Prevalence of Diabetes Is Higher Among Female than Male Zuni Indians

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OBJECTIVE — Test the hypothesis that diabetes and related risk factors are more common among female than male Zuni Indians.

RESEARCH DESIGN AND METHODS — We conducted a population-based, cross-sectional survey of the Zuni Indians aged ≥5 years. We used households within neighborhood clusters as the sampling frame. We administered a questionnaire, collected blood and urine, and measured height and weight. Self-reported diabetes was used to assess previously diagnosed diabetes. Participants without a prior history of diabetes were classified as having newly diagnosed diabetes if they had HbA_{1c} >7.0% or random glucose ≥11.1 mmol/l during the survey.

RESULTS — The prevalence of previously diagnosed diabetes among Zuni Indians aged ≥5 years (n = 1,503) was higher among female Zuni Indians (16.7% [95% CI 14.1–19.3]) than male Zuni Indians (9.7% [7.4–12.1]) ($P < 0.001$). The prevalence of newly diagnosed diabetes was similar among female Zuni Indians (2.4% [1.4–3.4]) and male Zuni Indians (2.4% [1.2–3.6]). The prevalence of previously and newly diagnosed diabetes was higher among female Zuni Indians (19.1% [16.4–21.9]) than male Zuni Indians (12.2% [9.5–14.8]) ($P < 0.001$). The prevalence of obesity was higher among female Zuni Indians (34.3% [30.9–37.7]) than male Zuni Indians (21.5% [18.4–24.7]) ($P < 0.001$). Obesity was associated with diabetes among female and male Zuni Indians. Physical inactivity was more common among female Zuni Indians (44.2% [40.7–47.8]) than male Zuni Indians (35.1% [31.5–38.7]) ($P < 0.001$). However, physical inactivity was not associated with diabetes among either female or male Zuni Indians. Gestational diabetes was a risk factor among female Zuni Indians.

CONCLUSIONS — Among the Zuni Indians, the prevalence of diabetes was 57% higher among female than male members of the population. Culture, tradition, and lifestyle differences may contribute to the higher prevalence of diabetes and obesity among female Zuni Indians.

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Among most populations worldwide, the prevalence of diabetes is similar among female and male members of the population (1). However, among American Indians, the prevalence of diabetes may be higher among female than male members of the population (2–6). The Zuni Indians, an American Indian tribe of New Mexico, have high rates of diabetes and diabetic complications (7). The present study was conducted to test the hypothesis that diabetes and related risk factors are more common among female than male Zuni Indians.

RESEARCH DESIGN AND METHODS

Study population

The 2000 Zuni Tribal Census (ZTC) (8) listed 10,228 tribal members. The median age was 26 years, and 8% of the population was aged ≥60 years. Of the Zuni Indians, ~80% live in the Zuni Pueblo. Immigration and emigration rates are low.

The Zuni Kidney Project survey

Between February 1999 and April 2002, the Zuni Kidney Project conducted a population-based cross-sectional survey (PBCSS) of Zuni Indians aged ≥5 years (n = 9,228), with the aim of recruiting ≥1,500 participants (7). We used household sampling within neighborhood clusters to maximize participation and reduce differential-surveillance bias. We administered a questionnaire, collected blood and urine, and measured height and weight. Serum glucose was measured using the glucose-oxidase method, and HbA_{1c} was measured using a latex immunoagglutination method. The study was approved by the University of New Mexico's human research review committee, the Indian Health Service's institutional review board, and the Zuni Tribal Council.

A previous diagnosis of diabetes was ascertained by the question: "Has a doctor, nurse or other health professional ever told you that you had diabetes?" Agreement of self-reported diabetes with medical records was 98% (7). Among female participants, the history of gestational diabetes mellitus (GDM) was ascertained by the question: "Has a doctor, nurse or other health professional ever told you that you had gestational diabetes?" Interviewers were trained to translate each question into the Zuni language and explain the meaning of each

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Abbreviations: GDM, gestational diabetes mellitus; IQR, interquartile range; OR, odds ratio; PBCSS, population-based cross-sectional survey; SHS, Strong Heart Study; ZTC, Zuni Tribal Census.

