American Indian and Alaska Native Infant and Pediatric Mortality, United States, 1999–2009

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Objectives. We described American Indian/Alaska Native (AI/AN) infant and pediatric death rates and leading causes of death.

Methods. We adjusted National Vital Statistics System mortality data for AI/AN racial misclassification by linkage with Indian Health Service (IHS) registration records. We determined average annual death rates and leading causes of death for 1999 to 2009 for AI/AN versus White infants and children. We limited the analysis to IHS Contract Health Service Delivery Area counties.

Results. The AI/AN infant death rate was 914 (rate ratio [RR] = 1.61; 95% confidence interval [CI] = 1.55, 1.67). Sudden infant death syndrome, unintentional injuries, and influenza or pneumonia were more common in AI/AN versus White infants. The overall AI/AN pediatric death rates were 69.6 for ages 1 to 4 years (RR = 2.56; 95% CI = 2.38, 2.75), 28.9 for ages 5 to 9 years (RR = 2.12; 95% CI = 1.92, 2.34), 37.3 for ages 10 to 14 years (RR = 2.22; 95% CI = 2.04, 2.40), and 158.4 for ages 15 to 19 years (RR = 2.71; 95% CI = 2.60, 2.82). Unintentional injuries and suicide occurred at higher rates among AI/AN youths versus White youths.

Conclusions. Death rates for AI/AN infants and children were higher than for Whites, with regional disparities. Several leading causes of death in the AI/AN pediatric population are potentially preventable. (*Am J Public Health.* 2014;104: S320–S328. doi:10.2105/AJPH.2013.301598)

Infant mortality is considered one of the most important indicators of a nation's health and social well-being, whereas pediatric mortality is a fundamental metric of children's health. In the United States, marked racial and ethnic disparities in infant and child mortality and morbidity have been consistently documented, but are poorly understood.[1–5]

Previous studies demonstrated a persistently high burden of infant and pediatric mortality among the American Indian/Alaska Native (AI/AN) population. For example, the infant mortality risk among AI/AN infants was approximately 76% higher than White infants in 6 states with high AI/AN populations in 1980.[6] More recently in 2009, the national infant death rate for infants of AI/AN mothers was 8.47 per 1000 live births compared with a non-Hispanic White rate of 5.33.[7] AI/AN children aged 1 to 19 years also had higher death rates than the overall US rate for children of all races.[4,8] Additionally, data available through the Indian Health Service (IHS) suggested regional differences in AI/AN infant and pediatric mortality patterns.[9]

Racial misclassification has been estimated to underreport AI/AN death rates.[10] A recent linkage between the National Vital Statistics System (NVSS) mortality data and the IHS patient registration file reduced AI/AN racial misclassification in death records.[10] We took advantage of this novel data to better describe overall and regional AI/AN infant and pediatric death rates and leading causes of death. Our analysis provides improved information that could be used to strengthen efforts to reduce racial and ethnic disparities in AI/AN infant and pediatric mortality.

METHODS

Detailed methods for generating the analytical mortality files are described elsewhere in this supplement.[10]

Population Estimates

We included bridged single-race population estimates developed by the US Census Bureau and the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS), adjusted for the population shifts because of Hurricanes Katrina and Rita in 2005, as denominators in the calculations of death rates.[11,12] Bridged single-race data allowed for comparability between the pre- and post-2000 racial/ethnic population estimates during this study.

During preliminary analyses, we discovered that the updated bridged intercensal populations estimates significantly overestimated AI/AN persons of Hispanic origin.[13] Therefore, to avoid underestimating mortality in the AI/AN populations, analyses were limited to non-Hispanic AI/AN persons. Non-Hispanic Whites were chosen as the most homogeneous referent group. For conciseness, we omitted the term "non-Hispanic" when discussing both groups.

Death Data

We obtained infant (< 1 year old) and pediatric (1–19 years of age) NVSS death records for 1999 to 2009 in the United States from the NVSS mortality data files, which included underlying and multiple causes of death, age, gender, race, and ethnicity.[14] NCHS applies a bridging algorithm nearly identical to the one used by the Census Bureau to assign a single race to decedents with multiple races reported on the death certificate; less than 1% of the AI/AN population was reported as multiple races.[15,16] We used the underlying cause of death for the present study and coded it according to the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* (*ICD-10*).[17]

We linked the Indian Health Service (IHS) patient registration database to death certificate data in the National Death Index (NDI) to identify AI/AN deaths misclassified as non-Native.[10] Following this linkage, a flag indicating a positive link to IHS was added as an

additional indicator of AI/AN ancestry to the NVSS mortality file. This file was combined with the population estimates to create an analytical file in SEER*Stat (version 8.0.2; National Cancer Institute, Bethesda, MD; AI/AN-US Mortality Database [AMD]), which includes all deaths for all races reported to NCHS from 1990 to 2009. Race for AI/AN deaths in this article was assigned as reported elsewhere in this supplement.[10] In short, it combines race classification by NCHS based on the death certificate and information derived from data linkages between the IHS patient registration database and the NDI.

