

ORIGINAL RESEARCH

# The Epidemic of Extreme Obesity Among American Indian and Alaska Native Adults With Diabetes

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## Abstract

### Introduction

The purpose of this study was to describe the prevalence of obesity among American Indian and Alaska Native (AI/AN) adults with diabetes and to examine the temporal trends for class I, II, and III obesity in this high-risk group during a 10-year period.

### Methods

We used data on body mass index (BMI) from the annual Diabetes Care and Outcomes Audit to estimate the prevalence of class I, II, and III obesity (class I = 30.0–34.9 kg/m<sup>2</sup>, class II = 35.0–39.9 kg/m<sup>2</sup>, and class III ≥40.0 kg/m<sup>2</sup>) in each year from 1995 through 2004. We also investigated trends in mean BMI during the 10-year period and the role of treatment in these trends using multivariable linear regression models.

### Results

Obesity was highly prevalent in this population in 2004 (class I, 28.9%; class II, 20.4%; class III, 20.3%). From 1995 through 2004, the percentage of obese adults increased from 16.7% to 20.4% in class II and 11.5% to 20.3% in class III ( $P < .001$ ), and the mean BMI increased from 32.1 kg/m<sup>2</sup>

to 34.4 kg/m<sup>2</sup>. The increase in BMI was greater in the younger age groups. Adjusted mean BMI increased significantly over 10 years for each of three treatment categories.

### Conclusion

Extreme degrees of obesity are a common and increasing problem among AI/AN adults with diabetes. We did not find an association between the type of diabetes treatment and the trend toward extreme degrees of obesity. The increase in extreme obesity could potentially affect the burden of morbidity and mortality among AI/AN adults with diabetes. Effective and culturally appropriate weight management interventions are needed.

## Introduction

Obese individuals are at particularly high risk for cardiovascular disease (CVD) and are also at increased risk for other serious medical conditions, including hypertension, certain forms of cancer, arthritis, sleep and breathing disorders, and gallbladder disease (1,2). Thus, obesity is an important risk factor for adverse health outcomes and a marker of increased health care cost. Evidence suggests that obesity can be treated (3-5). Short-term weight loss has been demonstrated to ameliorate obesity-related metabolic abnormalities and CVD risk factors (6), and at least one prospective randomized study is underway to examine the long-term consequences of intentional weight loss in overweight or obese people with diabetes (7). Although obesity is a major public health issue that will continue to require public health approaches aimed at preventing it, our knowledge and ability to apply patient-directed interventions is increasing and holds promise for people now affected.

The current epidemic of type 2 diabetes in the United States is largely a consequence of the epidemic of obesity, and weight reduction remains a cornerstone of therapy for people with diabetes (8,9). The Indian Health Service (IHS), a federally operated health care system, provides care to more than 1.5 million American Indian and Alaska Native (AI/AN) people, of whom more than 100,000 have diabetes (10). The extent and severity of obesity among AI/AN people with diabetes, however, has not been examined. Understanding the magnitude of the coexistence of these conditions could improve our ability to plan for medical services and estimate health care expenditures for this population at high risk for poor health.

The IHS conducts an annual system-wide assessment of services for and outcomes of AI/AN people with diabetes receiving services within the Indian health care system. Using this data source, we were able to describe the burden of obesity and the temporal trends in obesity among adults during a 10-year period.

## Methods

### Data source

We conducted a cross-sectional study using data collected annually during 10 years at health care facilities that collectively form a federally funded health care system for AI/AN people. The facilities include federally operated IHS hospitals, ambulatory clinics, health stations, and clinics from all 12 administrative IHS areas as well as facilities operated directly by tribal governments through contracts or compacts with the IHS. The system also includes American Indian organizations that provide services to AI/AN people residing in 34 urban metropolitan areas.

The Diabetes Care and Outcomes Audit (DCOA) is conducted annually by the IHS (11,12). The DCOA is performed at the facility level and is used for local feedback and performance improvement activities. At each participating facility, a systematic sample of medical records is selected from all patients with diabetes (13). A local diabetes coordinator abstracts information from the selected records using a standardized form covering more than 70 demographic and quality-of-care indicators. In some facilities, the DCOA is created using a computer application developed by the IHS that collects data from the facility's health information system.

