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Differences in food habits and cardiovascular disease risk factors among Native Americans with and without diabetes: the Inter-Tribal Heart Project

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Abstract

Objective: To examine differences in food habits among Native Americans with and without diabetes.
Design: A cross-sectional epidemiological study in which participants underwent a physical examination and answered an extensive interviewer-administered questionnaire to assess differences in food servings, preparation and eating habits.
Setting/participants: Participants aged ≥ 25 years were randomly selected from three reservations in Minnesota and Wisconsin. There were 990 persons without diabetes, 294 with a prior diagnosis of diabetes, and 80 with fasting glucose $>125\,\mathrm{mg\,dl^{-1}}$ but no prior diabetes diagnosis.
Results: Persons with prior diabetes diagnosis were less likely than those without diabetes to report eating fast-food meals two or more times per week, eat visible fat on meat or the skin on poultry, eat fried chicken or fried fish, to add fat to cooked vegetables and drink whole milk. Persons with previously undiagnosed diabetes were more likely than previously diagnosed persons to report eating fast-food meals two or more times per week, eat visible fat on meat and the skin on poultry, drink whole milk and eat fried fish, but were less likely to drink low-fat milk. Previously undiagnosed persons were more likely than either diagnosed persons or persons without diabetes to consume lard from cooked foods and use it when cooking.
Conclusion: Persons with diagnosed diabetes showed healthier eating patterns than those without diabetes, while undiagnosed persons showed some less favourable patterns. Because virtually all persons with diabetes in these communities receive nutrition education, the results suggest that nutrition education programmes for diabetics may be associated with healthier eating patterns.

Keywords
Diabetes
Food habits
Native Americans

The prevalence of diabetes has increased among Native Americans and Alaska Natives. From 1990 to 1997, diabetes prevalence increased by 30%[1,2]. Persons with type 2 diabetes are at increased risk of cardiovascular disease (CVD)[3,4]. Heart disease is the leading cause of death among Native Americans[5,6], and CVD death rates for Native Americans in some regions defined by the Indian Health Service (IHS) are higher than the average CVD death rates for the general US population[6].

Although nutrition and health education are important in preventing and controlling type 2 diabetes and CVD, results from the Third National Health and Nutrition Examination Survey (NHANES III) indicated that, among US adults with type 2 diabetes, 31% did not participate in physical activity, 62% ate fewer than 5 servings of fruits and vegetables per day and almost two-thirds consumed more than 30% of calories from fat[7]. Nutrition education among diabetics has been shown to increase participants' knowledge about their diet and improve blood glucose control[8,9]. It has also been reported that community-based outreach approaches to diabetes management in socially disadvantaged patients improve quality of care dramatically[10]. However, such health education classes are attended only by those persons who have a diabetes diagnosis. There is less information on dietary habits among those with undiagnosed diabetes but with plasma glucose levels that satisfy established criteria for diabetes[11]. From 1992 to 1994, the Centers for Disease Control and Prevention (CDC), the IHS and three Native American communities conducted the Inter-Tribal Heart Project (ITHP) to examine the prevalence of CVD risk factors among community members. In those communities,

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persons diagnosed with diabetes receive standard nutrition education through the IHS and tribal clinics when they are diagnosed. To assess the effectiveness of such nutrition counselling, we examined whether persons with diabetes reported different (and healthier) food habits from persons without diabetes or with undiagnosed diabetes and fasting glucose $\geq 7\,\text{mmol}\,l^{-1}$ ($\geq 126\,\text{mg}\,dl^{-1}$).

Methods

The ITHP is a CVD epidemiological and health promotion project among adults from one Menominee and two Chippewa communities in Wisconsin and Minnesota[12–14]. Data for the epidemiological study were collected between August 1992 and July 1994. Trained technicians and interviewers gathered information on physiological, medical, psychosocial and behavioural variables. Informed consent was obtained, and the Institutional Review Boards of each participating tribe, the IHS and the CDC approved the study.