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Age distribution of PBCSS participants: comparison with the 2000 ZTC ≥5 years (8)*

Age (years)	Female and male Zuni Indians combined		Female Zuni Indians		Male Zuni Indians	
	PBCSS	Census	PBCSS	Census	PBCSS	Census
5–19	28.9 (26.3–31.6)	32.7	23.7 (20.8–26.6)	31.5	34.7 (30.8–38.6)	34.0
20–39	42.3 (39.8–44.9)	37.8	41.2 (38.0–44.4)	36.6	43.5 (39.7–47.4)	39.0
40–59	21.6 (19.5–23.6)	21.6	26.6 (23.7–29.5)	23.5	16.0 (13.4–18.7)	19.6
≥60	7.2 (5.8–8.6)	7.9	8.5 (6.6–10.5)	8.4	5.7 (4.1–7.4)	7.4

Data are % of combined group or sex group (95% CI).

question, as needed. Agreement of self-reported history of GDM with medical records was assessed in 155 female participants with at least one live birth (72 with and 83 without self-reported history of GDM). Among participants with no prior diagnosis of diabetes, newly diagnosed diabetes was assessed by random glucose ≥11.1 mmol/l (9,10) or HbA_{1c} >7.0% (11,12). The cut point of 7.0% was chosen to maximize specificity and minimize false positives (28). The prevalence of newly diagnosed diabetes was also computed for HbA_{1c} cut points of 6.5 and 6.0%. For participants aged ≥20 years, overweight was defined as 25 ≤ BMI < 30, and obesity as BMI ≥30. For participants aged 5–19 years, BMI-for-age percentiles were obtained from sex-specific growth charts. Overweight was defined as 85th percentile ≤ BMI < 95th percentile, and obesity as BMI ≥95th percentile (13). Participants were defined as physically inactive if they indicated that they had not been routinely exercising. Exercise included leisure-time and work-related physical activity (7). In a pilot study of 50 participants from this community, reproducibility of a basic question on exercise was 100%, and the κ statistic was 1.0 (7).

Statistical analyses

Percents are reported with 95% CI in parentheses, and medians with the interquartile range (IQR) in parentheses. The prevalences of diabetes and related risk factors for Zuni Indians aged ≥5 years were age- and sex-adjusted to the ZTC (8) to accommodate any slight departures in the sample from the age and sex distribution within the ZTC and to provide more accurate estimates of the population prevalence. Variance estimates were obtained by Taylor series linearization to adjust for dependencies created by sampling within families and include the finite population correction factor, since >10% of the eligible population was enrolled in the study. Generalized estimating equations were used to assess potential risk factors for diabetes. Household members were grouped, and an exchangeable covariance matrix was used to accommodate the dependencies created by sampling multiple household members. Comparison of self-reported medical conditions with medical records was conducted using the κ statistic. Statistical analyses were conducted in SAS (SAS Institute, Cary, NC) and SUDAAN (RTI, Research Triangle Park, NC) to account for the complex study design. The level of statistical significance was $P < 0.05$.

RESULTS

Sample

During the enrollment period, 1,623 participants were recruited in the PBCSS. Of the participants, 120 were excluded from this analysis for the following reasons: the participant was not a Zuni Indian (n = 51), the laboratory results were pending (n = 45), or the participant chose not to provide all questionnaire information and specimens (n = 24). The resulting 1,503 Zuni PBCSS participants represent a significant portion (16%) of the eligible population. Of the participating households, >30% had at least one member enrolled in the PBCSS. The median number of enrolled individuals per participating household was 2 (range 1–15).