Voluntary, nonpunitive reporting of local audit results to the IHS Division of Diabetes Treatment and Prevention provides an opportunity for aggregation of diabetes care and outcomes measures into a national data set. Participation in national reporting among the approximately 300 facilities in the IHS system is high. During the period of this study, the number of facilities submitting data ranged from a low of 145 in 1996 to a high of 281 in 2004. The number of patients in the annual reports ranged from a low of 9557 in 1995 to a high of 33,769 in 2004. The increase in the sample size reflects several temporal trends in the audit process. An increased number of facilities participated in the audit, and an increase in the prevalence of diabetes resulted in a greater number of patients sampled at each facility. Also, the use of electronic auditing techniques appears to have increased the proportion of records audited at many of the facilities using electronic auditing. However, the criteria used for inclusion in the DCOA and the criteria for data collection in the audit did not change during the study period, and there was good comparability between manual and electronic record review for programs using electronic data auditing.

Of the potential records of patients aged 18 years and older who were included in the DCOA from 1995 through 2004, 156,080 records had information necessary to calculate body mass index (BMI). Of these records, 70 had an implausible BMI ( $<15.0 \text{ kg/m}^2$ ) and were excluded from the analyses, leaving 156,010 records. Of these, 17,674 records were missing data on duration of diabetes and treatment type and were excluded from the analyses. A total of 138,336 records (88.6% of all records) were used for analysis.

### Outcome variable

BMI was calculated from recorded height and weight. Obesity was categorized by grouping BMI values in the following categories: normal weight ( $<25.0 \text{ kg/m}^2$ ), overweight ( $25.0\text{--}29.9 \text{ kg/m}^2$ ), class I obesity ( $30.0\text{--}34.9 \text{ kg/m}^2$ ), class II obesity ( $35.0\text{--}39.9 \text{ kg/m}^2$ ), and class III obesity ( $\geq 40.0 \text{ kg/m}^2$ ) (14).

### Covariates

Demographic and clinical variables collected through the DCOA included sex, age, duration of diabetes, treatment type, and treatment facility. Age was calculated as the date of audit minus the date of birth. Duration of diabetes

was recorded in years since diagnosis. Treatment type was recorded as diet or exercise alone (no medication), oral agent(s), insulin, and oral agent plus insulin (combined with the insulin group for purposes of analyses). Treatment facility was recorded as the location where patients obtained treatment and audit data was collected.

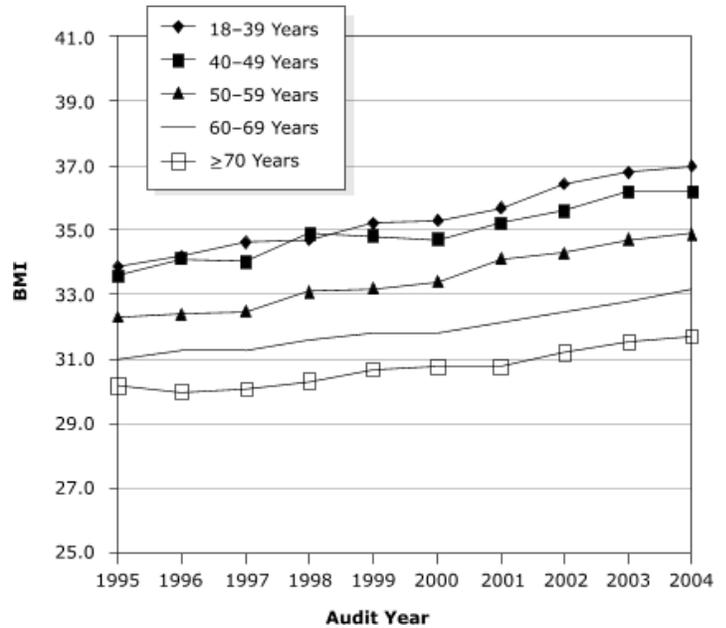
**Data analyses**

We conducted a descriptive analysis of BMI by demographic and clinical variables and by calendar year for all people with measured heights and weights and calculated BMI  $\geq 15$  kg/m<sup>2</sup>. We used analysis of covariance techniques to estimate least square mean BMI values and to test the hypotheses that BMI differed by age and calendar period. The analyses were adjusted for age, sex, duration of diabetes, treatment type, and treatment facility. Tests for temporal trends in obesity categories were conducted using logistic regression techniques and were adjusted for age, sex, duration of diabetes, treatment type, and treatment facility. All statistical analyses were conducted using SAS software (SAS Institute Inc, Cary, NC) (15).