Infant Mortality

We examined infant deaths for the overall infant period (birth through 364 days of age), neonatal period (birth through 27 days of age), and postneonatal period (28 through 364 days of age). Average annual infant death rates (IDRs), neonatal death rates (NDRs), and postneonatal death rates (PNDRs) were analyzed. The proportion of infant deaths that occurred during the postneonatal period was also examined and compared using the χ^2 test. The leading causes of infant death were categorized by the 71 rankable causes of infant death, which were derived from the *ICD-10* "List of 130 Selected Causes of Infant Death," as previously described.[18]

Infant death rates are typically reported per 1000 live births[7]; however, we used the AMD and US Census data to calculate IDRs, NDRs, and PNDRs per 100 000 corresponding infant population.[11,12] This alternative denominator was used to promote consistency in methods between infant and pediatric mortality measures in the present study and related studies, which are available in this supplement.[19] A comparison using publically available AI/AN infant death rates that used a per 1000 live birth denominator showed minimal overall and trend differences with the rates calculated using the census denominator.[7] Further details on the calculation of death rates using AMD and census data are available in this supplement.[10]

Pediatric Mortality

We calculated an overall age-adjusted pediatric death rate for youths 1 to 19 years of age. We analyzed average annual pediatric death rates for the following age groups: 1 to 4, 5 to 9, 10 to 14, and 15 to 19 years of age.

The leading causes of pediatric death were categorized using the 50 rankable causes of death, which were derived from the *ICD-10* "List of 113 Selected Causes of Death," as described previously.[18] The unintentional injuries were further stratified for the pediatric age groups and by region according to the external causes of injury,[20] as explained elsewhere in this supplement.[21]

Geographic Coverage

The population in the present study was limited to IHS Contract Health Service Delivery Area (CHSDA) counties, which, in general, contain federally recognized tribal reservations or off-reservation trusts, or are adjacent to them.[10] CHSDA residence is used by the IHS to determine eligibility for services not directly available within the IHS. Linkages studies indicated less misclassification of race for AI/AN persons in these counties.[22] 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 (these counties represent 20% of the 3141 counties in the United States).[10] Although less geographically representative, we restricted analyses to CHSDA counties for death rates for the purpose of offering improved accuracy in interpreting mortality statistics for AI/AN populations.

We restricted the analyses to all CHSDA counties combined and to CHSDA counties in each IHS region: Alaska, Pacific Coast, Northern Plains, Southern Plains, Southwest, and East (Table 1).[10] Similar overall and regional analyses were used for other health-related publications focusing on AI/AN populations,[5,23–25] and this approach was found to be preferable to the use of smaller jurisdictions, such as the administrative areas defined by IHS, which yielded less stable estimates.[26] Additional details about CHSDA counties and IHS regions, including population coverage, are provided elsewhere.[10,22]

Statistical Analysis

We calculated average annual infant and pediatric death rates as the number of deaths per 100 000 children of the corresponding population for 1999 to 2009. Average annual age-adjusted rates for overall pediatric deaths using the 2000 US standard population and average annual age-specific rates were calculated with SEER*Stat software (version 8.0.2; Census P25-1130).[10,11,27] We calculated standardized rate ratios (RRs) for AI/AN rates compared with corresponding White rates using SEER*Stat. We calculated the 95% confidence intervals (CIs) for the rates, and the RRs were calculated based on methods described by Tiwari et al. using SEER*Stat 8.0.2.[28,29] Statistical significance was considered at a P level of less than .05. All table cells with fewer than 10 deaths were suppressed because of data instability. Any cause of death requiring suppression because of small cell size in more than 3 regions is not shown. Research determinations were obtained from the IHS and Centers for Disease Control and Prevention (CDC). Both agencies determined that the linkages and analyses constituted a data improvement project for the purposes of surveillance and public health practice.

RESULTS

In the United States for 1999 to 2009, the AI/AN infant death rate of 914.3 was higher than the White IDR of 567.3 (RR = 1.61; 95% CI = 1.55, 1.67; Table 1). A significantly higher percentage of AI/AN infant deaths (53%) occurred during the postneonatal periods compared with White infants (34%; $P < .01$). The AI/AN neonatal death rate of 434.0 neonatal deaths was higher than the White NDR of 374.4 (RR = 1.16; 95% CI = 1.10, 1.22), as was the AI/AN postneonatal death rate of 480.4 compared with the White PNDR of 193.0 (RR = 2.49; 95% CI = 2.36, 2.63; Table 1). The AI/AN infant, neonatal, and postneonatal death rates were significantly higher for the Northern Plains region versus other regions, whereas the East region had significantly lower rates compared with overall rates ($P < .01$; Table 1).