Random samples of adults were drawn from IHS clinic user lists for each community, which were determined to be the most reliable sources for identifying members of the resident populations. All persons aged ≥25 years who had used the clinics within the previous 3 years were eligible to participate. A total of 2068 individuals were eligible after excluding deceased, non-resident and institutionalised persons. Among those who were eligible, 19% declined participation, 14% agreed to participate but did not report for the examination and 67% participated in the survey, resulting in a total of 1376 participants (527 men and 849 women)[14].

Trained interviewers conducted a food habits survey among participants. Food models were used to show portion sizes. Participants recalled how many times a week they consumed certain foods; for example, 'How many 3-oz portions of chicken or turkey do you eat per week?' Participants reported the number of food servings eaten daily, weekly or monthly, and these were standardised to the number of servings eaten per week for these analyses. Other questions ascertained food preparation and eating habits, including frequency of eating at fast-food restaurants, whether particular foods eaten were usually fried, types of fat used in cooking and added to cooked foods, and other food preparation methods. Due to length and time constraints, the tool used to assess dietary intake was adapted from standard food frequency surveys available at the time the study was developed and basically assessed frequency of intake. The selection of foods to be included was based on extensive collaborations between the IHS, CDC and the tribes that participated. Local representatives (tribal members) helped to determine the food topics based on foods eaten in the area and methods of preparation.

Nutrition education is provided to those with diabetes. For persons with diabetes, the IHS and tribal clinic nutrition education programme serving ITHP communities consisted of an annual consultation with a registered dietitian, who conducted a standardised IHS assessment of the patient's food habits and negotiated a food plan centred on the principles of 'eat less sugar, eat less fat, eat more fibre, and eat less food'. The IHS diabetes programme conducted annual standardised medical record audits of diabetes care, and in 1992, 62% (n audited = 183) of patients with diagnosed diabetes in the ITHP communities had documentation of nutritional education[15].

Participants were instructed to fast for at least 12 h prior to their physical examination. Blood chemistry was measured at the Medical Research Laboratory (Highland Heights, KY, USA). Serum total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C) and glucose were determined by enzymatic methods using a Hitachi 737 chemistry analyser and reagents from Boehringer Mannheim Diagnostics (Indianapolis, IN, USA). Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula[16] and was not calculated if triglycerides were $>4.52\,\text{mmol}\,l^{-1}$ ($400\,\text{mg}\,dl^{-1}$). Dyslipidaemia was categorised as follows: total cholesterol, $\geq 6.21\,\text{mmol}\,l^{-1}$ ($240\,\text{mg}\,dl^{-1}$); LDL-C, $\geq 4.14\,\text{mmol}\,l^{-1}$ ($160\,\text{mg}\,dl^{-1}$); HDL-C, $<0.91\,\text{mmol}\,l^{-1}$ ($35\,\text{mg}\,dl^{-1}$)[16]. High triglycerides was defined as a value $\geq 2.82\,\text{mmol}\,l^{-1}$ ($250\,\text{mg}\,dl^{-1}$)[17]. These cut-off points were those recommended by expert panels at the time of the study.

Physical examinations were conducted in tribal clinics by trained technicians. Blood pressure was measured with a mercury sphygmomanometer three times after an initial 5-min rest; the average of the second and third readings was used to estimate systolic (first Korotkoff sound) and diastolic (fifth Korotkoff sound) blood pressure. Hypertension was defined as systolic pressure ≥140 mmHg or diastolic pressure ≥90 mmHg or current use of hypertension medication[18]. Height (cm) and weight (kg) were measured with the patient dressed in light clothing and without shoes. Obesity was defined[19] as body mass index (BMI) $\geq 30.0\,\text{kg}\,m^{-2}$. Current cigarette smoking status and sedentary leisure-time activity were determined by a questionnaire administered by trained interviewers. Sedentary leisure time was defined as no participation in sports, exercise, gardening or other leisure-time activity during the previous 12 months. Known diabetes status was based on the person having been told by a doctor they had diabetes or current taking of diabetes medications. Previously undiagnosed diabetes status was based on the participant having a fasting glucose level $\geq 7\,\text{mmol}\,l^{-1}$ ($\geq 126\,\text{mg}\,dl^{-1}$) but reporting they had not been told they had diabetes or not taking diabetes medications.

