Racial Disparities in Health Status

A comparison of the morbidity among American Indian and U.S. adults with diabetes

JOAN O'CONNELL, PHD[1]
RONG YI, PHD[2]
CHARLTON WILSON, MD, FACP[3]
SPERO M. MANSON, PHD[1]
KELLY J. ACTON, MD, MPH, FACP[4]

OBJECTIVE — American Indians and Alaska Natives are 2.3 times more likely to have diabetes than are individuals in the U.S. general population. The objective of this study was to compare morbidity among American Indian and U.S. adults with diabetes.

RESEARCH DESIGN AND METHODS — We extracted demographic and health service utilization data for an adult American Indian population aged 18–64 years (n = 30,121) served by the Phoenix Service Unit from the Indian Health Service clinical reporting system. Similar data for a U.S. population (n = 1,500,002) with commercial health insurance, matched by age and sex to the American Indian population, were drawn from the MartketScan Research Database. We used Diagnostic Cost Groups to identify medical conditions for which each individual was treated and to assign a risk score to quantify his or her morbidity burden. We compared the prevalence of comorbidities and morbidity burden of American Indian and U.S. adults with diabetes.

RESULTS — American Indians with diabetes had significantly higher rates of hypertension, cerebrovascular disease, renal failure, lower-extremity amputations, and liver disease than commercially insured U.S. adults with diabetes ($P < 0.05$). The American Indian prevalence rates were 61.2, 6.9, 3.9, 1.8, and 7.1%, respectively. The morbidity burden among the American Indian with diabetes exceeded that of the insured U.S. adults with diabetes by 50%.

CONCLUSIONS — The morbidity burden associated with diabetes among American Indians seen at the Phoenix Service Unit far exceeded that of commercially insured U.S. adults. These findings point to the urgency of enhancing diabetes prevention and treatment services for American Indians/Alaska Natives to reduce diabetes-related disparities.

Diabetes Care 33:1463–1470, 2010

Although the epidemiology of diabetes differs among various racial/ethnic populations in the U.S. and other countries, the disease burden is considerable because of its association with high rates of morbidity and mortality and lower quality of life (1–9). Diabetes exerts a substantial burden among American Indians and Alaska Natives, who are 2.3 times more likely to have diabetes than are individuals in the U.S. general population and who have high rates of premature mortality (3,5,10–12). In 2004, the prevalence of diagnosed diabetes among American Indians and Alaska Natives aged ≥20 years was 16.3% (age-adjusted to the U.S. general population), and the rate is rapidly increasing (5).

To date, only a limited number of studies have compared the prevalence of comorbidities among American Indians and Alaska Natives with diabetes to similar rates among other populations. Higher rates of end-stage renal disease, lower-limb amputations, and heart disease have been documented among American Indians and Alaska Natives with diabetes (5,10,13–15). Many of these studies included a limited age range of study participants, addressed only one condition, or used previously published data to draw comparisons between American Indians and Alaska Natives and other populations and did not include adjustments for age differences among populations (5,10,13–15).

The Indian Health Service (IHS) provides health services to >1.9 million American Indians and Alaska Natives throughout the U.S. (16), including >300,000 with diabetes (5). The IHS annual budget of >$4.3 billion equates to ~$2,300 per individual (16). Included in the budget are Medicaid, Medicare, and commercial health insurance payments for IHS services provided to American Indians and Alaska Natives with such coverage and funds for the Special Diabetes Program for Indians (SDPI). In 1997, Congress passed legislation to create SDPI to provide additional IHS funding for diabetes prevention and treatment programs, funding nearly 400 diabetes programs in American Indian and Alaska Native communities in 2007 (5). Since the enactment of SDPI, intermediate clinical outcomes (e.g., blood glucose, blood pressure, and cholesterol levels) among American Indians and Alaska Natives with diabetes have improved (17), and the rate of diabetes-related end-stage renal disease has decreased (15).

Even with these improvements, diabetes-related disparities persist. Diabetes is the fourth leading cause of death among American Indians and Alaska Natives, and mortality due to diabetes among American Indians and Alaska Natives is ~4 times higher than that of the U.S. general population (18). Heart disease, the leading cause of American Indian and

From the [1]Centers for American Indian and Alaska Native Health, Colorado School of Public Health, University of Colorado Denver, Denver, Colorado; [2]Milliman, Inc., Wakefield, Massachusetts; the [3]Phoenix Indian Medical Center, Indian Health Service, Phoenix, Arizona; and the [4]Division of Diabetes Treatment and Prevention, Indian Health Service, Albuquerque, New Mexico.
Corresponding author: Joan O'Connell, joan.oconnell@ucdenver.edu.
Received 3 September 2009 and accepted 23 March 2010. Published ahead of print at http://care.diabetesjournals.org on 31 March 2010. DOI: 10.2337/dc09-1652.
The conclusions and opinions presented herein are those of the authors and not necessarily those of the Indian Health Service or the University of Colorado Denver. R.Y. is a former employee of Verisk Health. Neither that organization nor the Indian Health Service had a role in the design or conduct of the study; the management, analysis, and interpretation of the data; or the preparation of the manuscript. J.O. has full access to the IHS data, and R.Y. had full access to the U.S. reference data. Neither author had full access to both sets of data. IHS personnel provided IHS data extracts for the study.

