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Research Article

The Prevalence of Cardiovascular Disease and Other Comorbidities Among American Indian and Alaska Native Adults with Diabetes

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Abstract

Aims: American Indians and Alaska Native (AI/ANs) peoples experience significant health disparities compared to the U.S. general population. We report comorbidities among AI/ANs with diabetes to guide efforts to improve their health status.

Methods: Drawing upon data for over 640,000 AI/ANs who used services funded by the Indian Health Service, we identified 43,518 adults with diabetes in fiscal year 2010. We reported the prevalence of comorbidities by age and cardiovascular disease (CVD) status. Generalized linear models were estimated to describe associations between CVD and other comorbidities.

Results: Nearly 15% of AI/AN adults had diabetes. Hypertension, CVD and kidney disease were comorbid in 77.9%, 31.6%, and 13.3%, respectively. Nearly 25% exhibited a mental health disorder; 5.7%, an alcohol or drug use disorder. Among AI/ANs with diabetes absent CVD, 46.9% had 2 or more other chronic conditions; the percentage among adults with diabetes and CVD was 75.5%. Hypertension and tobacco use disorders were associated with a 71% (95% CI for prevalence ratio: 1.63 - 1.80) and 33% (1.28 - 1.37) higher prevalence of CVD, respectively, compared to adults without these conditions.

Conclusion: Detailed information on the morbidity burden of AI/ANs with diabetes may inform enhancements to strategies implemented to prevent and treat CVD and other comorbidities.

Keywords: *American Indians; Alaska Natives; Diabetes; Cardiovascular Disease; Mental Health Disorders; Kidney Disease*

Introduction

American Indian and Alaska Native (AI/AN) peoples experience significant health disparities, including those associated with diabetes and related complications [1-4]. In 2015, 15.1% of AI/ANs aged 18 years and older had diabetes, the prevalence in this group is the high-

est of all other U.S. population groups and more than double that of non-Hispanic whites [1]. In addition to being impacted disproportionately by the prevalence of diabetes, AI/ANs also experience earlier onset and higher rates of comorbidities than other populations [4-9]. The AI/AN all-cause mortality rate is 46% higher than that of non-Hispanic whites; this difference is largely attributable to greater AI/AN disparities in heart disease, stroke, diabetes, and kidney disease mortality [2,10-12]. Diabetes and the combination of diabetes and cardiovascular disease (CVD) not only contribute to higher mortality among AI/ANs of all ages, but also fuel higher rates of premature mortality (i.e. mortality among those younger than 65 years old) [10-12]. Forty-one percent of AI/AN diabetes-related deaths occur among persons younger than 65 years old, in contrast to 23.4% among non-Hispanic whites [10]. Approximately one-third of AI/AN deaths attributed to heart disease and one-quarter of those attributed to stroke occur before age 65 [11,12].

Contributing to the burden of diabetes among AI/ANs is the limited funding associated with their care. A large percentage of AI/AN peoples receive health care services through the federal government due to its trust responsibility to provide health care to members of federally recognized Tribes. This responsibility is fulfilled in part by the Indian Health Service (IHS), through programs and policies outlined in numerous federal statutes [13]. IHS includes hospitals, clinics, and health programs operated by the federal government, by Tribal organizations through contracts and compacts with IHS, and by urban Indian health organizations that receive modest IHS support. Combined, they serve approximately 2.6 million AI/ANs who live throughout the United States [14]. Unfortunately, this system of care has very limited funding: AI/AN per capita health spending was $4,078 in fiscal year 2017 [14-16]. Although this amount did not include all spending associated with patient care, it is substantially lower than per capita spending for the U.S. general population ($10,224) in 2017 [17]. In addition to IHS health resource constraints, provider shortages and community-level factors (e.g. low household income, rural geography) [5,16,18-22] also affect patient service use and health. For these reasons, detailed understanding of the morbidity burden is critical to inform targeted enhancement of services to improve health outcomes for AI/ANs with diabetes.

CVD is the leading cause of disability and death among adults with diabetes [23,24] and is associated with higher treatment costs and rates of preventable hospital stays among AI/AN adults with diabetes [25,26]. In an effort to reduce the disproportionate morbidity and mortality experienced by AI/ANs with diabetes and CVD, this study focused on providing a clear picture of the prevalence of diabetes-related comorbidities by age and CVD status. Comorbidities experienced by those without CVD may guide enhancements to policies and programs aimed at preventing CVD, while comorbidity patterns for those with CVD may better inform therapeutic interventions and related cardiovascular outcomes.

We were in the unique position to include data that represent nearly 30% of the IHS service population [19]. The data were obtained from a data infrastructure, developed through the IHS Improving Health Care Delivery Data Project (IHS Data Project), which includes comprehensive physical and behavioral health status information for over 43,000 AI/AN adults with diabetes who lived throughout the United States. This data infrastructure was created to provide population-based statistics on health status, utilization, and treatment costs; to supplement findings from other AI/AN studies; and address constraints of earlier studies of comorbidities among AI/ANs with diabetes that include small sample sizes (e.g. less than 4,000), limited age ranges (e.g. aged 45 years and older), partial geographic representation (e.g. 1 - 4 locations), and truncated scopes of analysis (e.g. one comorbidity) [5,7-9,27-30]. By reporting on the prevalence of selected diabetes-related comorbidities by CVD status, we hope the findings may ultimately contribute to reducing the CVD burden among AI/AN adults with diabetes and resources associated with potentially preventable hospitalizations of these adults while at the same time improving their health-related quality of life, day to day functioning and quality of clinical care.

Research Design and Methods

This cross-sectional analysis of existing IHS data was conducted to characterize the morbidity burden of AI/AN adults with diabetes over the life course. Our methods are based on those developed during an earlier project, namely the Phoenix Diabetes Utilization and Cost Study, which provided the first detailed analysis of health status, service use, and treatment costs for AIs who used IHS services in a single project site in the southwestern United States [8,25].

Data

The data were extracted from a data infrastructure developed through the IHS Data Project. These data include information for a purposeful sample of AI/ANs who lived in 14 Service Units (hereafter referred to as project sites) located throughout the United States with one project site in the East, 4 in the Northern Plains, 2 in the Southern Plains, 5 in the Southwest, 2 on the Pacific Coast and 1 in Alaska [2]. The IHS Data Project population was identified by project sites, rather than by random sampling, to enable us to obtain information about the local service delivery systems and treatment costs to create service and cost measures not available elsewhere. The project population was comparable to the national IHS service population in age and gender and includes AI/ANs living in urban, suburban and rural locations.

