RESEARCH

Mortality disparities: A comparison with the Haudenosaunee in New York State

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ABSTRACT: Identifying health status and disparities for Indigenous populations is the first logical step toward better health. We compare the mortality profile of the American Indian and Alaska Native (AI/AN) population with that of non-Hispanic whites in the Haudenosaunee Nations in New York State, the Indian Health Service (IHS) East region (Nashville Area) and the United States. Data from the linkage of IHS registration records with decedents from the National Death Index (1990-2009) were used to identify AI/AN deaths misclassified as non-AI/AN. Analyses were limited to persons of non-Hispanic origin. We analyzed trends for 1990-2009 and compared AI/AN and white persons in the Haudenosaunee Nations in New York State, IHS East region and the United States. All-cause death rates over the past two decades for Haudenosaunee men declined at a greater percentage per year than for AI/AN men in the East region and United States. This decrease was not observed for Haudenosaunee women with all-cause death rates appearing to be stable over the past two decades. Haudenosaunee all-cause death rates were 16% greater than that for whites in the Haudenosaunee Nations. The most prominent disparities between Haudenosaunee and whites are concentrated in the 25-44 year age group (Risk Ratio=1.85). Chronic liver disease, diabetes, unintentional injury, and kidney disease death rates were higher in Haudenosaunee than in whites in the Haudenosaunee Nations. The Haudenosaunee cancer death rate (180.8 per 100,000) was higher than that reported for AI/AN in the East (161.5 per 100,000).Haudenosaunee experienced higher rates for the majority of the leading causes of death than East AI/AN. These results highlight the importance of Haudenosaunee-specific data to target prevention efforts to address health disparities and inequalities in health.

KEYWORDS: cancer, diabetes, health disparities, obesity, Native American, American Indian, Haudenosaunee, Iroquois, New York, minority health.

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BACKGROUND

Health disparities are health differences that are closely linked with social, economic, or environmentally disadvantaged communities or populations (U.S. Department of Health and Human Services, 2008). Health disparities adversely affect groups of people who have systematically experienced greater obstacles to health based on characteristics historically linked to discrimination or exclusion. Health disparities are measured by tracking rates of illness, death, chronic conditions, and behaviors related to socio-demographic features such as race and ethnicity (U.S. Department of Health and Human Services, 2008) –as well as income and education.

American Indians and Alaska Natives (AI/ANs)—Native Americans—experience excesses of a number of diseases that may be linked to environmental obstacles, health behaviors, or lifestyles attributed to the possible epigenetic factors of trauma or stress (Brown et al., 2010; Shonkoff, Boyce, & McEwen, 2009; Cobb, Espey, & King, 2014; Warne, 2006). The most common causes of death for AI/AN populations are heart disease, cancer, unintentional injuries, diabetes, stroke, chronic liver disease and cirrhosis, chronic lower respiratory disease, suicide, influenza, pneumonia, and kidney diseases. Health disparities in Indian Country (Natural Resources Conservation Science, n.d.) vary regionally and correspond to similar trends in mortality rates (Espey et al., 2014a; White et al., 2014; Li et al., 2014; Murphy et al., 2014; Indian Health Services, 2016). Obesity is likely a contributing factor to many of these diseases with AI/AN men and women having a higher prevalence of obesity than their white counterparts (Cobb et al., 2014; Moore, Chadid, Singer, Kreger, & Denis, 2014; Haring et al. 2016).

Cancer Health Disparities

Kilbourne and colleagues define health disparities for public health as the "observed clinically and statistically significant differences in health outcomes or health care use between socially distinct vulnerable and less vulnerable populations that are not explained by the effects of selection bias," (Kilbourne, Switzer, Hyman, Crowley-Matoka, & Fine, 2006). The National Cancer Institute (NCI) has further defined cancer-related health disparities as "adverse differences in new and existing cancer incidence (new cases), morbidity (cancer related health complications), cancer mortalities (death), cancer survivorship and burden of cancer or related health conditions that exist among specific population groups in the United States" (NCI, n.d.).

Cancer is the second leading cause of death in New York State (NYS). In 2009, the age-adjusted cancer incidence rate for all cancers was 484.2 cases per 100,000 New Yorkers, which is the ninth highest in the United States (U.S.). The NYS age-adjusted mortality rate for all cancer sites is 164.3 per 100,000 population, which is almost 6% lower than the U.S. rate (173.8); the state's overall cancer mortality rate decreased by an average of 2% each year across all ages and races between 2005-2009. Notably for this report, only cancers of the uterus and liver/bile duct had increases in annual mortality rates when looking at 5-year rate changes (NYS Cancer Consortium, 2012).

Incidence and mortality rates in NYS by race/ethnicity are reported highest among black men (NYS Cancer Consortium, 2012); however, incidence and mortality rates for AI/AN populations in NYS are not available for comparison from the State Cancer Profiles on Cancer Control P.L.A.N.E.T. (https://ccplanet.

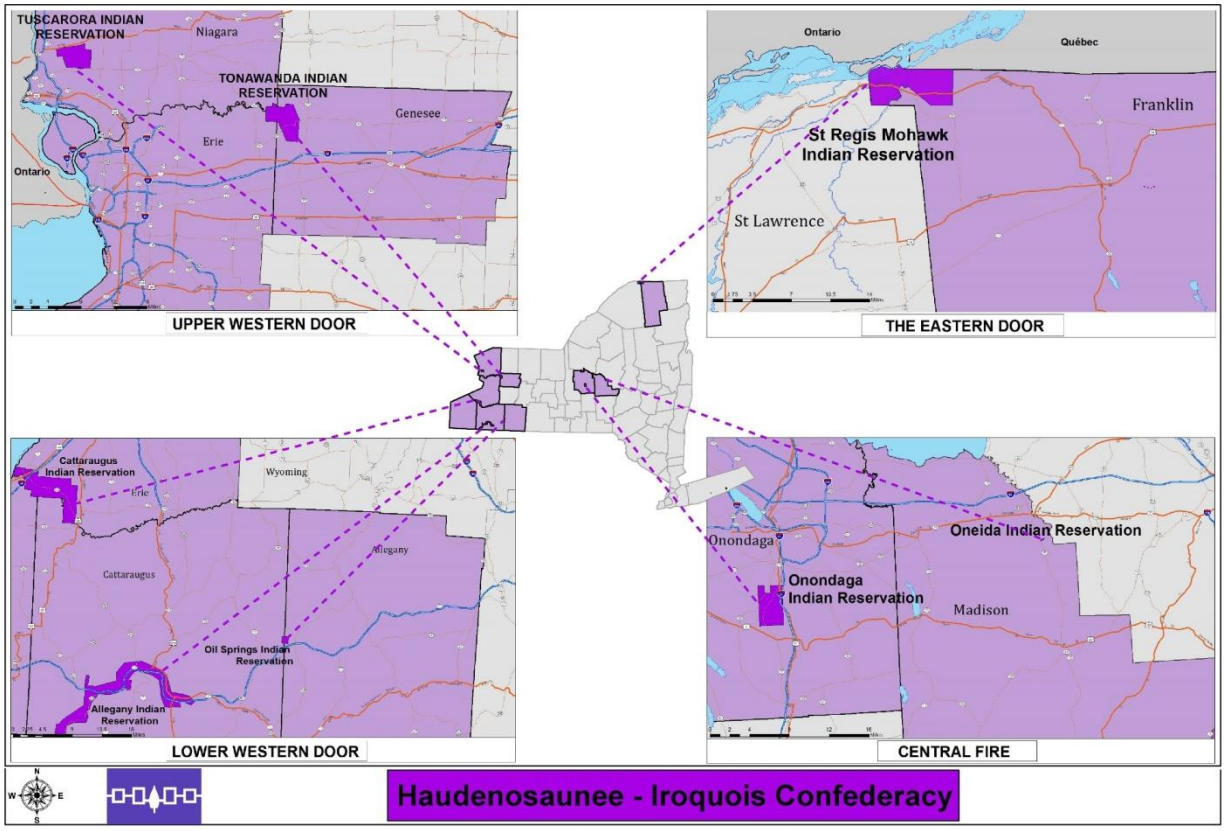
cancer.gov/) or the latest *NYS Comprehensive Cancer Control Plan*, possibly due to the challenges of reporting smaller case counts from identifiable areas and possible data-reporting errors. However, the *2012-2017 NYS Comprehensive Cancer Control Plan* text states that AI/AN populations were one of several populations identified by New York's Medicaid Redesign Team Health Disparities Workgroup "that may experience greater health disparities," (NYS Cancer Consortium, 2012). This team further states that "AI/AN groups face greater socioeconomic barriers than many other racial/ethnic groups" and "…should receive priority consideration when intervention strategies are being developed and implemented" (NYS Cancer Consortium, 2012).

