Period Life Tables for the Non-Hispanic American Indian and Alaska Native Population, 2007–2009

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Objectives. We estimated complete period life tables for the non-Hispanic American Indian and Alaska Native (AI/AN) population residing in Contract Health Service Delivery Area (CHSDA) counties for the period 2007–2009.

Methods. We used National Vital Statistics System mortality data files for years 2007–2009 corrected for AI/AN misclassification on death certificates, midyear 2008 revised census bridged race intercensal population estimates, and National Vital Statistics System birth data for years 2006–2009. We used the same methodology as that used to estimate official US annual life tables, with some minor modifications.

Results. For the period 2007–2009, the non-Hispanic AI/AN population in CHSDA counties had the lowest life expectancy at birth (71.1 years) of any racial/ethnic group for which official US life tables are estimated. By comparison, in 2008, life expectancy at birth was 73.9 years for the non-Hispanic Black population, 78.4 years for the non-Hispanic White population, and 80.8 years for the Hispanic population.

Conclusions. The life tables showed a clear mortality disadvantage for the non-Hispanic AI/AN population in CHSDA counties relative to other national populations. The findings suggested that further research is necessary to explore the causes behind these disadvantages. (*Am J Public Health.* 2014;104: S312–S319. doi:10.2105/AJPH.2013.301635)

The period life table provides a succinct snapshot of the mortality profile of a population at any given point in time. The most important life table measure and the one most widely used is the age-specific life expectancy or average number of years a person reaching a given age can expect to live. The life table also provides an easily understandable measure of the probability of dying at any particular age. As a result, the life table is widely used to describe the mortality profile of populations grouped by race, ethnicity, socioeconomic status, and other demographic and social characteristics. Official life tables for the US population have been produced decennially since 1900 and annually since 1945.[1] From its inception, the US life table program has included life tables by sex and race, with the racial categories restricted to White and Black. Starting with data year 2006, the ethnic and racial categories Hispanic, non-Hispanic White, and non-Hispanic Black were added to the program.[2] However, because of concerns over poor data quality, US life tables for other racial groups, such as the Asian, Pacific Islander, and American Indian and Alaska Native (AI/AN) populations, have to date not been included in the program.

The most significant data quality issue that has prevented the estimation of reliable life tables for these populations is the problem of ethnic and racial incongruence between the 2 data systems used to estimate the death rates that are the basis of the life table functions.[3] The denominators of the death rates are derived from census population estimates in which the ethnic and racial identity of the individual is based on the report of the respondent answering the census questionnaire for her- or himself and other members of the household. Numerators of the death rates are derived from death certificates in which the ethnic and racial identity of the decedent is typically provided by the funeral director with or without the input of next of kin. Evaluation studies of ethnic and racial agreement between these 2 data systems have consistently shown a high level of congruence for the White and Black populations, but a significant level of incongruence for other populations.[3] Assuming that the report from the respondent to the census is preferable, the problem is mainly one in which decedents' ethnic and racial identity is misclassified on the death certificate. A comparison of race as reported on the Current Population Survey, with race as reported on the death certificate for a national sample of deceased Current Population Survey respondents whose survey records were linked to their death certificates, revealed that approximately 30% of individuals who self-identified as an AI/AN person were classified as another race on the death certificates.[3]

A second important data problem, affecting all groups to varying degrees, is the underestimation of death rates at the oldest ages that results from age misstatement in both vital registration and census data.[4,5] To address this problem, the National Center for Health Statistics has traditionally used Medicare data to estimate mortality at the oldest ages.[1,5] Medicare data are considered more accurate than vital registration and census data because Medicare enrollees must have proof of age to enroll.[2] However, reliable Medicare data are available only for the Black and White racial groups. This is the result of an ethnic and racial classification system, derived from the Social Security Administration, that until relatively recently provided individuals with only 3 race categories from which to define themselves (White, Black, or other) when they applied for Social Security.[2] Other choices, including AI/AN, were added in 1980, but the result is that a significant number of individuals are still classified under the older system. For example, a linkage between Current Population Survey and 5 years of Medicare data (1991–1995) revealed that 37.6% of self-identified non-Hispanic AI/AN Current Population Survey respondents were classified as non-Hispanic White, 47.6% were classified as other, and 8.9% were classified as non-Hispanic AI/AN in the Medicare database.