Alaska Native mortality, appears to be more often fatal among American Indians than in other populations (3,10). American Indians and Alaska Natives have the highest rate of premature deaths from heart disease of all races, with 36% of deaths from heart disease classified as premature; the rate is nearly 2.5 times that of whites (12). Federal and tribal policy makers require detailed information about the prevalence of comorbidities among American Indians and Alaska Natives with diabetes to guide prevention and treatment strategies, and the allocation of health resources within IHS.

Here, we examined the prevalence of a number of comorbidities among American Indians aged 18–64 years with diabetes using IHS data for >30,000 American Indians who resided in reservation, rural, suburban, and urban areas of central Arizona and were served by the Phoenix Service Unit. In addition, we compared the prevalence of comorbidities among American Indians with diabetes with that of a commercially insured U.S. population, matched by age and sex to the American Indian population. We quantified the overall morbidity burden of American Indians and U.S. adults with diabetes using Diagnostic Cost Group (DCG) relative risk scores and compared their burdens by age, type of diabetes (type 1 and type 2), and cardiovascular disease status to examine the health needs of younger and older American Indian adults with diabetes.

RESEARCH DESIGN AND METHODS

— The American Indian study population resided in the Phoenix Service Unit, an IHS administrative unit located in central Arizona. Information concerning tribal affiliation is not provided as >100 tribes are represented, and IHS does not name tribes without their specific consent to honor tribal sovereignty. The Service Unit includes a large regional hospital in Phoenix, which provides inpatient and outpatient services, and small community-based clinics dispersed throughout the region. The Service Unit uses a unified electronic medical record and registration system, the Resource Patient Management System, which includes detailed administrative and clinical information similar to administrative claims for a commercial health insurance plan (19).

The American Indian study population included adults aged 18–64 years who were active users of IHS services between 1 October 2004 and 30 September 2005 (fiscal year [FY] 2005), reported the Phoenix Service Unit as their community of residence during FY 2005, and did not have Medicare coverage. The IHS definition of an active user during a fiscal year is a individual who had at least one outpatient visit during 1 of the past 3 fiscal years (FY 2003–2005 in this study). Because the insured U.S. study population did not include individuals with Medicare coverage, the American Indian study population excluded individuals aged 18–64 years with Medicare coverage ($n = 1,931$) and individuals aged ≥65 ($n = 1,113$). The resulting sample size was 30,121.

The insured U.S. study population was drawn from the 2005 MartketScan Research Database produced by Thomson Healthcare, a database of 13.2 million people with commercial health insurance of all major benefit types (fee-for-service, preferred provider organizations, and HMOs) (20,21). We identified a population sample from MarketScan that included adults aged 18–64 years with documented health coverage for medical and pharmacy services for 24 months between January 2004 and December 2005. Although we analyzed data for 2005, the inclusion criterion regarding 2004 data limited missing data associated with coverage changes. For example, if a individual started new coverage in 2004 that including a clause limiting coverage for preexisting conditions, the 2004 data may not include information on all of his or her conditions. The commercially insured U.S. adults (hereafter referred to as the U.S. study population, $n = 1,500,002$), a subset of the MarketScan sample, was matched with the American Indian study population by age (measured in years) and sex. We selected MarketScan as the comparison population for four key reasons: 1) the sample size allowed for a U.S. sample to be drawn to match the American Indian population; 2) the population had commercial health insurance coverage; 3) the administrative claims data had ICD-9 diagnostic codes from medical service records similar to the IHS data, and 4) DCG models could be used to assess the health status of both populations. The IHS Phoenix Area Institutional Review Board and the University of Colorado Denver Institutional Review Board approved the study protocol.

Data

For the American Indian study population, we extracted data from IHS databases on age, sex, and utilization of services in Arizona, Utah, Nevada, and California during FY 2005. Similar to administrative claims of private insurance companies, the IHS records included information on medical procedures, diagnostic codes, place of service, and volume. IHS refers patients to non-IHS facilities for specialty services not provided at the IHS facilities; much of this care is paid for through IHS Contract Health Services. We obtained Contract Health claims data from the IHS fiscal intermediary, Blue Cross Blue Shield New Mexico.

For the U.S. study population, we extracted similar data for calendar year 2005 from MarketScan. The U.S. study population was drawn to match the American Indian study population by sex and age-groups in 5-year age bands using bootstrapping with 100 iterations; the resulting ratio of U.S. to American Indian adults was 50:1. Given the lower prevalence of diabetes in the U.S. study population, the ratio of U.S. to American Indian adults with diabetes was 11.6:1. The ratio allowed for the assessment of comorbidities among U.S. and American Indian adults, including those who have a low prevalence, by age-group. MarketScan did not include measures of race/ethnicity or household income.

Analysis

Although the insured U.S. study population was matched by age and sex to the American Indian study population, the age distribution of the American Indian and U.S. adults with diabetes differed. To compare the health status of the American Indian and U.S. adults with diabetes, age-adjusted rates for the U.S. adults were calculated by the direct method using the age distribution of the American Indian adults with diabetes.