**Results**

We found that obesity was a common and increasingly prevalent problem among people with type 2 diabetes. In 1995, 59.2% of adults with diabetes were obese. By 2004, 69.6% of adults with diabetes were obese. Table 1 summarizes selected demographic and clinical measures of AI/AN adults with diabetes. Consistent with sex differences in the prevalence of diabetes in AI/AN adults, more women than men were included in the sample (16). Most patients used oral agents either alone or in combination with other oral agents. The average age at onset did not differ during the study period. The unadjusted mean BMI increased significantly from 32.1 in 1995 to 34.4 in 2004 ( $P < .001$ ) (Table 1). Adjustment for age, sex, duration of diabetes, treatment type, and treatment facility did not significantly change this trend.

The prevalence of class II and class III obesity was higher in women than men in each year of the study (Table 2). The prevalence of class II and class III obesity increased from 1995 to 2004 ( $P < .001$ ) in both men and women; however, the prevalence of class II and class III obesity increased significantly more for men than women, thus narrowing the sex difference. These trends were consis-



**Figure 1.** Adjusted mean body mass index (BMI [kg/m<sup>2</sup>]) by age among American Indian and Alaska Native adults with diabetes, Diabetes Care and Outcomes Audit, Indian Health Service, 1995–2004. Mean was adjusted for age, sex, duration of diabetes, treatment type, and treatment facility.

tently observed among 11 of 12 IHS administrative areas.

An increase in BMI was observed among all age groups from 1995 through 2004. The adjusted mean BMI was inversely related to age; the younger the age group, the higher the adjusted mean BMI ( $P = .04$ ) (Figure). In 2004, for age category 18 to 39, the adjusted mean BMI was 37.0; for 40 to 49, 36.2; for 50 to 59, 34.9; for 60 to 69, 33.2; and for 70 years and older, 31.7. The increase in BMI during the study period was greater in the younger age groups ( $P < .001$ ). Because the DCOA also contained information on diabetes treatment, we were able to investigate potential associations between obesity and type of treatment. Adjusted mean BMI increased significantly for each treatment category from 1995 through 2004 (Table 3).

Additional analyses that included records with missing data did not substantially change the results (data not shown).

**Discussion**

We found that the prevalence of obesity, as measured by BMI, increased among AI/AN adults with diabetes during

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the study period. A greater increase in BMI was observed among adults in the younger age categories. We found a greater percentage increase in obesity among men relative to women. While the sex difference in the prevalence of obesity has decreased, women remained more obese than men in every year studied. Notably, the increase in obesity has resulted in a large increase in the proportion of people with the most extreme degree of obesity.

The trends in obesity observed in this study may have important clinical and public health implications. The combination of diabetes and high BMI has been associated with increased risk for the development of more severe degrees of hyperglycemia, hypertension, dyslipidemia, retinopathy, and progressive loss of renal function (17-19). The relationship between obesity and cardiovascular disease morbidity and mortality are complex and nonlinear; however, obesity in its most extreme degrees is associated with higher all-cause and possible coronary cardiovascular disease mortality (20,21). The increase in obesity among adults with diabetes in this study could have implications for the burden of morbidity and mortality among AI/AN people with diabetes.

Obesity has been increasing among U.S. adults. Analysis of Behavioral Risk Factor Surveillance System (BRFSS) data shows a trend of increasing prevalence of extreme obesity compared with other classes of obesity in the U.S. population (22). BRFSS data and American Indian oversamples have described similar trends among American Indian adults. Between 1999 and 2003, 1000 American Indian adults aged 18 years and older living on or near the seven reservations in Montana were interviewed each year using an adapted BRFSS survey. During this period, the prevalence of obesity increased from 34% to 39% (23). The Strong Heart Study, an epidemiological study of cardiovascular disease risk factors in four American Indian communities, also documented the high prevalence of obesity, particularly among participants in the younger age groups (24). The trends in obesity in our study are also consistent with trends in the prevalence of obesity and extreme obesity among people with diabetes. Among adults with diabetes in an epidemiologic study in Rochester, Minn, the proportion of obesity increased from 33% to 49%, and extreme obesity nearly doubled from 5% to 9% over approximately 20 years (21).