The newly created AI/AN Mortality Database (AMD), which consists of National Vital Statistics System (NVSS) mortality data corrected for AI/AN misclassification through a linkage with Indian Health Service (IHS) patient registration records, dramatically reduces the problem of racial misclassification on death certificates for the AI/AN population.[6] In addition, restricting the analysis to the AI/AN population residing in the 637 Contract Health Service Delivery Area (CHSDA) counties, which generally either contain federally recognized tribal land or are adjacent to tribal lands, further mitigates the problem of racial misclassification on death certificates. For instance, although nationally, AI/AN misclassification on death certificates was found to be 30%, it was found to be around 20% for the AI/AN population residing in CHSDA counties.[3,7] Finally, methods developed to address the problem of age misstatement at the oldest ages for other population groups can be applied with some confidence in the estimation of non-Hispanic AI/AN life tables that will allow the tables to be estimated to the oldest age possible.[2]

We present period life tables for the non-Hispanic AI/AN (NH-AI/AN) population residing in CHSDA counties during the period 2007–2009. Our study population was limited to the non-Hispanic segment of the AI/AN population to avoid the underestimation of mortality in the total AI/AN population. During preliminary analyses of the AMD, we discovered that the revised bridged race intercensal population estimates produced by the Census Bureau significantly overestimated the Hispanic segment of the AI/AN population. More information about restricting analyses to the NH-AI/AN population in CHSDA counties can be found elsewhere.[6] Sixty-four percent of the NH-AI/AN population in the United States resides in the 637 CHSDA counties.[8] Although the study population included the majority of the NH-AI/AN population in the United States, important segments of this population were excluded, particularly those who resided in urban areas outside CHSDA counties who might differ with respect to poverty levels, health care access, and other socioeconomic factors that affect mortality.[9] To put the results in context, we compared the resulting NH-AI/AN life tables with the official US life tables for the non-Hispanic White, non-Hispanic Black, and Hispanic populations in 2008, the midyear of the period of interest (the versions of the life tables used are those updated with revised bridged race intercensal population estimates[10]).

METHODS

The methods used to estimate the NH-AI/AN life tables were the same as those used to estimate official annual US life tables with some minor modifications as described in detail in the following. Because of the lack of reliable vital statistics or Medicare data for ages older than 85 years, we used a statistical model (the Brass relational logit model) to estimate mortality for persons aged 85 years and older.[2] We summarized the overall methodology in the following, and we only elaborated on the modifications. A detailed description of the US life table methodology can be found elsewhere.[1]

Data

We used 3 sources of data to estimate the period life tables for the NH-AI/AN population in CHSDA counties: death counts from death certificates, birth counts from birth certificates, and census population estimates. We used 3 years (2007–2009) of final sex- and age-specific death counts for ages 0 to 99 years from the AMD data files. The AMD consists of NVSS annual mortality files (1999–2009) that were augmented with information derived from a linkage between IHS patient registration records and the National Death Index (NDI). IHS patient registration records were linked to the NDI to identify IHS AI/AN deaths. IHS AI/AN records for persons identified as deceased through the linkage with the NDI were then linked to the annual NVSS mortality files to correct or mitigate the problem of AI/AN misclassification on death certificates. The final numbers of deaths classified as AI/AN used to estimate the life tables included those who were already classified as AI/AN in the NVSS mortality file (as per classification on the death certificate) and those identified as AI/AN through the linkage with IHS AI/AN decedents (see Espey et al.[6] for a detailed description of the creation of the AMD database). Furthermore, the decedent was defined as NH-AI/AN if, in addition, the decedent was classified as non-Hispanic on the death certificate. The total number of deaths for the 3-year period was 36 942, with 20 059 male deaths and 16 883 female deaths. We used midyear 2008 sex- and age-specific census revised bridged race intercensal population estimates for ages 1 to 84 years.[8] We classified a population record as NH-AI/AN if so designated through the race and Hispanic origin items in the revised bridged intercensal population file.[8] We used final birth counts from the NVSS birth files for years 2006–2009.[11,12] In the NVSS birth files, the birth is designated as NH-AI/AN if the mother was classified as non-Hispanic and AI/AN on the birth certificate, based principally on self-reports.[11,12]

Analyses

Prior to estimating the life table functions, we applied standard preliminary adjustments to the data. First, deaths with unknown age were redistributed proportionally throughout known age categories. Second, both death and population counts were smoothed to reduce the impact of random errors and errors associated with age reporting. The smoothing technique we used was the Beers ordinary minimized fifth difference formula.[1,5]

The life table function from which all other life table functions are derived is the age-specific probability of dying, q_x. The q_x is derived from the observed population age-specific death rate, M_x. They are each defined as follows:

$$(1)\quad q_x = \frac{M_x}{1+\frac{1}{2}M_x}$$

and

$$(2)\quad M_x = \frac{D_x}{P_x}.$$

where D_x is the observed death count and P_x is the mid-year population estimate in a given year.