The data infrastructure was created by merging existing IHS electronic data stored on multiple platforms. Sources of IHS electronic data include the: 1) National Data Warehouse (NDW), which includes utilization data for Indian Health Service and Tribal (I/T) services; 2) Purchased/Referred Care (PRC) data, which includes information on specialty inpatient and outpatient services obtained from non-I/T providers and paid for by the I/Ts; 3) Centers for Medicare and Medicaid Services Cost Report data and 4) procurement cost data for prescribed medications. More information on the development of the data infrastructure is reported elsewhere [19]. This study included the analysis of fiscal year (FY) 2009 and FY2010 data.

Population

The study population includes AI/AN adults identified as IHS active users during FY2010 and who resided in one of the 14 project sites during that year (n = 295,393). An "IHS active user" during any one fiscal year is defined as a person who obtained services from an I/T or urban Indian health program at least once during that year or the two previous fiscal years. For example, an FY2010 active user utilized services at least once during FY2008-2010.

Measures

Demographic measures included age and gender. We used Sightlines™ DxCG Risk Solutions software to categorize diagnosed conditions among the AI/AN adults, drawing upon FY2009 and FY2010 NDW and PRC inpatient and outpatient electronic health records [31]. This software classifies the ICD-9-CM diagnostic codes into nearly 800 disease categories. The prevalence of diabetes, which included type 1 and 2, CVD and 9 other conditions that included diabetes-related complications (e.g. kidney disease, neuropathy) and conditions that may complicate their treatment (e.g. mental health disorder, alcohol, or drug abuse) was determined using combinations of those categories. Use of injectable anti-diabetic agents also identified adults with diabetes. CVD was defined as ischemic heart disease, congestive heart failure and other forms of heart disease, cerebrovascular disease and vascular disease. Amputations were assessed by diagnoses related to lower limb amputations. Mental health disorders included depression and other mood and anxiety disorders.

Analysis

SAS statistical software version 9.4 was used to create the data infrastructure and conduct the analyses [32]. We described the prevalence of comorbidities among adults with diabetes by age and CVD status. Multivariate regressions were estimated to understand associations between age, gender, and other conditions with CVD among the adults with diabetes. Since CVD status was binary, we considered using logistic regression to estimate the regression model. However, the relatively high prevalence of CVD among adults would produce inflated odds ratio estimates [33]. For this reason, we estimated generalized linear models with a Poisson distribution with a log link function, using the method proposed by Zou to produce robust confidence intervals [34].

Results

The prevalence of diabetes was 14.7% among AI/AN adults in FY2010 (Table 1). Among adults aged 18 - 34 years, the prevalence of diabetes was 3.3%. It increased to 12.7% among those aged 35 - 44 years and 20.6% among adults aged 45 - 54 years. More than one-third of adults aged 55 years and older had diabetes.

	All adults	Adults with diabetes		Adults without diabetes	
	N	N	%	N	%
Age group					
18 - 34	129,861	4,323	3.3%	125,538	96.7%
35 - 44	52,104	6,633	12.7%	45,471	87.3%
45 - 54	49,947	10,289	20.6%	39,658	79.4%
55 - 64	33,315	10,969	32.9%	22,346	67.1%
65+	30,166	11,304	37.5%	18,862	62.5%
Gender					
Male	135,686	18,868	13.9%	116,818	86.1%
Female	159,707	24,650	15.4%	135,057	84.6%
All adults	295,393	43,518	14.7%	251,875	85.3%

Table 1: *Prevalence of diabetes by age and gender, among American Indian and Alaska Native adults. Fiscal year 2010.*

The prevalence of CVD and other conditions by age and diabetes status are presented in table 2. Among the 43,518 adults with diabetes, the prevalence of hypertension and CVD, respectively, was 77.9% and 31.6%. Thirteen percent had kidney disease; 3.3% had end-stage renal disease (ESRD). The prevalence of amputations was 2.4%. Among males and females with diabetes, the prevalence of CVD was 36.3% and 28.0%, respectively (data not shown).

	All adults			Adults with diabetes			Adults without diabetes		
	N	%	CI	N	%	CI	N	%	CI
Hypertension									
18-34	7,273	5.6	(5.5-5.7)	1,886	43.6	(42.2-45.1)	5,387	4.3	(4.2-4.4)*
35-44	11,067	21.2	(20.9-21.6)	4,401	66.4	(65.2-67.5)	6,666	14.7	(14.3-15.0)*
45-54	18,100	36.2	(35.8-36.7)	8,060	78.3	(77.5-79.1)	10,040	25.3	(24.9-25.8)*
55-64	17,665	53.0	(52.5-53.6)	9,348	85.2	(84.6-85.9)	8,317	37.2	(36.6-37.9)*
65+	19,524	64.7	(64.2-65.3)	10,192	90.2	(89.6-90.7)	9,332	49.5	(48.8-50.2)*
All ages	73,629	24.9	(24.8-25.1)	33,887	77.9	(77.5-78.3)	39,742	15.8	(15.6-15.9)*
All ages with age adjustment[a]				30.9					(30.7-31.1)*
CVD									
18-34	2,694	2.1	(2.0-2.2)	316	7.3	(6.6-8.1)	2,378	1.9	(1.8-2.0)*
35-44	2,788	5.4	(5.2-5.6)	947	14.3	(13.5-15.1)	1,841	4.1	(3.9-4.2)*
45-54	5,620	11.3	(11.0-11.5)	2,419	23.5	(22.7-24.3)	3,201	8.1	(7.8-8.3)*
55-64	7,021	21.1	(20.6-21.5)	3,828	34.9	(34.0-35.8)	3,193	14.3	(13.8-14.8)*
65+	11,586	38.4	(37.9-39.0)	6,244	55.2	(54.3-56.2)	5,342	28.3	(27.7-29.0)*
All ages	29,709	10.1	(10.0-10.2)	13,754	31.6	(31.2-32.0)	15,955	6.3	(6.2-6.4)*

