal membership and therefore for eligibility for IHS services. Whether and how this discrepancy in tribal membership requirements may influence some of our findings is unclear, although our findings are consistent with prior reports. Finally, although the exclusion of Hispanic AI/AN persons from the analyses reduces the overall AI/AN deaths by less than 5%, it may disproportionately exclude some tribal members in states along the US–Mexico border and possibly elsewhere who have Hispanic surnames and may be coded as Hispanic at death.

### Future Directions

Linking IHS registration records and national death records as described in this report and elsewhere in this supplement is a useful—though imperfect—tool to describe mortality patterns in AI/AN populations. To build on these efforts, we propose that the public health community and supporting agencies consider making these linkages routine until a more robust way of presenting AI/AN mortality data becomes available. Another promising approach is the development and expansion of tribal rosters, such as the Northwest tribal roster,<sup>45</sup> to complement the IHS patient registration database and further improve race classification for AI/AN individuals through the use of data linkages. The high rate of misclassification of AI/AN race on death certificates has been documented in several prior studies<sup>9,46</sup> and in this supplement.<sup>34</sup> Data linkages and analysis by IHS regions restricted to CHSDA counties has allowed substantial progress in surveillance for cancer—and now mortality—in AI/AN populations, providing the most comprehensive picture of health status in this population currently available. To build on this progress, the vital statistics community and the many partners who bring mortality surveillance to fruition should continue efforts to improve race classification and routine reporting of mortality in AI/AN populations.

These improved data should be readily available to the tribes and to their partners in the public health community to more effectively plan, implement, and evaluate disease control and health promotion programs that aim to improve the health and well-being of AI/AN people. ■

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**Note.** The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or that of the Indian Health Service.

### Contributors

D. K. Espey led the conceptualization and design of the article and the preparation of the first draft and all revisions. M. A. Jim led the analysis and interpretation of the data. T. B. Richards provided valuable feedback on drafts of the article and prepared the figures. C. Begay, D. Haverkamp, and D. Roberts reviewed and edited multiple drafts. All authors approved the final version.

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### Human Participant Protection

The study did not involve human participants, so institutional review board approval was not necessary.

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