Because of the relatively small size of the NH-AI/AN population and resulting small age-specific counts of death, we used 3 years of death counts rather than 1 year, and M_x was estimated as

$$(3)\quad M_x = \frac{D_x^{2007} + D_x^{2008} + D_x^{2009}}{3 * P_x}$$

where the numerator of the rate is the sum of adjusted and smoothed death counts for each year of 2007–2009, and the denominator is the smoothed 2008 midyear population multiplied by 3. The probability of dying, q_x, for persons aged 1 to 99 years was then estimated by converting M_x as described in equation 1.

At infancy, deaths do not tend to occur in the middle of the age interval, but rather, the majority of deaths tend to occur at the beginning of the age interval. As a result, it is preferable to use actual birth cohorts rather than midyear population estimates to estimate the probability of dying at birth.[1,5] The birth cohorts that were at risk for dying during the 3-year period 2007–2009 included those born in years 2006–2009. As a result, q_x at birth was estimated as follows:

$$(4)\quad q_0 = \frac{D_0^{2007} + D_0^{2008} + D_0^{2009}}{\frac{1}{2}\left[B_{2006} + 2B_{2007} + 2B_{2008} + B_{2009}\right]}$$

where B refers to the total number of births in a given year.

We considered 2 alternatives regarding how to close the life table for the NH-AI/AN population. One was to use standard methods of closing the life table with a final age category of 85 years and older.[13] The other was to use a statistical model to estimate q_x for ages 85 to 99 years and close the life tables with the open-ended category 100 years and older. The second alternative was attractive for 2 reasons. First, it provided detailed information on mortality at the oldest ages for this population. Second, it made the final life table for the NH-AI/AN population comparable with the US life tables estimated for the White, Black, non-Hispanic White, non-Hispanic Black, and Hispanic populations.[1,10]

The Brass relational logit model is a statistical model that has been widely and successfully used to estimate mortality at the oldest ages for populations that lack reliable vital statistics or Medicare data.[1,2,13–15] The model expresses the age-specific mortality pattern of a population of interest as a function of the age-specific mortality pattern of a "standard" population. The model is expressed as follows:

$$(5)\quad \overline{Y}_x = a + bY_x^S$$

where

$$(6)\quad Y_x = \ln\left[\frac{q_x}{1 - q_x}\right]$$

$$(7)\quad Y_x^S = \ln\left[\frac{q_x^S}{1 - q_x^S}\right]$$

and q_x^S is the probability of dying in the standard population; q_x is the probability of dying in the population of interest; a is the predicted parameter that measures the level of mortality of the population of interest relative to the standard population; and b is the predicted parameter that measures the slope of the mortality function of the population of interest relative to the standard population.[1,2,13–15]

To estimate mortality at the oldest ages, usually ages older than 80 or 85 years, the standard is fit to data for the population of interest in the age interval 45 to 80 years or 85 years, depending on the quality of the observed data, and the predicted parameters are used to estimate the probabilities of death for ages older than 80 or 85 years. This method allows the relationship between the 2 populations in the younger adult ages to be carried over to the older ages.[1,2,13–15]

An important question is what population to use as the standard. Although there was no definitive rationale for choosing the non-Hispanic White population as the standard population in this case, we chose it for several reasons. First, it is the largest population in the United States with the most reliable mortality data. Second, it is used extensively in comparative mortality studies as the reference population from which to compare other racial and ethnic groups in the United States. Third, the relationship between its pattern of mortality and that of the NH-AI/AN population in CHSDA counties throughout the age interval 45 to 84 years is consistent. The ratio of NH-AI/AN to non-Hispanic White mortality in this age range declines at a consistent rate, and therefore, it is not unreasonable to assume that this relationship should continue into the oldest ages.

We used ordinary least squares (OLS) regression to fit equation 5 in the age range 45 to 84 years. The resulting predicted parameters a and b were then used to estimate the predicted probability of death for ages 85 to 120 years in the NH-AI/AN population. The predicted probability of death, $\bar{q}_x$, was predicted to age 120 years to estimate the life table population until no survivors remained.[1] Predicted $\bar{q}_x$ was estimated as follows:

$$(8)\quad \bar{q}_x = \frac{\exp\left[\overline{Y}_x\right]}{1 + \exp\left[\overline{Y}_x\right]} = \frac{\exp\left[a + bY_x^S\right]}{1 + \exp\left[a + bY_x^S\right]}.$$