All ages with age adjustment[a]								13.7	(13.6-13.8)*
Kidney disease/ESRD									
18-34	402	0.3	(0.3-0.3)	162	3.8	(3.2-4.4)	240	0.2	(0.2-0.2)*
35-44	677	1.3	(1.2-1.4)	401	6.1	(5.5-6.7)	276	0.6	(0.5-0.7)*
45-54	1,344	2.7	(2.6-2.8)	937	9.1	(8.6-9.7)	407	1.0	(0.9-1.1)*
55-64	1,960	5.9	(5.6-6.1)	1,520	13.9	(13.2-14.5)	440	2.0	(1.8-2.2)*
65+	3,923	13.0	(12.6-13.4)	2,763	24.4	(23.7-25.2)	1,160	6.2	(5.8-6.5)*
All ages	8,306	2.8	(2.8-2.9)	5,783	13.3	(13.0-13.6)	2,523	1.0	(1.0-1.0)*
All ages with age adjustment[a]								2.4	(2.3-2.5)*
Kidney disease without ESRD									
18-34	301	0.2	(0.9-1.1)	115	2.7	(2.2-3.2)	186	0.2	(0.1-0.2)*
35-44	487	0.9	(1.8-2.2)	276	4.2	(3.7-4.7)	211	0.5	(0.4-0.5)*
45-54	996	2.0	(5.8-6.5)	665	6.5	(6.0-7.0)	331	0.8	(0.8-0.9)*
55-64	1,431	4.3	(1.0-1.0)	1,058	9.7	(9.1-10.2)	373	1.7	(1.5-1.9)*
65+	3,291	10.9	(3.2-4.4)	2,220	19.6	(18.9-20.4)	1,071	5.7	(5.4-6.0)*
All ages	6,506	2.2	(5.5-6.7)	4,334	10.0	(9.7-10.2)	2,172	0.9	(0.8-0.9)*
All ages with age adjustment[a]								2.2	(2.1-2.3)*
ESRD									
18-34	101	0.1	(0.1-0.1)	47	1.1	(0.8-1.5)	54	0.0	(0.0-0.1)*
35-44	190	0.4	(0.3-0.4)	125	1.9	(1.6-2.2)	65	0.1	(0.1-0.2)*
45-54	348	0.7	(0.6-0.8)	272	2.6	(2.4-3.0)	76	0.2	(0.2-0.2)*
55-64	529	1.6	(1.5-1.7)	462	4.2	(3.9-4.6)	67	0.3	(0.2-0.4)*
65+	632	2.1	(1.9-2.3)	543	4.8	(4.4-5.2)	89	0.5	(0.4-0.6)*
All ages	1,800	0.6	(0.6-0.6)	1,449	3.3	(3.2-3.5)	351	0.1	(0.1-0.2)8
All ages with age adjustment[a]								0.3	(0.3-0.3)8
Neuropathy									
18-34	1,993	1.5	(1.5-1.6)	356	8.2	(7.5-9.1)	1,637	1.3	(1.2-1.4)*
35-44	2,486	4.8	(0.2-0.4)	989	14.9	(14.1-15.8)	1,497	3.3	(3.1-3.5)*
45-54	4,007	8.0	(0.4-0.6)	2,160	21.0	(20.2-21.8)	1,847	4.7	(4.5-4.9)*
55-64	3,714	11.2	(0.1-0.2)	2,528	23.1	(22.3-23.8)	1,186	5.3	(5.0-5.6)*
65+	3,740	12.4	(0.8-1.5)	2,710	24.0	(23.2-24.8)	1,030	5.5	(5.2-5.8)*
All ages	15,940	5.4	(1.6-2.2)	8,743	20.1	(19.7-20.5)	7,197	2.9	(2.8-2.9)*
All ages with age adjustment[a]								4.5	(4.4-4.6)*
Eye disease									
18-34	1,384	1.2	(1.2-1.3)	384	8.9	(8.1-9.8)	1,000	0.9	(0.9-1.0)*
35-44	1,656	3.6	(3.5-3.8)	1,057	16.0	(15.1-16.9)	599	1.5	(1.4-1.7)*
45-54	2,957	6.6	(6.3-6.8)	2,083	20.3	(19.5-21.1)	874	2.5	(2.4-2.7)*
55-64	3,848	12.6	(12.3-13.0)	2,918	26.7	(25.9-27.5)	930	4.8	(4.5-5.1)*
65+	6,047	22.1	(21.6-22.6)	3,944	35.0	(34.1-35.9)	2,103	13.1	(12.6-13.6)*
All ages	15,892	6.1	(6.0-6.2)	10,386	23.9	(23.5-24.3)	5,506	2.5	(2.5-2.6)*

All ages with age adjustment[a]								5.5	(5.4-5.6)*
Amputation									
18-34	70	0.1	(0.0-0.1)	34	0.8	(0.6-1.1)	36	0.0	(0.0-0.0)*
35-44	158	0.3	(0.3-0.4)	123	1.9	(1.6-2.2)	35	0.1	(0.1-0.1)*
45-54	299	0.6	(0.5-0.7)	259	2.5	(2.2-2.8)	40	0.1	(0.1-0.1)*
55-64	357	1.1	(1.0-1.2)	315	2.9	(2.6-3.2)	42	0.2	(0.1-0.3)*
65+	362	1.2	(1.1-1.3)	316	2.8	(2.5-3.1)	46	0.2	(0.2-0.3)*
All ages	1,246	0.4	(0.4-0.5)	1,047	2.4	(2.3-2.6)	199	0.1	(0.1-0.1)*
All ages with age adjustment[a]								0.1	(0.1-0.1)*
Mental health disorder									
18-34	14,597	11.2	(11.1-11.4)	972	22.5	(21.3- 3.8)	13,625	10.9	(10.7-11.0)*
35-44	8,431	16.2	(15.9-16.5)	1,729	26.1	(25.0-27.1)	6,702	14.7	(14.4-15.1)*
45-54	9,286	18.6	(18.3-18.9)	2,694	26.2	(25.3-27.0)	6,592	16.6	(16.3-17.0)*
55-64	6,375	19.1	(18.7-19.6)	2,668	24.3	(23.5-25.1)	3,707	16.6	(16.1-17.1)*
65+	4,479	14.9	(14.5-15.3)	2,151	19.0	(18.3-19.8)	2,328	12.3	(11.9-12.8)*
All ages	43,168	14.6	(14.5-14.7)	10,214	23.5	(23.1-23.9)	32,954	13.1	(13.0-13.2)*
All ages with age adjustment[a]								14.6	(14.5-14.7)*
Depression									
18-34	7,710	5.9	(5.8-6.1)	605	14.0	(13.0-15.1)	7,105	5.7	(5.5-5.8)*
35-44	4,902	9.4	(9.2-9.7)	1,116	16.8	(15.9-17.7)	3,786	8.3	(8.1-8.6)*
45-54	5,820	11.7	(11.4-11.9)	1,849	18.0	(17.2-18.7)	3,971	10.0	(9.7-10.3)*
55-64	4,220	12.7	(12.3-13.0)	1,846	16.8	(16.1-17.5)	2,374	10.6	(10.2-11.0)*
65+	2,771	9.2	(8.9-9.5)	1,399	12.4	(11.8-13.0)	1,372	7.3	(6.9-7.7)*
All ages	25,423	8.6	(8.5-8.7)	6,815	15.7	(15.3-16.0)	18,608	7.4	(7.3-7.5)*
All ages with age adjustment[a]								8.8	(8.7-8.9)*
Other mental health disorders[b]									
18-34	10,816	8.3	(8.2-8.5)	637	14.7	(13.7-15.8)	10,179	8.1	(8.0-8.3)*
35-44	5,865	11.3	(11.0-11.5)	1,072	16.2	(15.3-17.1)	4,793	10.5	(10.3-10.8)*
45-54	5,879	11.8	(11.5-12.1)	1,532	14.9	(14.2-15.6)	4,347	11.0	(10.7-11.3)*
55-64	3,629	10.9	(10.6-11.2)	1,387	12.6	(12.0-13.3)	2,242	10.0	(9.7-10.4)*
65+	2,474	8.2	(7.9-8.5)	1,124	9.9	(9.4-10.5)	1,350	7.2	(6.8-7.5)*
All ages	28,663	9.7	(9.6-9.8)	5,752	13.2	(12.9-13.5)	22,911	9.1	(9.0-9.2)*
All ages with age adjustment[a]								9.4	(9.3-9.5)*
Alcohol/drug abuse disorders									
18-34	6,901	5.3	(5.2-5.4)	403	9.3	(8.5-10.2)	6,498	5.2	(5.1-5.3)*
35-44	3,389	6.5	(6.3-6.7)	624	9.4	(8.7-10.1)	2,765	6.1	(5.9-6.3)*
45-54	3,033	6.1	(5.9-6.3)	793	7.7	(7.2-8.2)	2,240	5.7	(5.4-5.9)*
55-64	1,194	3.6	(3.4-3.8)	447	4.1	(3.7-4.5)	747	3.3	(3.1-3.6)*
65+	510	1.7	(1.6-1.8)	191	1.7	(1.5-1.9)	319	1.7	(1.5-1.9)*
All ages	15,027	5.1	(5.0-5.2)	2,458	5.7	(5.4-5.9)	12,569	5.0	(4.9-5.1)*
All ages with age adjustment[a]								4.1	(4.0-4.2)*