The percent of female participants was similar among the PBCSS (52.3% [95% CI 50.1–54.5%]) and the ZTC (51.9%). The age distribution (Table 1) was also similar among participants and the ZTC. However, compared with the ZTC, the PBCSS sample slightly underrepresented the age group of 5–19 years and slightly overrepresented the age group of 20–39 years, with some differences by sex. The percent of the PBCSS sample ≥25 years of age with at least a high school education (61.7% [58.3–65.1]) was similar to that in the ZTC (58.7%) (7).

Previously diagnosed diabetes

The prevalence of previously diagnosed diabetes, stratified by age and sex, was adjusted to the ZTC (Table 2). Among Zuni Indians aged ≥5 years, the overall prevalence of previously diagnosed diabetes was 13.4% (95% CI 11.7–15.1). The prevalence of previously diagnosed diabetes was higher among female Zuni Indians (16.7% [14.1–19.3]) than male Zuni Indians (9.7% [7.4–12.1]) (P < 0.001). The overall disparity was accounted for by the population ≥40 years of age.

Among participants with previously diagnosed diabetes, HbA_{1c} was >7.0%, and/or serum glucose was ≥11.1 mmol/l among 71.5% (95% CI 64.2–78.9) of female participants and 60.7% (48.3–73.0) of male participants. Among participants with previously diagnosed diabetes, the median age at diagnosis was 43.7 years (IQR 36.3–52.7) among female participants and 39.9 years (31.9–51.0) among male participants. The median duration of diabetes was 7 years (3–14) among female participants and 5 years (2–12) among male participants. Metabolic control was equally poor (i.e., HbA_{1c} >8.0%) among female participants (54.2% [95% CI 46.0–62.3]) and male participants (44.3% [31.5–57.0]).

Newly diagnosed diabetes

Among Zuni Indians aged ≥5 years, the estimated prevalence of newly diagnosed diabetes (random glucose ≥11.1 mmol/l or HbA_{1c} >7.0%), adjusted to the ZTC (Table 2), was 2.4% (95% CI 1.6–3.2). The prevalence of newly diagnosed diabetes was similar among female Zuni Indi-

Table 2—*Prevalence* of previously diagnosed diabetes, newly diagnosed diabetes, and previously plus newly diagnosed diabetes, stratified by age and sex, for the Zuni population*

Age (years)	*n*		Previously diagnosed diabetes		Newly diagnosed diabetes		Previously plus newly diagnosed diabetes	
	Female	Male	Female	Male	Female	Male	Female	Male
5–19	186	249	0.3 (0.0–0.9)	0.0	0.7 (0.0–1.9)	0.9 (0.0–2.5)	1.0 (0.0–2.4)	0.9 (0.0–2.5)
20–39	324	312	7.0 (4.2–9.9)	5.5 (3.1–7.7)	3.1 (1.2–5.0)	3.0 (1.1–5.0)	10.1 (6.8–13.5)	8.5 (5.5–11.5)
40–59	209	115	34.9 (28.5–41.3)†	23.9 (16.2–31.6)	4.1 (1.5–6.8)	3.2 (0.2–6.2)	39.0 (32.4–45.5)†	27.1 (19.1–35.1)
≥60	67	41	69.4 (58.1–80.7)†	39.8 (24.7–55.0)	1.2 (0.0–3.5)	4.2 (0.0–9.6)	70.6 (59.4–81.8)†	44.0 (28.7–59.3)
≥5	786	717	16.7 (14.1–19.3)‡	9.7 (7.4–12.1)	2.4 (1.4–3.4)	2.4 (1.2–3.6)	19.1 (16.4–21.9)‡	12.2 (9.5–14.8)
45–74	198	95	49.5 (42.5–56.6)†	35.6 (26.2–45.0)	3.8 (1.2–6.5)	4.8 (0.7–8.9)	53.4 (46.4–60.4)	40.4 (30.7–50.2)
≥20	600	468	24.3 (20.7–27.8)‡	14.8 (11.3–18.2)	3.2 (1.8–4.6)	3.2 (1.6–4.8)	27.5 (23.8–31.1)‡	18.0 (14.3–21.7)