Analyses included data for 1364 participants whose diabetes status was known. We examined differences in food servings, food habits and risk factor levels by diabetes status. Differences between groups were

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assessed by analysis of variance for continuous variables and by chi-square tests for categorical variables. Analysis of covariance for continuous dependent variables and multivariable logistic regression for categorical dependent variables were carried out for analyses adjusting for age and gender. Two sets of multivariable logistic models were used. To compare persons with diabetes with those without diabetes, the first model included dummy variables for prior and previously undiagnosed diabetes along with age and gender, with non-diabetic persons as the referent group. To compare previously undiagnosed persons with prior diagnosed persons, the second model included dummy variables for normal glucose and newly diagnosed persons along with age and gender, with previously diagnosed persons as the referent. A significance level of $P \leq 0.05$ for two-tailed tests was used to determine statistical significance.

Results

Of the 1364 participants, 990 persons did not have diabetes, 294 persons had a prior diabetes diagnosis and 80 persons had undiagnosed diabetes (Table 1). Compared with other groups, a higher percentage of persons with previously undiagnosed diabetes were men (47.5%, vs. 35.7% of previously diagnosed persons and 37.1% of persons without diabetes). There was a greater percentage of persons aged ≥65 years among those with a prior diabetes diagnosis (28.6%) than among those who were previously undiagnosed (13.7%) or who did not have diabetes (9.2%).

Overall, almost 36% of persons had at least one dyslipidaemia, 32% had high blood pressure and 47% were considered obese. Sixty per cent of persons with high blood pressure were taking hypertension medication, and 52% of persons with a prior diabetes diagnosis were taking diabetes medications. Persons with either previously diagnosed or previously undiagnosed diabetes were more likely to have high total cholesterol, high triglycerides, low HDL-C or any dyslipidaemia, compared with persons without diabetes. Persons with either previously diagnosed or previously undiagnosed diabetes were more likely to have hypertension and BMI $\geq 30\,\mathrm{kg\,m^{-2}}$ than were persons without diabetes.

Compared with persons without diabetes, age- and gender-adjusted analyses suggested that persons with prior diabetes diagnosis reported eating fewer servings of beef or pork and desserts per week, and slightly more servings of oatmeal or oat foods and servings of fruit per week (Table 2). Other food servings showed somewhat favourable trends but were not statistically significant. Persons with previously undiagnosed diabetes reported more servings of fruit or vegetable juice than did persons without diabetes; no other differences were statistically significant.

Food habits by diabetes status are shown in Table 3. In multivariable analyses adjusting for age and gender,

Table 1 Characteristics of participants ($n = 1364$) by diabetes status, Inter-Tribal Heart Project