We used Risksmart (21) software to identify diagnosed conditions among the American Indian and U.S. adults. Risksmart classifies the ICD-9-CM diagnostic codes entered on records for inpatient and outpatient services (excluding records for laboratory services) into 781 Diagnostic Groups, 184 Hierarchical Condition Categories, and 30 Aggregated Condition Categories. We assessed the prevalence of diabetes and related comorbidities using combinations of these groupings. We compared the Risksmart software data quality reports for the American Indian and U.S. data and found

Table 1—*Prevalence of diabetes among American Indian adults from central Arizona and commercially insured U.S. adults aged 18–64 years*

	American Indian adults from central Arizona			Commercially insured U.S. adults			Ratio of the prevalence of diabetes among American Indian and U.S. adults
	n	Diabetes	95% CI	*n*	Diabetes	CI	
All individuals with diabetes							
18–34 years	18,723	718 (3.8)	3.6–4.1	932,392	10,011 (1.1)	1.1–1.1*	3.6
35–44 years	6,429	784 (12.2)	11.4–13.0	320,158	9,735 (3.0)	3.0–3.1*	4.0
45–54 years	3,509	802 (22.9)	21.5–24.2	174,744	10,736 (6.1)	6.0–6.3*	3.7
55–64 years	1,460	489 (33.5)	31.1–35.9	72,708	8,868 (12.2)	12.0–12.4*	2.7
All ages	30,121	2,793 (9.3)	8.9–9.6	1,500,002	39,350 (2.6)	2.6–2.6*	3.5
Individuals with type 1 diabetes							
18–34 years	18,723	45 (0.2)	0.2–0.3	932,392	3,751 (0.4)	0.4–0.4*	0.6
35–44 years	6,429	35 (0.5)	0.4–0.7	320,158	1,906 (0.6)	0.6–0.6	0.9
45–54 years	3,509	15 (0.4)	0.2–0.6	174,744	1,454 (0.8)	0.8–0.9*	0.5
55–64 years	1,460	12 (0.8)	0.4–1.3	72,708	1,086 (1.5)	1.4–1.6*	0.6
All ages	30,121	107 (0.4)	0.3–0.4	1,500,002	8,197 (0.5)	0.5–0.6*	0.7
Individuals with type 2 diabetes							
18–34 years	18,723	673 (3.6)	3.3–3.9	932,392	6,260 (0.7)	0.7–0.7*	5.4
35–44 years	6,429	749 (11.7)	10.9–12.4	320,158	7,829 (2.4)	2.4–2.5*	4.8
45–54 years	3,509	787 (22.4)	21.0–23.8	174,744	9,282 (5.3)	5.2–5.4*	4.2
55–64 years	1,460	477 (32.7)	30.3–35.1	72,708	7,782 (10.7)	10.5–10.9*	3.1
All ages	30,121	2,686 (8.9)	8.6–9.2	1,500,002	31,153 (2.1)	2.1–2.1*	4.3

Data are *n*, *n* (%), or CI calculated at 95% confidence. *Indicates significance at the 0.05 level.

that the data were comparable with regard to diagnostic quality indicators.

DCG models use hierarchical algorithms to assign relative risk scores based on age, sex, and identified acute and chronic conditions. DCG Model 18, an all-encounter diagnosis model for commercially insured individuals, was used to assign a relative risk score to each individual. The score is a continuous variable typically ranging from a very small positive value for the healthiest individuals to >100 for the sickest. A higher risk score indicates higher morbidity burden or expected health resource use. For example, the relative risk scores for a 30-year-old man and a 50-year-old man with diabetes but no other comorbidities were 0.79 and 1.09, respectively, whereas that for a 50-year-old man with diabetes, congestive heart failure, and depression was 2.95. The risk score correlates with a individual's expected health service utilization and health spending for a 12-month period, compared with the average for a U.S. commercial population. The risk score can be converted to a dollar amount that represents a person's expected health resource use during the 12-month period. A relative risk of 1.0 in the MarketScan population translated in 2005 to ~$3,050 in medical and pharmacy spending (inclusive of health plan reimbursement, copayments, and deductibles), whereas a relative risk score of 3.0 translated to $9,150.

We used DCGs in this study because federal agencies (e.g., Centers for Medicare and Medicaid Services and Agency for Healthcare Research and Quality), state governments, and commercial insurance companies use DCG models to assess the morbidity burden of populations (22–24). In addition, the models were highly ranked by the Society of Actuaries in their comparative study of similar software tools (24).

RESULTS — The American Indian study population included a higher percentage of women and a lower percentage of older adults than the MarketScan population sample that met the inclusion criteria. Only 4.8% of the American Indian adults were aged 55–64 years compared with 18.0% of the MarketScan population sample. The U.S. study population was drawn from this MarketScan population sample, matched by age and sex to the American Indian study population. The findings presented in Tables 1–3 are for the American Indian adults and the U.S. study population.

The rate of diabetes was >3 times higher among the American Indian adults than among the U.S. adults (Table 1). More than 9% of American Indian adults had diabetes compared with 2.6% of U.S. adults ($P < 0.05$). Differences were observed across every age-group. The age distributions of American Indian and U.S. adults with diabetes differed; the percentages of American Indian and U.S. adults with diabetes aged 55–64 years were 17.5 and 22.5%, respectively. Whereas the prevalence of type 1 diabetes was statistically higher among U.S. adults (0.5% of U.S. adults compared with 0.4% of American Indian adults; $P < 0.05$), the prevalence of type 2 diabetes was higher among American Indian adults in every age-group ($P < 0.05$).