Data are % (95% CI). *Prevalence is age- and sex-adjusted to the Zuni Tribal population aged ≥5 years (8); variance estimates are adjusted for dependencies created by sampling within families and include the finite population correction factor. †$P < 0.05$, ‡$P < 0.001$, female vs. male members of the population.

ans (2.4% [1.4–3.4]) and male Zuni Indians (2.4% [1.2–3.6]). When we lowered the HbA_{1c} cut point to 6.5 and 6.0%, the prevalence of newly diagnosed diabetes increased to 3.6% (2.6–4.5) and 9.3% (7.8–10.7), respectively. For both cut points, the prevalence of newly diagnosed diabetes was similar among female and male Zuni Indians.

Previously and newly diagnosed diabetes

The prevalence of previously and newly diagnosed diabetes, stratified by age and sex, was adjusted to the ZTC (Table 2). Among Zuni Indians aged ≥5 years, the overall prevalence of previously and newly diagnosed diabetes was 15.8% (95% CI 14.0–17.6). The prevalence of previously and newly diagnosed diabetes was higher among female Zuni Indians (19.1% [16.4–21.9]) than male Zuni Indians (12.2% [9.5–14.8]) ($P < 0.001$). Among Zuni Indians aged ≥5 years, regardless of self-reported diabetes, HbA_{1c} and random glucose were more likely to be elevated among female Zuni Indians (14.6% [12.1–17.1]) than male Zuni Indians (8.2% [6.0–10.3]) ($P < 0.001$).

Diabetes and reproductive history

The percent agreement of self-reported history of GDM with medical records was 89%, and the κ statistic was 0.78 (95% CI 0.68–0.87). Among female subjects reporting at least one viable pregnancy (n = 417, pregnancies = 1,243), 20.9% (16.9–24.8) reported a history of GDM. Of those reporting a history of GDM, 36.3% (26.7–45.9) had a prior diagnosis of diabetes or newly diagnosed diabetes at the time of the PBCCS. The prevalence of diabetes (either previously diagnosed or newly diagnosed) was 33.3% (11.6–55.1), 37.6% (29.2–46.0), and 58.6% (50.3–67.0) among female participants ≥40 years of age with 0, 1–3, and ≥4 live births, respectively (n = 18, 125, and 133, respectively; $P < 0.05$ for 1–3 vs. ≥4 live births).

Risk factors for diabetes

The percent of Zuni Indians who were overweight, obese, and physically inactive, stratified by age and sex, was adjusted to the ZTC (Table 3). Among those 5–19 years of age, being overweight (BMI 85th–95th percentile) was more prevalent among female Zuni Indians (22.3% [95% CI 15.9–28.6]) than male Zuni Indians (10.2% [6.3–14.1]) ($P < 0.01$). However, among those aged ≥20 years, being overweight (BMI 25–30) was equally prevalent among female Zuni Indians (38.2% [34.3–42.2]) and male Zuni Indians (39.2% [34.7–43.8]).

In contrast, among those 5–19 years of age, the prevalence of obesity (BMI ≥95th percentile) was similar for female

Table 3—*Prevalence* of being overweight, obese, and physically inactive, stratified by age and sex, for the Zuni population*