Infant Leading Causes of Death

The top 2 leading AI/AN infant causes of death were congenital malformations (191.6 vs 134.9 for White infants [RR = 1.42; 95% CI = 1.31, 1.54]) and sudden infant death

TABLE 1—Infant, Neonatal, and Postneonatal Deaths and Average Annual Death Rates by Indian Health Services Region for American Indians/Alaska Natives Compared With Whites: Contract Health Service Delivery Area Counties, United States, 1999–2009

	AI/AN		White		
Region/Age	Count	Rate	Count	Rate	AI/AN:White RR (95% CI)
Northern Plains					
Infant	795	1163.4	5858	596.5	1.95* (1.81, 2.10)
Neonatal	377	551.7	3903	397.4	1.39* (1.25, 1.54)
Postneonatal	418	611.7	1955	199.1	3.07* (2.76, 3.42)
Alaska					
Infant	303	1295.1	323	503.7	2.57* (2.19, 3.02)
Neonatal	111	474.4	177	276.0	1.72* (1.34, 2.19)
Postneonatal	192	820.7	146	227.7	3.60* (2.89, 4.50)
Southern Plains					
Infant	540	824.5	2869	767.8	1.07 (0.98, 1.18)
Neonatal	268	409.2	1721	460.6	0.89 (0.78, 1.01)
Postneonatal	272	415.3	1148	307.2	1.35* (1.18, 1.54)
Southwest					
Infant	773	766.5	4716	559.1	1.37* (1.27, 1.48)
Neonatal	391	387.7	3131	371.2	1.04 (0.94, 1.16)
Postneonatal	382	378.8	1585	187.9	2.02* (1.80, 2.26)
Pacific Coast					
Infant	404	888.4	8381	522.6	1.70* (1.53, 1.88)
Neonatal	195	428.8	5447	339.6	1.26* (1.09, 1.46)
Postneonatal	209	459.6	2934	182.9	2.51* (2.17, 2.89)
East					
Infant	143	716.3	8948	554.6	1.29* (1.09, 1.52)
Neonatal	62	310.5	6139	380.5	0.82 (0.63, 1.05)
Postneonatal	81	405.7	2809	174.1	2.33* (1.85, 2.91)
Total					
Infant	2958	914.3	31 095	567.3	1.61* (1.55, 1.67)
Neonatal	1404	434.0	20 518	374.4	1.16* (1.10, 1.22)
Postneonatal	1554	480.4	10 577	193.0	2.49* (2.36, 2.63)

Note. AI/AN = American Indian/Alaska Native; CI = confidence interval; RR = rate ratio. Infant is defined as < 1 year; neonatal is defined as < 28 days, and postneonatal is defined as 28–364 days. Analyses are limited to persons of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the Indian Health Service patient registration database. Rates are per 100 000 persons and are age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[27] RRs are calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in table. Indian Health Service regions are defined as follows: AK[a]; Northern Plains (IL, IN,[a] IA,[a] MI,[a] MN,[a] MT,[a] NE,[a] ND,[a] SD,[a] WI,[a] WY[a]); Southern Plains (OK,[a] KS,[a] TX[a]); Southwest (AZ,[a] CO,[a] NV,[a] NM,[a] UT[a]); Pacific Coast (CA,[a] ID,[a] OR,[a] WA,[a] HI); East (AL,[a] AR, CT,[a] DE, FL,[a] GA, KY, LA,[a] ME,[a] MD, MA,[a] MS,[a] MO, NH, NJ, NY,[a] NC,[a] OH, PA,[a] RI,[a] SC,[a] TN, VT, VA, WV, DC). Percent regional coverage of AI/AN persons in Contract Health Service Delivery Area 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%.

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

[a]Identifies states with ≥ 1 county designated as Contract Health Service Delivery Area.

*$P < .05$.

syndrome (SIDS; 130.1 vs 54.3 [RR = 2.40; 95% CI = 2.16, 2.65]; Table 2). Compared with other AI/AN regions, both congenital malformations and SIDS had higher IDRs in the Alaska, Northern Plains, and Southwest regions, as well as in the Pacific Coast region for SIDS (Table A, available as a supplement to the online article at http://www.ajph.org).

Other leading infant causes of death with significantly higher IDRs for AI/AN versus White infants included unintentional injuries, homicide, and influenza or pneumonia; the greatest disparity existed for influenza or pneumonia (Table 2). In the neonatal period, congenital malformations were the most common cause of death. Bacterial sepsis, necrotizing enterocolitis, and SIDS also occurred at significantly higher rates in AI/AN versus White neonates (Table 2). The most common cause of death in the postneonatal period was SIDS. All top 10 causes of postneonatal death had significantly higher PNDRs for AI/AN post-neonates than White post-neonates. The causes with the largest disparities were influenza or pneumonia, meningitis, and homicide (Table 2).