Tobacco use disorders									
18-34	8,540	6.6	(6.4-6.7)	570	13.2	(12.2-14.2)	7,970	6.4	(6.2-6.5)*
35-44	5,260	10.1	(9.8-10.4)	949	14.3	(13.5-15.2)	4,311	9.5	(9.2-9.8)*
45-54	7,110	14.2	(13.9-14.5)	1,678	16.3	(15.6-17.0)	5,432	13.7	(13.4-14.0)*
55-64	4,510	13.5	(13.2-13.9)	1,488	13.6	(12.9-14.2)	3,022	13.5	(13.1-14.0)*
65+	2,538	8.4	(8.1-8.7)	972	8.6	(8.1-9.1)	1,566	8.3	(7.9-8.7)
All ages	27,958	9.5	(9.4-9.6)	5,657	13.0	(12.7-13.3)	22,301	8.9	(8.7-9.0)*
All ages with age adjustment[a]								10.9	(10.8-11.0)*
Liver disease									
18-34	2,116	1.6	(1.6-1.7)	271	6.3	(5.6-7.0)	1,845	1.5	(1.4-1.5)*
35-44	1,851	3.6	(3.4-3.7)	464	7.0	(6.4-7.6)	1,387	3.1	(2.9-3.2)*
45-54	2,756	5.5	(5.3-5.7)	920	8.9	(8.4-9.5)	1,836	4.6	(4.4-4.8)*
55-64	1,732	5.2	(5.0-5.4)	766	7.0	(6.5-7.5)	966	4.3	(4.1-4.6)*
65+	1,023	3.4	(3.2-3.6)	524	4.6	(4.3-5.0)	499	2.7	(2.4-2.9)*
All ages	9,478	3.2	(3.2-3.3)	2,945	6.8	(6.5-7.0)	6,533	2.6	(2.5-2.7)*
All ages with age adjustment[a]								3.5	(3.4-3.6)*
Presence of 2 or more conditions[c]									
18-34	10,347	8.0	(7.8-8.1)	1,457	33.7	(32.3-35.1)	8,890	7.1	(6.9-7.2)*
35-44	10,089	19.4	(19.0-19.7)	3,335	50.3	(49.1-51.5)	6,754	14.9	(14.5-15.2)*
45-54	15,286	30.6	(30.2-31.0)	6,233	60.6	(59.6-61.5)	9,053	22.8	(22.4-23.2)*
55-64	14,017	42.1	(41.5-42.6)	7,486	68.3	(67.4-69.1)	6,531	29.2	(28.6-29.8)*
65+	16,179	53.6	(53.1-54.2)	8,856	78.3	(77.6-79.1)	7,323	38.8	(38.1-39.5)*
All ages	65,918	22.3	(22.2-22.5)	27,367	62.9	(62.4-63.3)	38,551	15.3	(15.2-15.5)*
All ages with age adjustment[a]				25.8					(25.6-26.0)*

Table 2: *Prevalence of comorbidities among American Indian and Alaska Native adults by diabetes status. Fiscal year 2010. N is the number, % is percent and CI is the 95 percent confidence interval. Confidence interval limits may appear equal to each other or equal to reported percent because of rounding. CVD: Cardiovascular Disease; ESRD: End Stage Renal Disease. *: Indicates comorbidity rates in adults with and without diabetes significantly different at .05 level. [a]: The prevalence value for adults without diabetes was adjusted by age to match the age distribution of adults with diabetes [b]: Mental health disorders other than depression include anxiety, bipolar, and post-traumatic stress disorders.[c]: The presence of 10 conditions is counted, including hypertension, cardiovascular disease, kidney disease, neuropathy, eye disease, amputation, mental health disorders, alcohol or drug abuse, tobacco use disorder, and liver disease.*

A substantial percentage of younger and middle-aged adults with diabetes had a diagnosis of hypertension, CVD, or kidney disease. Among those aged 35 - 44 years, the prevalence of these comorbidities was 66.4%, 14.3% and 6.1%, respectively. Among patients aged 45 - 54 years, the prevalence increased to 78.3%, 23.5% and 9.1%. Approximately 90% of those aged 65 years and older with diabetes had hypertension, over half had CVD (55.2%), and almost one-fourth (24.4%) had kidney disease.