Table 1 shows predicted parameter estimates and model statistics for equation 5 for the total, male, and female populations. Overall model fit was excellent in all 3 cases as shown by the R^2 and F-test statistics. In each case, the model explained more than 99% of the variance, and the F-test statistics were highly significant. Resulting predicted probabilities of death for persons aged 85 years and older appeared quite reasonable. A comparison of the age patterns of mortality, based alternatively on the life tables estimated to ages 100 years and older with the use of the Brass model and life tables closed at age 85 years and older, showed that mortality patterns past ages 85 years based on the Brass model were consistent with the pattern at younger ages and increased at a smooth, consistent rate (Figure A, available as a supplement to the online version of this article at http://www.ajph.org).

To ensure a smooth transition from vital q_x^V to predicted $\bar{q}_x$, we blended the 2 values from ages 80 to 84 years with a graduating process as follows:

$$(9)\quad q_x = \frac{1}{6}\left[(85 - x)q_x^V + (x - 79)\bar{q}_x\right]$$

where $x = 80,\ldots,84$.

TABLE 1—Estimated Brass Relational Logit Model Parameters *a* and *b* for the Non-Hispanic American Indian and Alaska Native Population in Contract Health Service Delivery Area Counties: United States, 2007–2009

	Total	Male	Female
a (95% CI)	−0.1884 (−0.2349, −0.1418)	−0.1857 (−0.2437, −0.1276)	−0.1794 (−0.2190, −0.1398)
b (95% CI)	0.8377 (0.8271, 0.8483)	0.8327 (0.8188, 0.8465)	0.8413 (0.8327, 0.8498)
Model R^2	0.9985	0.9975	0.9990
F (1,38)	25 718.36	14 864.31	39 768.97
Prob > F	0.0000	0.0000	0.0000

Note. CI = confidence interval.

TABLE 2—Abridged Period Life Tables for the Total, Male, and Female Non-Hispanic American Indian and Alaska Native Population in Contract Health Service Delivery Area Counties: United States, 2007–2009

Age, Years	Probability of Dying Between Ages x to $x+n$ ($_nq_x$)	No. Surviving to Age x (l_x)	No. Dying Between Ages x to $x+n$ ($_nd_x$)	Person-Years Lived Between Ages x to $x+n$ ($_nL_x$)	Total No. Person-Years Lived Above Age x (T_x)	Expectation of Life at Age x (e_x)
			Total			
0–1	0.009062	100 000	906	99 547	7 110 253	71.1
1–5	0.002495	99 094	247	395 798	7 010 706	70.7
5–10	0.001422	98 847	141	493 843	6 614 908	66.9
10–15	0.001803	98 706	178	493 229	6 121 065	62.0
15–20	0.007295	98 528	719	491 053	5 627 836	57.1
20–25	0.012144	97 809	1188	486 210	5 136 784	52.5
25–30	0.013877	96 621	1341	479 812	4 650 574	48.1
30–35	0.016740	95 281	1595	472 565	4 170 762	43.8
35–40	0.021981	93 686	2059	463 482	3 698 197	39.5
40–45	0.028216	91 626	2585	451 892	3 234 715	35.3
45–50	0.035589	89 041	3169	437 548	2 782 823	31.3
50–55	0.046453	85 872	3989	419 745	2 345 275	27.3
55–60	0.060627	81 883	4964	397 445	1 925 530	23.5
60–65	0.081801	76 919	6292	369 510	1 528 085	19.9
65–70	0.116998	70 627	8263	333 462	1 158 575	16.4
70–75	0.174840	62 364	10 904	285 418	825 113	13.2
75–80	0.239856	51 460	12 343	227 045	539 694	10.5
80–85	0.347352	39 117	13 587	161 696	312 649	8.0
85–90	0.491041	25 530	12 536	95 323	150 953	5.9
90–95	0.654395	12 994	8503	41 624	55 630	4.3
95–100	0.795816	4491	3574	11 861	14 006	3.1
≥ 100	1.000000	917	917	2145	2145	2.3
			Males			
0–1	0.009835	100 000	984	99 508	6 796 130	68.0
1–5	0.002649	99 016	262	395 445	6 696 622	67.6
5–10	0.001501	98 754	148	493 358	6 301 177	63.8
10–15	0.002035	98 606	201	492 718	5 807 819	58.9
15–20	0.009525	98 405	937	489 999	5 315 102	54.0
20–25	0.017546	97 468	1710	483 259	4 825 103	49.5
25–30	0.018821	95 758	1802	474 328	4 341 844	45.3
30–35	0.022690	93 956	2132	464 615	3 867 516	41.2
35–40	0.028136	91 824	2584	452 862	3 402 901	37.1
40–45	0.035237	89 240	3145	438 581	2 950 039	33.1
45–50	0.044104	86 096	3797	421 321	2 511 458	29.2
50–55	0.059164	82 299	4869	399 735	2 090 137	25.4
55–60	0.074947	77 429	5803	373 037	1 690 402	21.8
60–65	0.097496	71 626	6983	341 234	1 317 365	18.4
65–70	0.135314	64 643	8747	302 299	976 131	15.1
70–75	0.203922	55 896	11 398	251 781	673 832	12.1
75–80	0.278636	44 497	12 399	191 874	422 050	9.5
80–85	0.399415	32 099	12 821	128 054	230 176	7.2
85–90	0.548437	19 278	10 573	68 530	102 122	5.3
90–95	0.704348	8705	6132	26 263	33 592	3.9
95–100	0.829818	2574	2136	6376	7329	2.8
≥ 100	1.000000	438	438	953	953	2.2