Haudenosaunee & Indian Health Service East Region

To address race misclassification in death records and cancer surveillance data, efforts have been made to better characterize and track the health status of AI/AN populations (Espey et al., 2014b; Espey et al., 2008). Mortality data provide essential information for measuring the health of a population. AI/AN mortality data are often presented for 12 Indian Health Service (IHS) Areas (Indian Health Service, n.d.) and six IHS regions (Northern Plains, Alaska, Southern Plains, Southwest, Pacific Coast, and East) (Espey et al., 2014b; Espey et al., 2008; Espey et al., 2007). Our interest lies in the IHS East region, which contains the same states as those in the IHS Nashville Area. This catchment includes a mixture of tribes with varying degrees of "first contact" with Europeans; varying levels of Nation-to-Nation relationships with the United States; differences in culture, customs, and language; and vast geographic distances between states from the Northeast to the Southeast.

Previous studies have worked with individual Northeast Native Nations to look at tribal data on matrilineal enrolled members only (Mahoney, Va, Stevens, Kahn, & Michalek, 2009). Others have used Nation-specific health center data for review (Schulz, Lalicata, Carnes, & Rith-Najarian, 1997) or obtained data from school systems for community health information (Botash, Kavey, Emm, & Jones, 1992). Specific tribal data are useful for each Nation individually and helpful when looking at enrolled citizens, non-enrolled membership populations, or school-aged children. There is also a need to look at population health from both enrolled and non-enrolled tribal members to paint an inclusive picture of global tribal wellness and its relation to disparities. Therefore, the IHS East region lacks an aggregated picture of health disparities from the largest Confederacy of Tribes in NYS, whose bloodlines are distinctly related through clan systems, language, and traditional practices. The Haudenosaunee have land throughout a majority of NYS (Figure 1). The Haudenosaunee Confederacy tribes include the Mohawk, Oneida, Onondaga, Tuscarora, Cayuga, and Seneca. The Mohawk are known as the "Keepers of the Eastern Door" and are responsible for protecting and defending the eastern boundaries of Haudenosaunee territory (Smithsonian NMAI, n.d.). The Onondaga are the "Keepers of the Central Fire" since the Onondaga Nation is considered the capital of the Confederacy (Smithsonian NMAI, n.d.). The Seneca are the "Keepers of the Western Door" and are responsible for protecting and defending the western boundaries of Haudenosaunee territory (Smithsonian NMAI, n.d.).

Figure 1. Haudenosaunee – Iroquois Confederacy



In this article, we provide an overview of leading causes of death and all-cause mortality trends for AI/ANs and whites in the Haudenosaunee Nations, the East region, and the United States. We utilize national mortality data that have been linked to the IHS patient registration data to improve race/ethnicity classification. Results will provide guiding information that can help shape solutions for health care needs for the Haudenosaunee in NYS.

METHODS

Detailed methods for generating the analytic mortality files are described elsewhere (Espey et al., 2014b). An abbreviated description follows.

Data sources

Population estimates. We used county-level population estimates produced by the U.S. Census Bureau as denominators in the rate calculations. To manage multiple race/ethnicity data collected since 2000, we used the National Center for Health Statistics (NCHS)/Census Bureau method of bridging race/ethnicity categories into single-race/ethnicity (Ingram et al., 2003). The NCI made further refinements regarding race/ethnicity, county geographic codes, and adjustments for population shifts because of Hurricanes Katrina and Rita in 2005, and provided public access to these estimates at the Surveillance, Epidemiology, and End Results (SEER) website (NCI SEER, n.d.).

During preliminary analyses, we discovered that the updated bridged intercensal populations estimates significantly overestimated AI/AN persons of Hispanic origin (Edwards et al., 2013). Therefore, to avoid underestimating mortality in AI/AN populations, we limited analyses to non-

Hispanic AI/AN persons. Non-Hispanic white was chosen as the most homogeneous referent group. For conciseness, the term "non-Hispanic" is henceforth omitted when discussing both groups.

Death records. Each state compiles death certificate data and sends them to the NCHS, where they are edited for consistency. The NCHS makes this information available to researchers as part of the National Vital Statistics System (NVSS), and includes underlying and multiple cause of death fields, state of residence, age, sex, race, and ethnicity (National Center for Health Statistics, n.d.). NCHS and the Census Bureau use the same bridging algorithm to assign a single race to decedents with multiple races reported on the death certificate (National Center for Health Statistics, 2004).

The IHS patient registration database was linked to the National Death Index (NDI) to identify IHS decedents who had received health care in IHS or tribal facilities and were misclassified as non-AI/AN (Espey et al., 2014b). Following this linkage, IHS records for persons identified as deceased were then linked to 1990 to 2009 annual NVSS mortality files as an additional indicator of AI/AN ancestry. These files were combined with corresponding annual bridged race intercensal population estimates to create an analytic file, the AI/AN Mortality Database (AMD), in SEER*Stat software version 8.0.4 (Surveillance Research Program, n.d.). Race for AI/AN deaths is assigned as reported elsewhere (Espey et al., 2014b). In short, the AMD combines race classification by NCHS on the basis of the death certificate and information derived from data linkages between the IHS patient registration database and the National Death Index.