Table 2 also includes the prevalence of mental health disorders and substance abuse among AI/AN adults with diabetes. Nearly 25% exhibited a mental health disorder; 15.7% were diagnosed with depression. The prevalence of alcohol or drug use disorders was 5.7%;

the prevalence was over 9% for those aged 18-44 years and decreased to 1.7% among those aged 65 years and older. The prevalence of tobacco use disorders among adults with diabetes was 13.0%; the prevalence of tobacco use disorders among those aged 65 years and older was also lower.

The prevalence of these conditions was statistically higher ($p < 0.05$) among adults with diabetes than those without diabetes for nearly every age group. Accordingly, the rates for all adults with diabetes were statistically higher ($p < 0.05$) than the age-adjusted rates for all adults without diabetes. Over 60% of adults with diabetes had two or more of the 10 comorbidities included in this study, compared to 25.8% of adults without diabetes (age-adjusted rate, $p < 0.05$).

Table 3 characterizes the prevalence of comorbidities among adults with diabetes by CVD status. Among adults with diabetes but not CVD, the prevalence of hypertension and kidney disease was 71.9% and 4.1%, respectively. The prevalence of mental health disorders, alcohol or drug use disorders, and tobacco use disorders was 22.1%, 5.8%, and 11.9%, respectively.

Condition and age group	Adults with diabetes and CVD			Adults with diabetes but not CVD		
	N	%	CI	N	%	CI
Hypertension						
18-34	213	67.4	(62.1-72.3)	1,673	41.8	(40.2-43.3)*
35-44	795	84.0	(81.5-86.2)	3,606	63.4	(62.2-64.7)*
45-54	2,134	88.2	(86.9-89.4)	5,926	75.3	(74.3-76.2)*
55-64	3,505	91.6	(90.6-92.4)	5,843	81.8	(80.9-82.7)*
65+	5,854	93.8	(93.1-94.3)	4,338	85.7	(84.7-86.7)*
All ages	12,501	90.9	(90.4-91.4)	21,386	71.9	(71.3-72.4)*
All ages with age adjustment[a]					80.3	(79.8-80.8)*
Kidney disease/ESRD						
18-34	84	26.6	(22.0-31.7)	78	2.0	(1.6-2.4)*
35-44	261	27.6	(24.8-30.5)	140	2.5	(2.1-2.9)*
45-54	673	27.8	(26.1-29.6)	264	3.4	(3.0-3.8)*
55-64	1,196	31.2	(29.8-32.7)	324	4.5	(4.1-5.1)*
65+	2,353	37.7	(36.5-38.9)	410	8.1	(7.4-8.9)*
All ages	4,567	33.2	(32.4-34.0)	1,216	4.1	(3.9-4.3)8
All ages with age adjustment[a]					5.7	(4.5-7.1)*

Kidney disease without ESRD						
18-34	52	16.5	(12.8-21.0)	63	1.6	(1.2-2.0)*
35-44	167	17.6	(15.3-20.2)	109	1.9	(1.6-2.3)*
45-54	451	18.6	(17.1-20.3)	214	2.7	(2.4-3.1)*
55-64	792	20.7	(19.4-22.0)	266	3.7	(3.3-4.2)*
65+	1,853	29.7	(28.6-30.8)	367	7.3	(6.6-8.0)8
All ages	3,315	24.1	(23.4-24.8)	1,019	3.4	(3.2-3.6)8
All ages with age adjustment[a]					5.0	(3.8-6.5)*
ESRD						
18-34	32	10.1	(7.2-14.0)	15	0.4	(0.2-0.6)*
35-44	94	9.9	(8.2-12.0)	31	0.6	(0.4-0.8)*
45-54	222	9.2	(8.1-10.4)	50	0.6	(0.5-0.8)*
55-64	404	10.6	(9.6-11.6)	58	0.8	(0.6-1.1)*
65+	500	8.0	(7.4-8.7)	43	0.9	(0.6-1.2)*
All ages	1,252	9.1	(8.6-9.6)	197	0.7	(0.6-0.8)*
All ages with age adjustment[a]					0.8	(0.0-3.9)*
Neuropathy						
18-34	62	19.6	(15.6-24.4)	294	7.3	(6.6-8.2)*
35-44	260	27.5	(24.7-30.4)	729	12.8	(12.0-13.7)*
45-54	812	33.6	(31.7-35.5)	1,348	17.1	(16.3-18.0)*
55-64	1,241	32.4	(31.0-33.9)	1,287	18.0	(17.2-18.9)*
65+	1,820	29.2	(28.0-30.3)	890	17.6	(16.6-18.7)*
All ages	4,195	30.5	(29.7-31.3)	4,548	15.3	(14.9-15.7)*
All ages with age adjustment[a]					17.1	(16.0-18.2)*
Eye disease						
18-34	65	21	(16.5-25.4)	319	8.0	(7.2-8.9)*
35-44	246	26	(23.4-29.0)	811	14.3	(13.4-15.2)*

45-54	745	31	(29.0-32.7)	1,338	17.0	(16.2-17.9)*
55-64	1,284	34	(32.1-35.1)	1,634	22.9	(22.0-23.9)*
65+	2,400	38	(37.3-39.7)	1,544	30.6	(29.4-31.9)*
All ages	4,740	35	(33.7-35.3)	5,646	19.0	(18.6-19.5)*
All ages with age adjustment[a]					24.5	(23.4-25.6)*
Amputation						
18-34	19	6.0	(3.8-9.3)	15	0.4	(0.2-0.6)*
35-44	71	7.5	(6.0-9.4)	52	0.9	(0.7-1.2)*
45-54	164	6.8	(5.8-7.9)	95	1.2	(1.0-1.5)*
55-64	235	6.1	(5.4-7.0)	80	1.1	(0.9-1.4)*
65+	270	4.3	(3.9-4.9)	46	0.9	(0.7-1.2)*
All ages	759	5.5	(5.2-5.9)	288	1.0	(0.9-1.1)*
All ages with age adjustment[a]					1.0	(0.2-3.2)*
Mental health disorders						
18-34	105	33.2	(28.3-38.6)	867	21.6	(20.4-22.9)*
35-44	331	35.0	(32.0-38.1)	1,398	24.6	(23.5-25.7)*
45-54	805	33.3	(31.4-35.2)	1,889	24.0	(23.1-25.0)*
55-64	1,081	28.2	(26.8-29.7)	1,587	22.2	(21.3-23.2)*
65+	1,328	21.3	(20.3-22.3)	823	16.3	(15.3-17.3)*
All ages	3,650	26.5	(25.8-27.3)	6,564	22.1	(21.6-22.5)*
All ages with age adjustment[a]					20.0	(19.1-21.0)*
Depression						
18-34	72	22.8	(18.5-27.7)	533	13.3	(12.3-14.4)*
35-44	223	23.6	(21.0-26.4)	893	15.7	(14.8-16.7)*
45-54	594	24.6	(22.9-26.3)	1,255	16.0	(15.2-16.8)*
55-64	775	20.3	(19.0-21.6)	1,071	15.0	(14.2-15.9)*
65+	871	14.0	(13.1-14.8)	528	10.4	(9.6-11.3)*