	Total ($n = 1364$)		Persons without diabetes ($n = 990$)		Persons with prior diabetes diagnosis ($n = 294$)		Persons with undiagnosed diabetes ($n = 80$)	
Characteristic	n/N	%	n/N	%	n/N	%	n/N	%
Gender								
Female	854/1364	62.6	623/990	62.9	189/294	64.3	42/80	52.5
Male	510/1364	37.4	367/990	37.1	105/294	35.7	38/80	47.5
Age group (years)								
25–44	598/1363	43.9	534/989	54.0	38/294	12.9	26/80	32.5
45–64	579/1363	42.5	364/989	36.8	172/294	58.5	43/80	53.7
65 and older	186/1363	13.6	91/989	9.2	84/294	28.6	11/80	13.7
Education								
Less than high school	405/1348	30.0	260/985	26.4	120/283	42.4	25/80	31.2
High school	437/1348	32.4	320/985	32.5	84/283	29.7	33/80	41.2
More than high school	506/1348	37.5	405/985	41.1	79/283	27.9	22/80	27.5
Dyslipidaemias								
Total cholesterol $\geq 6.21\,\mathrm{mmol\,l^{-1}}$	295/1359	21.7	196/988	19.8	79/291	27.1	20/80	25.0
Triglycerides $\geq 2.82\,\mathrm{mmol\,l^{-1}}$	206/1359	15.2	98/988	9.9	82/291	28.2	26/80	32.5
LDL-C $\geq 4.14\,\mathrm{mmol\,l^{-1}}$	232/1307	17.7	164/970	16.9	55/264	20.8	13/73	17.8
HDL-C $< 0.91\,\mathrm{mmol\,l^{-1}}$	130/1358	9.6	77/988	7.8	39/291	13.4	14/80	17.5
Any dyslipidaemia	485/1359	35.7	309/988	31.3	135/291	46.4	41/80	51.2
Hypertension	435/1364	31.9	237/990	23.9	167/294	56.8	31/80	38.7
BMI $\geq 30.0\,\mathrm{kg\,m^{-2}}$	634/1352	46.9	407/980	41.5	175/293	59.7	52/79	65.8
Smoking status								
Never	199/1353	14.7	139/985	14.1	47/288	16.3	13/80	16.2
Former	413/1353	30.5	274/985	27.8	117/288	40.6	22/80	27.5
Current	741/1353	54.8	572/985	58.1	124/288	43.1	45/80	56.2
No leisure-time physical activity	378/1344	28.1	252/983	25.6	99/281	35.2	27/80	33.7

LDL-C – low-density lipoprotein cholesterol; HDL-C – high-density lipoprotein cholesterol; BMI – body mass index.
Hypertension status: systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg or taking hypertension medication.

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Table 2 Reported food servings per week by diabetes status, Inter-Tribal Heart Project

Food	Servings per week, mean (standard error)		
	Persons without diabetes	Persons with prior diabetes diagnosis	Persons with undiagnosed diabetes
3-oz portions of beef or pork	6.2 (0.16)[a]	5.4 (0.31)[a]	5.9 (0.55)
3-oz portions of chicken or turkey	2.1 (0.07)	2.0 (0.13)	1.8 (0.23)
Servings of fish (3 oz per serving)	0.9 (0.03)	1.0 (0.06)	0.9 (0.11)
Servings of oatmeal or oat foods	2.3 (0.09)[c]	3.0 (0.18)[c]	2.4 (0.32)
1/2-cup servings of dried beans	1.1 (0.05)	1.0 (0.09)	1.1 (0.16)
1-oz servings of cheese	3.8 (0.17)	3.5 (0.34)	4.0 (0.60)
Number of eggs	4.9 (0.18)	5.0 (0.36)	5.6 (0.63)
1/2-cup servings of rice, pasta, potatoes, cereal	1.7 (0.11)	1.7 (0.22)	1.4 (0.39)
Bread, 1 slice	20.4 (0.46)	22.2 (0.89)	22.0 (1.6)
Bowls of salads (green or vegetable)	2.7 (0.12)	2.7 (0.22)	2.7 (0.40)
1/2-cup servings of vegetables	7.6 (0.17)	8.0 (0.32)	7.4 (0.57)
1/2-cup servings of fruit or vegetable juice	6.5 (0.28)[b]	7.1 (0.53)	9.1 (0.96)[b]
Servings of fruit	5.6 (0.19)[b]	6.6 (0.36)[b]	5.8 (0.64)
1-cup servings of milk	7.3 (0.28)	8.3 (0.55)	6.2 (0.97)
Desserts	4.1 (0.17)[c]	2.8 (0.33)[c]	3.3 (0.59)
Salty snacks	3.9 (0.18)	3.8 (0.34)	4.7 (0.62)
1-tsp servings butter, margarine, real mayonnaise	18.1 (0.50)	18.4 (0.97)	18.2 (1.7)

Means are adjusted for age and gender.
[a]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.05$.
[b]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.01$.
[c]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.005$.

persons with prior diabetes diagnosis were less likely than persons without diabetes to report eating fast-food meals two or more times per week, less likely to eat visible fat on meat or the skin on poultry, somewhat more likely to drink low-fat milk and less likely to drink whole milk, less likely to eat fried chicken or fried fish, and less likely to add fat to cooked vegetables.