Continued

TABLE 2—*Continued*

			Females			
0–1	0.008260	100 000	826	99 587	7 425 233	74.3
1–5	0.002338	99 174	232	396 165	7 325 646	73.9
5–10	0.001340	98 942	133	494 344	6 929 481	70.0
10–15	0.001564	98 810	155	493 758	6 435 137	65.1
15–20	0.004977	98 655	491	492 146	5 941 379	60.2
20–25	0.006582	98 164	646	489 277	5 449 233	55.5
25–30	0.008935	97 518	871	485 485	4 959 956	50.9
30–35	0.010887	96 647	1052	480 735	4 474 471	46.3
35–40	0.016054	95 594	1535	474 340	3 993 736	41.8
40–45	0.021603	94 060	2032	465 426	3 519 396	37.4
45–50	0.027688	92 028	2548	453 966	3 053 971	33.2
50–55	0.034955	89 480	3128	439 879	2 600 005	29.1
55–60	0.047787	86 352	4126	421 913	2 160 126	25.0
60–65	0.067597	82 225	5558	397 950	1 738 213	21.1
65–70	0.100874	76 667	7734	365 027	1 340 262	17.5
70–75	0.150706	68 933	10 389	319 637	975 235	14.1
75–80	0.210665	58 545	12 333	262 739	655 599	11.2
80–85	0.313219	46 211	14 474	195 492	392 860	8.5
85–90	0.461365	31 737	14 642	121 465	197 368	6.2
90–95	0.634761	17 095	10 851	56 057	75 903	4.4
95–100	0.788280	6244	4922	16 748	19 846	3.2
≥ 100	1.000000	1322	1322	3097	3097	2.3

Once q_x is obtained for each single year of age, the other life table functions are estimated as follows:

Survivor function:

$$(10)\quad l_x = l_{x-1}(1 - q_{x-1}),$$

where l_0 is set at 100 000.

Decrement function:

$$(11)\quad d_x = l_x - l_{x+1} = l_x q_x.$$

Person-years lived:

$$(12)\quad L_x = \frac{1}{2}(l_x + l_{x+1}).$$

Person-years lived at and above age x:

$$(13)\quad T_x = \sum_{x=0}^{\infty} L_x$$

Life expectancy at age x:

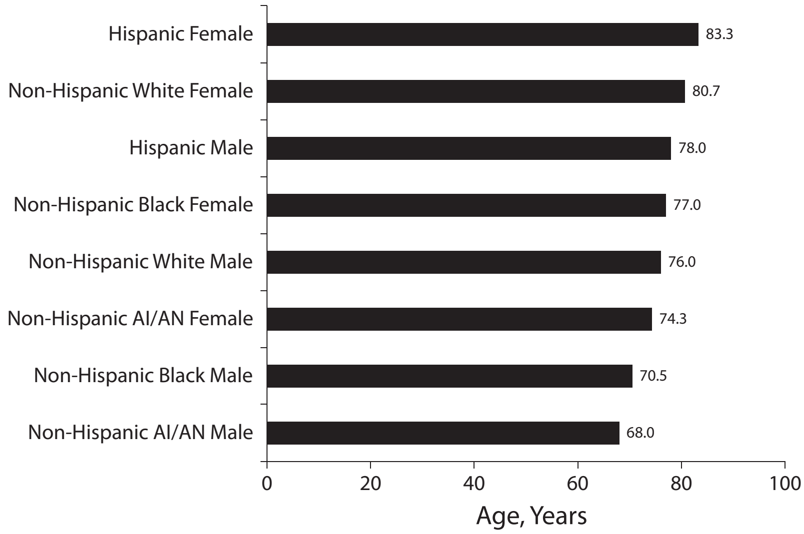
$$(14)\quad e_x = \frac{T_x}{l_x}.$$

All functions were estimated for ages up through age 120 years, but the life tables shown were closed with the open age category of 100 years and older. To close the tables with this final age category, ${}_{\infty}q_{100}$ is set equal to 1.0; ${}_{\infty}d_{100} = {}_{\infty}l_{100}$ and ${}_{\infty}L_{100}$ is estimated as the sum of the predicted L_x values for ages 100 to 120 years.