All ages	2,535	18.4	(17.8-19.1)	4,280	14.4	(14.0-14.8)*
All ages with age adjustment[a]					13.1	(12.1-14.2)*
Other mental health disorders[b]						
18-34	76	24.1	(19.7-29.1)	561	14.0	(13.0-15.1)*
35-44	201	21.2	(18.7-24.0)	871	15.3	(14.4-16.3)*
45-54	436	18.0	(16.5-19.6)	1,096	13.9	(13.2-14.7)*
55-64	545	14.2	(13.2-15.4)	842	11.8	(11.1-12.6)*
65+	694	11.1	(10.4-11.9)	430	8.5	(7.8-9.3)*
All ages	1,952	14.2	(13.6-14.8)	3,800	12.8	(12.4-13.2)*
All ages with age adjustment[a]					11.0	(10.0-12.0)*
Alcohol/drug abuse disorders						
18-34	55	17.4	(13.6-22.0)	348	8.7	(7.9-9.6)*
35-44	121	12.8	(10.8-15.1)	503	8.9	(8.1-9.6)*
45-54	241	10.0	(8.8-11.2)	552	7.0	(6.5-7.6)*
55-64	200	5.2	(4.6-6.0)	247	3.5	(3.1-3.9)*
65+	118	1.9	(1.6-2.3)	73	1.4	(1.2-1.8)*
All ages	735	5.3	(5.0-5.7)	1,723	5.8	(5.5-6.1)*
All ages with age adjustment[a]					3.7	(2.9-4.7)*
Tobacco use disorders						
18-34	64	20.3	(16.2-25.0)	506	12.6	(11.6-13.7)*
35-44	199	21.0	(18.5-23.7)	750	13.2	(12.3-14.1)*
45-54	565	23.4	(21.7-25.1)	1,113	14.1	(13.4-14.9)*
55-64	641	16.8	(15.6-18.0)	847	11.9	(11.1-12.6)*
65+	636	10.2	(9.5-11.0)	336	6.6	(6.0-7.4)*
All ages	2,105	15.3	(14.7-15.9)	3,552	11.9	(11.6-12.3)*
All ages with age adjustment[a]					5.3	(4.4-6.4)*
Liver disease						

18-34	29	9.2	(6.4-12.9)	242	6.0	(5.3-6.8)
35-44	108	11.4	(9.5-13.6)	356	6.3	(5.7-6.9)*
45-54	304	12.6	(11.3-14.0)	616	7.8	(7.3-8.4)8
55-64	348	9.1	(8.2-10.0)	418	5.9	(5.3-6.4)*
65+	332	5.3	(4.8-5.9)	192	3.8	(3.3-4.4)*
All ages	1,121	8.2	(7.7-8.6)	1,824	6.1	(5.9-6.4)*
All ages with age adjustment[a]					10.0	(9.0-11.0)*
Presence of 2 or more conditions[c]						
18-34	202	63.9	(58.5-69.0)	1,176	29.4	(28.0-30.8)
35-44	697	73.6	(70.7-76.3)	2,436	42.8	(41.6-44.1)*
45-54	1,884	77.9	(76.2-79.5)	3,896	49.5	(48.4-50.6)*
55-64	2,955	77.2	(75.8-78.5)	3,737	52.3	(51.2-53.5)*
65+	4,743	76.0	(74.9-77.0)	2,711	53.6	(52.2-55.0)*
All ages	10,481	76.2	(75.5-76.9)	13,956	46.9	(46.3-47.5)*
All ages with age adjustment[a]					51.2	(50.4-52.0)*

Table 3: *Prevalence of comorbidities among American Indian and Alaska Native adults with diabetes by cardiovascular disease (CVD) status. Fiscal year 2010.*

n is the number, % is percent and CI is the 95 percent confidence interval. Confidence interval limits may appear equal to each other or equal to reported percentage because of rounding.

ESRD, end stage renal disease.

**: Indicates comorbidity prevalence in adults with diabetes, with and without CVD significantly different at 0.05 level.*

a: The prevalence value for adults with diabetes and without CVD was adjusted by age to match the age distribution of adults with diabetes with CVD.

b: Mental health disorders other than depression include anxiety, bipolar, and post-traumatic stress disorders.

c: The presence of 9 conditions is counted, including hypertension, kidney disease, neuropathy, eye disease, amputation, mental health disorders, alcohol or drug abuse, tobacco use disorder and liver disease.

In FY2010, 13,754 adults had both diabetes and CVD. Among these adults, the prevalence of hypertension was 90.9% and the prevalence of kidney disease was 24.1%. Nine percent had ESRD. Nearly one-third had neuropathy, and 5.5% had a diagnosis related to a lower limb amputation. The prevalence of these three conditions among adults with both diabetes and CVD was statistically (age-adjusted rate, $p < 0.05$) higher than among adults with diabetes absent CVD. Similarly, the prevalence of mental health and substance use disorders was also higher, although the statistical significance of findings varied by age. Approximately three-quarters (76.2%) of adults with diabetes and CVD had two or more additional comorbidities. Among those diagnosed with diabetes absent CVD, the age-adjusted percentage with two or more comorbidities, other than CVD, was 51.2%, statistically lower than the percentage among adults with diabetes and CVD ($p < 0.05$).

Multivariate regressions were estimated to understand associations among age, gender, and other conditions, with CVD among adults with diabetes (Table 4). Controlling for age and comorbidities, males with diabetes were 25% more likely to have CVD than were females (95% CI 1.22 - 1.28). Nearly 80% of adults with diabetes had hypertension (Table 2); this condition was associated with a prevalence ratio of 1.71 (1.62 - 1.80) for CVD (71% higher prevalence of CVD compared to adults without hypertension). Having kidney disease or ESRD was associated with a prevalence of CVD more than twice that of those without these conditions [2.13 (2.07 - 2.19) and 2.57 (2.49 - 2.67), respectively]. Patients diagnosed with a tobacco use disorder had a 33% (1.28 - 1.37) higher prevalence of CVD compared to those without the disorder. Similarly, patients with neuropathy, eye disease, amputation-related procedures, mental health disorders, alcohol or drug abuse, and liver disease were more likely to also have CVD.