Pediatric Mortality and Leading Causes of Death

The overall pediatric death rate for AI/AN youths to 19 years of age was 73.2 compared with 29.1 for White youths from 1999 to 2009. The overall AI/AN pediatric death rates were significantly higher than the corresponding White pediatric rates by age group: 69.6 for ages 1 to 4 years (RR = 2.56; 95% CI = 2.38, 2.75), 28.9 for ages 5 to 9 years (RR = 2.12; 95% CI = 1.92, 2.34), 37.3 for ages 10 to 14 years (RR = 2.22; 95% CI = 2.04, 2.40), and 158.4 for ages 15 to 19 years (RR = 2.71; 95% CI = 2.60, 2.82; Table 3). By region and age category, the AI/AN pediatric death rates were highest for the Alaska region across all age categories ($P < .01$) except for ages 5 to 9 years. The Northern Plains 15 to 19 years death rate was also significantly higher than the rates for the other regions ($P < .01$; Table 3).

The leading cause of AI/AN pediatric death was unintentional injuries across all age groups (29.3 for 1–4 years, 15.6 for 5–9 years, 17.7 for 10–14 years, and 84.6 for 15–19 years) with RRs ranging from 2.57 to 2.98 compared with White children (Table 4). Regionally, the highest death rates from unintentional injuries in all age groups occurred in the Alaska, Northern Plains and Southwest regions (Table B, available as a supplement to the online version of this article at http://www.ajph.org). The leading cause of unintentional injury death for all pediatric age groups was motor vehicle crashes; rates in AI/AN youths were 2 to 4

TABLE 2—Leading Rankable Causes of Infant, Neonatal, and Postneonatal Deaths and Average Annual Death Rates for American Indians/Alaska Natives, Compared With Whites: Contract Health Service Delivery Area Counties, United States, 1999–2009

Age/Cause of Death[a]	AI/AN			White		AI/AN:White RR (95% CI)
	Rank	Count	Rate	Count	Rate	
Infant						
Congenital malformations	1	620	191.6	7396	134.9	1.42* (1.31, 1.54)
SIDS	2	421	130.1	2978	54.3	2.40* (2.16, 2.65)
Disorders related to short gestation and low birth weight, NEC	3	267	82.5	3958	72.2	1.14* (1.01, 1.29)
Unintentional injuries	4	219	67.7	1283	23.4	2.89* (2.49, 3.34)
Maternal complications of pregnancy	5	101	31.2	1706	31.1	1.00 (0.81, 1.23)
Complications of placenta, cord and membranes	6	81	25.0	1224	22.3	1.12 (0.88, 1.40)
Diseases of the circulatory system	7	78	24.1	700	12.8	1.89* (1.47, 2.39)
Influenza and pneumonia	8	76	23.5	265	4.8	4.86* (3.71, 6.29)
Bacterial sepsis of newborn	9	66	20.4	761	13.9	1.47* (1.12, 1.89)
Homicide	10	62	19.2	336	6.1	3.13* (2.34, 4.11)
Neonatal						
Congenital malformations	1	396	122.4	5484	100.1	1.22* (1.10, 1.36)
Disorders related to short gestation and low birth weight, NEC	2	256	79.1	3897	71.1	1.11 (0.98, 1.26)
Maternal complications of pregnancy	3	101	31.2	1690	30.8	1.01 (0.82, 1.24)
Complications of placenta, cord, and membranes	4	80	24.7	1213	22.1	1.12 (0.88, 1.40)
Bacterial sepsis of newborn	5	62	19.2	723	13.2	1.45* (1.10, 1.88)
Necrotizing enterocolitis of newborn	6	39	12.1	347	6.3	1.90* (1.33, 2.66)
Respiratory distress of newborn	7	38	11.7	773	14.1	0.83 (0.58, 1.15)
Intrauterine hypoxia and birth asphyxia	8	36	11.1	641	11.7	0.95 (0.66, 1.33)
SIDS	9	33	10.2	276	5.0	2.03* (1.37, 2.91)
Neonatal hemorrhage	10	32	9.9	639	11.7	0.85 (0.58, 1.21)
Postneonatal						
SIDS	1	388	119.9	2702	49.3	2.43* (2.18, 2.71)
Congenital malformations	2	224	69.2	1912	34.9	1.98* (1.72, 2.28)
Unintentional injuries	3	204	63.1	1127	20.6	3.07* (2.63, 3.56)
Influenza and pneumonia	4	73	22.6	249	4.5	4.97* (3.77, 6.47)
Diseases of the circulatory system	5	62	19.2	458	8.4	2.29* (1.73, 3.00)
Homicide	6	58	17.9	296	5.4	3.32* (2.46, 4.41)
Septicemia	7	25	7.7	232	4.2	1.83* (1.16, 2.76)
Other external causes	8	20	6.2	110	2.0	3.08* (1.81, 4.99)
Gastritis, duodenitis, and noninfective enteritis and colitis	9	19	5.9	183	3.3	1.76* (1.04, 2.83)
Meningitis	10	15	4.6	59	1.1	4.31* (2.27, 7.69)