In analyses adjusting for age and gender, persons with previously undiagnosed diabetes were more likely than persons with prior diabetes diagnosis to report eating fast-food meals two or more times per week, more likely to eat the visible fat on meat and the skin on poultry, less likely to drink low-fat milk and more likely to drink whole milk, and more likely to always eat fried fish. Persons with previously undiagnosed diabetes were more likely than either persons with previously diagnosed diabetes or persons without diabetes to use lard or meat drippings in cooked foods and when cooking.

Discussion

Guidelines for primary and secondary prevention of diabetes and CVD include dietary counselling[20–22]. In this context, findings from the Inter-Tribal Heart Project provide interesting insights into the association between health education and dietary habits among a population at high risk for diabetes and CVD.

In the USA, only about 19% of physician office visits for routine examination include counselling for physical activity, 2.8% include diet counselling and 10.4% include weight reduction advice[23]. Diabetes self-management is most effective when behavioural change strategies are incorporated into the education process[24]. A meta-analysis of various intervention methods among persons with diabetes suggested that dietary instruction has a significant effect on knowledge gain[25]. However, the Healthy Eating Index reported that only 10% of American Indians have healthy diets[26] and many health-care professionals do not pursue diet counselling with Native American patients[27,28]. Diet and exercise that induce a 5–7% weight loss can reduce the incidence of diabetes by 58% in high-risk individuals[29]. Similar results were reported from a Finnish study on diet and exercise intervention for those with impaired glucose tolerance (IGT). A 58% relative reduction in diabetes incidence was reported for the intervention group[30]. In the Da Qing IGT and Diabetes Study, 577 participants with IGT received diet and exercise intervention. The diet, exercise and diet-plus-exercise interventions were associated with 31%, 46% and 42% reductions in the risk of developing diabetes, respectively[31].

Although the cross-sectional nature and small sample size of our study does not allow us to presume cause and effect, the observation that persons with previously undiagnosed diabetes (based on fasting glucose level) reported some worse food habits than those with diabetes might result from the education that diabetic persons receive through diabetes care. More longitudinal observations are needed to confirm this. In the ITHP, a large percentage of persons who had diabetes reported that they received nutrition and diet counselling at the IHS and/or tribal clinics.

Clinics serving these communities also provide community-based health education programmes that are available to all community members. Although 29% of participants reported they were aware of programs to reduce CVD risk, only 2–11% participated in any such

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Table 3 Reported food habits by diabetes status, Inter-Tribal Heart Project