For the years 1990-1998, the underlying cause of death was coded according to the *International Classification of Diseases, Ninth Revision* (ICD-9) (World Health Organization, 1980). For 1999-2009, the *International Classification of Diseases, 10th Revision* (ICD-10) was used (World Health Organization, 1999). Trend analyses spanning *ICD-9* and *ICD-10* reporting years took into account comparability of cause of death recodes between the two revisions (Anderson, Minino, Hoyert, & Rosenberg, 2001). To present the leading cause of death in rank order, as established by death counts, we used the method developed by NCHS based on the recode for 113 selected causes of death (Anderson et al., 2001; Heron, 2012).

Geographic Coverage. The analyses in this article are restricted to IHS Contract Health Service Delivery Area (CHSDA) counties, which follow county boundaries and are established by IHS for each federally recognized tribe. The CHSDA consists of counties that include all or part of a reservation, and any county or counties that have a common boundary with the reservation (Indian Health Service, 2016). Linkage studies have indicated less misclassification of race/ethnicity for AI/AN persons in these counties (Jim et al., 2014).

The analyses were completed for AI/AN and white persons in the Haudenosaunee Nations, East region, and the United States. The Haudenosaunee Nations are situated in nine NYS counties: Allegany, Cattaraugus, Chautauqua, Erie, Franklin, Genesee, Madison, Niagara, and Onondaga. Only counties that touched one of the Haudenosaunee Nations were included in the analyses (Figure 1). The East region consists of Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Missouri,

New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia, and Washington, D.C. Identical or similar regional analyses have been used for other health-related publications focusing on AI/AN populations (Espey et al., 2014a; Denny & Taylor, 1999; Espey, Paisano, & Cobb, 2005; Wiggins et al., 2008).

Statistical methods. All rates, expressed per 100,000 population, were directly age-adjusted, using SEER*Stat software (Surveillance Research Program, n.d.), to the 2000 U.S. standard population and using 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 Department of Health and Human Services recommendation (Anderson, 1998a; Anderson, 1998b). Readers should avoid comparison of these data with published death rates adjusted using a different standard population.

Using the age-adjusted, all-cause death rates, standardized rate ratios (RRs) were calculated for AI/AN using white rates for comparison. Ninety-five percent confidence intervals (CI) for age-adjusted rates and standardized RRs were calculated based on methods described by Tiwari, Clegg, & Zou (2006) using SEER*Stat and were rounded to two decimal places.

We conducted trend analyses and comparability tests for age-standardized death rates using Joinpoint software, version 4.0.3 (Joinpoint Regression Program, 2017). We calculated annual percent change (APC) for each of the trend segments and average annual percent change (AAPC) for 1990-2009 to quantify the average trend over this period. We conducted tests to assess pairwise differences between AI/ANs and whites to determine whether the trends lines were parallel or coincident (Kim, Fay, Feuer, & Midthune, 2000), then we tested the average annual percentage change for the two groups to determine whether they were statistically different. Statistical significance was set at $P<.05$.

RESULTS

All-cause death rates and leading causes of death for the Haudenosaunee Nations, East, and United States comparing AI/AN with white persons in CHSDA counties are presented in Table 1. In subsequent results as well as in the discussion, "death rates" refers to analyses restricted to CHSDA counties only and for conciseness, the term "Haudenosaunee" will be used when discussing "Haudenosaunee Nations AI/AN". Comparisons of all-cause death rates in Haudenosaunee with those of whites in the Haudenosaunee Nations (RR=1.16) were greater than those in the East (RR=1.03) but not as high as those in the U.S. (RR=1.41).

Table 1 also ranks the leading causes of death for AI/AN compared to white persons by sex for the Haudenosaunee Nations, East, and United States for 1990-2009. The ten leading causes of death among the Haudenosaunee, in order, were heart disease, cancer, unintentional injury, diabetes, stroke, chronic liver disease, chronic lower respiratory disease, influenza and pneumonia, kidney disease, and septicemia. Rates for Haudenosaunee were significantly higher than whites for all causes (RR=1.16), heart disease (RR=1.12), unintentional injury (RR=2.08), diabetes (RR=3.46), chronic liver disease (RR=4.06), kidney disease (RR=3.31), and septicemia (RR=1.85); and significantly lower for cancer (RR=0.89). Rates for

stroke, chronic lower respiratory disease, suicide, and influenza and pneumonia were similar for Haudenosaunee and whites in the Haudenosaunee Nations.

Table 1. Death rates for All Causes for American Indians and Alaska Natives compared with whites, Males and Females, All Ages: CHSDA counties, United States, 1990-2009.

	Haudenosaunee Nations							East							United States						
	AI/AN			White			AI/AN:White	AI/AN			White			AI/AN:White	AI/AN			White			AI/AN:White
Cause of Deatha	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio
Males and Females																					
All Causes	...	2,419	975.9	...	376,422	844.6	1.16*	...	9,833	847.1	...	2,787,191	824.1	1.03*	...	184,633	1,158.4	...	8,298,817	823.7	1.41*
Heart disease	1	688	306.2	1	124,096	272.6	1.12*	1	2,396	232.4	1	851,677	246.3	0.94*	1	36,199	265.0	1	2,401,219	234.6	1.13*
Cancer	2	442	180.8	2	89,832	203.6	0.89*	2	1,827	161.5	2	666,908	197.6	0.82*	2	30,837	205.5	2	1,961,477	193.3	1.06*
Unintentional Injury	3	182	53.5	6	10,196	25.7	2.08*	3	939	55.2	5	103,959	35.2	1.57*	3	24,299	102.9	5	349,035	38.3	2.69*
Diabetes mellitus	4	151	61.1	7	7,865	17.6	3.46*	4	684	59.4	7	60,945	17.9	3.31*	4	10,549	71.0	8	194,187	19.1	3.71*
Stroke	5	109	48.7	3	24,581	53.4	0.91	5	504	51.9	3	176,518	50.6	1.03	6	7,816	61.5	3	557,403	54.3	1.13*
Chronic liver disease	6	105	34.5	11	3,529	8.5	4.06*	6	402	26.9	12	29,969	9.4	2.86*	5	8,547	42.0	11	93,030	9.6	4.39*
Chronic Lower Respiratory Disease	7	104	46.2	4	19,761	43.3	1.07	7	313	30.1	4	144,806	41.8	0.72*	7	6,348	47.9	4	483,387	47.0	1.02
Influenza and pneumonia	8	55	27.2	5	12,132	26.4	1.03	8	230	25.5	6	84,987	24.3	1.05	9	5,455	42.3	6	253,216	24.7	1.71*
Kidney disease	9	51	21.8	8	5,384	11.8	3.31*	12	138	7.3	22	8,736	3.2	2.29*	10	3,540	13.1	21	28,058	3.3	4.01*
Septicemia	10	50	20.9	9	5,256	11.7	1.85*	9	199	18.2	9	40,278	11.6	1.57*	11	3,137	22.6	10	99,171	9.7	2.34*
Suicide	11	30	8.1	12	3,156	8.5	0.95	11	158	8.7	11	33,398	11.7	0.75*	8	5,582	20.9	9	128,794	14.3	1.46*
Males																					
All Causes	...	1,251	1,184.1	...	178,253	1,040.7	1.14*	...	5,215	995.9	...	1,357,842	1,012.6	0.98	...	101,696	1,390.9	...	4,140,089	997.3	1.39*
Heart disease	1	360	395.0	1	59,191	348.5	1.13*	1	1,279	283.0	1	417,231	313.8	0.90*	1	20,488	337.1	1	1,215,776	296.0	1.14*
Cancer	2	200	199.2	2	45,076	251.6	0.79*	2	932	196.2	2	343,655	245.4	0.80*	3	15,503	242.1	2	1,025,335	236.3	1.02*
Unintentional injury	3	124	81.9	5	6,183	36.3	2.26*	3	628	76.2	5	65,649	49.5	1.54*	2	16,673	146.7	4	222,193	53.0	2.77*
Diabetes mellitus	4	74	69.1	7	3,700	21.0	3.29*	4	316	59.5	7	29,582	21.5	2.77*	5	4,830	71.3	8	94,905	22.3	3.20*
Chronic liver disease	5	64	44.3	11	2,180	11.8	3.77*	5	235	33.6	10	19,146	13.2	2.54*	4	4,836	50.3	10	59,327	13.0	3.86*
Stroke	6	48	50.6	4	9,094	55.0	0.92	6	222	53.4	4	66,913	51.6	1.03	7	3,350	61.8	5	216,472	54.6	1.13*
Chronic Lower Respiratory Disease	7	47	51.9	3	9,441	54.9	0.95	7	145	34.2	3	69,171	51.2	0.67*	8	3,182	58.8	3	238,332	57.1	1.03
Influenza and pneumonia	8	27	38.2	6	5,353	33.6	1.14	9	113	33.0	6	37,341	29.8	1.11	9	2,794	52.6	6	113,846	29.7	1.77*
Suicide	9	27	15.5	8	2,671	15.3	1.01	8	123	14.0	8	26,340	19.3	0.72*	6	4,452	34.6	7	102,346	23.7	1.46*