Characteristics	Model #1. Age and gender		Model #2. Age, gender, and comorbidities	
	PR	CI	PR	CI
Age group				
18-34	1.00[a]	--	1.00[a]	--
35-44	1.91	(1.69-2.15)	1.60	(1.42-1.80)
45-54	3.13	(2.80-3.50)	2.34	(2.10-2.60)
55-64	4.69	(4.21-5.23)	3.26	(2.93-3.62)
65+	7.43	(6.68-8.28)	4.70	(4.23-5.23)
Gender				
Male	1.30	(1.26-1.33)	1.25	(1.22-1.28)
Female	1.00[a]	--	1.00[a]	--
Health conditions[b]				
Hypertension			1.71	(1.63-1.80)
Kidney disease (without ESRD)			2.13	(2.07-2.19)
ESRD			2.57	(2.49-2.67)
Neuropathy			1.22	(1.19-1.25)
Eye disease			1.11	(1.08-1.14)
Amputations			1.22	(1.17-1.28)
Mental health disorder			1.20	(1.16-1.23)
Alcohol/drug abuse			1.10	(1.04-1.17)
Tobacco use disorder			1.33	(1.28-1.37)
Liver disease			1.16	(1.11-1.21)

Table 4: *Characteristics associated with cardiovascular disease among American Indian and Alaska Native adults with diabetes. Fiscal Year 2010.*

PR: Prevalence Ratio; CI, 95% Confidence Interval; ESRD: End Stage Renal Disease.

a: Referent group.

b: The referent groups are the absence of each disorder (PR = 1.00).

Discussion

A number of important studies have contributed to our knowledge of comorbidities among AI/ANs with diabetes [4,5,7-9,27,29,30,35,36]. This is the first study, to our knowledge, to include data for a large number of AI/ANs (n = 43,518) with diabetes and report on a sub-

stantially larger number of comorbidities. In relying on the data infrastructure that includes physical and behavioral health information for nearly 30% of the IHS user population, this study has addressed the limitations of earlier studies, such as small sample size, limited geographic representation, limited number of comorbidities assessed, and inability to report findings for both younger and older adults [4,5,7-9,27,29,30,35,36]. For example, the groundbreaking Strong Heart Study provided extremely valuable information about CVD and CVD risk factors among AI/ANs with diabetes [7,30,36,37] and recent Strong Heart Study findings continue to prominently inform on AI/AN health issues [38,39]. The Strong Heart Study initially included data for approximately 2,000 AI adults with diabetes aged 45 - 74 years who lived in four states.

Before the IHS Data Project infrastructure was created, it was not possible to conduct detailed analyses of multiple comorbidities among a large number of AI/AN adults with diabetes, analyses commonly conducted for other populations (e.g. Medicare, Medicaid, commercially insured populations) to evaluate patient needs and policies and programs implemented to address them [40,41]. AI/AN-specific data on the morbidity burden of AI/AN adults with diabetes with and without CVD will inform public health strategies to strengthen prevention and treatment of CVD and other comorbidities in this population.

To better understand the impact of this larger and more geographically broad study population, we compared current results to two earlier studies that employed similar methods and included data for a non-AI/AN reference population. We were not able to identify one study with data for AI/AN adults of all ages with a reference population. We compared our results for adults aged 18 - 64 years old to those of the Phoenix Diabetes Utilization and Cost Study (Phoenix study), which provided 2005 health status information for AI adults with diabetes aged 18 - 64 years for only one site in the Southwest [8] and compared results for adults aged 65 years and older to those of AI/AN Medicare enrollees aged 65 years and older located throughout the U.S. (Medicare study) [5]. The present study included a broader array of health conditions and describes a higher morbidity burden among the AI/AN adults with diabetes, than each of the comparison populations represented in these two studies.

In the Phoenix study, the morbidity burden of AI adults aged 18 - 64 years exceeded that of U.S. adults by 50%. Prevalence estimates of hypertension, kidney disease, ESRD, neuropathy, and amputations among adults aged 18 - 64 years in the present study were similar to those reported for the AI adults with diabetes in the Phoenix study and were statistically higher than those for U.S. adults with diabetes. The prevalence of CVD among AI/ANs in this study was statistically higher than that reported in the Phoenix study. These comparisons illustrate the substantially higher morbidity of AI/ANs with diabetes aged 18 - 64 years, compared to a similarly aged commercially insured population with diabetes.

Next, we compared findings for AI/ANs aged 65 years and older from this study to the Medicare study [19]. The prevalence of CVD was 55.2% among AI/AN adults with diabetes aged 65 years and older in the present study, which is similar to that reported for aged AI/AN Medicare enrollees with diabetes and somewhat lower than for aged non-Hispanic white Medicare enrollees with diabetes. The prevalence of ESRD reported in this study among AI/ANs with diabetes aged 65 years and older (4.8%) was also comparable to that reported for the aged AI/AN Medicare enrollees with diabetes, and substantially higher than that of the aged non-Hispanic white Medicare enrollees, which ranged between 1 - 2%. This comparison indicates that AI/AN adults aged 65 years and older had higher morbidity than the non-Hispanic white Medicare adults with diabetes of similar age. Furthermore, the Medicare study did not report other comorbidities that may affect diabetes treatment. The present study provided results on the prevalence of kidney disease, without ESRD (19.6%), mental health disorders (23.5%), alcohol and drug use disorders (5.7%), tobacco use disorders (13.0%), and other conditions, and offers a more complete depiction of the treatment needs for AI/AN adults with diabetes and CVD.

Three notable findings emerged from these results. The first highlights the opportunity for increased focus on CVD prevention. This focus may include efficiently directing sufficient resources to prevent and treat associated conditions, metabolic risk factors (e.g. hypertension, dyslipidemia) and behavioral risk factors (e.g. smoking) in order to substantially reduce CVD related morbidity and mortality [24].