RESULTS

Table 2 presents abridged period life tables for the NH-AI/AN population in CHSDA counties for the period 2007–2009 (complete versions of the period life tables are shown as data available as a supplement to the online version of this article at http://www.ajph.org). Although not an ideal comparison given that the NH-AI/AN life tables presented here were not representative of the national NH-AI/AN population, they were compared with national US life tables for the non-Hispanic White, non-Hispanic Black, and Hispanic populations in 2008 to provide a measure of comparison and because the latter were the only available sources of life expectancy for the various ethnic and racial groups in the United States. Life expectancy at birth was 71.1 years for the total NH-AI/AN population in CHSDA counties. By comparison, life expectancy at birth in 2008 was 73.9 years for the non-Hispanic Black population, 78.4 years for the non-Hispanic White population, and 80.8 years for the Hispanic population (updated 2008 US life tables can be found elsewhere[10]). The NH-AI/AN population in CHSDA counties had a life expectancy at birth that was 9.7 years lower than that of the Hispanic population, 7.3 years lower than that of the non-Hispanic White population, and 2.8 years lower than that of the non-Hispanic Black population.

Figure 1 shows the life expectancy at birth for the 8 Hispanic origin–race–sex populations. NH-AI/AN males had the lowest life expectancy at birth (68.0 years). They were followed in ascending order by non-Hispanic Black males (70.5 years), NH-AI/AN females (74.3 years), non-Hispanic White males (76.0 years), non-Hispanic Black females (77.0 years), Hispanic males (78.0 years), non-Hispanic White females (80.7 years), and Hispanic females (83.3 years).[10] The difference between NH-AI/AN males and the group with the highest life expectancy at birth, Hispanic females, was 15.3 years. NH-AI/AN male life expectancy at birth



Note. AI/AN = American Indian/Alaska Native.

FIGURE 1—Life expectancy at birth by sex for the non-Hispanic American Indian and Alaska Native population in Contract Health Service Delivery Area counties, 2007–2009, and for the Hispanic, non-Hispanic White, and non-Hispanic Black populations in the United States, 2008.