Table 2 includes the prevalence of comorbidities among adults with diabetes as well as age-adjusted prevalence rates because of the noted differences in the age distribution of American Indian and U.S. adults with diabetes. (Similar results are available by type from the authors.) Among American Indian adults with diabetes, the prevalence of hypertension ranged from 40.5% for those aged 18–34 years to 79.3% among those aged 55–64 years. The prevalence among all American Indian adults with diabetes was 61.2%—a rate nearly double the age-adjusted prevalence rate for U.S. adults with diabetes (31.5%; $P < 0.05$). The prevalence of cerebrovascular disease was higher among American Indian adults with diabetes than among U.S. adults with diabetes (6.9 and 5.5%, respectively;

Table 2—*Prevalence of comorbidities among American Indian adults from central Arizona and commercially insured U.S. adults ages 18–64 years with diabetes*

Condition and age group	American Indian adults from central Arizona with diabetes			Commercially insured U.S. adults with diabetes			Ratio of the prevalence of comorbidities among American Indian and U.S. adults with diabetes
	n (diabetes)	Condition	CI	*n* (diabetes)	Condition	CI	
Hypertension							
18–34 years	718	291 (40.5)	36.9–44.1	10,011	1,450 (14.5)	13.8–15.2*	
35–44 years	784	452 (57.7)	54.2–61.1	9,735	2,879 (29.6)	28.7–30.5*	
45–54 years	802	577 (71.9)	68.8–75.1	10,736	4,234 (39.4)	38.5–40.4*	
55–64 years	489	388 (79.3)	75.8–82.9	8,868	4,115 (46.4)	45.4–47.4*	
All ages	2,793	1,708 (61.2)	59.3–63.0	39,350	12,678 (32.2)	31.8–32.7*	1.9
All ages with age adjustment†					(31.5)	31.1–31.9*	1.9
Cerebrovascular disease							
18–34 years	718	31 (4.3)	2.8–5.8	10,011	272 (2.7)	2.4–3.0	
35–44 years	784	47 (6.0)	4.3–7.7	9,735	355 (3.6)	3.3–4.0*	
45–54 years	802	61 (7.6)	5.8–9.4	10,736	724 (6.7)	6.3–7.2	
55–64 years	489	53 (10.8)	8.1–13.6	8,868	953 (10.7)	10.1–11.4	
All ages	2,793	192 (6.9)	5.9–7.8	39,350	2,304 (5.9)	5.6–6.1	1.2
All ages with age adjustment†					(5.5)	5.3–5.7*	1.2
Ischemic heart disease							
18–34 years	718	26 (3.6)	2.3–5.0	10,011	162 (1.6)	1.4–1.9*	
35–44 years	784	33 (4.2)	2.8–5.6	9,735	403 (4.1)	3.7–4.5	
45–54 years	802	47 (5.9)	4.2–7.5	10,736	994 (9.3)	8.7–9.8*	
55–64 years	489	49 (10.0)	7.4–12.7	8,868	1,494 (16.8)	16.1–17.6*	
All ages	2,793	155 (5.5)	4.7–6.4	39,350	3,053 (7.8)	7.5–8.0*	0.7
All ages with age adjustment†					(7.2)	7.0–7.4*	0.8
Other forms of heart disease							
18–34 years	718	37 (5.2)	3.5–6.8	10,011	315 (3.1)	2.8–3.5	
35–44 years	784	33 (4.2)	2.8–5.6	9,735	461 (4.7)	4.3–5.2	
45–54 years	802	40 (5.0)	3.5–6.5	10,736	810 (7.5)	7.0–8.0*	
55–64 years	489	34 (7.0)	4.7–9.2	8,868	1,176 (13.3)	12.6–14.0*	
All ages	2,793	144 (5.2)	4.3–6.0	39,350	2,762 (7.0)	6.8–7.3*	0.7
All ages with age adjustment†					(6.6)	6.4–6.8*	0.8
CVD							
18–34 years	718	68 (9.5)	7.3–11.6	10,011	645 (6.4)	6.0–6.9*	
35–44 years	784	87 (11.1)	8.9–13.3	9,735	1,012 (10.4)	9.8–11.0	
45–54 years	802	124 (15.5)	13.0–18.0	10,736	1,982 (18.5)	17.7–19.2	
55–64 years	489	103 (21.1)	17.4–24.7	8,868	2,590 (29.2)	28.3–30.2*	
All ages	2,793	382 (13.7)	12.4–15.0	39,350	6,229 (15.8)	15.5–16.2*	0.9
All ages with age adjustment†					(15.0)	14.7–15.3	0.9
Renal failure							
18–34 years	718	25 (3.5)	2.1–4.8	10,011	105 (1.0)	0.8–1.2*	
35–44 years	784	25 (3.2)	2.0–4.4	9,735	194 (2.0)	1.7–2.3	
45–54 years	802	34 (4.2)	2.8–5.6	10,736	270 (2.5)	2.2–2.8	
55–64 years	489	26 (5.3)	3.3–7.3	8,868	364 (4.1)	3.7–4.5	
All ages	2,793	110 (3.9)	3.2–4.7	39,350	933 (2.4)	2.2–2.5*	1.7
All ages with age adjustment†					(2.3)	2.2–2.4*	1.7
Neuropathy							
18–34 years	718	71 (9.9)	7.7–12.1	10,011	634 (6.3)	5.9–6.8*	
35–44 years	784	129 (16.5)	13.9–19.0	9,735	773 (7.9)	7.4–8.5*	
45–54 years	802	145 (18.1)	15.4–20.7	10,736	874 (8.1)	7.6–8.7*	
55–64 years	489	123 (25.2)	21.3–29.0	8,868	689 (7.8)	7.2–8.3*	
All ages	2,793	468 (16.8)	15.4–18.1	39,350	2,970 (7.5)	7.3–7.8*	2.2
All ages with age adjustment†					(7.6)	7.3–7.9*	2.2
Amputations							
18–34 years	718	6 (0.8)	0.2–1.5	10,011	3 (0.0)	0.0–0.1	
35–44 years	784	13 (1.7)	0.8–2.6	9,735	13 (0.1)	0.1–0.2	