Previous studies documented that AI/ANs, compared to other populations, are more likely to experience early onset of diabetes [6,8]. In this study, nearly one-third of adults with diabetes had CVD, including a sizable percentage (7.3%) of adults with diabetes aged 18 - 34 years. The prevalence of CVD among those 35 - 44, 45 - 54 and 55 - 64 years was 14.3%, 23.5%, and 34.9%, respectively: these rates are statistically higher than those of the U.S. adults with diabetes reported in the Phoenix study [8]. This is especially noteworthy given the high percentage of AI/AN deaths due to heart disease and stroke that occur before age 65 and highlights the significance of a companion focus on CVD prevention [11,12]. This is particularly important due to the economic burden [42] of AI/AN CVD-related potentially preventable hospitalizations. In addition to IHS and Tribal funding, Medicare, Medicaid, and private insurance reimbursement mechanisms that account for the AI/AN patient characteristics (e.g. higher morbidity burden, rural population, lower income) and I/T delivery systems are needed to promote the financial sustainability of such service enhancements.

Second, prevention and treatment strategies need to consider age and gender-specific risk factors. For example, the type of strategy used and content of materials may differ by age and gender. Similar to national statistics and findings from other studies [30,36,43-45], AI/AN males with diabetes were more likely than were females to also have CVD. While estrogen and other female biological characteristics have been found to be protective against CVD [46], age- and gender-specific information on modifiable CVD risk factors (e.g. tobacco use among young and middle-aged adults) may inform efforts to reduce CVD risks and augment outreach and services. We will examine age and gender-specific risks using this data infrastructure in future analyses and obtain information from project sites about their efforts to address such risks.

Third, early diagnosis, treatment of concurrent conditions, education, and support will likely improve patient self-management, quality of life, and mortality risk while at the same time reducing expenditures associated with potentially preventable exacerbations of chronic diseases [42,47]. Nearly two-thirds (62.9%) of AI/AN adults with diabetes had two or more other chronic conditions; the age-adjusted percentage among adults with diabetes absent CVD was 51.2% and among those with diabetes and CVD, 76.2%. Among adults with both conditions, we found that these comorbidities occurred at alarmingly high rates among young, middle-aged, and older adults, underscoring the importance of diagnosing diabetes early and improving the ability of adults with diabetes to manage their condition to not only limit the onset of CVD, but the onset of these other conditions as well. Furthermore, patients with multiple comorbidities may require additional support (e.g. medication management; coordination between primary health care with specialty, behavioral health, and inpatient services) than those with fewer comorbidities [48,49]. Given the high rates of behavioral health disorders identified in this population [50,51], planners are encouraged to design more comprehensive, better-integrated programs with the "whole person" in mind. While comorbid depression or anxiety among adults with diabetes have been associated with higher medical expenditures than expenditures among those without such mental health conditions [52,53], use of collaborative care interventions and a team approach are associated with improved diabetes self-management and depression outcomes [54,55].

Limitations of the Study

Several study limitations merit acknowledgement. First, the study included data for IHS active users who lived in 14 project sites. They represent a large proportion of individuals eligible for I/T health services who live throughout the United States. However, the findings may not reflect the health status of AI/AN peoples who live elsewhere or who do not receive services from I/T providers, many of whom live in urban and suburban areas.

Second, similar to projects that involve the use of administrative health data, we reported the prevalence of conditions based on diagnoses included in medical service utilization records. In addition, we calculated the prevalence of tobacco use disorders rather than past and current smoking patterns due to the quality of those data in our data infrastructure. While this unique data infrastructure allowed us to include a large number of AI/ANs in the analyses, we did not have available the detail and accuracy of medical records. It is important to acknowledge that this data infrastructure includes information for services provided by I/T programs or paid for by those programs

through Purchased and Referred Care. We did not have data on other services used by the project population, and access to other services varied across the project sites. These factors may have biased downward the prevalence estimates and smoking risks, a bias which likely varied across project sites. Sites also varied by the types of services provided (e.g. specialty and inpatient services), Purchased and Referred Care utilization, and completeness of data.

Third, we used cross-sectional data for AI/AN adults with diabetes to examine associations among a number of health conditions with CVD to improve understanding of the morbidity burden of those with diabetes by CVD status. Although beyond the scope of this study, we intend to use this data infrastructure to conduct future longitudinal data analyses. For example, we will employ multivariate analyses to identify patient and provider characteristics associated with lower rates of CVD onset among AI/ANs with diabetes to inform policymakers of existing successful strategies.

Fourth, these IHS data do not include a wide array of personal and community characteristics that influence health-seeking behaviors and health outcomes such as social determinants of health (e.g. income, education, access to affordable and nutritious food) and health factors (e.g. geographic and financial access to services). In future analyses, we will merge county-level measures of AI/AN educational attainment and household income and other characteristics from U.S. Census data and other surveys to assess such relationships [56,57]. Moreover, there are over 570 federally recognized Tribes throughout the United States, and Tribal variation in culture, traditions, and history needs to be considered [22].

Despite the above limitations, our study is the first to include data for a large, geographically diverse sample of AI/AN adults aged 18 years and older with diabetes and who used I/T services. Based on data on physical and behavioral health diagnoses recorded in electronic health records, the results provide information on a large number of comorbidities by age and CVD status. The information can guide improvements in public health and clinical strategies to prevent and treat CVD, a condition that causes considerable morbidity and mortality among AI/ANs.

Future Directions

The Tribal Technical Advisory Group to the Centers for Medicare and Medicaid Services recommends that IHS, Tribal, and other federal and state policy makers use AI/AN-specific data to evaluate policies and programs proposed to limit their morbidity and mortality, and ultimately to reduce disparities between AI/ANs and other U.S. populations [58]. While the current analyses focused solely on the health status of adults with diabetes, the IHS Data Project's data infrastructure may also inform AI/AN utilization of preventive and primary care services, including medication use, and associations between their use with patient outcomes and treatment costs. Although beyond the scope of the present study, such analyses may be designed to apprise IHS and Tribes on implementation of evidenced-based services for AI/ANs who suffer from diabetes and other chronic diseases.

Conclusion

AI/ANs experience substantial disparities in morbidity and mortality associated with diabetes, heart disease, stroke, and ESRD, including premature mortality [2,10-12]. The IHS Standards of Care and Clinical Practice Recommendations: Type 2 Diabetes [59] provides guidance to clinicians and educators, useful clinical tools and resources, and patient education materials for an array of topics (e.g. blood pressure, glycemic control, depression, tobacco use), including those for older adults and patients with multiple comorbidities. This study's detailed results on multiple comorbidities among AI/AN adults with diabetes, by age and CVD status, provide support for using scarce IHS and Tribal resources to effectively implement and coordinate services, based on the IHS Standards of Care, for more favorable outcomes associated with CVD morbidity, mortality, service utilization and costs.

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