Note. AI/AN = American Indian/Alaska Native; CI = confidence interval; NEC = necrotizing enterocolitis; SIDS = sudden infant death syndrome. Infant is defined as < 1 year; neonatal is defined as < 28 days, and postneonatal is defined as 28–364 days. Analyses are limited to persons of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the Indian Health Service patient registration database. Rates are per 100 000 persons and are age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[27] RRs are calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in table. Indian Health Service regions are defined as follows: AK[b]; Northern Plains (IL, IN,[b] IA,[b] MI,[b] MN,[b] MT,[b] NE,[b] ND,[b] SD,[b] WI,[b] WY[b]); Southern Plains (OK,[b] KS,[b] TX[b]); Southwest (AZ,[b] CO,[b] NV,[b] NM,[b] UT[b]); Pacific Coast (CA,[b] ID,[b] OR,[b] WA,[b] HI); East (AL,[b] AR, CT,[b] DE, FL,[b] GA, KY, LA,[b] ME,[b] MD, MA,[b] MS,[b] MO, NH, NJ, NY,[b] NC,[b] OH, PA,[b] RI,[b] SC,[b] TN, VT, VA, WV, DC). Percent regional coverage of AI/AN persons in Contract Health Service Delivery Area 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%.

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

[a]Leading causes of death created using the National Center for Health Statistics list of 130 selected causes of infant death based on the *International Classification of Diseases, 10th Revision*.[17]

[b]Identifies states with ≥1 county designated as Contract Health Service Delivery Area.

*$P < .05$.

times higher than rates in White youths (Table C, available as a supplement to the online version of this article at http://www.ajph.org). Rates for other leading pediatric causes of unintentional injury death, including drowning, fire, poisoning, and firearm-related unintentional deaths, were significantly higher for AI/AN youths than White youths in all age groups (Table C). In the 10 to 14 and 15 to 19

TABLE 3—Pediatric Deaths and Average Annual Death Rates by Indian Health Service Region for American Indians/Alaska Natives Compared With Whites, Aged 1–19 years: Contract Health Service Delivery Area Counties, United States, 1999–2009

	AI/AN		White		
Region/Age, Years	Count	Rate	Count	Rate	AI/AN:White RR (95% CI)
Northern Plains					
1–4	197	78.8	1115	27.8	2.84* (2.43, 3.31)
5–9	95	31.4	784	14.8	2.13* (1.70, 2.60)
10–14	136	41.9	1034	17.6	2.39* (1.98, 2.86)
15–19	650	211.6	3737	59.4	3.56* (3.27, 3.87)
Alaska					
1–4	96	107.8	60	23.7	4.54* (3.26, 6.38)
5–9	45	38.4	46	14.0	2.75* (1.78, 4.24)
10–14	86	64.2	90	23.9	2.69* (1.98, 3.66)
15–19	290	233.3	238	66.3	3.52* (2.95, 4.20)
Southern Plains					
1–4	136	52.9	614	41.4	1.28* (1.05, 1.54)
5–9	109	31.5	338	18.1	1.74* (1.39, 2.16)
10–14	106	29.2	450	22.5	1.30* (1.04, 1.61)
15–19	445	124.4	1609	73.0	1.70* (1.53, 1.89)
Southwest					
1–4	276	72.3	982	29.6	2.45* (2.13, 2.80)
5–9	140	29.3	559	13.7	2.15* (1.77, 2.59)
10–14	233	42.4	809	18.6	2.27* (1.96, 2.63)
15–19	876	165.3	2857	64.8	2.55* (2.36, 2.75)
Pacific Coast					
1–4	106	59.8	1664	25.9	2.31* (1.88, 2.82)
5–9	51	21.7	1129	13.2	1.65* (1.22, 2.18)
10–14	75	27.0	1547	15.9	1.69* (1.32, 2.14)
15–19	346	124.7	5380	53.9	2.31* (2.07, 2.58)
East					
1–4	42	59.0	1594	24.0	2.46* (1.77, 3.35)
5–9	12	13.6	1101	12.4	1.10 (0.56, 1.92)
10–14	16	16.6	1438	15.1	1.10 (0.63, 1.79)
15–19	80	80.3	5451	56.2	1.43* (1.13, 1.78)
Total					
1–4	853	69.6	6029	27.2	2.56* (2.38, 2.75)
5–9	452	28.9	3957	13.6	2.12* (1.92, 2.34)
10–14	652	37.3	5368	16.9	2.22* (2.04, 2.40)
15–19	2687	158.4	19 272	58.4	2.71* (2.60, 2.82)

Note. AI/AN = American Indian/Alaska Native; CI = confidence interval; RR = rate ratio. Analyses are limited to persons of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the Indian Health Service patient registration database. Rates are per 100 000 persons and are age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[27] RRs are calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in table. Indian Health Service regions are defined as follows: AK[a]; Northern Plains (IL, IN,[a] IA,[a] MI,[a] MN,[a] MT,[a] NE,[a] ND,[a] SD,[a] WI,[a] WY[a]); Southern Plains (OK,[a] KS,[a] TX[a]); Southwest (AZ,[a] CO,[a] NV,[a] NM,[a] UT[a]); Pacific Coast (CA,[a] ID,[a] OR,[a] WA,[a] HI); East (AL,[a] AR, CT,[a] DE, FL,[a] GA, KY, LA,[a] ME,[a] MD, MA,[a] MS,[a] MO, NH, NJ, NY,[a] NC,[a] OH, PA,[a] RI,[a] SC,[a] TN, VT, VA, WV, DC). Percent regional coverage of AI/AN persons in Contract Health Service Delivery Area 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%.