Age (years)	*n*†		Overweight‡		Obese§		Physically inactive‖	
	Female	Male	Female	Male	Female	Male	Female	Male
5–19	186	249	22.3 (15.9–28.6)¶	10.2 (6.3–14.1)	21.6 (15.1–28.0)	22.8 (16.9–28.7)	23.7 (17.9–29.4)	20.2 (15.4–25.1)
20–39	324	312	34.6 (29.5–39.7)	39.1 (33.7–44.6)	42.5 (37.1–47.8)**	24.9 (20.2–29.5)	59.7 (54.3–65.1)¶	46.9 (41.4–52.4)
40–59	209	115	40.4 (33.8–47.1)	39.8 (30.8–48.7)	38.8 (32.2–45.3)**	18.3 (11.3–25.3)	53.8 (47.1–60.5)††	39.4 (30.6–48.2)
≥60	67	41	47.8 (35.4–60.1)	38.6 (23.6–53.6)	34.2 (23.0–45.4)††	6.5 (0.0–15.1)	27.4 (16.5–38.4)	29.4 (15.2–43.4)
≥5	786	717	33.2 (29.8–36.6)	29.4 (25.8–32.8)	34.3 (30.9–37.7)**	21.5 (18.4–24.7)	44.2 (40.7–47.8)¶	35.1 (31.5–38.7)
45–74	198	95	42.9 (35.9–49.9)	40.3 (30.4–50.2)	41.5 (34.6–48.5)**	13.3 (6.4–20.3)	48.8 (41.8–55.8)	35.6 (25.9–45.3)
≥20	600	468	38.2 (34.3–42.2)	39.2 (34.7–43.8)	40.2 (36.3–44.0)**	20.9 (17.2–24.5)	53.7 (49.7–57.7)¶	42.7 (38.2–47.3)

Data are % (95% CI). *Prevalence is age- and sex-adjusted to the Zuni Tribal population aged ≥5 years (8); variance estimates are adjusted for dependencies created by sampling within families and include the finite population correction factor. †BMI information was missing for 9 participants, physical activity information was missing for 9 participants; ‡participants were classified as being overweight if 85th percentile ≤ BMI < 95th percentile (age 5–19 years), or 25 ≤ BMI < 30 (age ≥20 years); §participants were classified as being obese if BMI ≥95th percentile (age 5–19 years), or if BMI ≥30 (age ≥20 years); ‖participants were classified as being physically inactive if they indicated that they had not been routinely exercising. Exercise included both leisure-time and work-related physical activity. ¶$P < 0.01$, **$P < 0.001$, ††$P < 0.05$, female vs. male members of the population.

Zuni Indians (21.6% [95% CI 15.1–28.0]) and male Zuni Indians (22.8% [16.9–28.7]). However, among those aged ≥20 years, the prevalence of obesity (BMI ≥30) was significantly higher for female Zuni Indians (40.2% [36.3–44.0]) than male Zuni Indians (20.9% [17.2–24.5]) ($P < 0.001$). Among Zuni Indians ≥60 years of age, obesity was over fourfold more common among female Zuni Indians (34.2% [23.0–45.4]) than male Zuni Indians (6.5% [0.0–15.1]) ($P < 0.05$).

Among those aged 20–39 and 40–59 years, female Zuni Indians (20–39 years: 59.7% [95% CI 54.3–65.1]; 40–59 years: 53.8% [47.1–60.5]) were more likely to be physically inactive than male Zuni Indians (20–39 years: 46.9% [41.4–52.4]; 40–59 years: 39.4% [30.6–48.2]) ($P < 0.05$). Among those aged 5–19 and ≥60 years, female and male Zuni Indians were equally likely to be physically inactive.

Table 4 presents the estimated odds ratios (ORs) for diabetes (either previously diagnosed or newly diagnosed) among participants aged ≥20 years. Separate models were constructed for female and male participants and for the group as a whole. Both the univariate and multivariate models included adjustment for age and, when female and male participants are combined, for sex. Two multivariate models for female participants are shown. Model A contains the female-specific variables of parity and GDM. Model B contains the same variables used in the male model. Among both female and male participants, obesity, being overweight, and older age were associated with diabetes. Among female participants, a history of GDM was associated with diabetes in both the univariate and multivariate models. A history of four or more live births was associated with diabetes in the univariate model, but not in the multivariate model. Female sex tended to be associated with increased ORs for diabetes in the combined univariate (OR 1.70 [95% CI 1.20–2.39]) ($P < 0.01$) and multivariate (1.39 [0.97–1.98]) ($P = 0.07$) models.