Kidney disease	10	24	26.7	9	2,500	15.3	1.74*	11	91	19.6	9	19,719	15.4	1.28	11	1,370	23.7	11	49,475	12.5	1.89*
Assault (homicide)	11	20	10.9	23	399	2.3	4.68*	10	110	12.0	19	5,902	4.4	2.73*	10	2,663	20.1	20	18,832	4.4	4.56*
Females																					
All Causes	...	1,168	827.9	...	198,169	708.5	1.17*	...	4,618	730.9	...	1,429,349	683.9	1.07*	...	82,937	970.8	...	4,158,728	688.3	1.41*
Heart disease	1	328	248.5	1	64,905	218.9	1.14*	1	1,117	194.6	1	434,446	196.0	0.99	1	15,711	209.2	1	1,185,443	186.7	1.12*
Cancer	2	242	169.3	2	44,756	174.4	0.97	2	895	139.5	2	323,253	166.5	0.84*	2	15,334	180.2	2	936,142	164.1	1.10*
Diabetes mellitus	3	77	54.8	6	4,165	15.3	3.58*	3	368	58.4	8	31,363	15.3	3.81*	4	5,719	70.2	8	99,282	16.7	4.20*
Stroke	4	61	46.2	3	15,487	51.7	0.89	5	282	50.0	3	109,605	49.1	1.02	5	4,466	60.8	3	340,931	53.3	1.14*
Unintentional injury	5	58	31.7	7	4,013	16.9	1.87*	4	311	36.2	7	38,310	22.4	1.62*	3	7,626	63.4	7	126,842	24.8	2.56*
Chronic Lower Respiratory Disease	6	57	42.5	4	10,320	37.0	1.15	6	168	27.8	4	75,635	36.2	0.77*	7	3,166	40.9	4	245,055	40.7	1.01
Chronic liver disease	7	41	25.5	12	1,349	5.7	4.47*	7	167	21.3	12	10,823	6.1	3.49*	6	3,711	34.7	13	33,703	6.5	5.37*
Septicemia	8	33	23.8	9	2,890	10.3	2.30*	10	99	15.6	10	20,222	9.5	1.64*	10	1,396	16.7	10	41,899	6.9	2.41*
Influenza and pneumonia	9	28	21.6	5	6,779	22.3	0.97	8	117	21.2	5	47,646	21.0	1.01	8	2,661	35.5	6	139,370	21.6	1.65*
Kidney disease	10	27	19.2	10	2,884	9.9	1.94*	9	108	17.5	9	20,559	9.5	1.85*	9	1,767	22.2	9	49,696	8.0	2.79*

Note: AI/AN indicates: American Indian/Alaska Native; CHSDA: Contract Health Service Delivery Area. All analyses were limited to decedents of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the IHS patient registration database. Rates are per 100,000 people and were age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130). Rate ratios were calculated in SEER*Stat (version 8.3.2) before rounding of rates and may not equal RRs calculated from rates presented in the table. States and years data excluded because Hispanic origin was not collected on the death certificate: LA: 1990; NH: 1990-1992; OK: 1990-1996. East region is defined as: 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. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: East = 18.4%; total US = 64.2%.

Source: AI/AN Mortality Supplement Database (1990-2009).

† Identifies states with ≥ 1 county designated as CHSDA.

*P<0.05

In men, all cause death rates in the Haudenosaunee Nations (1,184.1 per 100,000) were higher than those in the East (995.9) but not as high as those in the U.S. (1,390.9). The leading cause of death was heart disease for both AI/AN and white men, with rates that ranged from 283.0 in East AI/AN to 395.0 for Haudenosaunee. The next ten leading causes of death for Haudenosaunee men were cancer, unintentional injury, diabetes, chronic liver disease, stroke, chronic lower respiratory disease, influenza and pneumonia, suicide, kidney disease, and homicide. Rates for Haudenosaunee males were significantly higher than whites for all causes (RR=1.14), heart disease (RR=1.13), unintentional injury (RR=2.26), diabetes mellitus (RR=3.29), chronic liver disease (RR=3.77), kidney disease (RR=1.74) and homicide (RR=4.68); and significantly lower for cancer (RR=0.79). Rates for suicide, stroke, chronic lower respiratory disease, and influenza and pneumonia were similar for Haudenosaunee and whites in the Haudenosaunee Nations.