(continued)

Table 2—*Continued*

Condition and age group	American Indian adults from central Arizona with diabetes			Commercially insured U.S. adults with diabetes			Ratio of the prevalence of comorbidities among American Indian and U.S. adults with diabetes
	n (diabetes)	Condition	CI	*n* (diabetes)	Condition	CI	
45–54 years	802	15 (1.9)	0.9–2.8	10,736	17 (0.2)	0.1–0.2	
55–64 years	489	15 (3.1)	1.5–4.6	8,868	15 (0.2)	0.1–0.3	
All ages	2,793	49 (1.8)	1.3–2.2	39,350	48 (0.1)	0.1–0.2*	14.4
All ages with age adjustment†					(0.1)	0.1–0.2*	14.4
Mental health disorders‡							
18–34 years	718	114 (15.9)	13.2–18.6	10,011	1,145 (11.4)	10.8–12.1*	
35–44 years	784	171 (21.8)	18.9–24.7	9,735	1,125 (11.6)	10.9–12.2*	
45–54 years	802	167 (20.8)	18.0–23.6	10,736	1,068 (9.9)	9.4–10.5*	
55–64 years	489	84 (17.2)	13.8–20.5	8,868	688 (7.8)	7.2–8.3*	
All ages	2,793	536 (19.2)	17.7–20.7	39,350	4,026 (10.2)	9.9–10.5*	1.9
All ages with age adjustment†					(10.4)	10.1–10.7*	1.8
Substance abuse§							
18–34 years	718	73 (10.2)	8.0–12.4	10,011	96 (1.0)	0.8–1.1*	
35–44 years	784	127 (16.2)	13.6–18.8	9,735	73 (0.7)	0.6–0.9*	
45–54 years	802	102 (12.7)	10.4–15.0	10,736	83 (0.8)	0.6–0.9*	
55–64 years	489	31 (6.3)	4.2–8.5	8,868	50 (0.6)	0.4–0.7*	
All ages	2,793	333 (11.9)	10.7–13.1	39,350	302 (0.8)	0.7–0.9*	15.5
All ages with age adjustment†					(0.8)	0.7–0.9*	14.9
Liver disease							
18–34 years	718	45 (6.3)	4.5–8.0	10,011	288 (2.9)	2.5–3.2*	
35–44 years	784	63 (8.0)	6.1–9.9	9,735	307 (3.2)	2.8–3.5*	
45–54 years	802	57 (7.1)	5.3–8.9	10,736	429 (4.0)	3.6–4.4*	
55–64 years	489	34 (7.0)	4.7–9.2	8,868	335 (3.8)	3.4–4.2*	
All ages	2,793	199 (7.1)	6.2–8.1	39,350	1,359 (3.5)	3.3–3.6*	2.1
All ages with age adjustment†					(3.4)	3.2–3.6*	2.1

Data are *n*, *n* (%), or CI calculated at 95% confidence. *Indicates significance at the 0.05 level. †The age distribution of the commercially insured U.S. adults with diabetes differed from the age distribution of the American Indian adults with diabetes. For this reason, we calculated age-adjusted rates for the commercially insured U.S. adults with diabetes for each condition. ‡Mental health disorders include a broad array of disorders such as depression, posttraumatic stress, anxiety, and other mental disorders. §Substance abuse includes alcohol and drug use disorders and psychoses and excludes tobacco use disorders.

$P < 0.05$), whereas the prevalence of ischemic heart disease and other types of heart disease was lower among the American Indian adults (5.5 and 5.2%, respectively, among American Indian adults and 7.2 and 6.6% among U.S. adults; $P < 0.05$). We defined cardiovascular disease (CVD) to include cerebrovascular disease, ischemic heart disease, and other forms of heart disease. The prevalence of CVD was significantly higher among younger American Indian adults with diabetes (those aged 18–34 years) than among younger U.S. adults with diabetes. In contrast, CVD was less prevalent among older American Indian adults with diabetes (aged 55–64 years).

American Indian adults with diabetes were significantly more likely to have renal failure, lower-extremity amputations, and neuropathy than were U.S. adults with diabetes. The rate for amputations among American Indian adults was >10 times that of U.S. adults. Mental health disorders and liver disease were approximately twice as prevalent among American Indian adults. For example, 19.2% of all American Indian adults with diabetes had a mental health disorder (e.g., depression or anxiety) compared with 10.4% of all U.S. adults ($P < 0.05$); the difference was most pronounced at older ages. The prevalence of liver disease was 7.1% among American Indian adults and 3.4% among U.S. adults ($P < 0.05$); variations by age were not observed. Substance abuse (e.g., alcohol and drug use disorders) was also more prevalent among American Indian adults.