CONCLUSIONS — The present study demonstrates that the prevalence of diabetes is higher among female than male Zuni Indians. The magnitude of the disproportion observed in this study (57%) is much greater than what was reported in earlier studies among the Zuni Indians (7%) (14,15), Pima Indians

Table 4—*Estimated ORs for diabetes (either previously diagnosed or newly diagnosed) from generalized estimating equations among PBCSS participants aged ≥20 years*

	Female participants (n = 593)			Male participants (n = 462)		Female plus male participants (n = 1,055)	
Variable	Univariate model*	Multivariate model A†	Multivariate model B†	Univariate model*	Multivariate model B†	Univariate model*	Multivariate model B†
Female	—	—	—	—	—	1.70 (1.20–2.39)	1.39 (0.97–1.98)
Age (years)							
20–39	0.16 (0.10–0.25)	0.17 (0.11–0.28)	0.16 (0.10–0.25)	0.22 (0.12–0.39)	0.19 (0.10–0.35)	0.18 (0.13–0.26)	0.17 (0.12–0.25)
40–59 (ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
≥60	3.36 (1.85–6.10)	2.92 (1.50–5.67)	3.28 (1.77–6.10)	1.89 (0.90–4.00)	2.40 (1.11–5.20)	2.66 (1.70–4.16)	2.88 (1.80–4.61)
BMI (kg/m^2)							
<25 (ref)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25–29.9	1.85 (1.04–3.29)	1.86 (1.05–3.31)	1.86 (1.05–3.31)	2.18 (1.15–4.17)	2.12 (1.12–4.03)	2.07 (1.35–3.19)	2.08 (1.35–3.20)
≥30	2.40 (1.37–4.22)	2.37 (1.34–4.19)	2.45 (1.39–4.31)	3.62 (1.71–7.67)	3.55 (1.68–7.50)	2.87 (1.83–4.52)	2.88 (1.83–4.54)
Physical inactivity	0.88 (0.58–1.33)	0.81 (0.52–1.26)	0.84 (0.55–1.28)	1.38 (0.80–2.37)	1.28 (0.74–2.22)	1.03 (0.74–1.43)	0.97 (0.69–1.35)
Parity							
0	0.45 (0.19–1.07)	0.49 (0.20–1.17)	—	—	—	—	—
1–3 (ref)	1.00	1.00	—	—	—	—	—
≥4	1.71 (1.10–2.68)	1.54 (0.96–2.47)	—	—	—	—	—
Gestational diabetes	3.19 (1.75–5.83)	2.86 (1.53–5.34)	—	—	—	—	—

Data are OR (95% CI). *The univariate model includes only one variable, with adjustment for age and, when female and male participants are combined, sex; †the multivariate model includes all applicable variables, with multivariate model A including the female-specific variables of parity and GDM, and multivariate model B omitting these variables.

(26%) (3), Strong Heart Study (SHS) participants (11–39%) (5,6), and Navajo Indians (39%) (4). Moreover, our study extends earlier observations by demonstrating that the prevalence of obesity is also significantly higher among female than male Zuni Indians, and this contributes to the higher prevalence of diabetes among female Zuni Indians.

Obesity was significantly associated with diabetes. Furthermore, the OR for diabetes for female participants decreased from 1.70 (95% CI 1.20–2.39) to 1.39 (0.97–1.98) after adjustment for BMI and physical activity. Higher prevalences of both obesity and diabetes among female than male participants were also reported at the SHS sites in Arizona and the Dakotas (5,16). In contrast, at the SHS site in Oklahoma, the prevalences of obesity and diabetes were similar among female and male participants (5,18). Thus, the higher prevalence of obesity among female Zuni Indians may contribute to their higher prevalence of diabetes.

We also observed a higher prevalence of physical inactivity among female than male Zuni Indians. Although we used a nonvalidated questionnaire to collect information on physical activity, validation of exercise is often infeasible (17) and was not possible in this study. In our study, physical inactivity was not associated with diabetes. However, it may contribute to the high prevalence of obesity among female Zuni Indians.