Because our study was cross-sectional, we cannot determine the cause or causes of our observations. It is possible

that AI/AN adults with diabetes have become more obese during the study period just as U.S. adults have become more obese. Treatment of diabetes may limit weight loss, and some pharmacologic agents used to treat people with diabetes are associated with weight gain (25). In longitudinal studies among the Pima Indians of Arizona, pharmacologic treatment had a statistically significant limiting effect on weight loss in people after the onset of diabetes (26), and clinical trial data from the United Kingdom Prospective Diabetes Study showed the greatest increase in weight among people using insulin and certain pharmacologic agents (27). With more interest in using intensive therapies since publication of the findings of the United Kingdom Prospective Diabetes Study, which were released during the study period, changes in treatment practice toward improved glycemic control (10) could explain some of the observed trends. Such treatment changes, however, would not explain the increase in mean BMI found in patients who were not treated with such agents (Table 3). Alternatively, the observed increases in obesity could reflect unintentional changes in who was included in the DCOA or how the audit was conducted. For example, an unrecognized selection bias toward participants with greater BMIs or a bias toward collection of data from participants with higher BMIs over time could create a temporal trend. To examine this possibility, we analyzed the percentage of participants who were missing BMI data during the study period and did find that the percentage of participants with missing data decreased from 17.6% in 1995 to 4.5% in 2004. However, the inclusion and exclusion criteria remained the same during the study period and never included weight restrictions, so the decrease in the number of patients with missing BMI values likely reflects better medical record documentation and less likely reflects differences in data reporting or in participant selection. Confounding due to other cohort differences is also unlikely to explain the results because adjustment for age, sex, diabetes duration, treatment type, and treatment facility did not substantially change our observations. Furthermore, the large dataset and the large number of different auditors should limit the chance of a one-way systematic selection bias toward more obese patients for inclusion. Still, changes based on modifications of health care usage bias, diagnostic criteria, or case ascertainment of diabetes cannot be fully excluded. Longitudinal studies would be required to fully address these and other questions about the cause of our observations.

Health care programs can be tailored to meet the

lifestyle, preferences, and resources of individuals with obesity. Options include dietary and physical activity interventions with behavioral modification strategies, antiobesity drugs, and, for certain individuals, surgical interventions (28). Public health approaches to weight management may also have a role, particularly if they are combined with interventions directed at individuals (29). By documenting increasing trends in obesity among people with type 2 diabetes, this study helps to focus both clinical and public health attention on a major health challenge facing health professionals serving not only American Indian and Alaska Native people but also Latino, African American, and other communities that are experiencing an increase in prevalence of obesity and type 2 diabetes (30). The challenge will be to better understand the physiologic, socioeconomic, and lifestyle factors influencing obesity in adults with type 2 diabetes and to design, develop, implement, and evaluate effective and culturally appropriate interventions to address the trends in obesity in these high-risk groups.

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## Tables

**Table 1. Selected Demographic and Clinical Variables From Representative Years of the Diabetes Care and Outcomes Audit Among American Indian and Alaska Native Adults With Type 2 Diabetes, Indian Health Service, 1995–2004**

Variable	1995 (N = 7106)	1999 (N = 10,651)	2004 (N = 28,508)
Sex, no. (%)			
Male	2780 (39.1)	4243 (39.8)	12,099 (42.4)
Female	4326 (60.9)	6408 (60.2)	16,409 (57.6)
Treatment type, no. (%)			
Diet or exercise alone	1009 (14.2)	1292 (12.1)	5,476 (19.2)
Oral agent(s)	3397 (47.8)	6212 (58.3)	15,894 (55.8)
Insulin	2700 (38.0)	3147 (29.5)	6,846 (24.0)
Unknown or missing	0	0	292 (1.0)
Age at audit, y, mean (SD)	55.6 (13.4)	55.2 (13.6)	54.9 (13.8)
Duration of disease, y, mean (SD)	9.2 (7.6)	8.7 (7.5)	8.3 (7.3)
Age at onset, y	46.4 (13.2)	46.5 (13.2)	46.6 (13.4)
Body mass index, unadjusted mean (SD)	32.1 (6.7)	33.0 (7.0)	34.4 (7.8)
Body mass index, adjusted <sup>a</sup> mean (SD)	32.1 (0.1)	33.0 (0.1)	34.4 (0.1)
Men	31.3 (0.1)	32.1 (0.1)	33.7 (0.1)
Women	32.6 (0.1)	33.7 (0.1)	34.9 (0.1)

<sup>a</sup>Adjusted for age, sex, duration of diabetes, treatment type, and treatment facility.