In women, all cause death rates in the Haudenosaunee Nations (827.9 per 100,000) were greater than those in the East (730.9) but not as high as those in the United States (970.8). For AI/AN and white populations, all-cause death rates were substantially lower for women than for men in the Haudenosaunee Nations, East, and United States. The two leading causes of death for both AI/AN and white women were heart disease and cancer with heart disease death rates that ranged from 186.7 for U.S. whites to 248.5 for Haudenosaunee and cancer death rates that ranged from 139.5 for East AI/AN to 180.2 for U.S. AI/AN. The remaining leading causes of death for Haudenosaunee women are diabetes mellitus, stroke, unintentional injury, chronic lower respiratory disease, chronic liver disease, septicemia, influenza and pneumonia, and kidney disease. Rates for Haudenosaunee women were significantly higher than whites for all causes (RR=1.17), heart disease (RR=1.14), unintentional injury (RR=1.87), diabetes mellitus (RR=3.58), chronic liver disease (RR=4.47), kidney disease (RR=1.94), and septicemia (RR=2.30). Rates for cancer, stroke, chronic lower respiratory disease, and influenza and pneumonia were similar for Haudenosaunee and whites in the Haudenosaunee Nations.

Cancer death rates and leading cancer causes of death for the Haudenosaunee Nations, East, and U.S. comparing AI/AN with white persons by sex for 1990-2009 are presented in Table 2. The six leading causes of cancer death among the Haudenosaunee were lung and bronchus (lung), colon and rectum (colorectal), liver and intrahepatic bile duct (liver), pancreas, kidney and renal pelvis (kidney), and stomach cancer. The Haudenosaunee all malignant cancers death rates was 180.8, which was higher than the East AI/AN death rates (161.5) but not as high as those for U.S. AI/AN (205.5). Rates for Haudenosaunee were significantly higher than whites for liver cancer (RR=2.58) and significantly lower for all malignant cancers (RR=0.89). The rates for lung, colorectal, pancreas, stomach and kidney cancer were similar for Haudenosaunee and whites in the Haudenosaunee Nations. Comparisons of liver cancer mortality in AI/AN with white populations were greatest in the Haudenosaunee Nations (RR=2.58) than those in the East region (RR=1.57) and the United States (RR=2.40). Very large differences in liver cancer mortality were observed with higher rates among Haudenosaunee men (RR=2.69) and Haudenosaunee women (RR=2.84 – data not shown) when compared to whites.

Table 2. Death rates for Cancer Causes for American Indians and Alaska Natives compared with whites, Males and Females, All Ages: CHSDA counties, United States, 1990-2009.

	Haudenosaunee Nations							East							United States						
	AI/AN			White			AI/AN:White	AI/AN			White			AI/AN:White	AI/AN			White			AI/AN:White
Cause of Death[a]	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio	Rank	Count	Rate	Rank	Count	Rate	Rate Ratio
Males and Females																					
All Malignant Cancers	...	442	180.8	...	89,837	203.6	0.89*	...	1,827	161.5	...	666,932	197.6	0.82*	...	30,838	205.5	...	1,961,554	193.3	1.06*
Lung and bronchus	1	135	54.0	1	25,949	58.8	0.92	1	497	43.2	1	194,011	57.3	0.75*	1	7,906	53.1	1	563,590	55.2	0.96*
Colon and rectum	2	49	21.4	2	9,554	21.3	1.01	2	189	17.5	2	67,629	19.8	0.89	2	3,137	21.5	2	193,141	18.9	1.14*
Liver and intrahepatic bile duct	3	21	9.1	11	1,558	3.5	2.58*	4	79	6.6	9	14,036	4.2	1.57*	4	1,463	9.7	9	40,715	4.0	2.40*
Pancreas	4	19	8.1	3	5,044	11.3	0.71	3	90	8.3	3	37,287	11.0	0.76*	3	1,479	10.0	3	107,762	10.6	0.95*
Kidney and renal pelvis	5	15	6.0	9	1,837	4.2	1.44	6	59	5.1	10	13,800	4.1	1.24	6	1,215	7.8	8	41,953	4.1	1.88*
Stomach	6	13	5.3	8	1,906	4.3	1.24	5	59	5.0	8	14,393	4.2	1.19	5	1,237	8.2	10	37,171	3.7	2.23*
Males																					
All Malignant Cancers	...	200	199.2	...	45,081	251.6	0.79*	...	932	196.2	...	343,674	245.4	0.80*	...	15,503	242.1	...	1,025,385	236.4	1.02*
Lung and bronchus	1	59	52.6	1	14,513	78.9	0.67*	1	287	57.9	1	110,650	76.9	0.75*	1	4,354	67.6	1	320,431	71.8	0.94*
Colon and rectum	2	21	21.6	3	4,623	26.1	0.83	2	86	17.9	3	33,390	24.1	0.74*	2	1,586	24.7	3	97,516	22.7	1.09*
Prostate	3	21	28.5	2	4,690	28.2	1.01	3	86	27.5	2	35,587	27.3	1.01	3	1,319	27.7	2	114,978	28.7	0.97
Liver and intrahepatic bile duct	4	12	13.9	11	937	5.2	2.69*	4	51	9.3	8	8,966	6.3	1.47*	4	878	12.7	10	25,830	5.8	2.19*
Females																					
All Malignant Cancers	...	242	169.3	...	44,756	174.4	0.97	...	895	139.5	...	323,258	166.5	0.84*	...	15,335	180.2	...	936,169	164.1	1.10*
Lung and bronchus	1	76	53.4	1	11,436	45.2	1.18	1	210	32.8	1	83,361	43.4	0.76*	1	3,552	42.4	1	243,159	42.8	0.99
Colon and rectum	2	28	20.6	3	4,931	18.1	1.14	3	103	17.0	3	34,239	16.8	1.02	3	1,551	19.1	3	95,625	16.1	1.19*
Breast	3	27	17.9	2	7,255	29.5	0.61*	2	124	17.6	2	50,154	26.9	0.65*	2	1,970	21.6	2	146,357	26.5	0.82*
Pancreas	4	12	8.8	4	2,658	10.0	0.88	4	54	9.3	4	19,256	9.6	0.98	4	771	9.4	4	54,284	9.3	1.02

Note: AI/AN: American Indian/Alaska Native; CHSDA: Contract Health Service Delivery Area. All analyses were limited to decedents of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the IHS patient registration database. Rates are per 100,000 people and were age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130). Rate ratios were calculated in SEER*Stat (version 8.3.2) before rounding of rates and may not equal RRs calculated from rates presented in the table. States and years data excluded because Hispanic origin was not collected on the death certificate: LA: 1990; NH: 1990-1992; OK: 1990-1996. East region is defined as: 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. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: East = 18.4%; total US = 64.2%.

Source: AI/AN Mortality Supplement Database (1990-2009).

† Identifies states with ≥ 1 county designated as CHSDA.

*P<0.05

In men, the all malignant cancers death rates range from 196.2 for East AI/AN to 251.6 for Haudenosaunee Nations whites. For all AI/AN males, the leading cancer causes of death are lung, colorectal, prostate, and liver. With the exception of lung cancer, Haudenosaunee men have higher cancer death rates for the leading cancer causes of death than the East AI/AN men. Rates for Haudenosaunee males were significantly higher than whites for liver cancer (RR=2.69); and significantly lower for all malignant cancers (RR=0.79) and lung cancer (RR=0.67). Rates for colorectal and prostate cancer were similar for Haudenosaunee and whites in the Haudenosaunee Nations.