In our study, a high proportion of female participants reported a history of GDM, confirming previous observations among the Zuni Indians (18) and other American Indians (19,20). GDM is associated with diabetes in both the univariate and multivariate models. This is consistent with the broad general agreement that GDM is an early marker of the development of diabetes later in life (21).

Several additional factors may contribute to the higher prevalence of diabetes among female Zuni Indians: *1*) they may be more likely to seek medical advice, and thus be diagnosed with diabetes; *2*) sensitivity of random glucose and HbA_{1c} may be higher among female than male Zuni Indians; *3*) female members of the population may be more likely to self-report diabetes than their male counterparts; and *4*) increased longevity among female Zuni Indians may lead to survivor bias.

The Navajo Health and Nutrition Survey reported a higher prevalence of newly diagnosed diabetes among male members of the population (4), suggesting that they are less likely to be diagnosed with diabetes. In our study, the prevalence of newly diagnosed diabetes was similar between female and male Zuni Indians. Thus, it is unlikely that the higher prevalence of diabetes among female Zuni Indians can be explained by a greater likelihood of being diagnosed with diabetes.

In our study, participants with no prior diagnosis of diabetes were classified as having newly diagnosed diabetes if they had HbA_{1c} >7.0% or random glucose ≥11.1 mmol/l. Because these measurements have relatively low sensitivity, we may have underestimated the prevalence of newly diagnosed diabetes, compared with studies using an oral glucose tolerance test or fasting glucose (4,22). However, this underestimation is likely to be equally distributed between female and male Zuni Indians. It is possible that the sensitivity of random glucose and HbA_{1c} for the diagnosis of diabetes is higher among female than male Zuni Indians. However, the current criteria for the diagnosis of diabetes in both clinical (9,10) and epidemiological settings (11,12) do not recommend different cut points for female and male participants.

The validity of self-reported information on medical history, assessed by comparison with medical records, was high for both female and male participants (7). Furthermore, among participants reporting a prior diagnosis of diabetes, similar proportions of female and male participants had documented random hyperglycemia and/or elevated HbA_{1c}. Thus, the higher prevalence of diabetes among female Zuni Indians cannot be explained by less valid self-reported medical information.

In our study, the prevalence of obesity declines more with advancing age among males than female Zuni Indians. Furthermore, the prevalence of diabetes increases less with advancing age among male than female Zuni Indians. These observations may be explained by a survivor effect, i.e., obese diabetic male Zuni Indians dying earlier than female Zuni Indians. Among the Pima Indians, death rates are higher among male than female members of the population, and prevalence of diabetes is higher among female than male Pima Indians (5,23). Thus, a survivor effect may contribute to the higher prevalence of diabetes among female than male Zuni Indians.

Among the U.S. population, American Indians had the largest increase in the prevalence of diagnosed diabetes over the last decade (2,24). Among the Zuni Indians, the prevalence of diagnosed diabetes observed in this study is 15.8%, and it is likely to have increased from what was previously reported: 4.3% in 1975 (14) and 8.0% in 1985 (15). However, the availability of only crude prevalence estimates from historical data does not allow us to precisely estimate the magnitude of the increase. This increase has occurred despite a successful community-based exercise and weight control program (Zuni Diabetes Project) that has been implemented since 1983 (25,26).

The high prevalence of diabetes among female Zuni Indians is a public health concern. Studies among the Pima Indians have shown that in utero exposure to hyperglycemia may confer on the offspring an increased risk of diabetes and obesity above that genetically transmitted (27). This may result in a further increase in the prevalence of diabetes among future generations. Furthermore, because the SHS has shown that diabetes has a greater negative impact on cardiovascular risk factors in female than male members of the population (16), we may expect increasing prevalence of cardiovascular disease among women.

In summary, among the Zuni Indians, the estimated prevalence of diabetes is 57% higher among female than male members of the population. Additional studies are needed to identify the factors responsible for the higher prevalence of obesity and diabetes among female Zuni Indians.

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