The mean DCG relative risk score for American Indian adults aged 18–64 years with diabetes was 5.4 (Table 3). In other words, their risk for use of health resources was >5 times that of an average U.S. adult with commercial insurance. The mean relative risk among American Indian adults with diabetes was 50% higher than that of U.S. adults with diabetes, for whom the age-adjusted mean risk was 3.6 ($P < 0.05$). This result suggests that, controlling for age and sex, American Indian adults with diabetes were at 50% greater risk for health resource use than U.S. adults with diabetes because of the presence of other health conditions. Adults with both diabetes and CVD had higher risk than adults with diabetes but not CVD. The relative risk of American Indian adults with diabetes and CVD was 13.3, ~40% higher than the risk among U.S. adults with both conditions.

CONCLUSIONS — We documented the higher prevalence of comorbidities, including hypertension, cerebrovascular disease, lower-extremity amputations, mental health disorders, and liver disease, among American Indian adults with diabetes living in central Arizona compared with those of a sample of commercially insured U.S. adults with diabetes. These comorbidities not only complicate diabetes treatment and influence a individual's ability to manage his or her own diabetes

Table 3—*DCG relative risk scores for American Indian adults from central Arizona and commercially insured U.S. adults aged 18–64 years with diabetes by age, type of diabetes, and cardiovascular disease status*

Age group	American Indian adults from central Arizona with diabetes	Commercially insured U.S. adults with diabetes	Ratio of relative risk scores for American Indian and U.S. adults with diabetes*
All individuals with diabetes			
18–34 years	4.8 (4.3–5.3)	3.2 (3.1–3.3)†	1.5
35–44 years	5.1 (4.6–5.6)	3.2 (3.1–3.3)†	1.6
45–54 years	5.7 (5.2–6.2)	3.7 (3.6–3.8)†	1.5
55–64 years	6.0 (5.4–6.5)	4.5 (4.4–4.7)†	1.3
All ages	5.4 (5.1–5.6)	3.6 (3.6–3.7)†	1.5
All ages with age adjustment‡		3.6 (3.5–3.6)†	1.5
Type of diabetes			
Type 1 diabetes			
18–34 years	8.9 (5.7–12.1)	3.5 (3.3–3.7)†	
35–44 years	10.9 (6.7–15.2)	4.6 (4.3–5.0)†	
45–54 years	15.6 (6.7–24.6)	6.3 (5.8–6.7)†	
55–64 years	19.3 (10.6–28.1)	7.7 (7.1–8.4)†	
All ages	11.7 (9.2–14.1)	4.8 (4.6–5.0)†	2.4
All ages with age adjustment‡		4.7 (4.6–4.9)†	2.5
Type 2 diabetes			
18–34 years	4.5 (4.1–5.0)	3.0 (2.8–3.1)†	
35–44 years	4.9 (4.4–5.3)	2.8 (2.7–2.9)†	
45–54 years	5.5 (5.1–5.9)	3.3 (3.2–3.4)†	
55–64 years	5.6 (5.1–6.2)	4.1 (4.0–4.2)†	
All ages	5.1 (4.9–5.3)	3.3 (3.2–3.4)†	1.5
All ages with age adjustment‡		3.2 (3.2–3.3)†	1.6
CVD status			
Diabetes with CVD			
18–34 years	14.8 (11.4–18.2)	10.2 (9.3–11.2)†	
35–44 years	15.6 (12.2–18.9)	9.6 (8.8–10.3)†	
45–54 years	12.3 (10.3–14.3)	8.9 (8.4–9.4)†	
55–64 years	11.5 (9.6–13.3)	9.1 (8.7–9.5)†	
All ages	13.3 (12.0–14.5)	9.2 (8.9–9.5)†	1.4
All ages with age adjustment‡		9.3 (9.0–9.6)†	1.4
Diabetes without CVD			
18–34 years	3.8 (3.5–4.1)	2.7 (2.6–2.7)†	
35–44 years	3.8 (3.5–4.1)	2.4 (2.4–2.5)†	
45–54 years	4.5 (4.1–4.8)	2.5 (2.4–2.6)†	
55–64 years	4.5 (4.1–4.9)	2.7 (2.6–2.7)†	
All ages	4.1 (3.9–4.3)	2.6 (2.5–2.6)†	1.6
All ages with age adjustment‡		2.6 (2.5–2.6)†	1.6

Data are means (CI) calculated at 95% confidence. *The ratio of DCG relative risk scores was calculated by dividing the mean American Indian adult risk score by the mean U.S. adult risk score. †Significant at the 0.05 level. ‡The age distribution of the commercially insured U.S. adults with diabetes differed from the age distribution of the American Indian adults with diabetes. For this reason, we calculated age-adjusted rates for the commercially insured U.S. adults with diabetes.

but are also associated with lower quality of life and higher mortality.