	Persons without diabetes		Persons with prior diabetes diagnosis		Persons with undiagnosed diabetes	
Food habits reported	*n*/*N*	%	*n*/*N*	%	*n*/*N*	%
How often eat fast-food meals?						
Never	126/985	12.8	56/278	20.1	13/78	16.7
Less than once per week	285/985	28.9	91/278	32.7	18/78	23.1
Once per week	291/985	29.5	79/278	28.4	17/78	21.8
Two or more times per week	283/985	28.7[a]	52/278	18.7[b]	30/78	38.5[a,b]
Usually eats the visible fat on meat	315/981	32.1	82/273	30.0[c]	33/77	42.9[c]
Does not eat meat	10/981	1.0	1/273	0.4	1/77	1.3
Usually eats the skin on chicken and turkey	558/979	57.0[c]	122/273	44.7[c,d]	47/77	61.0[d]
Does not eat chicken or turkey	28/979	2.9	8/273	2.9	3/77	3.9
Of cheese you eat, how often is it low-fat, reduced-calorie or lite?						
Almost always	116/957	12.1	45/268	16.8	12/71	16.9
Half the time/sometimes	137/957	14.3	27/268	10.1	3/71	4.2
Rarely or never	625/957	65.3	164/268	61.2	49/71	69.0
Does not eat cheese	79/957	8.2	32/268	11.9	7/71	9.9
Type of milk usually drunk						
Skimmed or low-fat 1%	120/980	12.2[e]	36/274	13.1[e,a]	3/76	3.9[a]
Low-fat 2%	450/980	45.9	162/274	59.1	36/76	47.4
Whole	131/980	13.4[e]	16/274	5.8[e,f]	12/76	15.8[f]
Does not drink milk	279/980	28.5	60/274	21.9	25/76	32.9
Type of butter or margarine usually used						
Butter	285/973	29.3	66/272	24.3[a]	28/74	37.8[a]
Tub margarine/squeeze margarine	231/973	23.7	79/272	29.0	11/74	14.9
Stick margarine	447/973	45.9	126/272	46.3	33/74	44.6
Does not use butter or margarine	10/973	1.0	1/272	0.4	2/74	2.7
Of the beef/pork you eat, how often is it fried?						
Almost always	287/980	29.3	57/274	20.8	25/75	33.3
Half the time/sometimes	500/980	51.0	138/274	50.4	37/75	49.3
Rarely or never	178/980	18.2	78/274	28.5	12/75	16.0
Does not eat beef or pork	15/980	1.5	1/274	0.4	1/75	1.3
Of the chicken you eat, how often is it fried?						
Almost always	197/979	20.1	44/273	16.1	16/74	21.6
Half the time/sometimes	382/979	39.0	88/273	32.2	25/74	33.8
Rarely or never	367/979	37.5[e]	133/273	48.7[e]	30/74	40.5
Does not eat chicken	33/979	3.4	8/273	2.9	3/74	4.0
Of the fish you eat, how often is it fried?						
Almost always	452/983	46.0[a]	107/274	39.0[a,b]	36/75	48.0[b]
Half the time/sometimes	217/983	22.1	59/274	21.5	13/75	17.3
Rarely or never	173/983	17.6[a]	78/274	28.5[a]	11/75	14.7
Does not eat fish	141/983	14.3	30/274	10.9	15/75	20.0
Kind of fat usually added to cooked vegetables						
Liquid cooking oils	84/963	8.7	23/268	8.6	4/74	5.4
Margarine or solid vegetable shortening	305/963	31.7	76/268	28.4	12/74	16.2
Lard, meat drippings or butter	221/963	22.9[a]	51/268	19.0[b]	24/74	32.4[a,b]
Does not add fat to cooked vegetables	353/963	36.7[c]	118/268	23.4[c]	34/74	45.9
Skims the fat from meat juices	664/951	69.8	205/268	76.5	49/74	66.2
Usually adds salt to foods at the table	754/978	77.1	190/272	69.8	64/78	82.0

[a,b]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.01$.
[c,d]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.05$.
[e,f]Difference between diabetes status groups with similar superscript is statistically significant, $P \leq 0.005$.

programmes. For the programmes specifically on diet and heart disease, less than 10% of men and women in the ITHP reported any participation[14]. The health education classes offered to those diagnosed with diabetes is standard care practice, which is more than persons in the general community receive. Therefore, it might be expected that persons with diabetes have better eating habits as a result of diabetes education.

We recently reported that, among persons with diabetes, there were no differences in reported food habits between those who attended and those who did not attend such community-based health education programmes[32]. Although no differences were observed, such programmes may reinforce healthy behaviours learned in the clinic setting. Furthermore, for persons without diabetes or other chronic disease who may not receive specialised counselling, such community-based programmes may be the only local sources of health information. There is a paucity of data available on dietary habits among Native Americans with diagnosed and undiagnosed diabetes. Results from the ITHP study shed light on a lifestyle factor among a population that is at high risk for chronic disease.