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

[a]Identifies states with ≥ 1 county designated as Contract Health Service Delivery Area.

*$P < .05$.

year olds, suicide was the second leading cause of death, with higher rates compared with those for the White age groups (RR = 4.50; 95% CI = 3.58, 5.61; and RR = 3.65; 95% CI = 3.33, 4.00, respectively; Table 4). The highest suicide rates occurred in the 15 to 19 years group in the Alaska, Northern Plains, and Southwest regions (Table B). Influenza and pneumonia deaths occurred at significantly higher rates in AI/AN children than White children across all age groups, with RRs ranging from 2.22 to 4.52 (Table 4).

DISCUSSION

Our analysis of AI/AN infant and pediatric death rates used current and novel national mortality data, which allowed for more reliable estimation of death rates for AI/AN persons in the CHSDA counties. We illustrated that there were marked racial disparities in death rates between AI/AN and White infants and children, as also shown in previous studies.[2–4,6,8,30,31] Similar to previous reports, the AI/AN postneonatal death rate was more markedly elevated than the White PNDR compared with their respective NDRs.[4,7,8] This disproportionately higher AI/AN postneonatal death rate supported previous studies that suggested that factors following discharge to home, such as maternal socioeconomic and behavioral factors, primary health care access and utilization, and infant care issues influenced AI/AN infant mortality.[32–35] In addition, preterm and low birth weight were reported,[36,37] with previous studies finding a lack of uniformity in access to adequate prenatal and perinatal care for pregnant AI/AN women.[31,37]

Similar to previous reports of mortality disparities between AI/AN and White children,[8,31] we revealed that overall pediatric death rates for AI/AN children were higher than those for White children, across all age groups and most regions. Elevated rates of high-risk behaviors, such as substance abuse and emotional distress, have been reported for AI/AN adolescents, which likely contributed to their higher rates of unintentional injury, homicide, and suicide, all of which were leading causes of AI/AN pediatric death.[31,38] In states with reservations, an estimated 65% of motor vehicle–related deaths, 75% of suicides, and 80% of homicides among AI/ANs involved alcohol.[39]

TABLE 4—Leading Rankable Causes of Pediatric Deaths and Average Annual Death Rates for American Indians/Alaska Natives, Compared With Whites, 1–19 years: Contract Health Service Delivery Area Counties, United States, 1999–2009

	AI/AN			White		
Age, Years/Cause of Death[a]	Rank	Count	Rate	Count	Rate	AI/AN:White RR (95% CI)
1–4						
Unintentional injuries	1	358	29.3	2257	10.2	2.88* (2.57, 3.22)
Homicide	2	73	5.9	378	1.7	3.48* (2.67, 4.48)
Congenital malformations	3	66	5.4	630	2.8	1.88* (1.44, 2.43)
Malignant neoplasms	4	32	2.7	588	2.7	1.00 (0.68, 1.43)
Diseases of heart	5	28	2.3	173	0.8	2.91* (1.88, 4.36)
Influenza and pneumonia	6	23	1.9	145	0.7	2.87* (1.76, 4.48)
Septicemia	7	22	1.8	104	0.5	3.79* (2.27, 6.04)
5–9						
Unintentional injuries	1	244	15.6	1518	5.2	2.98* (2.60, 3.42)
Malignant neoplasms	2	33	2.1	708	2.4	0.86 (0.59, 1.22)
Congenital malformations	3	28	1.8	257	0.9	2.02* (1.32, 3.00)
Homicide	4	16	1.0	149	0.5	2.00* (1.11, 3.36)
Influenza and pneumonia	5	14	0.9	58	0.2	4.52* (2.33, 8.20)
Diseases of heart	6	11	0.7	114	0.4	1.78 (0.86, 3.31)
Septicemia	7	–	0.6	37	0.1	4.49* (1.91, 9.48)
10–14						
Unintentional injuries	1	309	17.7	2198	6.9	2.57* (2.27, 2.89)
Intentional self-harm/suicide	2	101	5.7	412	1.3	4.50* (3.58, 5.61)
Homicide	3	31	1.8	178	0.6	3.15* (2.08, 4.64)
Malignant neoplasms	4	30	1.7	705	2.2	0.77 (0.52, 1.11)
Congenital malformations	5	22	1.3	272	0.9	1.48 (0.91, 2.29)
Diseases of heart	6	16	0.9	189	0.6	1.56 (0.87, 2.60)
Septicemia	7	13	0.7	58	0.2	4.06* (2.04, 7.50)
15–19						
Unintentional injuries	1	1435	84.6	10 797	32.7	2.59* (2.45, 2.73)
Intentional self-harm/suicide	2	564	33.2	2994	9.1	3.65* (3.33, 4.00)
Homicide	3	232	13.8	878	2.7	5.17* (4.46, 5.99)
Malignant neoplasms	4	76	4.4	1091	3.3	1.34* (1.05, 1.69)
Diseases of heart	5	44	2.6	451	1.4	1.89* (1.35, 2.58)
Congenital malformations	6	27	1.6	343	1.0	1.51 (0.98, 2.23)
Influenza and pneumonia	7	15	0.9	130	0.4	2.22* (1.21, 3.80)