The morbidity burden among the American Indian with diabetes exceeded that of the U.S. adults with diabetes by 50%. Accordingly, American Indian adults with diabetes in this study would be expected to use 50% more health resources than U.S. adults with diabetes and commercial insurance. The magnitude of increased risk among American Indians with diabetes remained fairly constant across all ages. Using the 2005 MarketScan health expenditure for an adult with average risk ($3,050), a U.S. adult with diabetes was estimated to cost ~$12,800 during 2005 and an American Indian adult with diabetes ~$19,260. The IHS was the primary provider of medical services for the American Indian adults included in this study. Service delivery and treatment costs within the IHS differ from services accessed in the private sector. Consequently, MarketScan health expenditure estimates are not directly comparable to IHS health expenditures. However, the findings concerning the exceedingly higher risk of American Indian adults with diabetes may be used to evaluate the financial resources available to meet treatment needs of American Indians with diabetes.

Furthermore, the findings may be used to inform efforts to enhance prevention and treatment programs, particularly programs to prevent complications among American Indians with diabetes. The findings document the need for strong linkages between behavioral and physical health providers for younger adults with diabetes. CVD was prevalent among American Indian and U.S. adults with diabetes, yet the morbidity burden among American Indian adults with both diabetes and CVD was ~40% higher than that of U.S. adults with both conditions. Given the high rates of premature death from heart disease among American Indians and Alaska Natives, the specific treatment needs of these patients should be explored. Finally, DCG risk scores may be used to target interventions for those with extremely high risk to reduce the likelihood of additional complications associated with diabetes.

This is the first study to compare the prevalence of several comorbidities and the overall morbidity burden of American Indian adults with diabetes with those for commercially insured U.S. adults with diabetes, controlling for age differences. However, it is important to note several limitations. First, the study included data for only IHS active users. Still, they represent a very large proportion of individuals eligible for IHS services in the Service Unit (25). Second, we analyzed American Indian data for services obtained at non-IHS facilities if IHS provided payment for the services through Contract Health Services. Consequently, we did not have data with the diagnostic codes for services not reimbursed by IHS. This may have biased downward the prevalence rates of diabetes and other conditions (e.g., heart disease) reported for American Indian adults in this study.

Third, we chose a U.S. adult population with commercial health insurance as our comparison population. Although the prevalence of diabetes among the MarketScan adult sample was similar to the estimated prevalence among U.S. adults aged 18–64 years (7), we recognize that the average household income of commercially insured U.S. adults exceeded that of the American Indian population, who may have had an average household income closer to that of Medicaid and uninsured populations. Adults with lower incomes and nonmajority ethnic and racial backgrounds are often less likely to use medical services for several reasons including financial and geographic access, culture, and discrimination. MarketScan does not include data for individuals with Medicaid or Medicare coverage or uninsured individuals. We did not consider using a Medicaid population as a comparison population because the age and sex distributions of adult Medicaid populations, which are driven by eligibility categories, differ from those of the American Indian adults. With limited financial access to medical services, the diagnostic codes recorded in claims data for uninsured individuals may underestimate their disease burden. We believe the diagnostic codes recorded in the MarketScan data are a reasonable indicator of the health status of the commercially insured U.S. study population. The differences between the American Indian and the U.S. adults observed in this study are undoubtedly larger than would be differences between American Indians and a representative U.S. population that included adults with lower incomes and in poorer health than the commercially insured adults. We were unable to identify data for a representative U.S. sample that is comparable to the IHS data. We concluded that the strengths of the MarketScan data (e.g., a large sample that allowed for a study of comorbidities among individuals with diabetes and the ability to use DCG models to identify comorbidities and to quantify the morbidity burden) far exceeded the limitations inherent in its use.

Fourth, we extracted data for somewhat different time periods for the American Indian adults (FY 2005) and U.S. adults (calendar year 2005). We believe this difference had minimal impact on the findings. For both study populations, prevalence rates were based on administrative data for one 12-month period and most likely underestimated actual prevalence rates. Finally, this study provides important information concerning morbidity for nearly 2,800 American Indian adults in central Arizona with diabetes. However, there are >550 federally recognized tribes throughout the U.S. and tribal variations in culture, traditions, history, and the prevalence of diabetes are well documented (5,25). For example, the diabetes prevalence among all American Indian adults in the Phoenix Service Unit, including those with Medicare coverage and aged ≥65 years, was 10.9% during FY 2005, a rate that is consistent with previous IHS estimates. During 2004, the prevalence among American Indians and Alaska Natives aged ≥20 years was <10% in Alaska and >20% in North Dakota (5). Consequently, these results may not be generalizable to other American Indian and Alaska Native populations and additional studies are needed.

The morbidity burden among American Indians with diabetes far exceeded that of commercially insured U.S. adults with diabetes. The information concerning the prevalence of comorbidities among American Indians with diabetes may inform government and tribal efforts to enhance diabetes prevention and treatment and ultimately reduce disparities between American Indian and U.S. populations in diabetes-related morbidity and premature mortality.

Acknowledgments— This study was supported by grant HHS1242200400049C from the Indian Health Service and by grant P60 MD000507 from the National Institutes of Health, National Center for Minority Health and Health Disparities to the University of Colorado Denver, Colorado School of Public Health (J.O. and S.M.M.).

No potential conflicts of interest relevant to this article were reported.

Parts of this study were presented in abstract form at the 68th annual meeting of the American Diabetes Association, San Francisco, California, 6–10 June 2008.

We acknowledge Jody Sekerak from the Indian Health Service and Sue Ehrhart from Eyak Technology, LLC for their assistance with extracting and understanding data from the Indian Health Service Resource Patient Management System.