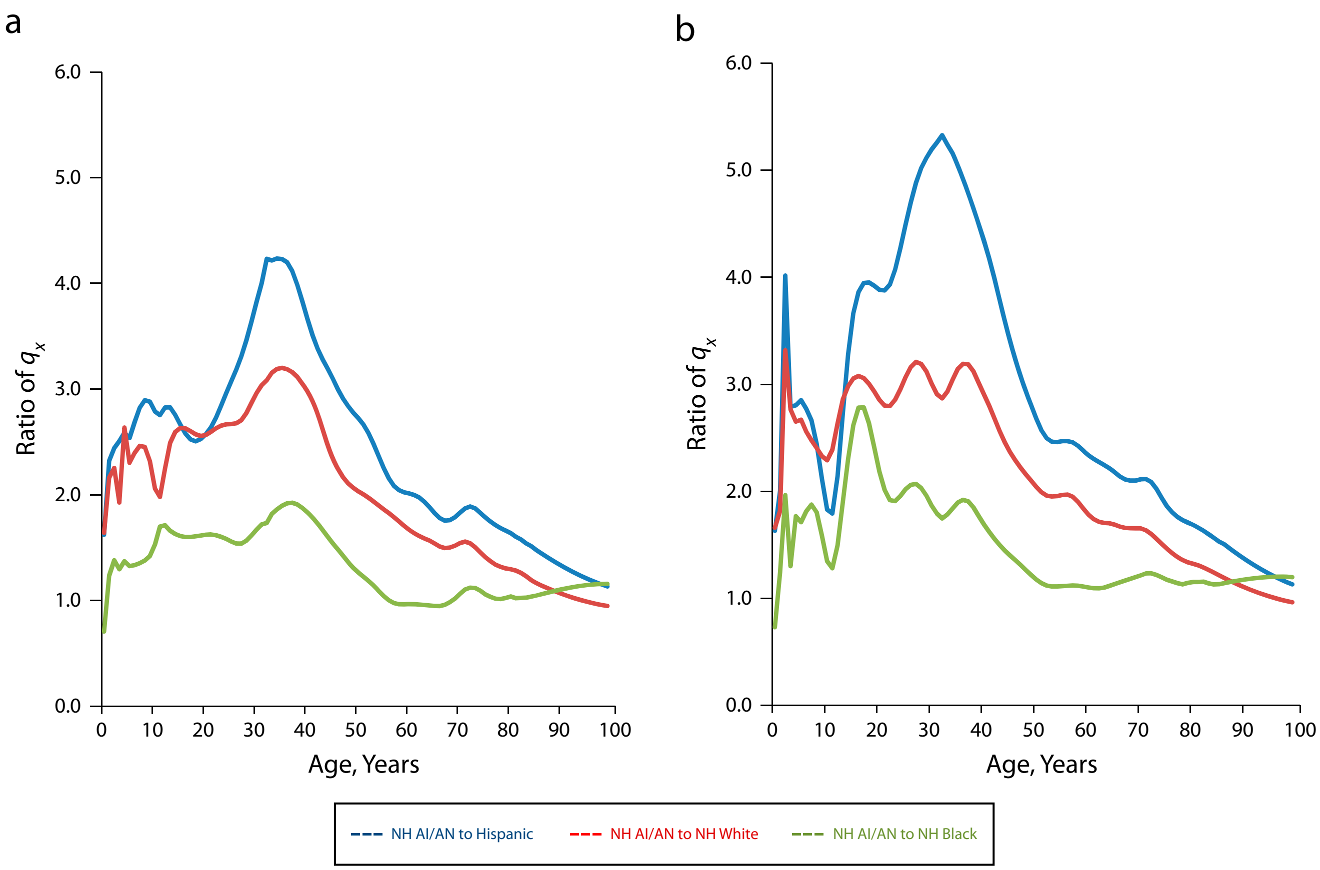
was closest to that of non-Hispanic Black males, but still lower by 2.5 years. NH-AI/AN female life expectancy at birth was higher only than that of non-Hispanic Black and NH-AI/AN males. NH-AI/AN female life expectancy at birth was 9.0 and 6.4 years lower than that of Hispanic and non-Hispanic White females, respectively.

The life expectancy disadvantage experienced by the NH-AI/AN population in CHSDA counties extended throughout the entire age span, although it diminished with increasing age, and showed a small reversal at ages 95 years and older in comparison with the non-Hispanic White population (Figure B available as a supplement to the online version of this article at http://www.ajph.org). It was greatest at the youngest ages. For example, the difference with the Hispanic population remained above 8 years for both males and females from birth to age 25 years and declined with age, but remained above 6 years by age 45 years. It is not until approximately age 80 years that the difference fell below 2 years for both males and females. A similar pattern, although with more pronounced variation by sex, was seen in the comparison of the NH-AI/AN with non-Hispanic White populations. Among males, the difference remained close to 8 years from birth to age 20 years, and slightly above or very close to 6 years from birth to age 20 years among females. The difference for both males and females did not fall below 4 years until age 50 years and below 2 years until age 70 years.

The mortality disadvantage experienced by the NH-AI/AN population in CHSDA counties relative to the other groups was more clearly seen in a comparison of the age-specific probabilities of dying (q_x) between the NH-AI/AN population and each of the other groups. Figure 2 shows, for males and females separately, ratios of NH-AI/AN to Hispanic, non-Hispanic White, and non-Hispanic Black age-specific probabilities of dying. The NH-AI/AN mortality disadvantage was greatest at ages younger than 50 years, generally, with differences somewhat more pronounced among females. For example, NH-AI/AN females had a probability of dying at birth that was 1.6 times greater than that of both non-Hispanic White and Hispanic females. Their probability of dying rose to 3 and 4 times that of non-Hispanic White and Hispanic females, respectively, at age 2 years, declined somewhat thereafter, and then began a sharp increase, where at age 32 years, NH-AI/AN females experienced a probability of dying that was 5.5 times that of Hispanic females and 3 times that of non-Hispanic White females. The ratios declined steadily, but it was not until ages 51 and 74 years that they fell below 2 in comparison with non-Hispanic White and Hispanic females, respectively, and it only reached 1 at age 95 years in comparison with non-Hispanic White females. Relative to non-Hispanic Black females, NH-AI/AN females faired relatively better, although, with the exception of a lower probability of dying at birth, they experienced around 2 times the probabilities of dying at most ages in the age range of 2 to 45 years. NH-AI/AN males exhibited a very similar age-specific pattern of mortality disparities as females, although differences with the other racial/ethnic groups were not as pronounced.