In women, the all malignant cancers death rates range from 139.5 for East AI/AN to 180.2 U.S. AI/AN. Haudenosaunee cancer mortality rates in women were 169.3 compared to 139.5 for the East AI/AN. The Haudenosaunee reflected rates that were lower than those of whites, but this new data showed all malignant cancer death rates for Haudenosaunee women to be higher than those reported for the East AI/AN. For females in the Haudenosaunee Nations, the leading cancer causes of death were lung, colorectal, breast, and pancreatic cancer. With the exception of pancreatic cancer, Haudenosaunee women had higher cancer death rates for the leading cancer causes of death than the East AI/AN women. Rates for Haudenosaunee females were significantly lower than whites for breast cancer (RR=0.61). Rates for all malignant cancers, lung, colorectal and pancreatic cancer were similar for Haudenosaunee and whites in the Haudenosaunee Nations.

Death rates for all causes by age for AI/AN compared to whites for 1990-2009 are shown in Table 3. When examined by age, disparities in all-cause mortality were most evident in younger age groups, particularly ages 25 to 44 years. This pattern was apparent for the Haudenosaunee Nations, East, and United States. It was particularly prominent in the United States, where all-cause death rates in this age group for AI/AN were 2.6 times higher than that for whites, and the Haudenosaunee Nations, where all-cause death rates for Haudenosaunee were 1.9 times higher than that for whites. The disparities in all-cause mortality were higher in the Haudenosaunee Nations than in the East and were statistically significantly different for all age groups.

Table 3. Death Rates for All Causes by Age for American Indians and Alaska Natives Compared with whites, Males and Females: CHSDA Counties, United States, 1990-2009.

		AI/AN		White		AI/AN:White	
Region	Age Group	Count	Rate	Count	Rate	Rate Ratio	95% CI
Haudenosaunee Nations	0-24 years	148	89.7	6,330	56.5	1.59*	1.34-1.87
	25-44 years	247	225.3	12,065	121.6	1.85*	1.63-2.10
	45-64 years	711	964.2	53,480	602.2	1.60*	1.48-1.72
	65-84 years	1,047	4273.9	191,781	3770.6	1.13*	1.06-1.21
	85+ years	266	12190.7	112,766	15251.0	0.80*	0.71-0.90

East	0-24 years	737	95.1	51,632	61.9	1.54*	1.43-1.65
	25-44 years	1,239	228.9	116,623	148.7	1.54*	1.45-1.63
	45-64 years	2,959	790.2	426,452	613.3	1.29*	1.24-1.34
	65-84 years	3,813	3617.8	1,358,821	3528.4	1.03	0.99-1.06
	85+ years	1,085	10875.0	833,663	14863.3	0.73*	0.69-0.78
US	0-24 years	18,394	144.2	177,184	65.1	2.22*	2.18-2.25
	25-44 years	28,658	386.3	367,061	149.4	2.59*	2.55-2.62
	45-64 years	50,735	1063.7	1,319,759	606.0	1.76*	1.74-1.77
	65-84 years	64,931	4638.5	4,019,450	3511.5	1.32*	1.31-1.33
	85+ years	21,915	15583.2	2,415,363	14974.6	1.04*	1.03-1.05

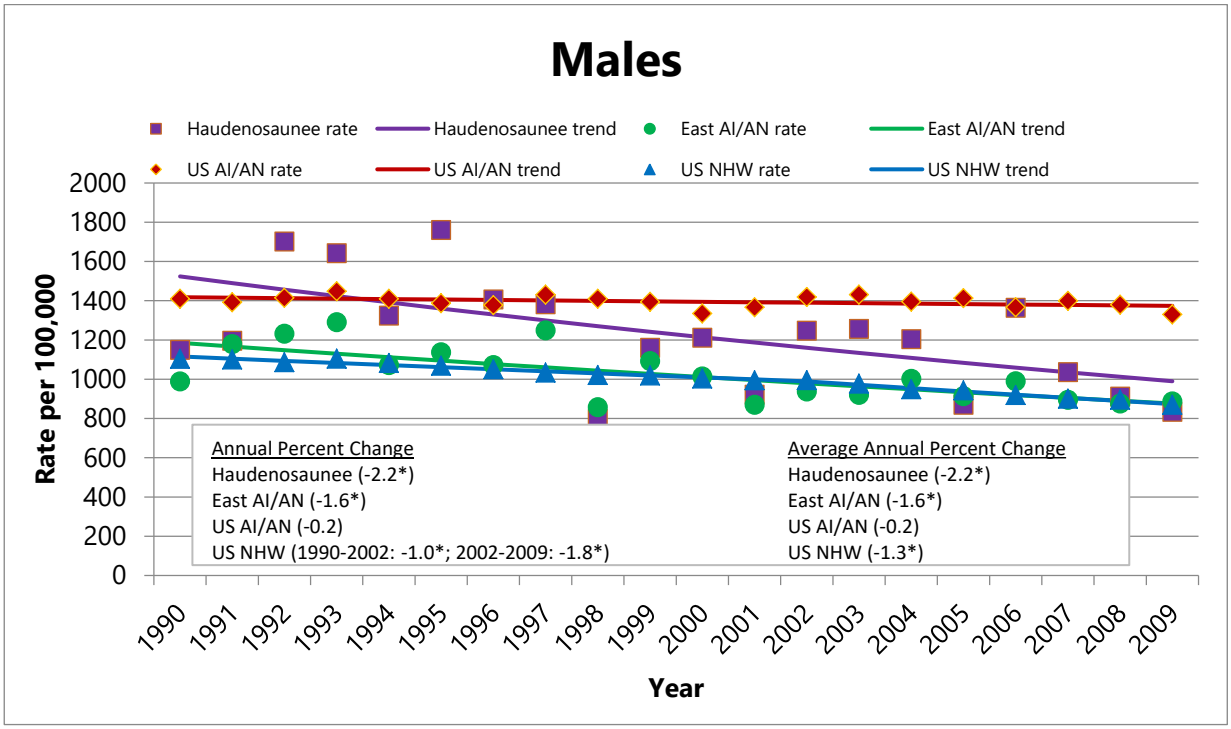
Note: AI/AN: American Indian/Alaska Native; CHSDA: Contract Health Service Delivery Area. All analyses were limited to decedents of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the IHS patient registration database. Rates are per 100,000 people and were age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130). Rate ratios were calculated in SEER*Stat (version 8.3.2) before rounding of rates and may not equal RRs calculated from rates presented in the table. States and years data excluded because Hispanic origin was not collected on the death certificate: LA: 1990; NH: 1990-1992; OK: 1990-1996. East region is defined as: 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. Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: East = 18.4%; total US = 64.2%.