References

1. Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, Rao PV, Yajnik CS, Prasanna Kumar KM, Nair JD, Diabetes Epidemiology Study Group in India (DESI). High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia 2001;44:1094–1101
2. Gan D (Ed). *Diabetes Atlas. Executive Summary*. Brussels, Belgium, International Diabetes Federation, 2003
3. Rhoades DA. Racial misclassification and disparities in cardiovascular disease among American Indians and Alaska Natives. Circulation 2005;111:1250–1156
4. Murray CJ, Kulkarni SC, Michaud C, Tomijima N, Bulzacchelli MT, Iandiorio TJ, Ezzati M. Eight Americas: investigating mortality disparities across races, counties, and race-counties in the United States. PLoS Med 2006;3:1513–1524
5. Indian Health Service. *Special Diabetes Program for Indians, 2007 Report to Congress: On the Path to a Healthier Future*. Bethesda, MD, Indian Health Service, 2009
6. Zhang X, Norris SL, Chowdhury FM, Gregg EW, Zhang P. The effects of interventions on health-related quality of life among persons with diabetes. Diabetes Care 2007;45:820–834
7. American Diabetes Association. Economic costs of diabetes in the U.S. in 2007. Diabetes Care 2008;31:596–615
8. Li G, Zhang P, Wang J, Gregg EW, Yang W, Gong Q, Li H, Li H, Jiang Y, An Y, Shuai Y, Zhang B, Zhang J, Thompson TJ, Gerzoff RB, Roglic G, Hu Y, Bennett PH. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. Lancet 2008;371: 1783–1789
9. Xie J, Wu EQ, Zheng ZJ, Sullivan PW, Zhan L, Labarthe DR. Patient-reported health status in coronary heart disease in the United States, age, sex, racial, and ethnic differences. Circulation 2008;118: 491–497
10. Howard BV, Lee ET, Cowan LD, Devereux RB, Galloway JM, Go OT, Howard WJ, Rhoades ER, Robbins DC, Sievers ML, Welty TK. Rising tide of cardiovascular disease in American Indians. The Strong Heart Study. Circulation 1999;99: 2389–2395
11. Acton KJ, Burrows NR, Geiss LS, Thompson T. Diabetes prevalence among American Indians and Alaska Natives and the overall population—United States, 1994–2002. MMWR Morb Mortal Wkly Rep 2003;52:702–704
12. Oh SS, Croft JB, Greenlund KJ, Ayala C, Zheng ZJ, Mensah MD, Giles WH. Disparities in premature deaths from heart disease—50 states and the District of Columbia, 2001. MMWR Morb Mortal Wkly Rep 2004;53:121–125
13. Rith-Najarian S, Dannels E, Acton K. Preventing amputations from diabetes mellitus: the Indian Health Service experience. West Indian Med J 2001;50(Suppl 1): 41–43
14. Resnick HE, Carter EA, Sosenko JM, Henly SJ, Fabsitz RR, Ness FK, Welty TK, Lee ET, Howard BV, Strong Heart Study. Incidence of lower-extremity amputation

in American Indians. Diabetes Care 2004;27:1885–1891

15. Burrows NR, Li Y, Williams DE. Racial and ethnic differences in trends of end-stage renal disease: United States, 1995–2005. Adv Chronic Kidney Dis 2008;15:147–152
16. Indian Health Service. Fact sheet: Indian Health Service fiscal year 2008 budget [article online], 2008. Indian Health Service. Available from http://info.ihs.gov/budget08.asp. Accessed 26 April 2008
17. Wilson C, Gilliland S, Cullen T, Moore K, Roubideaux Y, Valdez L, Vanderwagen W, Acton K. Diabetes outcomes in the Indian Health System during the era of the Special Diabetes Program for Indians and the Government Performance and Results Act. Am J Public Health 2005;95:1518–1522
18. Indian Health Service. *Trends in Indian Health, 2000–2001*. Bethesda, MD, Indian Health Service, 2004
19. Wilson C, Lynch SL, Saria R, Peterson D. Patients with diagnosed diabetes mellitus can be accurately identified in an Indian Health Service patient registration database. Public Health Rep 2001;116:45–50
20. Zhao Y, Ash AS, Ellis RP, Ayanian JZ, Pope GC, Bowen B, Weyuker L. Predicting pharmacy costs and other medical costs using diagnoses and drug claims. Med Care 2005;43:34–43
21. Verisk Health. *DxCG Models and Methodologies Guide*, Version 2.3. Boston, MA, Verisk Health, 2008
22. Pope GC, Kautter J, Ellis RP, Ash AS, Ayanian JZ, Lezzoni LI, Ingber MJ, Levy JM, Robst J. Risk adjustment of Medicare capitation payments using the CMS-HCC model. Health Care Financ Rev 2004;25:119–141
23. Agency for Healthcare Research and Quality. Medical Expenditure Panel Survey: MEPS HC-081: 1996–2001 risk adjustment scores [article online], 2001. Available from http://www.meps.ahrq.gov/mepsweb/data_stats/download_data/pufs/h81/h81doc.shtml. Accessed 29 April 2008
24. Winkelman R, Memud S. A Comparative Analysis of Claims-Based Tools for Health Risk Assessment. Schaumburg, IL, Society of Actuaries, 2007
25. US Census Bureau. *Characteristics of American Indians and Alaska Natives by Tribe and Language: 2000*. Washington, DC, U.S. Government Printing Office, 2003