Note. AI/AN = American Indian/Alaska Native; CHSDA = Contract Health Service Delivery Area; CI = confidence interval; RR = rate ratio. Dashes indicate that counts less than 10 are suppressed; if no cases reported, then rates and RRs could not be calculated. Patients ages 0–24 y are included in overall totals, but rows have been suppressed because of the small number of cases. Analyses limited to persons of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the Indian Health Service patient registration database. Rates are per 100 000 persons and are age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[27] RRs are calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in table. Indian Health Service regions are defined as follows: AK[b]; Northern Plains (IL, IN,[b] IA,[b] MI,[b] MN,[b] MT,[b] NE,[b] ND,[b] SD,[b] WI,[b] WY[b]); Southern Plains (OK,[b] KS,[b] TX[b]); Southwest (AZ,[b] CO,[b] NV,[b] NM,[b] UT[b]); Pacific Coast (CA,[b] ID,[b] OR,[b] WA,[b] HI); East (AL,[b] AR, CT,[b] DE, FL,[b] GA, KY, LA,[b] ME,[b] MD, MA,[b] MS,[b] MO, NH, NJ, NY,[b] NC,[b] OH, PA,[b] RI,[b] SC,[b] TN, VT, VA, WV, DC). Percent regional coverage of AI/AN persons in Contract Health Service Delivery Area 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%.

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

[a]Leading causes of death created using the National Center for Health Statistics list of 130 selected causes of infant death based on the *International Classification of Diseases, 10th Revision*.[17]

[b]Identifies states with ≥1 county designated as Contract Health Service Delivery Area.

*$P < .05$.

Although the AI/AN population is often studied as a whole, significant geographic variations exist in the patterns and burden of disease.[8,9,19] Understanding regional disparities can inform targeted and more effective local interventions to reduce mortality and morbidity among infants and children. Among infants, the Alaska and Northern Plains regions experienced the highest overall death rates; these regional differences were demonstrated in previous mortality and morbidity studies dating back to some of the earliest surveys of AI/AN health in the 1940s.[3,34,36] Higher rates of SIDS, unintentional injuries, and influenza or pneumonia contributed to these rate disparities. Among the deaths for those aged 1 to 19 years, the Alaska, Northern Plains, and Southwest regions had the highest overall rates. The higher burden of unintentional injuries in these regions, especially among youths aged 10 to 19 years, contributed to these regional pediatric death rate disparities. Although these disparities were likely multifactorial, 1 contemporary factor contributing to all 3 might be substance use, as studies found higher prevalence or earlier initiation of tobacco, marijuana, and alcohol use among youths in the Northern Plains and Alaska regions.[40,41] Previous studies also reported higher youth mortality disparities in the Alaska region compared with other regions, especially in rural areas and among infants, that might be related to the consequences of poverty.[25,42–44]

The overall AI/AN death rate for SIDS was 2 times higher in AI/AN infants compared with White infants in this study, a finding that was consistent with studies conducted over the last 25 years.[8,45,46] Even more striking was the marked regional variation, with Alaska and Northern Plains AI/AN infants having regional rates 4 times that of White infants. The differences in SIDS rates have not been explained by socioeconomic status, maternal age, birth weight, or prenatal care.[45] The high rate of maternal cigarette use in the Alaska and Northern Plains regions and a conversely low smoking rate in the Southwest region were discussed as potential factors explaining the regional variation, but this needs further study.[45] Other SIDS risk factors identified in a case control study of Northern Plains AI/AN infants included infant overdressing and maternal alcohol use.[34] The US nationwide "Back

to Sleep" campaign established in 1991 was credited with a national decrease in the SIDS death rate.[36,47] However, disparities in AI/AN versus White infant SIDS deaths remain, indicating that the "Back to Sleep" campaign might not be enough or that the relationship between SIDS and sleeping position might be more complex in the AI/AN rural community than in urban populations.[36,48] Additionally, more recent declines and current disparities for SIDS might be a result of changing terminology and better death investigation practices.[49,50]