Food preparation methods are also associated with poor glycaemic control and increased risk for diabetes. In our study, some reported preparation methods used by diabetics appeared to be healthier than those used by persons without diabetes. Persons with diabetes were more likely not to fry chicken or fish than were persons without diabetes, and not to add fat to cooked vegetables. Gittelsohn *et al.* reported that, among native Canadians who resided on reserves in north-western Ontario province, choice of cooking method and addition of fat during preparation increased the risk of IGT two-fold[33]. In the present study, those who were told they had diabetes had more favourable dietary habits than those with high fasting glucose, and showed some healthier patterns than persons without diabetes. This observation supports the probability that those diagnosed with diabetes changed dietary habits after being diagnosed. Various programmes are implemented by the IHS for individuals with diagnosed diabetes; however, to reduce the risk of developing diabetes, it would be useful to expand these programmes to include those who may have risk factors that predispose them to diabetes, such as IGT or high glucose levels[34].

The cross-sectional nature of the study limits our knowledge about the duration of dietary patterns and whether differences in food habits are related to nutrition counselling. However, nutrition education efforts that teach specific behavioural skills can influence eating habits[27]. The ITHP study used a dietary tool that was interviewer-administered; therefore, even though 42% of people with diabetes had less than a high school education, participant education level would not affect use of the tool. The small sample sizes in our study also limit our ability to adjust for various factors that may be related to differences in food habits. For example, co-morbid conditions may influence eating habits, but it is not known whether differences are due to diabetes status or to other factors such as co-morbidities with diabetes. Because this is a cross-sectional study, we are unable to determine improvements in some metabolic outcomes. Although people with diabetes in our study may have improved blood glucose and lipid levels, these improvements may not be observed when compared with the levels of non-diabetics. Miller *et al.* reported similar results in a 10-week nutrition intervention study that evaluated the intervention impact on blood glucose and lipid levels among people with diabetes[35]. Despite improvements in blood glucose levels, less than half of the participants met guidelines for metabolic outcomes set by the American Diabetes Association[35]. Many diabetes education programmes have been criticised as being too brief to meet the needs of clients[34]. It is also possible that greater improvements in metabolic parameters require more intensive therapy that combines exercise, diet and pharmacological therapy[35]. Moreover, the extent to which persons may be able to change their diets may be influenced by environmental and economic development factors that include food availability and cost[36–38].

In addition to the limits of a cross-sectional study design, there may be misreporting of dietary intake, which could lead to a measurement error especially since some participants had received some nutrition education and others had not[39–41]. There are various factors related to misreporting in dietary data collection, including misinterpretation of portion sizes, psychosocial factors related to health such as the stigmatism of obesity and demographic factors such as socio-economic status[42]. Another factor that may lead to misreporting is exposure to nutrition education or public health messages. In the ITHP study the diabetic participants were offered nutrition education and this could subsequently lead to dietary recall bias. Nutrition education programmes at the work-site have shown to influence dietary changes such as a reduction in dietary fat intake[43]. Peer support can lead to increased intakes of nutrients such as calcium among preadolescent females[44]. Therefore nutrition education can result in actual changes in dietary behaviours.

Currently, federally funded research emphasises participatory approaches in community health studies[45]. It is possible that self-directed learning experiences that are based on an appreciation for the culture and history of a group may be more effective. A randomised lifestyle intervention conducted among Pima Indians in Arizona reported that the group which was allowed to have experiences in their intervention that were self-directed, based on their culture and history, maintained their better lifestyle habits for longer than the group provided with structured lifestyle intervention guidelines[46]. Early prevention can also be effective. The IHS is now placing special emphasis on prevention of diabetes by the efforts of paediatricians involved in the care of children living on reservations[47].

The dietary habits survey utilised in the ITHP study was developed by the CDC and IHS based on standard food frequency surveys available at the time, such as NHANES. The survey developed was a shorter and simple measurement tool of food habits, which could provide relevant information for planning health promotion efforts in the ITHP communities[14].

Dietary intervention, along with other lifestyle interventions, should be the first approach in primary prevention and an important component of secondary diabetes prevention. The serious consequences of diabetes and CVD in the Native American population suggest that efforts to reduce the burden of these diseases need to be intensified.

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