**Table 2. Trends in Class of Body Mass Index by Sex Among American Indian and Alaska Native Adults With Type 2 Diabetes, Diabetes Care and Outcomes Audit, Indian Health Service, 1995–2004**

Body Mass Index	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	% change
<b>Class I (30.0–34.9 kg/m<sup>2</sup>)</b>											
All	2193 (30.9)	2261 (30.0)	2290 (30.3)	2814 (30.6)	3228 (30.3)	3234 (29.3)	4631 (29.8)	4905 (29.7)	6954 (28.6)	8232 (28.9)	–6.5
Men	896 (32.2)	978 (32.7)	964 (31.2)	1201 (32.7)	1356 (32.0)	1407 (31.0)	2032 (31.5)	2186 (31.8)	3184 (31.1)	3766 (31.1)	–3.4
Women	1297 (30.0)	1283 (28.3)	1326 (29.7)	1613 (29.2)	1872 (29.2)	1827 (28.1)	2599 (28.7)	2719 (28.2)	3770 (26.9)	4466 (27.2)	–9.3
<b>Class II (35.0–39.9 kg/m<sup>2</sup>)</b>											
All	1192 (16.7)	1329 (17.6)	1320 (17.5)	1618 (17.6)	1957 (18.4)	2063 (18.7)	2955 (19.0)	3261 (19.8)	4873 (20.1)	5814 (20.4)	+22.2
Men	415 (14.9)	473 (15.8)	449 (14.5)	582 (15.8)	714 (16.8)	791 (17.4)	1189 (18.4)	1293 (18.8)	1938 (18.9)	2369 (19.6)	+31.5
Women	777 (18.0)	856 (18.9)	871 (19.5)	1036 (18.8)	1243 (19.4)	1272 (19.6)	1766 (19.5)	1968 (20.4)	2935 (20.9)	3445 (21.0)	+16.7
<b>Class III (≥40.0 kg/m<sup>2</sup>)</b>											
All	816 (11.5)	929 (12.3)	960 (12.7)	1343 (14.6)	1581 (14.9)	1710 (15.5)	2648 (17.1)	2926 (17.7)	4760 (19.6)	5784 (20.3)	+76.5
Men	216 (7.7)	285 (9.5)	313 (10.1)	422 (11.5)	459 (10.8)	547 (12.1)	885 (13.7)	984 (14.3)	1603 (15.6)	2044 (15.6)	+102.6
Women	600 (13.9)	644 (14.2)	647 (14.5)	921 (16.7)	1122 (17.5)	1163 (17.9)	1763 (19.4)	1942 (20.2)	3157 (22.5)	3740 (22.8)	+64.0

All values are number (percentage) unless otherwise indicated.

**Table 3. Adjusted<sup>a</sup> Mean (SE) of Body Mass Index by Treatment Type Among American Indian and Alaska Native Adults With Diabetes, Diabetes Care and Outcomes Audit, Indian Health Service, 1995–2004**

Type of Treatment	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	P Value <sup>b</sup>
Diet or exercise alone	32.3 (0.22)	32.5 (0.22)	32.4 (0.21)	33.1 (0.20)	33.2 (0.20)	33.0 (0.18)	32.8 (0.15)	33.4 (0.13)	33.4 (0.11)	33.8 (0.10)	<.001
Oral agent(s)	32.1 (0.11)	32.3 (0.10)	32.6 (0.10)	32.9 (0.09)	33.0 (0.08)	33.1 (0.08)	33.6 (0.07)	33.9 (0.72)	34.4 (0.06)	34.6 (0.06)	<.001
Insulin	32.0 (0.14)	31.8 (0.16)	32.4 (0.15)	32.9 (0.14)	31.6 (0.13)	33.2 (0.14)	33.6 (0.12)	33.8 (0.12)	34.1 (0.11)	34.1 (0.10)	<.001

<sup>a</sup>Adjusted for age, sex, duration of diabetes, treatment type, and treatment facility.

<sup>b</sup>P value determined by analysis of covariance.

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