DISCUSSION

The AMD database largely eliminates the problem of ethnic and racial misclassification on death certificates for NH-AI/AN decedents. As a result, we were able to estimate reliable complete period life tables for the NH-AI/AN population residing in CHSDA counties. The life tables presented showed a clear mortality disadvantage for this population. NH-AI/AN life expectancy at birth was lower by close to a decade relative to the Hispanic and non-Hispanic White populations. The NH-AI/AN mortality disadvantage remained high throughout the younger ages and diminished only in the oldest ages. These results were consistent with previous research that showed that socioeconomically disadvantaged populations exhibit poorer health and higher mortality than their better-off counterparts. The mortality disadvantage exhibited by the NH-AI/AN population in CHSDA counties appeared to be even greater than might be expected given national-level standard measures of socioeconomic status. In terms of high school and college graduation rates, median family income, and poverty rates, the national NH-AI/AN population is not very different from the non-Hispanic Black population and is better off than the Hispanic population with respect to some measures, such as percentage with a high school diploma or a bachelor's degree or higher.[16,17] However, these national-level standard



Note. AI/AN = American Indian and Alaska Native; NH = non-Hispanic. Data are for non-Hispanic-AI/AN persons in Contract Health Service Delivery Area counties from 2007–2009; data for Hispanic, non-Hispanic White, and non-Hispanic Black US populations are from 2008.

FIGURE 2—Ratio of non-Hispanic American Indian and Alaska Native to Hispanic, non-Hispanic White, and non-Hispanic Black age-specific probabilities of dying for (a) males and (b) females: United States, 2007–2009.

socioeconomic status measures mask the profound social and economic disadvantages experienced by NH-AI/AN persons in CHSDA counties, which are predominantly rural, isolated areas with limited employment opportunities or access to quality health care.[18,19]

Although the life tables presented here gave us, for the first time, the most complete view of the mortality profile of the NH-AI/AN population in the United States, they nevertheless contained important limitations. The most significant limitation was that they represented the mortality profile of a segment of the NH-AI/AN population, not the entire population. According to the 2008 midyear bridged race intercensal population estimates, the NH-AI/AN population in CHSDA counties accounted for 64% of the total NH-AI/AN population in the United States, and according to the AMD database, 75.5% of all NH-AI/AN deaths in the period 2007–2009 occurred to those who resided in CHSDA counties.

Another limitation deserving of consideration was the use of the Brass relational logit model to extend the life tables to ages 100 years and older. The model appeared to fit the data exceedingly well and produced apparently robust mortality estimates consistent with what we would expect them to look like. However, the model relied on an unverified assumption: that the relationship between the NH-AI/AN and non-Hispanic White mortality patterns at ages 45 to 84 years extended to ages 85 years and older. Although we believed that this was a reasonable assumption, we had no empirical evidence that this was the case. However, we were heartened in the choice of this method by the finding that there was no difference in life expectancy at birth and minimal differences in life expectancy at age 85 years from those produced by life tables based exclusively on available vital registration (AMD) and census data and closed at age 85 years and older using standard methods (complete life tables closed at age 85 years and older are provided as data available as a supplement to the online version of this article at http://www.ajph.org).

Finally, one other important limitation that serves as an incentive for continued research on ways to increase our knowledge of the mortality profile of the NH-AI/AN population in the United States was that the life tables presented here for the NH-AI/AN population in CHSDA counties masked important heterogeneity within this area. CHSDA counties are spread throughout 35 states and 6 distinct IHS regions (Northern Plains, Alaska, Southwest, Southern Plains, Pacific Coast, and East); basic death rates showed considerable variation among those regions.[6] For example, age-adjusted death rates for NH-AI/AN persons varied from 16170.3 per 100 000 in the Northern Plains to 881.7 in the East region.[6] This recommends that the next important step is the estimation of IHS region-specific life tables. This will require the pooling of more than 3 years of mortality data and could be facilitated by the continued expansion of the AMD database. ■

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***Note**. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.*

Contributors

E. Arias originated the study, developed the analytical plan, performed the statistical analyses, wrote the article, and participated in the creation of the mortality database used in the study. J. Xu participated in the creation of the mortality database used in the study and conducted background research. M. A. Jim participated in the creation of the mortality database used in the study and contributed key data quality information.

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Human Participant Protection

No protocol was needed for this study because the data were obtained from secondary sources.

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