Unintentional injuries accounted for 41% of all deaths among AI/AN children and was the leading cause of death for all pediatric age groups.[21] AI/AN infants and youths had death rates of unintentional injuries at least double those of White infants and youths. A *Morbidity and Mortality Weekly Report* on years of potential life lost from unintentional injuries for persons ages 0 to 19 years among all racial/ethnic groups estimated an average of 890 years of potential life lost per every 100 000 persons aged 0 to 19 years. Of the approximately 12 000 pediatric deaths reported each year in the report, a higher burden occurred among AI/AN youths, again indicating the scope of this public health problem.[51] Motor vehicle crashes were the leading cause of injury-related deaths. The disparity in the AI/AN burden of motor vehicle–related deaths suggested that AI/AN youths have not benefited to the same degree as White children from interventions, such as increased child safety seat and safety-belt use.[52–54] In a survey of more than 13 000 7th to 12th grade AI/AN youths, 44% reported never wearing a seatbelt, and 38% admitted to drinking and driving.[31] These risks were found to be more prevalent among rural AI/AN drivers,[55] which might contribute to some of the regional disparities found in this study. Additionally, AI/ANs had the highest alcohol-related motor vehicle death rates of all racial/ethnic groups, with children at risk both as passengers of impaired drivers and as adolescent drivers.

Suicide was the second leading cause of death for AI/AN youths aged 10 to 19 years, with death rates at least 3 to 4 times that of White youths.[56] A national survey of AI/AN youth behavior from 1997 found that 32% of females and 22% of males reported a history of at least 1 suicide attempt.[38] Previous reports showed that firearms and hanging were the most common methods for suicide in AI/AN youths.[57] Risk factors identified for suicide in the AI/AN pediatric population include mental health disease, substance use, and violence perpetration.[58,59] Strategies that might reduce suicide deaths in AI/AN youths include integrating and promoting suicide prevention efforts across multiple settings, including enhanced social support, community connectedness, and access to mental health and preventive services.[60]

As observed in previous studies of mortality and hospitalizations related to lower respiratory tract infections, AI/AN infants and children were disproportionately affected by influenza and pneumonia deaths.[3,25,43,61,62] Although overall rates declined, our findings indicated that the disparity persists. Regionally, influenza or pneumonia death rates were highest in the Southwest and Alaska regions, as also noted in a study of lower respiratory tract infection hospitalizations in AI/AN children.[62] Higher rates in these regions may be related to increased likelihood of children living on reservations or in traditional rural villages, living below the poverty line, in crowded households, or without indoor plumbing compared with White youths.[63] As part of the efforts to address this preventable disparity, the IHS implemented vigorous immunization efforts, which resulted in a decrease in *Haemophilus influenza* type b and pneumococcal invasive disease.[64–66] The introduction of the 13-valent and 23-valent pneumococcal vaccines, as well as expansion of influenza vaccination among AI/AN children, might further reduce the disparity gaps.[67,68]

Limitations

This study utilized a novel national mortality data set that reduced AI/AN racial misclassification on death certificates through linkage with the IHS electronic health records, although some AI/AN racial misclassification on death records might have remained. There was substantial variation between federally recognized tribes 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 might influence some of our findings was unclear, although our findings were consistent with previous reports. In addition, individuals of mixed race ancestry who used the IHS health care system benefits might or might not consider themselves to be AI/AN and might differ demographically from those AI/AN persons who did not.[10] Furthermore, this study was limited to non-Hispanic AI/AN individuals and to those residing in CHSDA counties. Although the exclusion of Hispanic AI/AN persons from the analyses reduced the overall count of deaths among AI/AN populations by less than 5%, it might disproportionately affect some states. AI/AN residents in urban areas were less likely to live in CHSDA counties, which might affect results because AI/AN residents of urban areas differed from all AI/AN people in poverty levels and health care access.[69,70]

We were also limited in our ability to examine some of the leading causes of death regionally by the small number of infant and pediatric deaths, which had to be suppressed for data instability.[10] In addition, we used the underlying rather than multiple cause of death data; this conservative method may have underestimated the rates for specific causes of death, which might not have been listed as the underlying cause of death. Finally, trends over time in AI/AN infant and pediatric mortality were outside the scope of this study, but these trends are important to examine in the future.

Conclusions

Death rates for AI/AN infants and children were higher than for White infants and children, with significant regional disparities. Several of the leading causes of death with higher rates in AI/AN infants and youths are preventable, such as unintentional injuries and influenza or pneumonia. Others, such as SIDS and suicide, had risk factors that could be targeted among the AI/AN population. Implementing and strengthening prevention strategies and improved tracking of AI/AN infant and pediatric mortality should contribute to reductions in health disparities for AI/AN infants and children.

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This article was accepted July 29, 2013.

Note. *The findings and conclusions in this article are those of the author(s) and do not necessarily represent the official position of the US Departments of Health and Human Services, CDC, or IHS.*

Contributors

All authors participated in the concept and design of the study and interpretation of data. C. A. Wong, F. C. Gachupin, M. F. MacDorman, J. E. Cheek, S. Holve, and R. J. Singleton wrote the initial draft of the article. All authors reviewed and revised the article.

Acknowledgments

We gratefully thank David Espey and Melissa Jim (CDC) for their technical contributions to this study.

Human Participant Protection

Research determinations were obtained from IHS and CDC. Both agencies determined that the linkages and analyses constituted a data improvement project for the purposes of surveillance and public health practice; therefore, no formal institutional review board approvals were required.

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