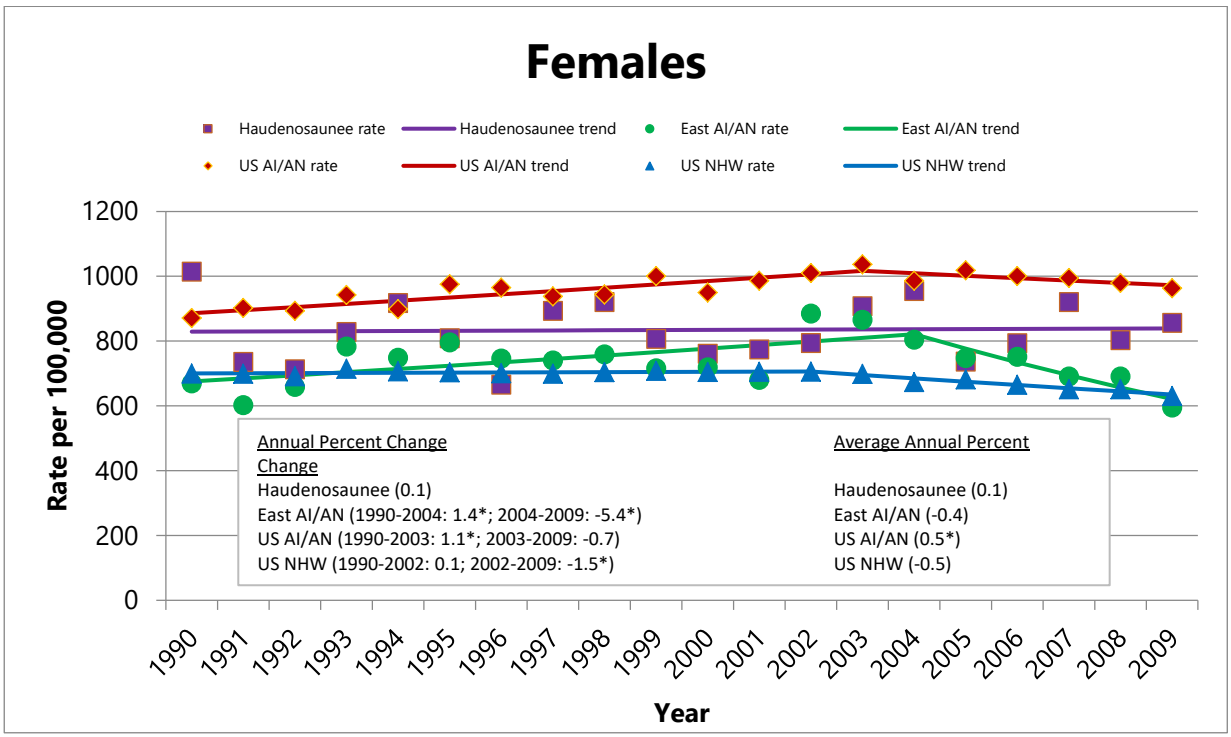
Source: AI/AN Mortality Supplement Database (1990-2009).

† Identifies states with ≥ 1 county designated as CHSDA.

*P<0.05

Figure 2 summarizes trends in all-cause mortality in CHSDA counties from 1990-2009 for Haudenosaunee, East AI/AN, U.S. AI/AN, and U.S. whites by sex. All-cause death rates for Haudenosaunee males declined 2.2% per year, whereas for East AI/AN males death rates declined 1.6% per year. Nationally, all-cause death rates remained stable for AI/AN males, whereas for white males, death rates declined 1.3% per year. Haudenosaunee females and East AI/AN females remained stable. Nationally, all-cause death rates for AI/AN females significantly increased 0.5% per year, whereas white female death rates were stable.





Note. AI/AN = American Indian/Alaska Native; CHSDA: Contract Health Service Delivery Area. Analyses are limited to persons of non-Hispanic origin. AI/AN race is reported from death certificates or through linkage with the IHS patient registration database. * α = 0.05.

Figure 2. Annual age-adjusted all-cause death rates and Joinpoint trend lines for males and females: CHSDA counties, US, 1990-2009

DISCUSSION

Haudenosaunee all-cause death rates were substantially greater than those for East AI/AN but not as great as those for U.S. AI/AN. The most prominent disparities for all-cause death rates of Haudenosaunee are concentrated in the younger age groups. The significant decrease in all-cause death rates over the past two decades for Haudenosaunee males is declining at a greater percentage per year than East AI/AN, U.S. AI/AN and U.S. whites. Unfortunately, this decrease was not observed for Haudenosaunee females with all-cause death rates appearing to be stable over the past two decades. Lastly, the leading specific cause of death and age at death disparities indicates potential areas of intervention that can improve mortality among the Haudenosaunee.

Health disparities

Among the Haudenosaunee of NYS, the six leading causes of death compared to whites for both males and females combined between 1990 and 2009 were heart disease, cancer, unintentional injury, diabetes, stroke, and liver disease. Statistically significant differences were found between Haudenosaunee and whites for deaths related to unintentional injury, diabetes, and chronic liver disease (see Table 1). Although cancer was the second leading cause of death for both Haudenosaunee and whites, the Haudenosaunee had a lower cancer death rate than whites.

Cancer

Deaths related to all malignant cancers were higher among the Haudenosaunee than the IHS East region as a whole. After IHS linkage, death rates for Haudenosaunee men and women were higher than the IHS East region. However, these numbers were lower than all AI/ANs combined and whites which also coincided with previous findings (Mahoney et al., 2009; Mahoney, Michalek, Cummings, Hanley, & Snyder, 1989).

The top two leading cancers that caused death among the Haudenosaunee were lung and colorectal, with death rates nearly equivalent to those of whites. These new results were comparable to previous studies listing lung cancer and colon cancer as the leading causes of mortality for tribally enrolled men of one tribe of the Haudenosaunee, followed by lung, cervix, and breast cancer for enrolled women of the same Nation (Mahoney et al., 1989).

This analysis shares *new concerns* which were difficult to assess in a previous study of one Haudenosaunee Nation based on a limited number of cases (Mahoney et al., 2009).

First, liver disease and liver cancer is of significant concern in these new findings. Chronic liver disease was classified as the fifth leading cause of death in AI/ANs, with alcoholic liver disease, Hepatitis C Virus (HCV) infection and non-alcoholic fatty liver disease as the most common contributors (Suryaprasad et al., 2014). Non-alcoholic fatty liver disease or NASH, sometimes referred to as diabetes hepatitis, is an increasingly recognized condition that may progress to end-stage liver disease and cancer (Batman & Scheuer, 1985; Nagore & Scheuer, 1988; Picardi & D'Avola, 2006). Obesity, type 2 diabetes, and hyperlipidemia are also coexisting conditions frequently associated with this disease (Suryaprasad et al., 2014; Than & Newsome, 2015; Aleksandrova, Stelmach-Mardas, & Schlesinger, 2016). Further, there are data that suggest that steatosis with other liver disease, such as the HCV

infection, could increase the risk of liver disease (Angulo, 2002).

Diabetes

Type 2 diabetes is often related to obesity and both often co-occur with other conditions and chronic diseases (Bril & Cusi, 2017; Rice et al., 2016; Vigneri, P., Frasca, Sciacca, Pandini, & Vigneri, R., 2009). These include fatty liver disease and certain types of cancer. Both chronic liver disease and liver cancer were concerns for both males and females of the Haudenosaunee compared to whites. Regionally, diabetes mortality for the Haudenosaunee nearly mirrored that found in the East region and among other AI/AN populations in NYS (data not shown) (Cho et al., 2014). However, mirroring nationwide findings, Haudenosaunee men and women die nearly 3.5 times more than whites from diabetes.

In regards to sex, diabetes rates in Haudenosaunee men were higher than those reported for East AI/AN, and closely mirrored rates for US AI/AN men. Mortality associated with diabetes for Haudenosaunee women was slightly lower than previous statistics shown for all AI/AN women in the East. These findings are similar to recent national data that indicated that age-adjusted diabetes prevalence rates among AI/AN persons were at least twice those of whites or the total U.S. population and ranked as the fourth leading cause of death for AI/AN persons (Cho et al., 2014).

LIMITATIONS

These results have several limitations. 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. AI/AN who are not members of federally recognized tribes are not eligible for IHS services and are therefore not represented in the IHS patient registration database. Additionally, some eligible decedents may have never used IHS services and were therefore not included in the IHS patient registration database. Second, the findings from CHSDA counties do not represent all AI/AN populations in the US or the East region, which includes only 18.2% of the total AI/AN population (Espey et al., 2014b). 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 (Jacobs-Wingo et al., 2016; Urban Indian Health Institute, 2008). Third, federally recognized tribes vary substantially in the proportion of native ancestry required for tribal membership and therefore for eligibility for IHS services. Whether or how this discrepancy in tribal membership requirements may influence some of our findings is unclear, although our findings are consistent with prior reports. Fourth, to capture enrolled and non-enrolled Haudenosaunee, analyses were restricted to the nine counties that comprise most of the Haudenosaunee Nations. The nine county restriction may have excluded Haudenosaunee that that do not live in these counties and included AI/ANs that belong to other tribes. Finally, although the exclusion of Hispanic AI/AN persons from the analyses reduces the overall US AI/AN deaths by less than 5%, it may disproportionately exclude some tribal members. For instance, tribal members in states along the US-Mexico border and possibly elsewhere who have Hispanic

surnames and may be coded as Hispanic on the death certificate.

FUTURE RESEARCH

More research is needed to investigate what is causing the high mortality of liver disease and associated cancers affecting the Haudenosaunee. The relationship between mortality and obesity has been further supported in previous research from a member tribe of the Haudenosaunee. The research showed that, during a 30-year study period, 8.3 percent of years of potential life loss were due to digestive disorders that may be related to obesity and dietary practices (Mahoney et al. 1989). Further, in another tribe of the Haudenosaunee, six cardiovascular disease risk factors were evaluated. Of 95 school children, 55 represented 39 interrelated families. Seventy-two percent of the family histories included diabetes mellitus and 42% of the children's physical examinations revealed obesity (weight/height greater than 90th percentile) (Botash et al., 1992).

Future investigation is needed to discover if variables causing liver disease differ among the Haudenosaunee. These include specific variances between fatty liver disease, HCV, and the role of both alcoholic and non-alcoholic cirrhosis. Potential co-occurring conditions of concern related to liver disease and liver cancer are common among the Haudenosaunee and may be additive or synergistic in the development of disease. Hepatitis C infection rates should be evaluated. Otherwise, the stereotype of assuming the problems are all related to alcoholism might delay a more complete understanding of the health risks within this population. The impact of historical trauma, inducing adverse childhood experiences, among AI/ANs is just now being evaluated for its relationship to cancer (Brown et al., 2010; Shonkoff et al., 2009).

This is an initial paper and comparisons to ethnically and racially diverse populations that may be facing similar social determinants of health in the same geographic regions should be explored. Recent updated cancer incidence and mortality evaluations have clearly identified the importance of regional differences across AI/AN populations (Espey et al., 2014a; Plescia, Henley, Pate, Underwood, & Rhodes, 2014). Disparities in cancer and other diseases are due to inequalities in socioeconomic status, sexual orientation, gender, disability status, geographic location, discriminatory practices, or some combination of factors (Brennan Ramirez, Baker, & Metzler, 2008; Krieger, Emmons, & Williams, 2009). Further, future studies could also include the review of other Haudenosaunee populations outside of NYS (i.e., Haudenosaunee located in Canada, Wisconsin, and Oklahoma).

For the Haudenosaunee and other AI/AN populations, chronic diseases, such as diabetes, heart disease and cancer, are now the norm (Cobb et al., 2014; Acton et al., 2002; Burrows, Geiss, Engelgau, & Acton, 2000; Go et al., 2013). There was a time when infectious diseases were the major health focus. Cancer was previously reported for whites and blacks only in the SEER Cancer Statistics Review. Now we know that all segments of the population, large and small, should have data that will guide resources and appropriate interventions in reducing cancer (Wallerstein & Duran, 2010). The definitions of population data are also very important, as shown here, so that the limitations can be understood and data of higher quality can be collected going forward. Understanding factors affecting small

population groups is crucial to overcoming disparities and will likely require new research designs with community-based participatory research as the guiding principle (Srinivasan et al., 2015). The community should be heard and their feedback incorporated into the way in which questions are asked and data used to develop culturally appropriate interventions (Cochran et al., 2008).

Overall, these new findings provide a crucial framework for tribal health centers, AI/AN urban centers, and those who work with the Haudenosaunee in NYS. These new data identify health disparity rates higher for the Haudenosaunee than previously published or in comparison to aggregate data for all Native Nations in the IHS East region. There should be a realization of cultural and traditional views of the Haudenosaunee and understanding of what is important to future generations, including the integration or enhancement of interventions and prevention programs. Such programs could also include the philosophies and traditional viewpoints of the people of the confederacy wrapped in a framework of resiliency and courage. Lastly, it is also important to be cognizant of historical factors related to environmental shifts, and generational stress, and how these may contribute to current health disparities (Brown et al., 2010; Shonkoff et al., 2009; Warne, 2005; Anda, Butchart, Felitti, & Brown, 2010; Felitti et al., 1998; Mehta et al., 2013).

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Disclaimer

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.

Conflict of interest

The authors declare that no competing or conflict of interests exists. The funders had no role in study design, writing of the manuscript, or decision to publish.

Authors' contributions

Dr. Rodney Haring, Dean Seneca, and Melissa Jim worked collaboratively on conceptualization, project aims, goals, methods, and results. Melissa Jim was the primary statistician and epidemiological reviewer. Dr. Deborah Erwin focused on health disparities overview and manuscript structuring and Dr. Judith Kaur assisted with discussion items. Whitney Ann Henry and Marissa Haring provided literature review support and assistance with manuscript writing and review.

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